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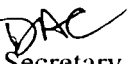
United States Department of State

*Assistant Secretary of State for Oceans and
International Environmental and Scientific Affairs*

Washington, D.C. 20520

September 2, 1994

TO: IWG/GEA Principals

FROM: David A. Colson 
Acting Assistant Secretary, OES

SUBJECT: Agency Clearance of the U.S. Climate Action Report

Attached for final agency clearance is a copy of the Climate Action Report. We have incorporated suggestions received during the review process and expect that it is now in final form. As Principals on the IWG/GEA, we ask that you:

- let us know immediately should you find any errors that may have been overlooked; and
- ensure that this document has the full and final clearance of your agency.

Please send notification of clearance to:

Daniel A. Reifsnyder, Director
Office of Global Change, Room 4333
Department of State
Washington, DC 20520-7818
Tel: 202-647-4069
Fax: 202-647-0191

by **COB Thursday, September 8**. If we have not heard from you by that time, we will assume that the Report has been cleared and will proceed with the production schedule timed to enable us to meet our commitment to submit the document to the INC by September 21.

We appreciate the valuable assistance your agencies have provided throughout this project. We believe that the document we present to the INC will be exemplary and indicative of our level of commitment to addressing the threat of climate change.

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Climate Action Report

**Submission of the United States of America Under the
United Nations Framework Convention on Climate Change**

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In June 1992 in Rio de Janeiro, world leaders and citizens of 176 countries gathered to agree on ways of working together to preserve and enhance the global environment. The Earth Summit aroused the hopes and dreams of people around the world and set in motion ambitious plans to address the planet's greatest environmental threats. We shared a common vision: to provide a higher quality of life for ourselves and our children.

At the Earth Summit, the United States joined other countries in signing the Framework Convention on Climate Change, an international agreement whose ultimate objective is to:

achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

introduction and overview



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The United States—and the international community—has confronted the threat of global climate change because most scientists agree that the threat is real. There is no doubt that human activities are increasing atmospheric concentrations of greenhouse gases, especially carbon dioxide, methane, and nitrous oxide. Models predict that these increases in greenhouse gases will cause changes in climate locally, regionally, and globally, with potential adverse consequences to ecological and socioeconomic systems. The best current predictions suggest that the rate of climate change could far exceed any natural changes that have occurred in the past 10,000 years. Of course, there are uncertainties regarding the magnitude, timing, and regional patterns of climate change. But any human-induced change that does occur is not likely to be reversed for many decades—or even centuries—because of the long atmospheric lifetimes of the greenhouse gases and the inertia of the system.

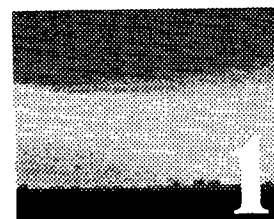
With this global threat in mind, President Clinton stated on Earth Day 1993:

We must take the lead in addressing the challenge of global warming that could make our planet and its climate less hospitable and more hostile to human life. Today, I reaffirm my personal and announce our nation's commitment to reducing our emissions of greenhouse gases to their 1990 levels by the year 2000. I am instructing my Administration to produce a cost-effective plan ... that can continue the trend of reduced emissions. This must be a clarification call, not for more bureaucracy or regulation or unnecessary costs, but instead for American ingenuity and creativity to produce the best and most cost-efficient technology.

In October 1993, the United States released the *Climate Change Action Plan* (Clinton and Gore 1993), detailing the initial U.S. response to climate change. The Plan outlined a comprehensive set of measures to reduce net emissions, covering greenhouse gases in all sectors of the economy. It focused on partnerships between the government and the private sector to help solve this pressing problem, and is now undergoing rapid implementation. The Plan laid a foundation for U.S. participation in the international response to the climate challenge. And finally, the Plan included a process for monitoring its effectiveness and for adapting to changing circumstances.

This document, the *Climate Action Report*, represents the first formal U.S. communication under the Framework Convention on Climate Change, as required under Articles 4.2 and 12. It is a snapshot—a description of the current U.S. program. It does not seek to identify additional policies or measures that might ultimately be taken as the United States continues to move forward in addressing climate change, nor is it intended to be a revision of the U.S. *Climate Change Action Plan*. It is not a substitute for existing or future decision-making processes—whether administrative or legislative—or for additional measures developed by or with the private sector. Meeting the formal reporting requirements in the Climate Convention, this document is also intended to identify existing policies and measures, and thus to assist in establishing a basis for considering future actions.

This document has been developed using the methodologies and format agreed to at the 9th Session of the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change. We assume that this communication, like those of other



countries, will be reviewed and discussed in the evaluation process for the Parties of the Convention. We hope that the measures detailed here provide useful examples of possible directions for the future.

This chapter briefly describes the climate-system science that sets the context for U.S. action, and then provides an overview of the U.S. program, which is the focus of the remainder of this report. In particular, the United States includes information in this report on: national circumstances, providing a context for action; an inventory of U.S. greenhouse gas emissions; mitigation programs; adaptation programs; research and education programs; international activities, including contributions to international financial mechanisms that address climate change; and a brief discussion of the future direction of the U.S. effort.

The Science

The scientific community has long noted the potential for human activities to contribute to global climate change. A broad international consensus regarding this issue has been developed over the past several years (and has been reported in the Intergovernmental Panel on Climate Change assessment reports); this summary is drawn from that consensus view. As the actions being taken by the United States ultimately depend on our understanding of the science, it is appropriate to review this information here.

The driving energy for weather and climate comes from the sun (Figure 1-1). The Earth intercepts solar radiation (short-wave and visible parts of the spectrum). About one-third of that radiation is reflected, and the rest is absorbed by different components of the climate system,

including the atmosphere, the oceans, the land surface, and biota. The energy absorbed from solar radiation is balanced, in the long term, by outgoing radiation from the Earth-atmosphere system. This terrestrial radiation takes the form of long-wave, invisible infrared energy. The magnitude of this outgoing radiation is determined by the temperature of the Earth-atmosphere system.

Several natural and human activities can change the balance between the energy absorbed by the Earth and that emitted in the form of long-wave, infrared radiation. These activities are both natural (including changes in solar radiation and volcanic eruptions) and human-induced, arising from industrial and land-use practices that release or remove heat-trapping "greenhouse" gases, thus changing the atmospheric composition.

Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and ozone (O_3). While water vapor has the largest effect, its concentrations are not directly affected, on a global scale, by human activities. Although most of these gases occur naturally (the exceptions are CFCs, HCFCs, HFCs, and PFCs), human activities have contributed significantly to increases in their atmospheric concentrations. Many greenhouse gases have long atmospheric residence times (several decades to centuries), which implies that the atmosphere will recover very slowly from such emissions, if at all.

Internationally accepted science indicates that increasing concentrations of greenhouse gases will ultimately raise atmospheric and oceanic temperatures and could alter associated



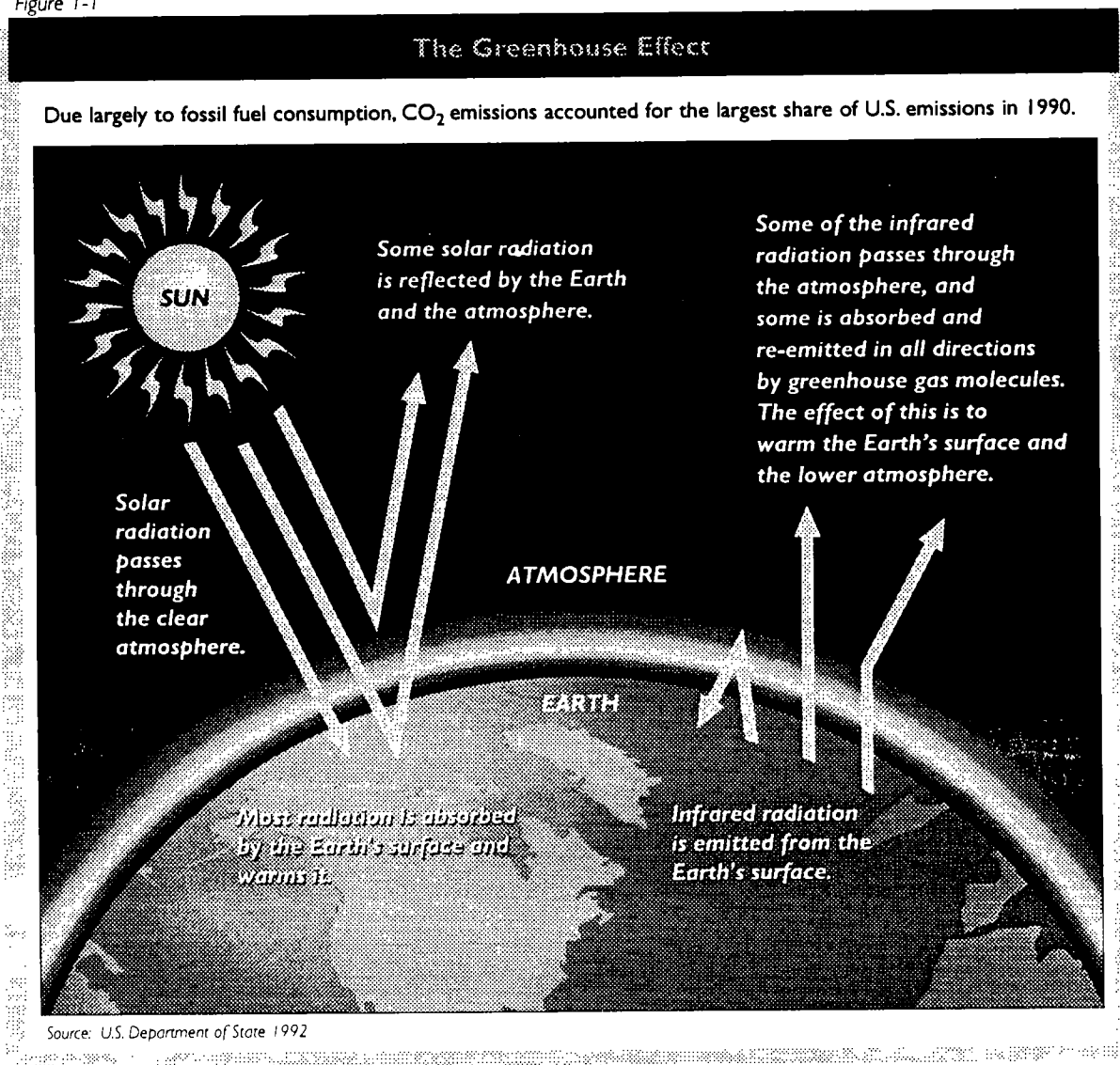
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circulation and weather patterns. Large computer-driven climate models predict that the equilibrium change in the average temperature of the globe's atmosphere as a consequence of doubling of CO₂ or its equivalent is unlikely to lie outside the range of 1.5–4.5°C (2.5–8°F), with a best estimate of 2.5°C (4.5°F). The equilibrium sea level rise associated with such doubling has been estimated to range between a few centimeters and one meter (about 2 inches to approximately 3 feet), with a best estimate of approximately 20

centimeters (8 inches). Because of the large thermal inertia of the Earth system, the equilibrium warming from added greenhouse gases is not reached until many decades after these emissions are released into the atmosphere.

While current analyses are unable to predict with confidence the timing, magnitude or regional distribution of climate change, the best scientific information indicates that such changes are very likely to occur if greenhouse gas concentrations continue to increase.

Figure 1-1





National Circumstances: A Context for U.S. Action

A nation's vulnerability and response to climate change are greatly affected by its institutions, governing structures, economic arrangements, energy use patterns, land uses, population growth and distribution, and many other factors. U.S. policymakers must take into account the complexities and special characteristics of the political, social, and economic orders in the United States. A description of land-use patterns sets the context for the discussion, in a subsequent chapter, of climate change impacts and adaptation measures, while energy, economic, and political factors shape the U.S. approach to mitigating climate change.

The United States is by far the world's largest economy, although per-capita GDP growth has slowed in recent years. The United States is also the world's largest producer and consumer of energy, and the largest producer of greenhouse gases. U.S. energy intensity (the amount of energy required to produce a unit of GDP) has improved by 27 percent from its 1970 peak, remaining stable since 1986. Like other industrialized countries, the United States relies heavily on fossil fuels to power its industrial, residential, and transportation sectors, although, as in other countries, renewable-energy sources, such as solar and biomass fuels, are anticipated to supply greater amounts of power in the coming decades.

Despite dramatic increases in the number of residences, number of electrical appliances, and the amount of heated space per person, residential energy use has remained roughly constant, due to efficiency improvements. Energy use in the commercial sector has increased substantially, however, due to that sector's extremely rapid

growth. Industrial energy intensity has improved by over 35 percent since 1972, resulting in energy savings of more than 12 quadrillion BTUs annually. A 34 percent decrease in average per-kilometer fuel consumption has partly offset a 50 percent increase in vehicle kilometers traveled since 1969, resulting in continuing growth of energy consumption and associated greenhouse gas emissions in the transportation sector.

The United States has a large and diverse land area of approximately 931 million hectares (2.3 billion acres) including cropland, grassland, pastures, ranges, wetlands, urban/suburban areas, protected areas, and other special uses. Forested areas have expanded in the past twenty years, though the amount of old-growth forests continues to decline. While total wetland areas have declined over the past several decades, the rate of decline has slowed; wetlands are anticipated to be among the land areas most severely affected by climate change. The amount of land devoted to urban use continues to increase, although only approximately 4.5 percent of total land area is classified as urban. U.S. population growth is slow overall, though immigration and internal migration contribute to faster growth in the South and in coastal regions, resulting in increased stress to coastal zones and heightened vulnerability to climate change. Low population densities in the United States result in relatively high energy use per capita, despite significant improvements in energy efficiency.

The United States has a market economy; the government has long played an important role in intervening to correct market failures and achieve various social ends. All levels of government have been involved in the protection of the environment. The federal government has actively sought to improve the quality of the natural environment and promote public health for



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the past twenty-five years. Most recently, government policies, even in "nonenvironmental" sectors, such as transportation, energy, and construction, are increasingly showing an awareness of the challenge of climate change. The Clinton Administration has made the formulation and implementation of its comprehensive *Climate Change Action Plan* a national priority.

Inventory of Greenhouse Gases

The Framework Convention on Climate Change calls upon Parties to: "periodically update, publish, and make available to the Conference of Parties ... national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties." This commitment was included in the Convention because it was clear to all countries that any effective climate policy must begin with an accurate inventory of gases that may influence global warming. A useful inventory must take into account the global warming potential of the various gases and analyze their production by different sectors of the economy, as well as account for their sequestration by carbon sinks, such as forests. At the 9th Session of the Intergovernmental Negotiating Committee (INC), guidelines for preparing greenhouse gas inventories were adopted; the discussion in this report follows the agreed format.

The most important anthropogenic greenhouse gases are carbon dioxide, methane, and nitrous oxide. Atmospheric concentrations of all three have increased significantly since the Industrial Revolution, almost certainly because

of human activities. Based on a recent recomputation of 1990 U.S. greenhouse gas emissions following the INC guidelines, the United States estimates that net emissions totaled 1,348 million metric tons of carbon equivalent (MMTCE) (Table 1-1). This represents a decrease in the previous estimate of 1,462 MMTCE, which was used in the development of the *Climate Change Action Plan*.

The relative effects of greenhouse gases can be compared using "global warming potentials." According to the 1990 inventory carried out by the United States, carbon dioxide accounted for 85 percent of the total global warming potential of all U.S. anthropogenic emissions not controlled by the *Montreal Protocol*, followed by methane with 11 percent, nitrous oxide with 3 percent, and hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) with 1 percent. These percentages have not changed significantly since 1990, although the use of HFCs and PFCs is expected to increase in future years. Total emissions have increased slightly since 1990 (Figure 1-2).

U.S. emissions of carbon dioxide, the principal anthropogenic greenhouse gas, are divided fairly evenly among industry (34 percent), transportation (31 percent), and utilities (35 percent, of which residences account for 19 percent and commercial buildings for 16 percent). Absorption of carbon dioxide in U.S. forests (carbon "sinks") has increased in recent years.

The principal sources of anthropogenic methane emissions are landfills (37 percent) and agriculture (32 percent), with coal, oil, and natural gas production accounting for most of the remainder. Nitrous oxide, an extremely potent greenhouse gas, is released principally through nitrogen-based fertilizers and industrial production of synthetic fiber.



Table 1-1

Recent Trends in U.S. Greenhouse Gas Emissions: 1991-1993 (Millions of Metric Tons)

Since 1990, overall emissions of carbon dioxide have increased, while emissions of other greenhouse and photochemically important gases have remained relatively constant or have declined.

Gas/Source	Emissions (Full Molecular Weight)				Emissions (Direct and Indirect Effects; Carbon Equivalent)			
	1990	1991	1992	1993	1990	1991	1992	1993
Greenhouse Gases								
Net Carbon Dioxide (CO₂)	4,520	4,463	4,541	-	1,233	1,218	1,239	-
Fossil Fuel Combustion	4,895	4,835	4,908	5,013	1,335	1,319	1,339	1,367
Other	62	61	62	-	17	17	17	-
Total	4,956	4,896	4,970	-	1,352	1,336	1,356	-
Forests (sink)	(436)	(433)	(429)	-	(119)	(118)	(117)	-
Methane (CH₄)	27.0	26.9	27.0	-	162	162	161	-
Landfills	10.0	10.1	10.2	10.3	60	61	61	62
Agriculture	8.6	8.5	8.6	8.8	52	51	52	53
Coal Mining	4.4	4.2	4.0	-	26	26	24	-
Oil and Gas Systems	3.2	3.3	3.3	-	19	20	20	-
Other	0.8	0.8	0.8	-	5	5	5	-
Nitrous Oxide (N₂O)	0.4	0.4	0.4	-	30	32	32	-
Industrial Processes	0.2	0.2	0.2	-	14	14	14	-
Agriculture	0.1	0.1	0.1	-	9	10	10	-
Fossil Fuel Consumption	0.1	0.1	0.1	-	7	7	7	-
HFCs and PFCs	*	*	*	-	19.2	19.6	20	-
Photochemically Important Gases								
Carbon Monoxide (CO)	82.7	81.4	78.1	-	-	-	-	-
Nitrogen Oxides (NO_x)	21.4	21.2	21.0	-	-	-	-	-
Nonmethane Volatile Organic Compounds (NMVOCs)	19.1	18.7	17.9	-	-	-	-	-
Net U.S. Emissions	-	-	-	-	1,444	1,432	1,452	-

Note: The totals presented in the summary tables in this chapter may not equal the sum of the individual source categories due to rounding.

* The total of each of these gases does not exceed 0.01 million metric tons.

Source: U.S. EPA 1994



Also included in the U.S. inventory are carbon monoxide (CO), nitrogen oxides (NO_x), and nonmethane volatile organic compounds (NMVOCs). These compounds have an indirect effect on climate change—for example, by increasing the atmospheric life of methane. Their relative and absolute contributions to climate change are uncertain.

U.S. Mitigation Actions

The Climate Convention calls for Annex I

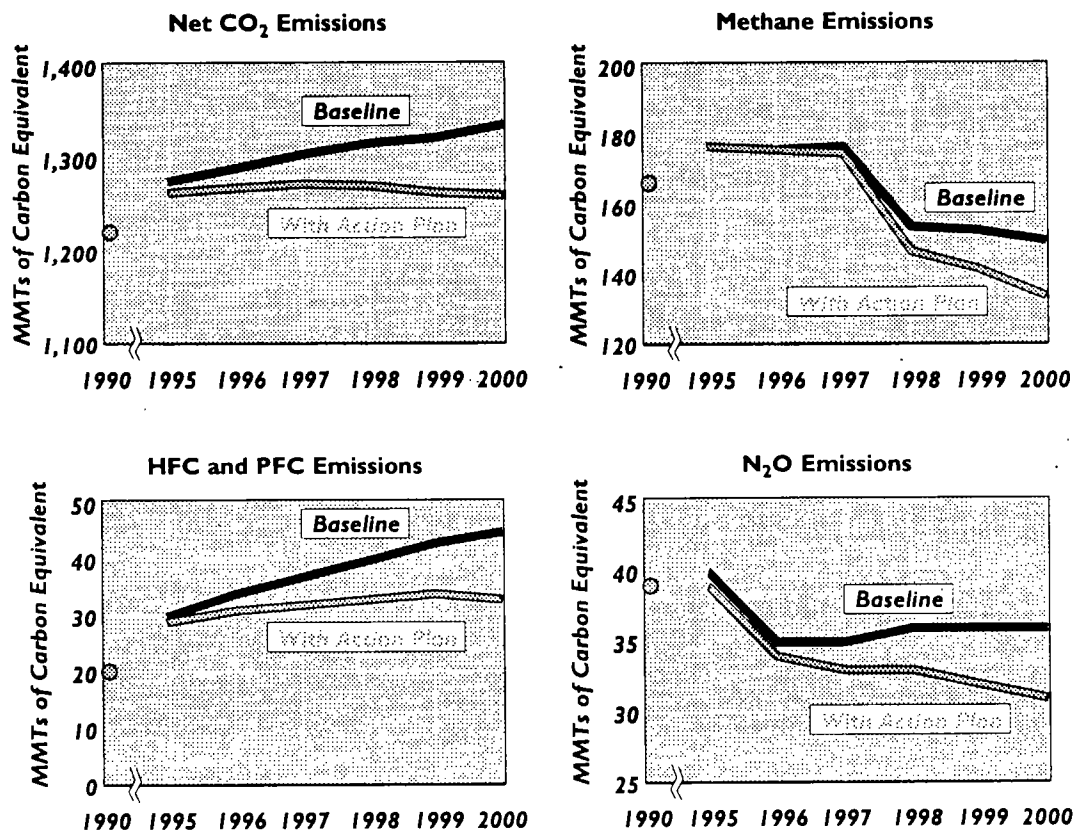
Parties (developed countries and countries with economies in transition to market economies) to aim to return their emissions of greenhouse gases to their 1990 levels by the year 2000. As with the reporting of inventories, the Intergovernmental Negotiating Committee, at its 9th Session, agreed on a format for reporting measures to address emissions and sinks of greenhouse gases. This report follows that recommended format.

The basis for the U.S. response to the challenge set forth in the Convention is the *Climate*

Figure 1-2

Effect of the Action Plan on Greenhouse Gas Emissions

The Action Plan reduces emissions for all greenhouse gases. Without it, projected net greenhouse gas emissions would rise to 1,674 millions of metric tons of carbon equivalent by the year 2000.



Source: US DOE 1994



Change Action Plan, announced by President Clinton and Vice President Gore in October 1993. The Plan blends market incentives, voluntary initiatives, research and development, improved regulatory frameworks, and intensified existing programs to achieve the reductions in emissions necessary to meet the U.S. commitment. As noted above, in 1990, U.S. emissions totaled 1,462 million metric tons of carbon equivalent (MMTCE). The Action Plan projects an emission level of 1,459 MMTCE by the year 2000, based on factors as anticipated in the fall of 1993.

The emission estimates reported in this section are slightly different from those used in the inventory described above. The data in the inventory chapter reflect recent guidance from the INC, which was only received after the actions in this section were proposed, analyzed, and adopted. A complete description of the inventory values used in Chapter 3 are reported in *Inventory of U.S. Greenhouse Gas Emissions and Sinks for 1990–1993* (U.S. EPA 1994); and a description of the inventory estimates used in developing the emission reductions projected in this section are provided in the *Climate Change Action Plan: Technical Supplement* (U.S. DOE 1994). Along with this report, both documents are provided to the Parties of the Climate Convention as part of the formal U.S. submission.

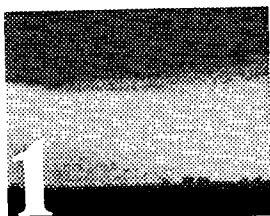
The Plan's comprehensive, portfolio approach addresses energy demand in all sectors, as well as energy supply and forestry (Table 1-2). This broad approach lessens the risk that poor performance in one sector will jeopardize the Plan as a whole. It is also cost-effective. In undiscounted dollars, the approximately \$60 billion in costs for the Plan from 1994 to 2000 are anticipated to be offset by approximately \$60 billion in energy savings for businesses and consumers

by 2000. An additional \$200 billion in savings is anticipated for 2001–2010.

Voluntary programs and market-based incentives are at the heart of the U.S. approach. Two of the most prominent programs in this effort are Green Lights and Climate Challenge. In the Green Lights program, over 4,500 companies have committed to a national effort to improve the efficiency of office lighting. And more than 750 utilities, representing over 80 percent of U.S. electric utility generation capacity, have already signed up for the Climate Challenge, under which they will inventory current emissions and report on actions to reduce them. Other aspects of the Plan improve information flows to private companies and encourage the accurate valuation of energy costs throughout corporate structures.

The Plan also concentrates on the reduction of methane and nitrous oxide, both of which have a greater global warming potential than carbon dioxide, ton for ton, and includes strategies to limit the growth of HFC and PFC emissions.

Although the United States provides a blueprint for reaching the near-term aim of the Climate Convention through domestic measures alone, it also recognizes the contribution that "joint implementation" could make toward achieving the Convention's goals. Thus, the United States is promoting cooperative efforts with other countries to take measures to reduce or sequester carbon. Toward this end, the United States has announced the U.S. Initiative on Joint Implementation, which sets ground rules for the qualification and evaluation of joint implementation projects.



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Table 1-2

Summary of Emission-Reduction Actions

The Action Plan uses a portfolio approach, targeting opportunities to reduce greenhouse gas emissions in all major areas: energy demand, energy supply, forestry, methane, and other gases.

Action # Description		GHG Reductions in 2000 (MMTCE)
Commercial Energy-Efficiency Actions		
Partnership Programs		
1	Coordinate DOE Rebuild America & EPA Energy Star Buildings	3.1
2	Expand EPA's "Green Lights" Program	2.5
Development, Commercialization, and Training		
3	Establish State Revolving Fund for Public Buildings	1.1
4	Expand Cost-Shared Demonstration of Emerging Technologies	} 3.8
5	Establish Energy-Efficiency and Renewable-Energy Information and Training Programs	
Commercial Demand Combined Results		10.6
Residential Energy-Efficiency Actions		
Appliance Improvements		
6	Form "Golden Carrot" Market-Pull Partnerships	} 11.8
7	Enhance Residential Appliance Standards	
Home Improvements		
8	Promote Home Energy-Rating Systems and Energy-Efficient Mortgages	} 4.4
9	Expand "Cool Communities" Program in Cities and Federal Facilities	
10	Upgrade Residential Building Standards	
11	Create Energy-Efficiency Programs and Housing Technology Centers	
Residential Demand Combined Results		16.3
Industrial Energy-Efficiency Actions		
Accelerated Efficiency		
12	Create a "Motor Challenge" Program	8.8
13	Establish Industrial "Golden Carrot" Programs for Industrial Air Compressors, Pumps, Fans, and Drives	} 2.9
14	Accelerate the Adoption of Energy-Efficient Process Technologies, Including the Creation of One-Stop Shops	
15	Expand and Enhance Energy Analysis and Diagnostic Centers	0.5
Pollution Prevention		
16	Accelerate Source Reduction, Pollution Prevention, and Recycling	4.2
17	Reduce Use of Fertilizers	2.7
18	Reduce Use of Pesticides	
Industrial Demand Combined Results		19.0
Transportation Energy-Efficiency Actions		
19	Reform Federal Tax Subsidy for Employer-Provided Parking	} 6.6
20	Adopt a Transportation System Efficiency Strategy	
21	Promote Greater Use of Telecommuting	
22	Develop Fuel-Economy Labels for Tires	1.5
Transportation Demand Combined Results		8.1

Figures in the table are given in constant (real) 1991 dollars, but are not discounted. Discounting future savings will tend to lower the apparent cost-effectiveness of many of the options, but the effect of that adjustment will depend on the discount rate used and the time profile of investment and cost savings. It is not possible to determine how much of this expenditure represents new investment and how much represents a shift in the composition of investment from a macroeconomic perspective.

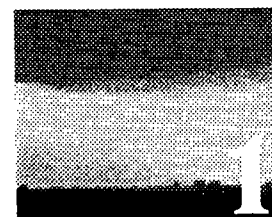
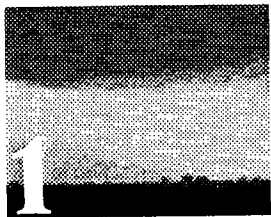


Table 1-2, continued

Summary of Emission-Reduction Actions		
Energy Supply		
Enhanced Natural Gas Utilization		
23	Increase Natural Gas Share of Energy Use Through Federal Regulatory Reform	2.2
24	Promote Seasonal Gas Use for the Control of Nitrogen Oxides	2.8
25	Commercialize High-Efficiency Gas Technologies	0.6
Enhanced Renewable Commercialization		
26	Form Renewable-Energy Market Mobilization Collaborative and Technology Demonstrations	0.8
27	Promote Integrated Resource Planning	1.4
Improved Performance of Existing Zero-Emission Technologies		
28	Retain and Improve Hydroelectric Generation at Existing Dams	2.0
Improved Energy Efficiency		
29	Accelerate the Development of Efficiency Standards for Electric Transformers	} 0.8
30	Launch EPA's "Energy Star Transformers"	
31	Reduce Electric Generation Losses Through Transmission Pricing Reform	0.8
Energy Supply Combined Results		10.8
Methane-Reduction And -Recovery Actions		
32	Expand "Natural Gas STAR"	3.0
33	Increase Stringency of Landfill Rules	4.2
34	Expand Landfill Outreach Program	1.1
35	Launch Coalbed Methane Outreach Program	2.2
36	Expand RD&D for Methane Recovery from Coal Mining	1.5
37	Expand RD&D for Methane Recovery from Landfills	1.0
38	Expand AgSTAR Partnership Program with Livestock Producers	1.5
39	Improve Ruminant Productivity and Product Marketing	1.8
Methane-Reduction and -Recovery Combined Results		16.3
HFC, PFC, and Nitrous Oxide Reduction Actions		
40	Narrow Use of High GWP Chemicals Using the Clean Air Act and Production Stewardship to Reduce Emissions	5.0
41	Create Partnerships with Manufacturers of HFC-22 to Eliminate HCFC-23 Emissions	5.0
42	Launch Partnership with Aluminum Producers to Reduce Emissions from Manufacturing Processes	1.8
17	Improve Efficiency of Fertilizer Nitrogen Use	4.5
HFC, PFC and Nitrous Oxide Combined Results		16.3
Forestry Actions		
43	Reduce the Depletion of Nonindustrial Private Forests	4.0
44	Accelerate Tree Planting in Nonindustrial Private Forests	0.5
16	Accelerate Source Reduction, Pollution Prevention, and Recycling	5.0
9	Expand "Cool Communities" Program in Cities and Federal Facilities	0.5
Forestry Combined Results		10.0
Total for Energy Sectors		66.0
Total for Nonenergy Sectors		42.6
GRAND TOTAL		108.6



Progress Toward Implementation

On the basis of assumptions regarding the costs of energy, the rate of growth of the U.S. economy, and the availability of funding for the programs outlined in the Plan, the United States projected a return of its greenhouse gas emissions to their 1990 levels by the year 2000. However, since the time these projections were prepared and the U.S. Action Plan was published, the economy has grown at a more robust rate than anticipated, the price of oil fell sharply before recently rising toward projected levels, and the U.S. Congress, which must appropriate funding for federal agency programs, does not appear likely to authorize full funding for the actions contained in the Plan. Unless offset by unanticipated emission reductions, the difference between the future anticipated when the Plan was developed and that anticipated under the present circumstances is likely to imply that the United States must develop additional measures to meet the emissions commitment made by the President on Earth Day.

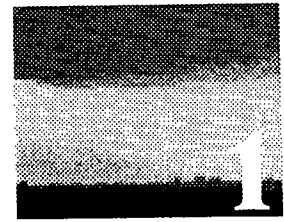
However, differences between earlier assumptions and current circumstances are only now being evaluated. Furthermore, the coming months will cause changes, either increasing or decreasing the gap. For example, the outstanding industry response seen in voluntary programs that are "unscored" in the current Plan could deliver benefits sufficient to make up any shortfall in "scored" programs. As a consequence, it is not yet possible to present a modified projection of the effects of measures outlined in Chapter 4 on mitigation as a function of this difference, or to detail the additional measures that may be taken to close the gap. The United States is committed to a full review of the U.S. Action

Plan in late 1995. In this review, a comprehensive analysis of the overlapping effects of the changes in economic assumptions and funding levels—as well as changes in the anticipated effects of individual measures—will be made. It is anticipated that, as a result of this review process, additional measures will be taken to ensure that the U.S. commitment is met.

Impacts and Adaptation

The impact of global change on natural ecosystems cannot be predicted with accuracy, in part because these complex systems are not yet well understood. The government is working to increase our knowledge base through the federal interagency Committee on Environment and Natural Resources and through the U.S. Ecosystem Management Initiative. Both of these efforts bring together experts from many federal agencies to examine how systems can be understood and kept healthy in their totality. However, despite the best efforts of governments to deal with the climate threat, it is unlikely that climate alteration can be avoided entirely. Further study is needed to see how natural systems can best adapt to climate change.

The National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine recently looked into the effects of climate change on the various principal ecosystems found in the United States (NAS/NAE/IM 1992). They found that U.S. water supplies, particularly some of the more vulnerable river systems, would be greatly influenced by possible increases in evaporation and changes in rain patterns. The extremely delicate wetlands and estuarine waterways found in U.S. coastal zones could be affected by sea level rise, alterations in upland water flow, human settle-



ment patterns, and other consequences of a changed climate. U.S. agriculture and industry appeared relatively less vulnerable to climate change. Lightly managed ecosystems of whatever type, by contrast, appeared extremely vulnerable. Forest systems might find that their most favorable climates shift hundreds of miles to the north, perhaps too rapidly for the trees to adapt. Work on understanding the impacts from and adaptation to the effects of climate change will remain a priority of federal agencies for many years to come.

Among the key areas on which U.S. adaptation efforts focus are contingency planning and consideration of uncertainty in ranges of potential outcome. The increased unpredictability of future events due to climate change and the increased risks of surprises or large-scale losses render this effort all the more important. Some of the efforts to manage for increased vulnerability include the establishment of the Floodplain Management Task Force, the efforts to better predict "El Niño" events (which lead to global changes in atmospheric behavior over relatively short periods), and water-use and coastal zone management programs, which focus on some of the most vulnerable systems.

Research and Public Education

Paramount to successfully mitigating and adapting to climate change is an ability to understand, monitor, and predict future changes. This, in turn, requires substantial research on the global climate system and the dissemination of such information to better enable society to respond appropriately. To address these needs, the United States has developed the U.S. Global Change Research Program, which, with a proposed budget in fiscal year 1995 of \$1.8 billion,

is the largest climate change research program in the world.

The U.S. Research Program, which is part of the Committee on Environment and Natural Resources, supports a wide range of policy-relevant research programs. These include trace atmospheric species and their effects on climate, the role of terrestrial and marine ecosystems in climate change and the impacts of climate change on these ecosystems, the socioeconomic and policy implications of climate change, and potential measures to mitigate and adapt to climate change. To facilitate the full and open exchange of climate change data, the U.S. Research Program is developing the Global Change Data and Information System, which will provide the infrastructure for linking global change data bases and information available within the various agencies of the federal government and will make them available to the public.

Recognizing the importance of international cooperation in global change research, the United States plays a major role in a variety of international efforts to understand and assess the state of knowledge about global change. The U.S. Research Program, in addition to its key role in support of domestic efforts, is a major contributor to international global change research programs, primarily through the Intergovernmental Panel on Climate Change, the World Climate Research Program, the International Geosphere-Biosphere Program, and the Human Dimensions of Global Environmental Change Program. In addition the United States is engaged in bilateral research projects and internationally coordinated research programs involved with climate change, placing special emphasis on the development of networks and institutes to promote the develop-



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ment of regional capabilities to conduct global change research. Similarly, U.S. scientists are contributing research information and are playing leadership roles in the assessments of the Intergovernmental Panel on Climate Change, which is supplying much of the scientific input to the international policy decisions on climate change.

Since decision making on national response strategies to climate change ultimately resides with the public, the U.S. is beginning to develop programs for general education, communication, and dissemination of climate change information. While many of these activities are organized under the U.S. Research Program, its member agencies have longstanding programs for educational outreach, many of which now are being extended to include climate change information and are turning from a purely domestic focus to include international activities.

International Activities

The success of the Framework Convention on Climate Change relies preeminently on cooperation among nations. To foster closer international cooperation on climate change, the United States is engaged in a wide range of bilateral and multilateral activities.

The United States provides technical assistance and facilitates the transfer of energy-efficient technologies through its Country Studies program, bilateral mitigation and adaptation projects, and information sharing and trade facilitation. The Country Studies program, funded at \$25 million over two years, helps developing countries and countries with economies in transition generate inventories of greenhouse gases, assess their vulnerability to climate change, and evaluate strategies for reducing net emissions of

greenhouse gases and adapting to the potential impacts of climate change.

A host of bilateral projects aimed at mitigating climate change are supported by the U.S. government, through the U.S. Agency for International Development and other key agencies involved in the climate change issue. U.S. bilateral mitigation projects include efforts on energy demand, power generation and distribution, renewables, clean coal, privatization, clean air, methane, and forestry. As part of its bilateral assistance programs, the United States also helps build capacity in countries to assess and/or minimize vulnerability to climate change.

A critical element of technology transfer is making information about available technologies easily accessible to foreign government agencies and private-sector firms, and helping them secure financing for beneficial technologies. To meet this need, the United States has established a number of information-sharing and trade-facilitation programs, with 1994 funding for such projects totaling more than \$10 million.

In multilateral fora related to global climate change policy matters, the United States plays a leadership role, which carries with it considerable financial responsibilities. In addition to participating actively in the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change, the United States has provided substantial financial resources to the INC, totaling \$____, or ____ percent of the total INC budget in 1994.

In support of the Global Environment Facility (GEF), the United States has pledged \$430 million (out of a \$2 billion total) to the GEF's replenishment. U.S. bilateral programs will continue to strengthen collaboration with the restructured GEF as a complement to U.S. contributions to the core fund.



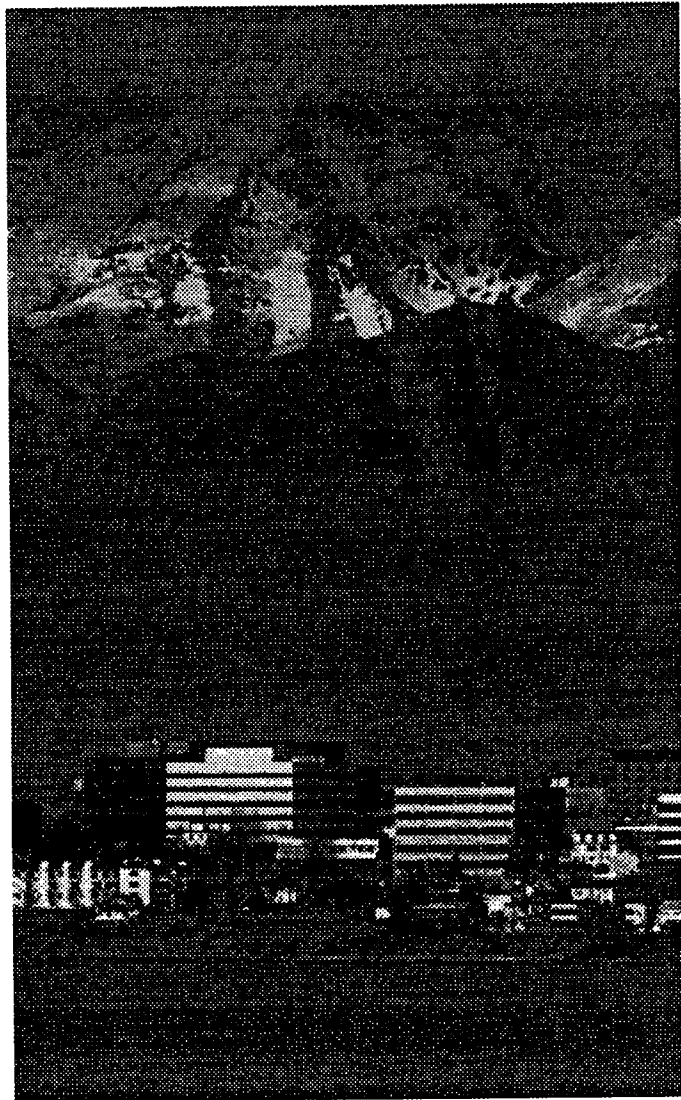
The Future

The United States is making significant strides toward reducing greenhouse gas emissions to their 1990 levels by the year 2000. To track the effectiveness of the programs and measures being implemented under the *Climate Change Action Plan*, U.S. agencies have established individual and joint tracking systems to develop performance indicators and progress milestones. Interim assessments to date show that significant progress has been made in meeting—and in some cases exceeding—these milestones, while in other cases specific measures are not performing as well as expected. However, as mentioned above, the overall combination of changes in economic growth, low oil prices, and fluctuations in energy demand currently suggests that the United States may need to implement additional measures to meet its commitment to return emissions to their 1990 level by the year 2000. It is important to recognize that the future effectiveness of current actions may be enhanced or diminished by changing circumstances in the domestic and international arenas.

As recommended by the guidelines adopted at the INC's 9th Session (UN/INC 1994), the United States has also provided a preliminary estimate of its emissions of greenhouse gases through the year 2010. Although the United States will continue to revise this estimate, the preliminary results indicate that to meet the ultimate objective of the Convention, the United States, and all nations, will need to develop additional measures to combat the longer-term trend of rising emissions. Toward this end, the United States has established a working group to devise a long-run strategy for examining all policies that could affect U.S. greenhouse gas emission levels beyond the year 2000, with particular

attention being given to accelerating technology research, development, and deployment and addressing expected increases in transportation needs.

Finally, in addition to continued activity in the domestic arena, the United States has been, and will continue to be, an active participant in international negotiations under the United Nations Framework Convention on Climate Change.



A country's climate, economic health and composition, demographic trends, political and institutional systems, energy production and consumption, and natural resources determine its vulnerability and adaptability to the effects of climate change. Identifying the opportunities for and costs of reducing the likelihood of climate change by adopting policies to limit greenhouse gas emissions and augment sinks also requires a thorough examination of all of these factors.

Perhaps the key element of a country's national circumstances is its political will. The Clinton Administration has made the formulation and implementation of its *Climate Change Action Plan* a priority, demonstrated by Chapter 4 of this document, which presents a detailed plan for mitigating greenhouse gas emissions to 1990 levels by the year 2000. Furthermore, many of the elements of the Plan have already been implemented, while an effort is under way to obtain legislative approval for others.

This chapter presents a snapshot of the national characteristics of the United States, current conditions and trends in those conditions, and their link to climate change issues and policymaking.

national
circumstances

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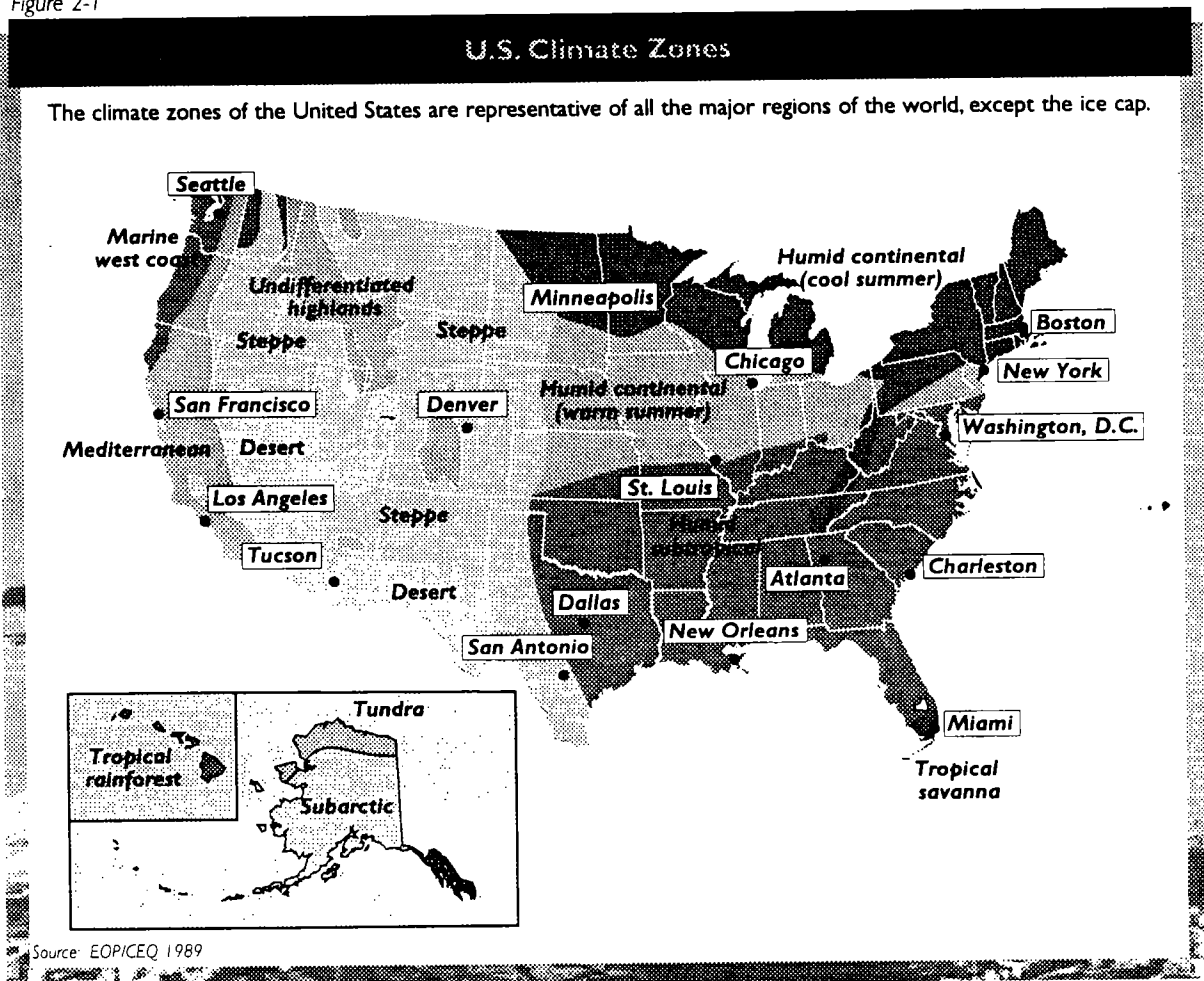


The U.S. Climate

The climate zones of the United States are representative of all the major regions of the world, except the ice cap (Figure 2-1). Some states encompass as many as five distinct climate types. Because of this broad diversity, describing the effects of climate change on the United

States as either positive or negative overall would be an oversimplification. For example, states with cooler climates may have extended growing seasons and lower heating bills. In the Sunbelt, on the other hand, energy consumption for cooling may rise, along with the emissions it

Figure 2-1





generates (Figure 2-2). The net effect on energy consumption would depend on the net change in heating- and cooling-degree days.

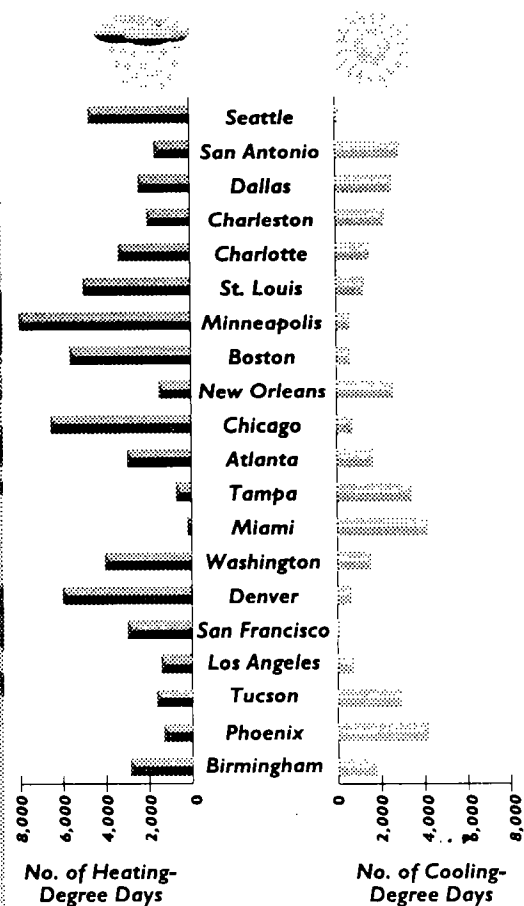
Baseline rainfall levels are also central to determining the vulnerability of the United States to global warming. Most of the western states are currently arid. The reduced rainfall and increased evaporation from global warming projected for midcontinental areas of the United States by general circulation models may exacerbate the scarcity of freshwater resources in those states. And although the eastern states have only rarely experienced severe drought, they are increasingly vulnerable to flooding and storm surges—particularly in densely populated coastal area—as sea level rises. If extreme weather events—such as tornadoes, hurricanes, and floods—occur with greater frequency and/or intensity, damages could be very expensive. However, there is great uncertainty about whether extreme events will become more common as a result of climate change.

Climate change may also benefit some plants and animals. Warmer temperatures may allow them to expand their range northward. Higher levels of CO₂ may boost the growth and productivity of some plants—particularly agricultural crops, where nutrients can be closely monitored.

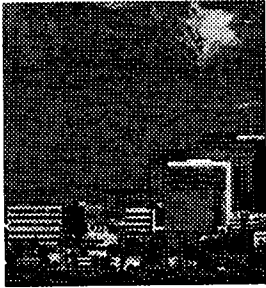
Figure 2-2

Heating- and Cooling-Degree Days in the U.S.

While states with cooler climates may benefit from global warming because of reduced demand for heating, energy consumption for cooling may rise in states with warmer climates, along with the emissions it generates.



Source: U.S. DOC/NOAA 1994b



U.S. Population Trends

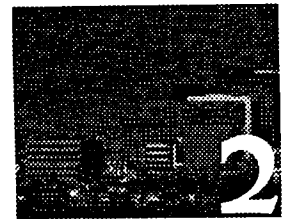
Demographic factors are critical determinants of a nation's economic and environmental health, its vulnerability to climate change, and its ability to mitigate and adapt to the effects of climate change. In particular, population levels and growth drive a nation's consumption of energy and other resources, while settlement patterns and population density affect dependence on transportation, the availability of land for various uses, and the vulnerability of coastal areas to flooding in the event of sea level rise.

With a population of over 250 million in 1993, the United States is the third most populous country in the world, after China and India. Its population density, however, is far lower: 27 people per square kilometer, versus 126 and 304 people per square kilometer in China and India, respectively. Average life expectancy at birth is now 75.8 years, with the population aging rapidly—the current median age of 33.1 years has risen by 5.1 years since 1970. The aging is a result of a number of factors—delay in child-birth as a result of increased female participation in the work force, expanded use of contraception, and higher life expectancy. Overall, population growth has slowed to about 1.1 percent per year.

The geographic distribution of the population has significant bearing on the global warming issue. For example, more and more people are moving to the drier, warmer climate of the

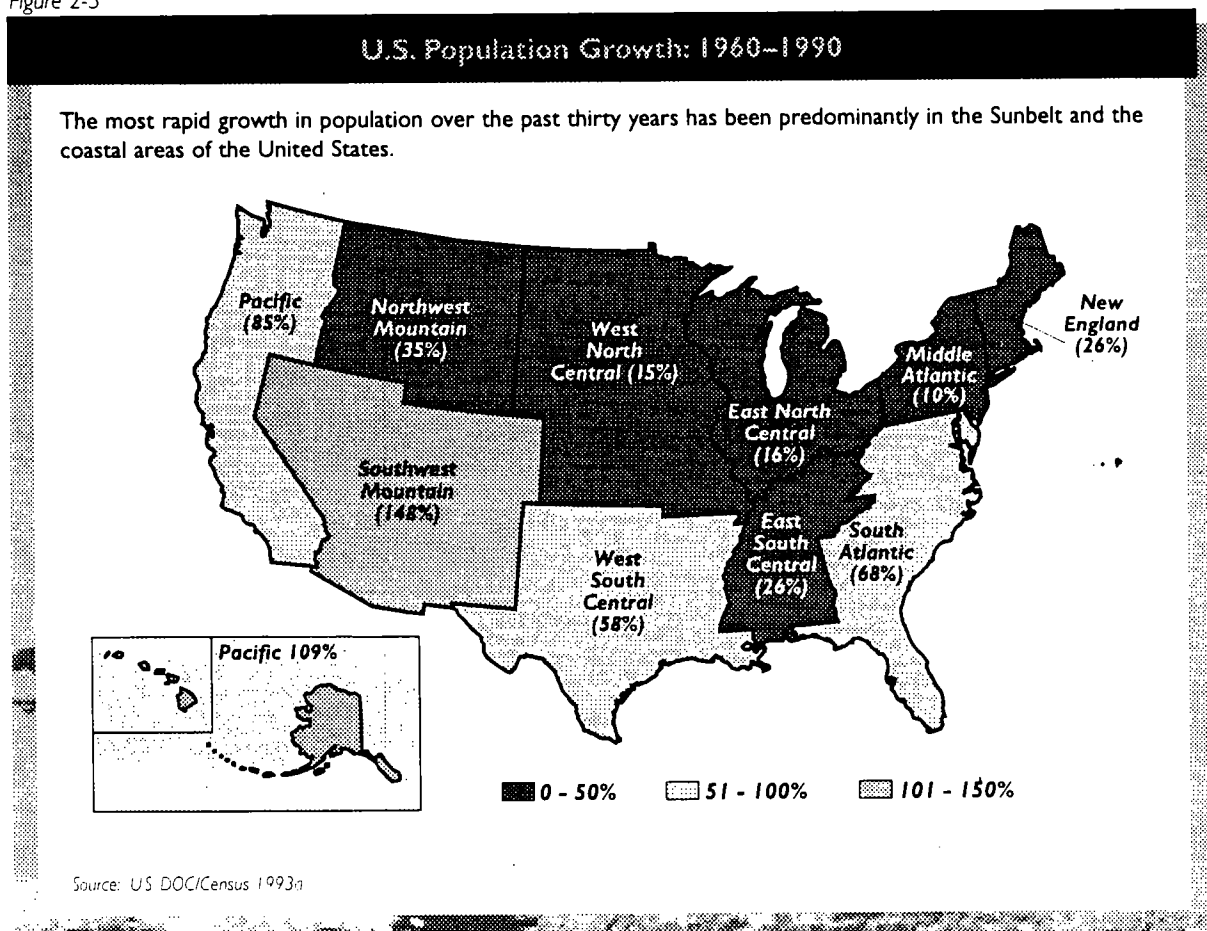
Sunbelt. Nine of the twelve fastest-growing U.S. metropolitan areas in 1990 were located in Florida. In most of the nation's coastal areas, population growth has been positive and generally very large (Figure 2-3). For instance, from 1970 to 1990, the population along the Southeast Atlantic coast grew by 74 percent. Overall, 110 million people live in these coastal areas, with densities exceeding 192 people per square kilometer in 20 percent of these counties, and densities in the urban cores of some of these areas exceeding 3,800 people per square kilometer. Studies conducted by the U.S. government anticipate a 15 percent increase in coastal population over the next two decades, concentrated in California, Florida, and Texas.

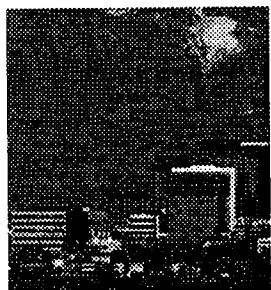
This pattern of growth has resulted in over 50 percent of the population living in metropolitan areas with more than one million people—up from 29 percent in 1950. Despite this growing trend toward urbanization, the population densities in U.S. metropolitan areas are far lower than in metropolitan areas around the world. For example, the ten largest European cities on average have population densities four times greater than the ten largest U.S. cities. The relatively low densities in the United States result in relatively high energy use per capita, leading, for example, to more energy-intensive transport. For purposes of comparison, from 1960 to 1990 the U.S. population increased by



38 percent, while the population of the European Union increased by 15.8 percent. Projections through 2020 show a similar disparity: the United States is projected to grow by 29 percent, and the European Union by only 2.6 percent.

Figure 2-3





U.S. Natural Resources

The natural resources of the United States are vast and varied. Its diverse climate zones, topography, and soils support many ecological communities and supply 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 and, therefore, have influenced the pattern of U.S. greenhouse gas emissions.

Land Resources

The United States has a total land area of approximately 931 million hectares (2.3 billion acres). The state of Alaska alone has a land area of approximately 166 million hectares (410 million acres). Because Alaska is so large, and its land-use patterns differ significantly from those in the 48 contiguous states and Hawaii, Alaskan land use is treated separately in this report.

About 77 percent, or 600 million hectares (1.5 billion acres), of U.S. land in the contiguous states is privately held, another 2 percent is owned by state or local governments. These together are referred to as nonfederal lands. Alaska has 87.4 million acres of nonfederal lands. The U.S. federal government owns about 263 million hectares (650 million acres), or 21 percent of the contiguous land area (Figure 2-4). In addition, federal lands include 131 million hectares (323 million acres) in Alaska.

Although the private sector has played a primary role in developing and managing U.S. natural resources, federal, state, and local governments have also been important in managing and protecting these resources through regulation, economic incentives, and education. Governments also manage lands set aside for forests, parks, wildlife reserves, special research areas, recreational areas, and in suburban/urban open spaces.

Of U.S. nonfederal lands in the contiguous 48 states, about 155 million hectares (382 million acres) are cropland, 51 million hectares (125 million acres) are pasture land, 162 million hectares (399 million acres) are range, and 160 million hectares (395 million acres) are forest land. There are approximately 36 million privately owned acres enrolled in the Conservation Reserve Program; these include highly erodible lands planted to perennial grasses or trees. Developed nonfederal lands (including transportation routes, cities, towns, and villages) now encompass 37 million hectares (92 million acres)—an increase of 18 percent in the past decade.

In Alaska, nonfederal land use in 1994 included 0.05 million hectares (0.13 million acres) of cropland, 21 million hectares (52 million acres) of wetlands, and 6 million hectares (15 million acres) of grazing lands, comprised of range, pasture, and tundra. Federal land use

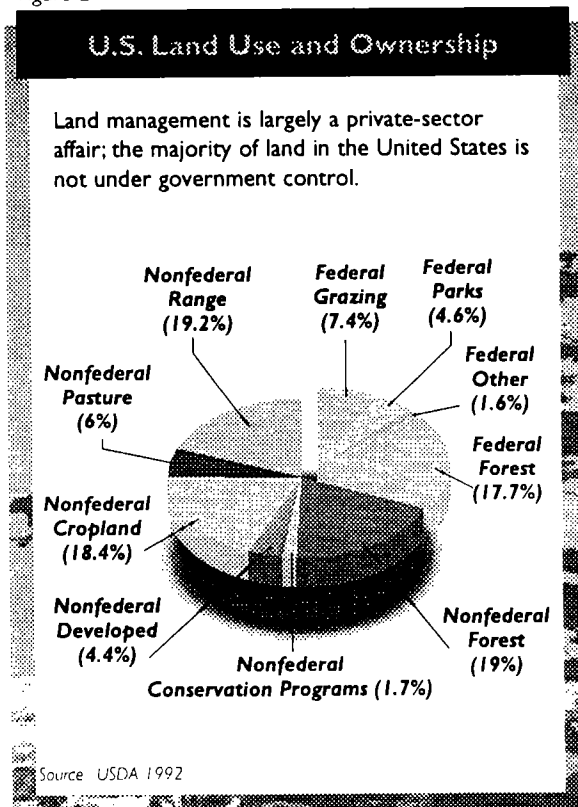


included 31 million hectares (77 million acres) of forest, 63 million hectares (155 million acres) of wetlands, and 37 million hectares (91 million acres) of tundra.

Forests

Forest land offers a significant sink for greenhouse gases, but may also be highly vulnerable to changes in the climate system. 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. Forest land in the contiguous United States has increased since the 1960s, from 251 million hectares (620 million acres) to 298 million hectares (737 million acres) in 1992. Of this 1992 total, 198 million hectares (489 million acres) were timberland, 80 percent of which is privately owned.

Figure 2-4



Management inputs over the past several decades have been gradually increasing 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 1.37. This ratio reflects substantial new-forest growth.

Grazing Lands

Grazing lands, including both range and pasture, are environmentally important to the United States. They are the single largest land use and thus have the potential to absorb significant quantities of greenhouse gases. They also include major recreational and scenic areas, serve as a principal source of wildlife habitat, and comprise a large area of the nation's watersheds. Like forest ecosystems, these ecosystems are vulnerable to rapid climate changes, particularly shifts in temperature and moisture regimes. Range ecosystems are more resilient than forest ecosystems, however, because of their ability to sustain long-term droughts. Long-term management of grasslands can greatly increase the carbon held in these soils and thus can increase the carbon "sink."

Range ecosystems are any of a number of different communities, usually denoted by the dominant vegetation. They are generally managed by varying grazing patterns, by using fire to shift species abundance, and by occasionally disturbing the soil surface to improve water infiltration. Pasture land, in contrast, is a grazing ecosystem that relies on more intensive management inputs, such as fertilizer, chemical pest management, and introduced or domesticated species. Range accounts for 161 million hectares (399 million acres), while nonfederal pasture land accounts for 51 million hectares (125 million acres). U.S. pasture land includes native grasslands, savannas, alpine meadows, tundra,

many wetlands, some deserts, and areas seeded to introduced and genetically improved species.

The total area of nonfederal pasture and range declined by 7 percent, approximately 6 million hectares (16 million acres), between 1982 and 1992. Most of this land was converted to urban and suburban land uses. The reasons for the decline in forested grazing lands are decreasing demand for livestock, as reflected in static prices for animals and animal fiber; conversion to shorter-rotation forests, which have reduced the quality of available forage; and reduced grazing on hilly terrains due to the resulting vulnerability to soil erosion.

Approximately 13 million hectares (33 million acres) of range and pasture are still in a highly erodible state due to sheet and rill erosion, and an additional 15 million hectares (38 million acres) are highly erodible due to wind erosion. Nevertheless, the general condition of grazing lands, both range and pasture, has been improving over the past twenty years.

Climate change would decrease the productivity of grazing lands, but could actually benefit their overall ecological condition. Warmer and drier conditions may adversely affect the land at first. As extreme drought continues, however, lack of easily available water could result in reduced grazing, which could allow the land to recover.

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 U.S. cropland has declined by 9 percent in the past decade—from 170 million hectares (420 million acres) to 155 million hectares (382 million acres)—as conser-

vation programs for the most environmentally sensitive and highly erodible lands have removed approximately 16 million hectares (39 million acres) from cropping systems.

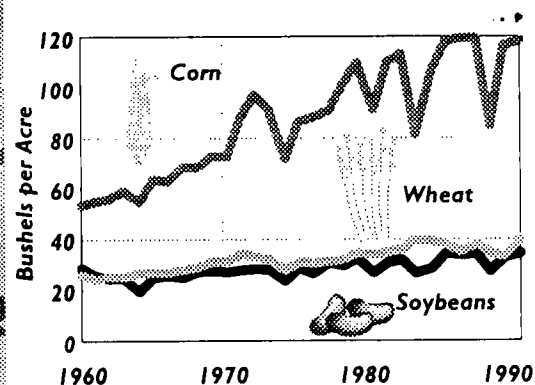
Although the United States harvests about the same area as it did in 1910, it feeds a population that has grown by two and one-half times since then, and its food exports have expanded considerably. This heightened efficiency of U.S. agriculture is depicted in Figure 2-5, which shows the yields of three major U.S. agricultural crops. Climate change could enhance agricultural productivity in some areas. Experimental results suggest that under a doubling of atmospheric CO₂ and ideal water and nutrient conditions, corn, sugar cane, and sorghum yields may increase by slightly less than 20 percent and wheat, soybean and rice yields may increase by 20–60 percent.

Between 1947 and 1989, the total output of livestock and livestock products rose 1.8 times, while during the same period production per unit of breeding stock rose 2.2 times. The total

Figure 2-5

U.S. Crop Yields: 1960-1990

Although the United States harvests about the same area as it did in 1910, its yields have generally increased.



Source: USDA 1993



number of cattle peaked at 132 million head in 1975 and declined to 100 million head in 1992. Sheep numbers over the past two decades have varied from 8.5 million head in 1977 to 7.7 million head in 1992. This reflects the significant decline in average beef and lamb consumption per capita in recent years.

Ruminant animals, such as cattle and sheep, produce significant quantities of methane as part of their digestive process. The breakdown of livestock manure is another source of methane. This gas is second to carbon dioxide as a major man-made contributor to global warming.

Wetlands

Wetland ecosystems, a substantial source of methane, represent some of the more biologically important and ecologically significant systems on the planet. They represent a boundary condition ("ecotone") between land and aquatic ecosystems. As such, 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; anchor shorelines, and prevent erosion. A wide variety of wetland types exists in the United States, ranging from permafrost-underlain wetlands in Alaska to tropical rain forests in Hawaii.

Wetland ecosystems are highly dependent upon upland ecosystems and are thus vulnerable to changes in the health of the upland ecosystems as well as to environmental change brought about by shifts in climate regimes. Coastal wetlands may be drowned by a rising sea and may be unable to migrate inland because of human settlements. Prairie potholes and riparian wetlands

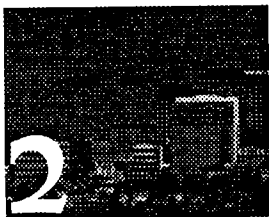
may decrease in dry areas made even drier by changing climate. Tundra wetlands will shrink as temperatures increase and allow the permafrost to thaw and drain.

Since the nation's founding in the eighteenth century, the continental United States has lost 47 million of its original 89 million hectares (221 million acres) of wetlands. The data suggest that 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 185,000 hectares (458,000 acres) per year, the losses declined to about 117,000 hectares (290,000 acres) per year from the mid-1970s to mid-1980s. Agricultural uses have accounted for about 54 percent of wetland loss since the colonial period of our nation's history, and, according to the U.S. Department of the Interior, a significant additional share was lost as a result of federal flood control and drainage projects. The reduced rate of wetland loss since the mid-1980s is attributable to a combination of government programs and low crop prices, which have reduced conversions of wetlands to agricultural uses. Future losses from such conversions are likely to be even smaller, as the United States implements a "no net loss" policy for wetlands, a goal embraced in 1989.

Alaska's 71 million hectares (176 million acres) of wetlands easily exceed the 42 million hectares (104 million acres) of wetlands in the continental United States. Many of these areas are federally owned, although precise figures are not available. Total wetland losses in Alaska have been less than one percent since the mid-1800s, although in coastal areas they have been higher.

Biological Resources

During the past twenty years, we have



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become more aware of the reduction in the diversity of life at all levels, both within the United States and worldwide. Warmer temperatures may exacerbate this trend by shifting climate zones faster than ecosystems can migrate. To better understand and catalogue both previous and future changes, the United States has begun a comprehensive, nationwide survey of its biodiversity, including its wildlife, called the National Biological Survey.

Information on endangered species is already available through various sources. In 1991, the U.S. government added 71 domestic species to the Threatened and Endangered Species List, for a total of 668 species. Some 4,000 species remain candidates for listing. A 1990 assessment of recovery status for listed species revealed that 38 percent are declining, 10 percent are improving, 31 percent are stable, 2 percent are extinct, and 19 percent are of unknown status. Of the U.S. plant and animal species listed as threatened or endangered in 1990, fully 40 percent are plants, and slightly more than 10 percent are mammals, with approximately equal proportions (about 14 percent) of birds, fish, and invertebrates, and a lesser percentage (7.3 percent) of reptiles and amphibians.

Water Resources

The development of water resources has been key to the growth and prosperity of the United States. Abundant and reliable water systems have enabled urban and agricultural centers to flourish in arid and semi-arid regions of the United States. For instance, between 1954 and 1992, irrigated agricultural land more than doubled, from 12 million hectares (29 million acres) to 25 million hectares (62 million acres).

Currently, most of the nation's freshwater

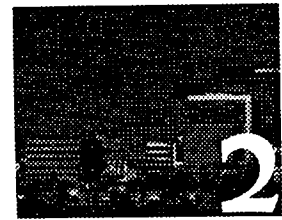
demands are met by diversions from streams, rivers, lakes, and reservoirs and by withdrawals from ground-water aquifers. Even though total withdrawals of surface water more than doubled from 1950 to 1980, they remained less than 21 percent of the renewable supply in 1980. However, some areas of the country still experience intermittent water shortages during periods of drought.

In the arid sections of the western United States, there is increasing competition for water—not only from traditional agricultural and hydropower sources, but also for drinking water in growing urban areas, American Indian water rights, industry, recreation, and support of 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. Recently enacted state legislation adopts a market-based approach to water pricing and allocation, thus offering the potential to alleviate some effects of projected shortfalls. Also pertinent is the federal government's insistence that certain minimum-flow requirements be met to preserve threatened and endangered species.

Potential climate changes, including changes in the periodicity and frequency of precipitation and rising temperatures, may have a significant effect on water resources and resource infrastructure.

Energy Resources

The United States has vast resources of fossil fuels (Table 2-1). Coal, which has the highest emissions of greenhouse gases per unit of energy, is particularly abundant, with current recoverable reserves totaling about 265 billion short tons. The vast majority—88.9 percent—of this figure is



bituminous coal. Lignite and anthracite coal provide 9.5 and 1.5 percent of total coal reserves, respectively.

Government estimates suggest that other undiscovered economically recoverable energy resources in the United States include 145.6 billion barrels of crude oil and 1,265.8 trillion cubic feet of natural gas as of January 1, 1992. Proved reserves in the same year were 23.7 billion barrels for oil and 165 trillion cubic feet for natural gas. Proved reserves of oil have been declining ever since the addition of reserves under Alaska's North Slope in 1970. U.S. energy resources also include some 120 million kilograms (265 million pounds) of uranium oxide, recoverable at \$14 per kilogram (\$30 per pound) or less.

Knowledge of energy resources is important for placing the climate change issue in context. The abundant fossil fuel resources of the United States have contributed to low prices and relatively energy-intensive activities. Concerns about global climate change may make these resources relatively less attractive than renewable resources or other forms of energy that produce lower greenhouse gas emissions.

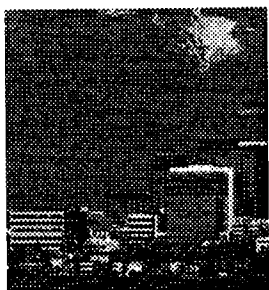
Table 2-1

U.S. Energy Resources: January 1992

The United States has vast resources of fossil fuels. Coal reserves are particularly abundant, with current recoverable reserves totaling about 265 billion short tons.

Type of Fuel	Total Recoverable Resources	
Coal	Billions of Short Tons	Quads
High sulfur	80.2	1,877
Medium sulfur	84.3	2,166
Low sulfur	100.2	2,628
Total	264.7	6,690
Crude Oil	Billions of Barrels	Quads
Proved	23.7	137.5
Remaining economically recoverable resources	145.6	844.3
Total	169.3	981.8
Natural Gas	Trillions of Cubic Feet	Quads
Proved	165.0	170.0
Remaining economically recoverable resources	1,265.8	1,303.8
Total	1,430.8	1,473.8

Sources: U.S. DOE/EIA 1993c, 1993d, and 1994b



The U.S. Economy

The United States can be characterized most accurately as a mixed economy. Some economic activity is carried out by private decision makers (e.g., companies and consumers) and organized in markets, and other economic activity is carried out by federal, state, and local governments. Much of the private-sector market activity in the U.S. economy is subject to some sort of government action or oversight, such as that provided by the antitrust division of the U.S. Department of Justice.

Government and the Market Economy

Several principles, institutions, and technical factors have contributed to the evolution of America's mixed economy. The first of these is the respect for individual rights, including the right to own and use private property to one's own advantage.

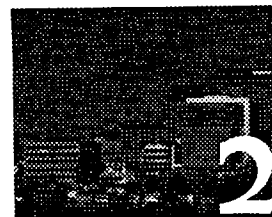
The U.S. economic system is also underpinned by a belief that voluntary exchange is the most efficient means of organizing economic activity. Put another way, in the absence of "market failures," relative prices would ideally be the sole basis on which economic agents within the U.S. economy would make decisions about production and consumption. Combined with a system of well-defined and well-protected private-property rights, the price system would

lead to an allocation of the resources of the U.S. economy that produces the greatest possible social welfare.

However, markets do fail. The production of some goods and services creates costs or benefits that are not captured by the price system, causing too much or too little of the good or service to be produced to maximize social welfare. In such cases, the U.S. government has intervened to promote a more socially beneficial allocation of resources.

For instance, the U.S. government (as well as state and local governments) intervenes in the market to provide for public goods, such as national defense and public infrastructure. Another common reason for government intervention in the market is the presence of externalities, which exist when the social costs of an activity differ from its private costs. For example, vehicle owners bear only part of the costs of emissions from motor vehicles; other members of society and the environment bear the rest in the form of poor air quality. As a practical matter, it is very difficult to establish accurately the cost of the externality in order to internalize it by a fee, a tax, or a regulation. Government intervention may include limiting the physical quantity of pollution that individuals may produce, or charging polluters a fee for each unit of pollution emitted.

In addition to providing public goods and



attempting to mitigate the effects of externalities, the federal government transfers wealth among various members of the U.S. society for social, cultural, or political purposes. Such transfers include commodity support to agricultural producers, and income maintenance and health-care provisions for low-income families.

While the role of government in the U.S. economy is large, many government interventions are intended to facilitate or support well-functioning markets. By protecting property rights, producing such public goods as roads and other types of infrastructure, reducing externalities, and ensuring a minimum standard of living for all of its citizens, the U.S. government fosters an environment in which market forces can operate.

Finally, the federal government itself is a source of imperfection in the U.S. economy. Over time, the government has created barriers through its regulatory and fiscal processes that impede the smooth functioning of markets, leading to wasteful inefficiencies.

Composition and Growth

The willingness of U.S. policymakers, the business community, and the public to tackle more long-run and strategic environmental issues, such as climate change, to a large extent depends on the health of the economy. A robust economy encourages this type of forward thinking, as concerns about unemployment and growth lessen.

At the same time, policies to reduce greenhouse gas emissions are likely to benefit some components of the economy, while adversely affecting others. For instance, the current economic health and activities of the energy-producing and -consuming sectors, the international

trade situation, and the state of the U.S. budget deficit are all important factors in shaping U.S. climate change policies.

From 1960 to 1993, the U.S. economy grew at an average annual rate of 3 percent, raising the real gross domestic product (GDP) from nearly \$2 trillion to over \$5 trillion (in 1987 dollars). With population growth averaging 1.1 percent over the same period, this meant an annual increase of 1.8 percent in real GDP per capita, from \$10,903 in 1960 to \$19,874 in 1993 (in 1987 dollars).

Employment over this period almost doubled—from 65 million to 120 million—as the labor force participation rate rose from 59 to 66 percent, with the largest growth in the work force attributed to women.

This rapid growth has been led by the U.S. service sector, which includes communications, utilities, finance, insurance, and real estate. Between 1960 and 1993, this sector expanded from 28.8 percent of the economy to 36.5 percent. Employment in the service sector nearly tripled, while employment in industries that might be directly associated with the climate change issue (agriculture, mining, forestry, and fisheries) declined by 287,000 full-time equivalents (Figure 2-6).

To a large extent, pollution control expenditures move with the economy, with increases in such expenditures during boom times and reductions during recession. Nevertheless, real abatement expenditures have increased as a percentage of GDP. From 1972 to 1992, pollution abatement and control expenditures rose from \$46 billion to \$88 billion per year, or from 1.5 to 1.8 percent of GDP.

The economic growth over the previous thirty years masks several economic problems that may influence the design and implementa-



tion of U.S. climate policy. Most important, there were serious structural difficulties in the U.S. economy, evidenced by the low growth in productivity over the last two decades. Annual

productivity growth averaged 3.1 percent from 1947 to 1973, but only 1.0 percent since then.

The increasing dependence of the United States on trade, coupled with weak foreign economic performance over the past few years, has increased the influence of external events on U.S. economic performance. During 1991–93, the country experienced the worst foreign economic performance in thirty years. In the 1990s, growing U.S. reliance on foreign computers led a surge of imported capital goods, with overall imports in 1993 at their highest percent of GDP since World War II (13.2 percent).

In addition, from 1989 to 1993, the U.S. economy grew by only 1.8 percent annually, with the civilian unemployment rate above 6 percent since November 1990 (but attaining 6 percent in May 1994). The “recovery” that began in 1991 has been slow by historical standards.

The U.S. economic expansion consolidated in 1993, setting the stage for sustained growth in 1994. In the first quarter of 1994, real GDP grew at the long-run historical average rate of 3 percent. The outlook for the U.S. economy is for moderate, but steady economic growth over the mid-1990s, with a projected annual growth in GDP of 2.5 to 3 percent. This growth should be sufficient to reduce unemployment to about 5.5 percent by 1999, while producing healthy increases in real disposable income and increased real wages.

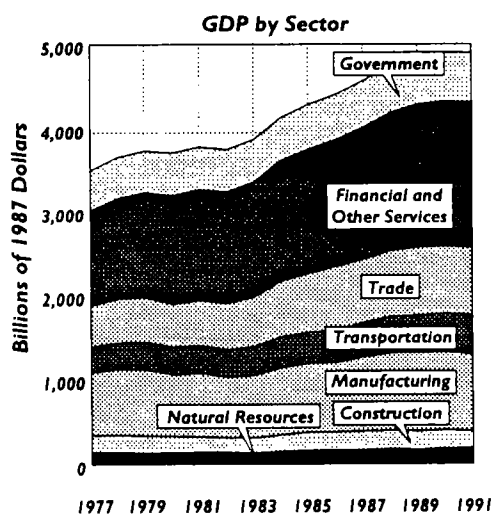
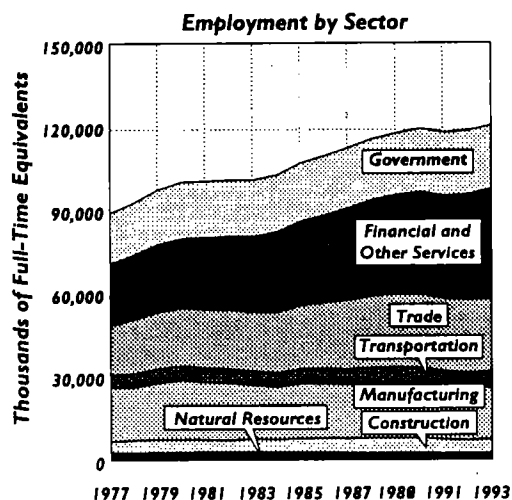
The U.S. Federal Budget

Since 1970, federal outlays for natural resources and the environment have increased sevenfold. Federal discretionary outlays for the management of the environment and natural resources totaled \$31.3 billion in 1993 and \$33.6 billion in 1994. The proposed increase, to \$35.2

Figure 2-6

U.S. Economic Growth: 1960–1991

While the service and transport sectors are two of the engines driving U.S. economic growth, transport is a far larger source of greenhouse gas emissions.



Sources: U.S. DOC/ESA/BEA 1991a and 1994b



billion in 1995, evidences a deep and continuing commitment to environmental protection, given that overall discretionary federal outlays proposed for 1995 are unchanged from 1993 actual spending.

The projections for tight federal budgets in the foreseeable future are directly related to deepening public concern over budget deficits. The federal budget has been in deficit for thirty-three of the past thirty-five years, with the peak deficit in 1992 of \$290 billion. Until 1975, the ratio of deficit to GDP was stable or falling. However, from 1975 through 1992, this ratio began an upward trend, which fluctuated with the business cycle (Figure 2-7). Until the 1980s, the ratio of public debt to GDP also was stable or falling. From 1980 through 1992, however, this ratio dramatically increased.

Changes in the tax code and U.S. budget outlays enacted in 1993, along with projections for stable growth, are expected to reverse the trend of ever-increasing deficits, while reducing the ratio of the deficit to GDP to about 2 percent by 1995.

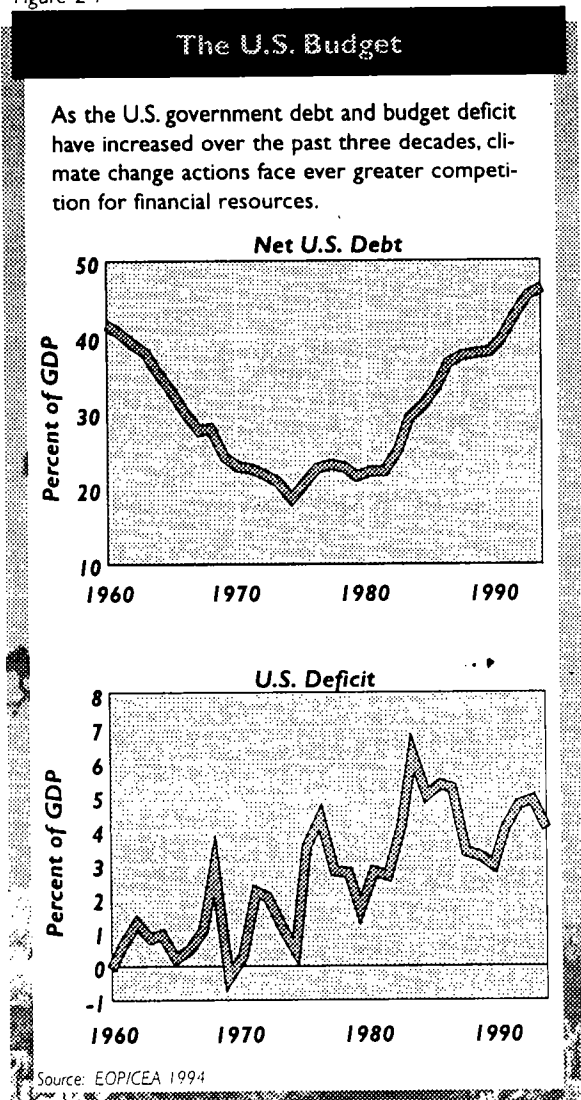
Growing political pressure for substantial reductions in the U.S. deficit has recently been reflected in procedures that make it difficult for new or expanded programs to pass the Congress. In 1990 Congress passed the "pay-as-you-go" provisions of the Omnibus Budget Reconciliation Act, which created caps on total discretionary spending. Thus, any increase in such spending passed by Congress must be offset by decreases elsewhere. The same process applies to passage of new mandatory spending programs, which can be offset either by cuts in existing spending or with tax increases. In light of these budget-constraining systems and a federal budget that is growing only slightly in nominal terms, new programs, such as those that

might be needed to respond to the *Climate Change Action Plan*, will be in direct competition for funds from a host of existing and other new programs.

National Revenue Structure

Federal, state, and local governments in the United States collect most of their general revenue from taxes on income, retail sales, and property. Environmental programs are mostly

Figure 2-7





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funded through federal agencies, but state and local governments contribute substantially.

Federal Revenue

The major sources of federal government revenue are individual and corporate income taxes (Table 2-2). Indeed, the federal govern-

ment raises more money from income taxes than state and local governments raise from all taxes combined.

The U.S. government levies no property or general sales tax, but does collect sales taxes on selected excises, such as motor fuel and alcoholic beverages. The government also earns revenues

Table 2-2

U.S. Government Revenues: 1991 (Millions of Dollars)

The vast majority of the U.S. revenue is derived from taxes. The federal government imposes taxes of 18.4 cents on gasoline and 24.4 cents on diesel fuel, as well as other, lower, taxes on waterways, railroads, and jet fuels. Gasoline and diesel revenues in FY 1992 were \$19.4 billion, of which \$16.3 billion was earmarked for the highway trust fund and \$3.1 billion went to the general fund.

Sources of Revenue	Federal	State	Local	Total
General Revenue				
Intergovernmental Revenue	3,234	143,533	201,901	—
From federal	—	134,926	19,172	—
From state	3,234	—	182,729	—
From local	—	8,607	—	—
General Revenue, Own Sources	809,105	408,188	339,890	1,557,183
Taxes	641,982	310,561	214,728	1,167,271
Individual income taxes	467,827	99,279	10,062	577,168
Corporate income taxes	98,086	20,357	1,886	120,328
Property taxes	—	6,228	161,706	167,934
Customs duties	16,034	—	—	16,034
General sales and gross receipts	—	103,165	22,283	125,448
Selective sales and gross receipts	42,461	50,369	9,753	102,583
Gift and death taxes	11,138	4,284	NA	15,422
Motor vehicle and operators' licenses	—	10,996	NA	10,996
All other	6,436	15,882	9,039	31,357
Lottery revenue	—	19,167	—	19,167
Current charges	*167,123	47,334	77,933	*370,745
Miscellaneous general revenue	—	31,126	47,229	—
Total	812,339	551,721	541,791	1,557,183
Special Revenue				
Utility and Liquor Stores	—	60,736	60,736	—
Insurance Trusts	—	117,943	506,286	—
Total	1,200,682	659,971	612,221	2,124,205

Source: U.S. ACIR 1993



from environmental and natural resource management. In 1991, it collected over \$8.4 billion in revenues from such activities as leasing and extracting natural resources on federal lands, taxes on emissions of chlorofluorocarbons, and penalties for oil spills and hazardous waste cleanup.

State Revenue

Sales taxes are the largest single source of state revenue (Table 2-3). Almost all states also administer income taxes, but their aggregate collections are much smaller than federal income tax revenue. All fifty of the states receive revenue from sales or gross receipts taxes, and only five do not impose a general sales tax. States also levy

excise taxes on motor fuel and alcohol.

Local Revenue

Property taxes are by far the major source of local revenue (Table 2-2). It is not uncommon for cities to levy general sales and local income taxes, but in many cases the taxes are limited to coverage of employee payroll, rather than taxes on income from all sources. Local income taxes are often administered locally, whereas local sales taxes are usually "piggybacked" on the administration of state sales taxes. Relatively high local tax rates are often a key factor in the movement of taxpayers from cities into suburbs, where their energy consumption for transportation and heating is generally higher.

Table 2-3

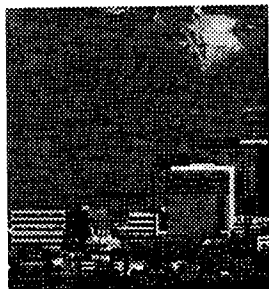
State Taxation

All fifty of the states receive tax revenue; only five do not impose a general sales tax. In addition, tax rates vary widely from state to state.

Type of Tax	Number of States Using Tax	Range of Tax Rates
General Property	42 and DC* Exceptions are DE, HI, IA, NY, OK, SD, TN, TX	Not available
General Sales	45 and DC Exceptions are AK, DE, MT, NH, OR	3-7%
Individual Income	43 and DC Exceptions are AK, FL, NV, SD, TX, WA, WY	Marginal rates from 0.4% to 11.0%
Corporate Income	46 and DC Exceptions are NV, SD, TX, WA, WY	1.0-12.25%
Selective Excises		
Motor fuel	All 50 states and DC	\$.075-\$.30/gallon
Cigarette	All 50 states and DC	\$.025-\$.65/pack
Alcoholic beverage	All 50 states and DC	
Beer		\$.02-\$1.05/gallon
Spirits		\$1.50-\$13.85/proof gallon (or percentage in some states)

*Property tax for CT rounds to zero

Source: Tax Foundation 1994



U.S. Energy Production and Consumption

The United States is the world's largest energy producer and consumer. The nation's patterns of energy use are determined in part by its economic growth, land area, climate regimes, low population density, and significant indigenous resources. Much of the infrastructure of U.S. cities, highways, and industries was developed in response to abundant and relatively inexpensive energy resources. Figure 2-8 depicts the energy flows through the U.S. economy in 1992.

The effects of global warming are likely to change patterns of our nation's use of energy. For instance, regional shifts in economic activities and population related to global warming will affect the U.S. energy mix, because different regions of the country rely on different mixes of energy resources to generate power and meet other energy needs. Furthermore, activities to mitigate greenhouse gas emissions and adapt to any negative effects of global warming that remain will surely be based on substantial involvement of the energy sectors. In general, this involvement is likely to take the form of changes in the energy mix or technologies used to produce commodities—or even in the types of commodities that are produced—in residential and commercial energy use, and in vehicles and the fuels that power them. Changes in the behavior of energy users of all types are also likely outcomes of mitigation or adaptation activities.

Energy Production

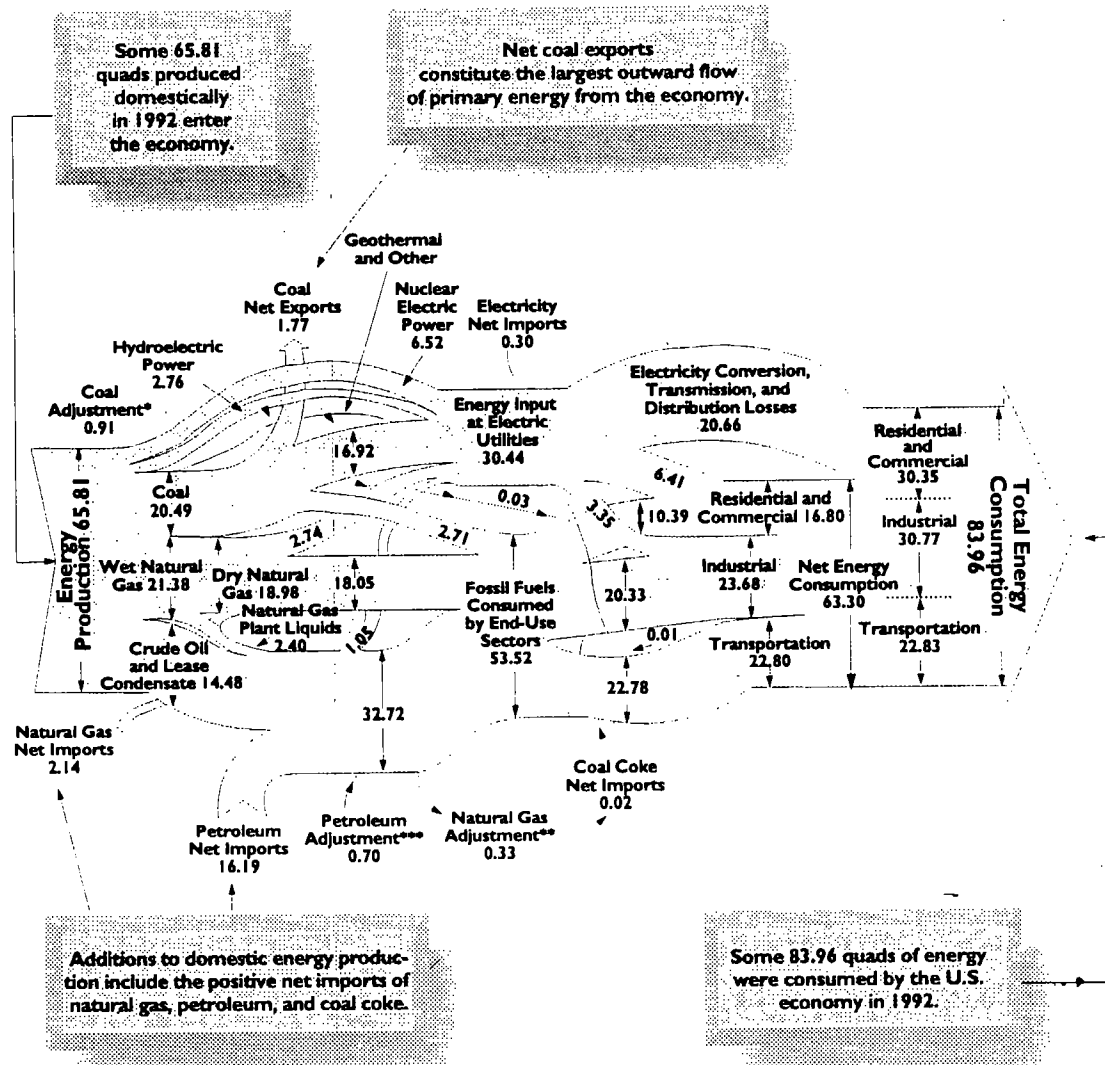
Coal, natural gas, and petroleum have long comprised the bulk of U.S. energy production since 1960, accounting for 96.1 percent of production in 1960 but falling to 85.5 percent in 1993. The commercial introduction of nuclear electric power and expanded hydroelectric generation has displaced some of the fossil fuel production (Figure 2-9), but further displacement is not expected to continue, given public opposition to nuclear power and further damming of rivers. Energy production from other renewable resources, such as geothermal, solar, wind, and waste products, is still a small share of the total.

Before 1970, the United States imported a small amount of energy, primarily in the form of petroleum. Lower acquisition costs for imported crude oil in the early 1970s, however, put U.S. oil producers at a comparative disadvantage. By 1971, this gap led to a divergence in trends of energy production and consumption.

Domestic oil production is projected to continue to decline, due to depletion of existing reserves, with few new discoveries. Oil production may increase slightly after 2006, however, in response to rising prices and technological gains. Even so, as the increase in oil consumption continues to outpace production, U.S. net oil imports are expected to rise to 60 percent of U.S. consumption by 2010, up from about 44

Figure 2-8

Energy Flows Through the U.S. Economy (Quadrillion Btus)



* Stock changes, losses, and unaccounted for.

** Supplemental gaseous fuels, net storage withdrawals, and balancing item.

*** Other liquids, net stock change, refinery processing gain, and unaccounted for

Notes: Data are preliminary. Sum of components may not equal totals due to independent rounding; the use of preliminary conversion factors; and the exclusion of changes in stocks, miscellaneous supply and disposition, and unaccounted-for quantities. In addition, due to a lack of consistent historical data, some consumption of renewable-energy sources is not included. In 1992, an estimated 3.0 quadrillion Btus of renewable energy consumed by users other than electric utilities is not included.

Source: U.S. DOE/EIA 1992a



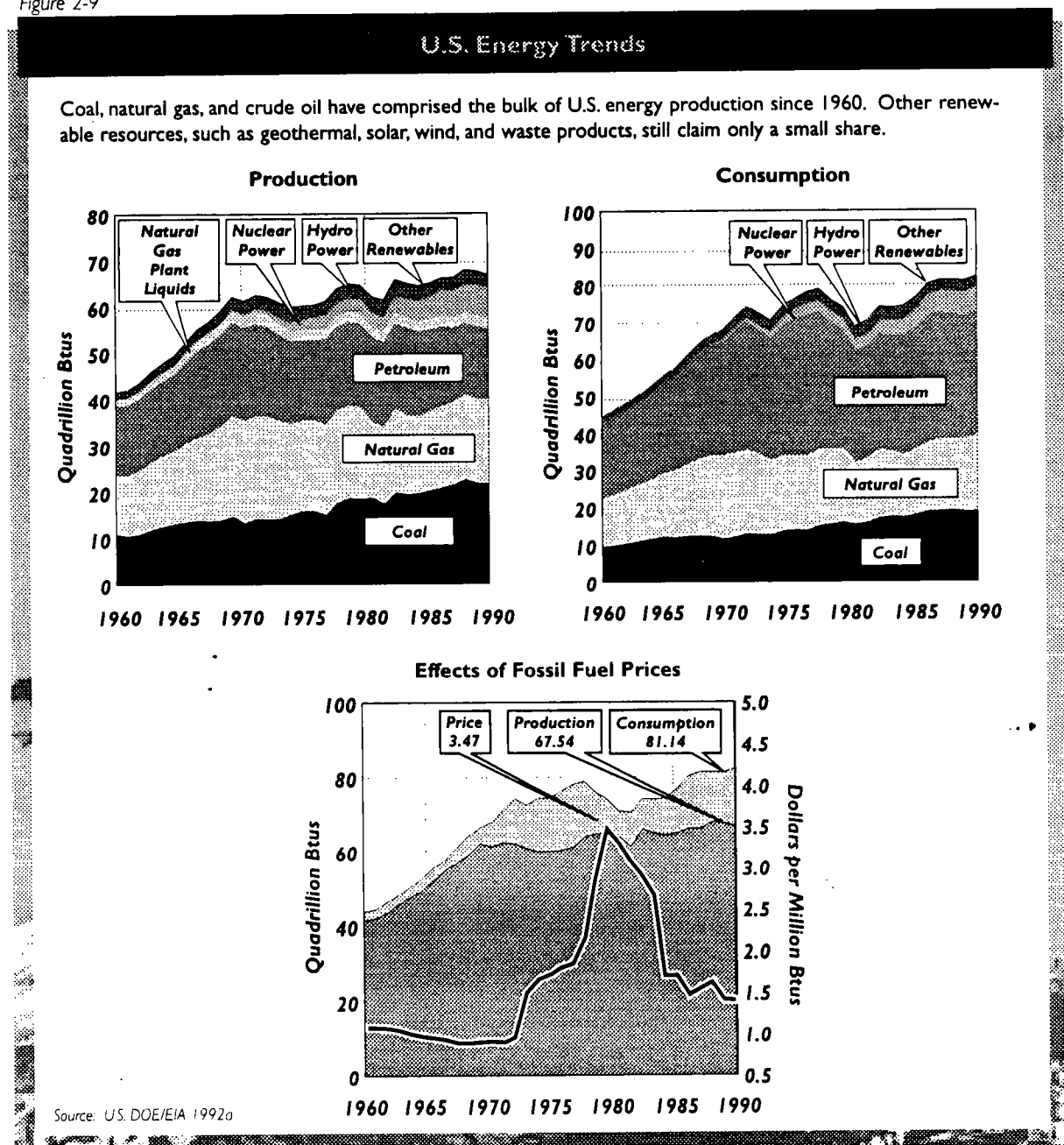
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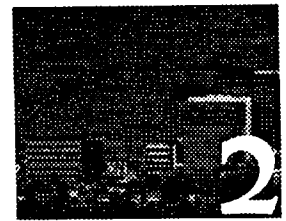
percent in 1993 (U.S. DOE/EIA 1994b).

Coal is the largest source of domestic energy. With expected increases in demand for electric power production and exports, coal's share of U.S. energy production is projected to increase from 31 percent in 1991 to 35 percent in 2010.

Because of the availability of lower-cost sources, domestic production of natural gas—the second largest source of domestic energy supply—is expected to reverse its historical decline. However, the share of energy production contributed by natural gas is expected to decrease from 29 percent in 1993 to 27 percent

Figure 2-9





in 2010.

Between now and 2010, emerging renewable sources—especially solar, wind, biomass, geothermal, and biofuels (excluding hydroelectric), which currently contribute a scant 4.8 percent to domestic energy supply—are expected to grow steadily at rates exceeding those of other sources.

Energy Consumption

On the consumption side, rapid economic growth, even when combined with the decreasing energy intensity 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. Demand dampened during and after the international oil price shocks in 1973–74 and 1979–80, with some significant declines in oil use.

In 1986, real crude oil prices fell dramatically to one-third of peak rates during the 1979–80 supply disruption and were less than peak rates during the 1973–74 disturbance. Since 1986, crude oil prices and retail oil prices have fluctuated. While rising from 1980 through 1988, U.S. oil consumption has leveled off as oil prices recovered and U.S. economic growth slowed.

Growth in the economy, population, and vehicle miles traveled could have propelled U.S. energy consumption far beyond its nearly 100 percent growth since 1960, if not for impressive reductions in the energy intensity of the U.S. economy. There has been a 27 percent decrease in energy use per dollar of GDP from its 1970 peak, with intensity basically flat after 1986. Most of these efficiency improvements have come from the industrial sector, although the

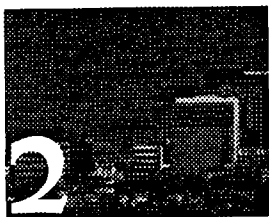
household and transportation sectors also experienced gains. In terms of the level of energy intensity relative to other countries, the United States ranks slightly behind the Organization of Economic Cooperation and Development's (OECD's) average in energy use per dollar of GDP—0.43 kilograms of oil equivalent per dollar of GDP, versus 0.41 for OECD—and significantly behind Norway and Japan. In contrast, Canadian energy intensity is considerably higher than that of the United States, at 0.53 kilograms of oil equivalent per dollar of GDP.

Turning to consumption by sector, in 1993, the generation, transmission, and distribution of electricity accounted for 20.54 quadrillion BTUs (quads) of energy consumption, leaving 63.2 quads for direct consumption by end users. Industry and transportation consumed nearly three-quarters of this direct energy, while the residential and commercial sectors used 27 percent.

Industrial Energy Use

Comprised of manufacturing, construction, agriculture, and mining, the industrial sector accounts for slightly over one-third of total energy use in the United States, and approximately 33 percent of total U.S. carbon emissions in 1990. Industry's share of end-use energy consumption has dropped significantly over the past thirty years. In 1960, industrial energy use accounted for 46 percent of all energy consumed; by 1972, it had fallen to 42 percent, and by 1990, to 36.8 percent.

Similarly, from 1972 to 1990, industrial energy intensity (energy use divided by industrial contribution to GDP) improved by 35.3 percent. Approximately two-thirds of the decline in intensity over the period 1972–90 was due to structural shifts, such as the changing array of



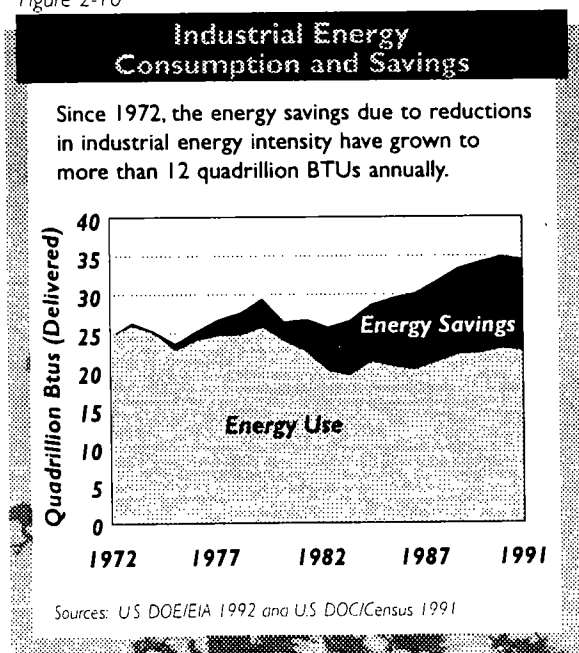
products that industry produced. Since 1972, the energy savings due to reductions in energy intensity has grown to more than 12 quadrillion BTUs annually (Figure 2-10).

The manufacturing sector has steadily reduced its energy intensity over the past two decades, although the rate of improvement has slowed since 1985, when energy prices fell. Of the fifteen major energy-consuming industry groups in the manufacturing sector, most continued to reduce their energy intensity between 1980 and 1991.

Residential and Commercial Energy Use

The number, size, and climatic distribution of residential and commercial buildings, as well as the market penetration of heating and cooling technologies and major appliances, are good indicators of energy consumption and greenhouse gas emissions associated with residential and commercial activities. Today, these activities account for roughly 35 percent of the U.S. carbon emissions.

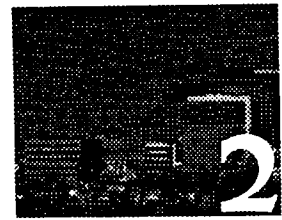
Figure 2-10



The United States has about 94 million housing units, approximately half of which are detached and occupied by a single family. Since 1960, the average number of people per residence has declined from 3.33 to 2.63. As a consequence, the average heated space per person has increased to 56 square meters (602 square feet) in 1990, compared to 50 square meters (534 square feet) in 1980.

In addition, during this period the penetration of major heating and cooling technologies and of major energy-using appliances increased substantially. By 1990, nearly all U.S. households had space heating, water heating, refrigeration, cooking, and color television sets; about 68 percent had some form of space cooling; 75 percent had clothes washers; and roughly 50 percent had clothes dryers and dishwashers. On the other hand, this period has seen large gains in energy efficiency, which, in spite of the growth in appliance penetration and heating/cooling space per person, have resulted in a 25 percent drop in average household energy use—from 138 million BTUs per household in 1978 to 101 million BTUs in 1987. On net, with the substantial increase in the number of U.S. households, overall energy use in this sector has remained roughly stable since the mid-1970s.

The commercial sector has been the fastest-growing economic sector in the United States. In 1990, there were about 70 billion square feet of commercial building space, which encompasses all nonresidential, privately owned, and public buildings. Virtually all commercial buildings are heated, and over 80 percent are cooled. In addition, the past decade has seen a major increase in the use of computers and other energy-consuming office equipment. Rapid growth in this sector has substantially increased the energy services



required by commercial buildings, but, as in the residential sector, substantial efficiency gains have reduced the net increases in energy demand and carbon emissions.

Transportation Energy Use

The U.S. transportation system has evolved into a multimodal system, including highway, mass transit, air, rail, waterborne, and pipeline transport (Figure 2-11). The current U.S. surface

Figure 2-11

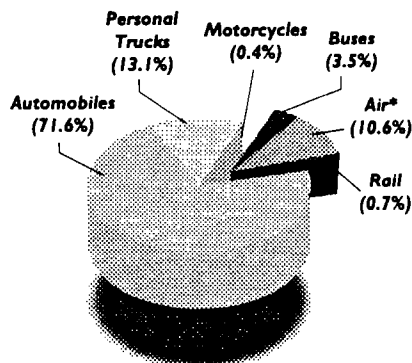
U.S. Transportation: Characteristics and Trends

The United States relies heavily on transportation, with people and goods on the move. More than 27 percent of domestic energy is consumed by this sector.



Passenger Travel

Of the 3,385 total passenger miles traveled in 1990, private vehicles accounted for approximately 85 percent.

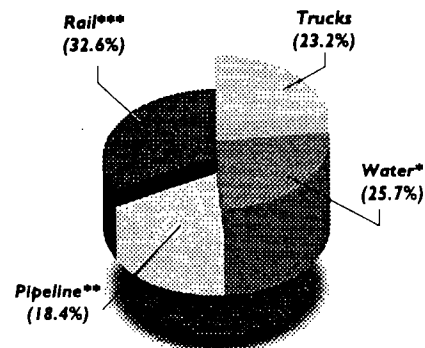


*Certificated route air carriers and general aviation.



Freight Movement

While 32.6 percent of the 3,169 ton miles of freight moved in 1990 was via rail, the overall distribution was relatively evenly divided over all modes.



*1989 data.

**Coal slurry and crude oil and products pipeline only.

***Class I rail only.



Vehicle Stock

Vehicle stock closely reflects the number of passenger and freight miles traveled.

Vehicle	New Sales	In Use
Automobiles	9,301	123,276
Trucks	4,364	56,023
Motorcycles	462	4,259
Buses		589
Aircraft*		212
Commercial Water Vehicles**		39
Railroad Cars		661

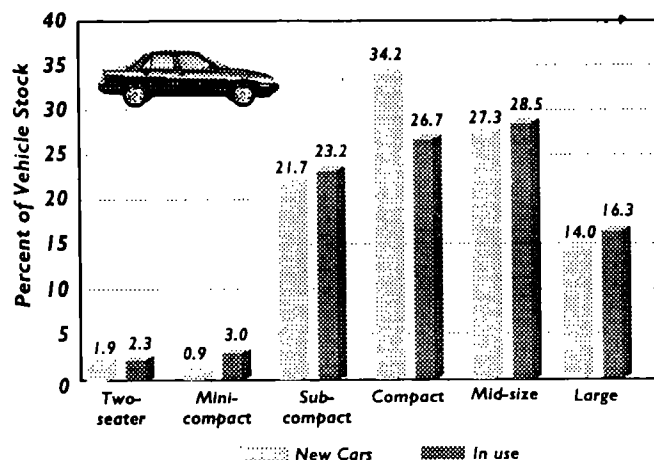
* General aviation aircraft only.

** 1989 data



Driver Preference

Driver preference in automobiles is for mid- to small-size cars.





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transportation system is dominated by automobiles and light trucks, with the latter now comprising almost 40 percent of new passenger vehicle purchases. In 1990, the highway share of passenger travel was 85 percent, with most of the remainder accounted for by air travel (11 percent). In contrast, the share of bus and rail was 4 percent.

Over 3.1 trillion ton-miles of freight are moved in the United States each year. The predominant mode of intercity freight is rail, followed by waterways, highways, pipelines, and air. Although the trend is now reversing, between 1960 and 1990, the number of railroad cars in use declined, whereas the number of motor vehicles and air carriers increased dramatically, and the number of water-transport vessels and oil pipelines grew steadily.

Motor vehicle ownership, use, and efficiency provide good indicators of the nation's energy consumption in the transportation sector, which accounts for approximately one-third of U.S. greenhouse gas emissions. Between 1960 and 1991, the number of cars and trucks registered in the United States more than doubled—from 74 million to 192 million. Rising incomes have much to do with this growth in vehicle ownership. Population growth has been important as well. Since 1960, the driving-age population has grown from 121 million to 192 million in 1990, while licensed drivers have increased from 72 percent of this group to 87 percent over the same period.

A 50 percent increase in vehicle kilometers traveled since 1969 has been partly offset by a 34 percent decrease in the amount of fuel consumed

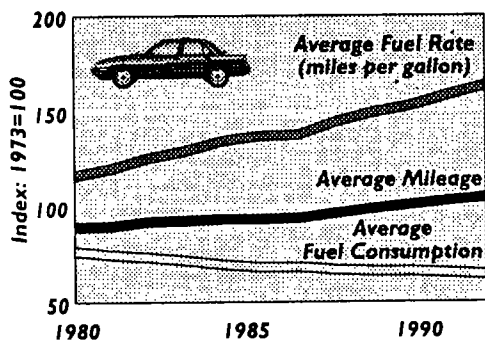
Figure 2-11, continued

U.S. Transportation: Characteristics and Trends



Passenger Car Use

The preference for smaller-sized cars has led to a 34 percent decrease in the amount of fuel consumed per kilometer.

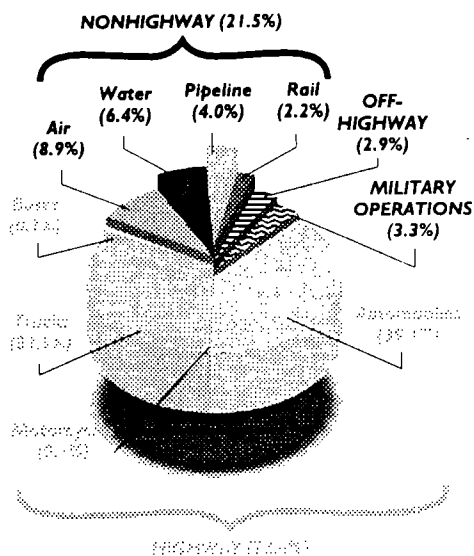


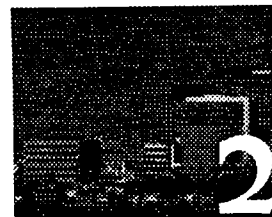
Source: U.S. DOT 1993



Energy Use

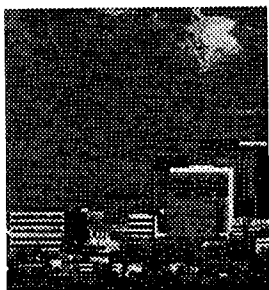
Nearly three-quarters of the 22,090 trillion Btus used in transport is consumed on our country's roads.





per kilometer. In 1990, personal passenger vehicles in the United States traveled a total of 2.4 trillion kilometers (1.6 trillion miles), using 273 billion liters (82 billion gallons) of fuel, with an average fuel efficiency of almost 8.9 kilometers traveled per liter (21 miles per gallon) of fuel. By contrast, in 1969 U.S. personal-passenger vehicles traveled a total of 1.6 trillion kilometers (1 trillion miles), using 242 billion liters (64 gallons) of fuel, with an average fuel efficiency of about 5.7 km/liter (4 mpg).

The causes for the rapid rise in vehicle miles traveled are many, although their relative importance is unclear. In 1990, there were more personal vehicles than licensed drivers (1.02 vehicles per licensed driver), compared to 0.74 vehicles per licensed driver in 1960. This increase in ownership rates translates into increased vehicle use by reducing people's need to carpool or use public transportation. And these vehicles are being driven farther—up from 5,906 kilometers (9,510 miles) in 1960 to 7,415 kilometers (11,940 miles) on average in 1990. Greater vehicle ownership and use are related to changing patterns of land use, the changing composition and location of work and shopping centers, reduced costs of driving, increased labor force participation of women, and a host of other factors.



U.S. Governing Institutions

The political and institutional systems participating in the development and protection of the nation's 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 office of the President, departments, and independent agencies; the legislative branch (the U.S. Congress); and the judicial branch (the U.S. court system). There is a distinct separation of powers in this tripartite system—quite different from parliamentary governments.

Federal Departments and Agencies

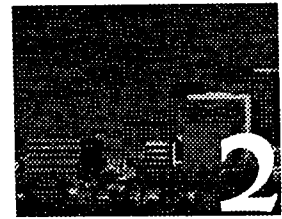
There are fourteen executive departments in the executive branch, seven agencies, and a host of commissions, boards, other independent establishments, and government corporations. The traditional functions of a department or agency are to help the President propose legislation; to enact, administer, 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 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 U.S. Departments of Energy, Transportation, Agriculture, Treasury, Commerce, Interior, and State, as well as the U.S. Environmental Protection Agency.

The U.S. Congress

Responsibility for climate change and other environmental and natural resource issues at the national level also resides with Congress, which is the legislative branch of the U.S. government. Congress influences environmental policy through two principal vehicles: the creation of laws and the oversight of the federal executive branch. Under its constitutional authority, the Senate must provide its advice and consent before the United States can ratify international treaties, such as the U.N. Framework Convention on Climate Change.



The U.S. Congress consists of two elected chambers, the Senate and the House of Representatives, having generally equal functions in lawmaking. The Senate has 100 members, two representing each state; the House has 435 members, each of whom represents a district in a state allocated by population. Less populated regions of the country, therefore, have proportionately greater influence in the Senate than in the House. Environmental proposals, like most other laws, may be initiated in either chamber. After their introduction, proposals—or “bills”—are referred to specialized committees and subcommittees, where most legislative work takes place.

Committees and subcommittees hold public hearings on the bills to receive testimony from interested and expert parties. After reviewing the testimony, they deliberate and revise the bills. Committees then submit the bills 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.

State and Local Governments

States, localities, and even regional associations still 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 utili-

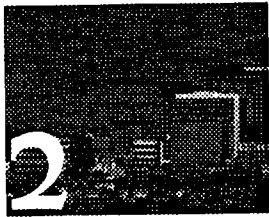
ty commissions. In addition, the regulation of building codes—strongly tied to the energy efficiency of buildings—is also controlled at the state and local levels.

Each of the fifty states enjoys significant autonomy in its approach to environmental regulation and management activities. States implement federal laws by issuing permits and by monitoring compliance with regulatory standards. States also generally have the discretion to set standards more stringent than the national standards. In addition to regulation, some states and localities have developed programs that encourage energy efficiency and conservation or otherwise mitigate projected levels of 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 usually is 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 federal court system is three-tiered: the district court level; the first appellate (circuit) court level; and the second and final appellate level—the U.S. Supreme Court. There are ninety-four federal district courts, organized into federal circuits, and thirteen federal appeals



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courts.

Cases usually enter the federal court system at the district court level. However, disputes between states may be brought directly before the Supreme Court. In civil environmental cases, complaints are brought on behalf of the government and are filed by the U.S. attorney general. Any other person (regardless of citizenship) may also file a complaint alleging a grievance.

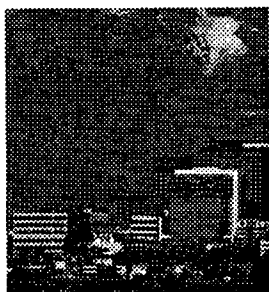
Sanctions and relief in civil environmental cases may include monetary penalties, awards of damages, and injunctive and declaratory relief. For example, courts may direct that pollution cease, that contaminated sites be cleaned up, or that environmental impacts be assessed before a project proceeds. Criminal cases under federal environmental laws may be brought only by the government (the attorney general or state attorneys general). Criminal sanctions in environmental cases may include fines and imprisonment.

Scientific Institutions

Climate change is a highly technical, scientific issue. Political action, at any level, requires sound advice and information from the scientific community. Thus, governments must have access to the best scientific information available. The independent, congressionally chartered National Academy of Sciences (NAS) and the National Academy of Engineering (NAE) are important sources of high-level scientific advice. The NAS is a key link between the academic and federal research communities, convening special study groups. An example of issues addressed is the identification of prudent actions that could be taken to reduce greenhouse gases or adapt to global warming. NAS and NAE panels are periodically requested by Congress or federal sci-

ence agencies to address global climate change issues. At present the NAS is going through a transition to strengthen its ability to provide scientific advice to the public sector that is both timely and pertinent to policy decisions.

Organizing advice on climate change for the federal government is the task of the newly established cabinet-level National Science and Technology Council (NSTC). Chaired by the President, the Council was created to coordinate research and development on science and technology. One of the committees under the NSTC focuses exclusively on environmental and natural resource issues. The largest and most mature program under this committee is the U.S. Global Change Research Program, described in depth in Chapter 6 of this report. A high-ranking, private-sector committee has also been formed to interact with the NSTC and enhance opportunities for public-private partnerships. The President's Committee of Advisors on Science and Technology provides the links to the private sector that will help guide federal investments in science toward national goals.



U.S. Policies Related to Climate Change

U.S. climate change policies focus primarily on mitigating climate change. Where mitigation strategies are infeasible, policymakers must work to identify ways to adapt to those effects, so as to minimize environmental and economic losses.

Agriculture and Land-Use Policies

For the past fifty years, agricultural and forestry policies have increasingly reflected the principles of conservation and sustainable use for food and fiber production. Legislation and public-private partnerships have focused on protecting a productive resource base by creating incentives to reduce soil erosion on crop, range, and pasture lands; maintain or expand wetlands; enhance privately owned wildlife habitat; and improve water quality.

U.S. policies to improve forest conservation on both public and private lands involve initiatives for reforestation, improved harvest systems, and the sustained use of all forest resources. In 1991, over 25 million trees were planted or improved in urban areas alone. In 1992, nearly \$20 million was available to cost-share tree planting and improvements in rural areas. The federal government also encourages state foresters and private nonindustrial landowners to develop forest stewardship plans before harvesting their timber.

Recently, the U.S. government adopted the principle of ecosystem management for publicly owned forest lands, announced an end to clearcutting as a standard harvesting practice on those lands, and launched a major research effort focusing on ecosystem management.

The conservation title of the 1985 Farm Bill and its subsequent amendments changed the priorities of U.S. federal soil- and water-conservation agencies, of their state and local program participants, and of farmers themselves. It accomplished this through such programs as the Conservation Reserve Program and the "Swampbuster" and "Sodbuster" provisions, by giving farmers incentives to prevent pollution and conserve highly erodible lands. The Conservation Reserve Program pays farmers for easements on environmentally sensitive cropland, including farmed wetlands and prior-converted cropland. The Swampbuster provision protects the environmental values of wetlands by outlawing the conversion of wetlands to cropland. The Sodbuster provision reduces the incentive for converting grasslands and forests to crop production by requiring the use of conservation measures on all such converted land.

Environmental Policies

In the twenty-four years since the first Earth Day, the United States has struggled to achieve



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a balance between the protection of the environment on the one hand, and the consumption of resources and discharge of waste on the other. In particular, there has been a tension between the use of energy that fuels our economy and the need to protect our environment.

Until the late 1980s, U.S. environmental programs were largely focused on directly controlling the environmental releases from the energy-producing sector and heavy-manufacturing industries that have historically used a significant amount of energy, such as the metal production and pulp and paper industries.

From 1970 to 1990, the U.S. Congress enacted the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act, which empowered the U.S. Environmental Protection Agency (EPA) and other federal agencies to place significant environmental controls on U.S. industries, in particular on the extraction, production, distribution, and use of energy throughout our economy. During this period, EPA directed industrial facilities to use "end-of-pipe" pollution control technologies that often required significant amounts of energy to operate.

In the latter half of the 1980s, the United States began to focus more on preventing pollution and promoting energy efficiency than on technologies that controlled the pollution after it had been produced. For instance, EPA and the U.S. Department of Energy (DOE) are now promoting and implementing a series of voluntary energy-efficiency programs that encourage major U.S. companies to reduce their electrical energy consumption at their facilities. Besides preventing pollution, this reduced energy consumption often results in substantial profits for program participants.

Another major shift in the direction of U.S.

environmental policy was a new emphasis on identifying effective policies for reducing environmental pollution other than direct "command-and-control" regulation. For instance, under the Clean Air Act Amendments of 1990, EPA is working with utilities to curb sulfur dioxide levels through an "allowance trading" system that allows them to buy and sell to each other sulfur dioxide permits as a means of meeting requirements for reducing emissions.

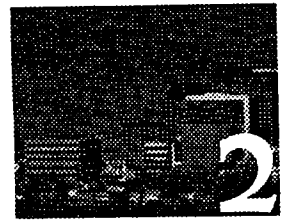
Energy Policies

DOE supports a broad range of energy technology research, development, demonstration, and deployment programs. Virtually all of the

Clean Air Act Amendments

Implementation of the 1990 Clean Air Act Amendments achieves substantial reductions in greenhouse gases and their chemical precursors and contributes to the goals of the Action Plan by:

- Directly reducing carbon dioxide as a result of more efficient electricity generation.
- Reducing U.S. emissions of volatile organic compounds, carbon monoxide, and nitrogen oxides, which will curb ground-level ozone, in addition to reducing emissions of the more familiar pollutants, such as sulfur dioxide.
- Promoting enhanced energy conservation and clean fuels, such as natural gas.
- Developing and implementing programs involving nonregulatory approaches for the reduction of air pollutants, including CO₂ emissions.
- Requiring EPA to prepare national and international inventories of methane, monitor and report CO₂ emissions from certain stationary sources, and develop a research program to measure, monitor, and analyze air pollutants.



technologies that DOE is developing could lead to significant reductions in greenhouse gases, especially beyond 2000. The Energy Policy Act of 1992 has expanded these efforts and has authorized many new initiatives. It particularly emphasizes measures likely to reduce greenhouse gas emissions, such as expanded efficiency standards and incentives, the accelerated development and deployment of renewable-energy technologies, and the introduction of alternative fuels in the transportation sector.

Transportation Policies

Traditionally, U.S. transportation policy has focused on promoting commerce and trade,

national security concerns, safety, and personal mobility. Along with other factors, this focus has contributed to the development of an extensive local and interstate highway network and a widespread dependency on the automobile. While these original goals are still highly valued, increasing concerns about the environmental impacts of the construction and use of transportation facilities have led policymakers to reevaluate traditional methods by which to achieve transportation policy objectives. The result has been an aggressive campaign by federal transportation officials to encourage more effective use of the existing transportation system and increased flexibility for state and local transportation officials in deciding how to meet

The U.S. Energy Policy Act

Several titles of the U.S. Energy Policy Act (EPAAct) are extremely important to the overall U.S. strategy of reducing greenhouse gas emissions.

■ Title I—The energy efficiency title establishes energy-efficiency standards, promotes research and development of energy-efficient technologies, promotes dissemination of energy-saving information, and provides incentives for state and local authorities to promote energy efficiency. ■ Titles III, IV, V, and VI—The alternative fuels and vehicle titles provide monetary incentives, establish federal requirements, and provide for 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—The renewable-energy title, the revenue provisions, the energy and environment title, and the energy and economic growth title promote increased research, development, production, and use of renewable-energy sources and more energy-efficient technologies. ■ Title XVI—The global climate change title provides for the collection, analysis, and reporting of information pertaining to global cli-	- mate change, including a voluntary reporting program to recognize utility and industry efforts to reduce greenhouse gas emissions. ■ Title XXIV—This title facilitates efforts to increase the efficiency and electric power production of existing federal and nonfederal hydroelectric facilities. ■ Title XXVIII—This title streamlines licensing for nuclear plants, which enables nuclear power to displace carbon-emitting sources.
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their citizens' demand for safe, efficient, and environmentally friendly travel. Examples include promoting carpools, the use of mass transit, and telecommuting over single-passenger-vehicle travel.

Environmental concerns, including greenhouse gas emissions, have emerged as a priority in U.S. transportation policy. Significant federal efforts to limit the impacts of transportation on environmental quality began in the 1960s, in response to concerns about urban air quality and impacts of road construction on the natural environment.

In the 1970s, the federal government established standards for automotive fuel efficiency, based on the average fuel-efficiency levels of all automobiles sold in the United States by each producer. These norms, called the "corporate average fuel economy" (CAFE) standards have risen from an initial level of 7.7 kilometers per liter (18 miles per gallon) in 1978 to 12 kpl (28 mpg) in 1990. As a result, U.S. average fuel efficiency has risen from about 9 kpl (14 mpg) in 1978 to 13 kpl (21 mpg) in 1990. Large increases in overall vehicle miles traveled, however, have offset these gains in fuel efficiency.

Recent legislation reflects a growing awareness of the environmental implications of transportation policy. In 1991, the President signed into law a major revision and updating of U.S. transportation law and programs, called the Intermodal Surface Transportation Efficiency Act (ISTEA), as well as a major revision to the Clean Air Act. Together, these acts integrate environmental and transportation planning and policymaking at the federal, state, and local levels, to an unprecedented degree. For instance, state and local governments will be considering congestion management and transportation-demand-management strategies (including mar-

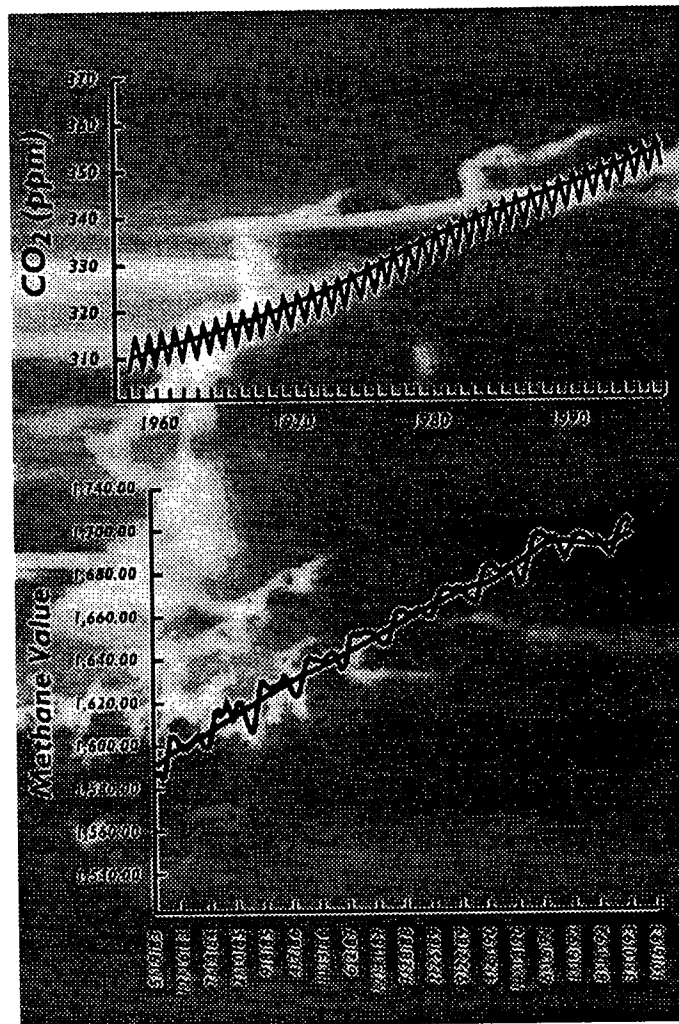
Intermodal Surface Transportation Efficiency Act

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 provides for improved operation of the transportation system and gives state and local governments increased flexibility in spending federal funds for a variety of projects that would help reduce greenhouse gas emissions. For instance, state and local transportation officials may redirect federal highway construction funds toward the development of high-occupancy-vehicle (carpool) lanes and transit facilities. Additionally, ISTEA provides for testing and implementing intelligent-vehicle and highway-system technologies and services to reduce congestion, energy use, and emissions. The Act also created the Congestion Management and Air Quality Improvement Program to allow state and local officials to direct transportation funds to help certain areas meet the standards set by the Clean Air Act Amendments of 1990.

ket pricing), which will have the ancillary effect of reducing greenhouse gas emissions.

The Clean Air Act Amendments of 1990 also set federal and state agencies on a course to develop and promote alternative-fueled vehicles. To address continuing air pollution problems in U.S. cities, the Amendments called for tighter vehicle-emission standards and other emission-reduction measures for areas violating the National Ambient Air Quality Standard for ambient tropospheric ozone. As a result, some cities and states—most notably California—have instituted "low-emission-vehicle" programs, which require a small but growing portion of new-car sales be composed of these vehicles. Alternative-fuel infrastructure and vehicle conversions are also receiving a boost through the use of ISTEA funds.

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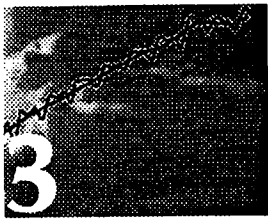


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Central to any study of climate change is the development of an emission inventory that identifies and quantifies a country's primary sources and sinks of greenhouse gases. The inventory process is important for two reasons: (1) it provides a basis for the ongoing development of a comprehensive and detailed methodology for estimating sources and "sinks" of greenhouse gases, and (2) it provides a common and consistent mechanism that enables all signatory countries to the United Nations' Framework Convention on Climate Change to estimate emissions and to compare the relative contributions of different emission sources and greenhouse gases to climate change. Moreover, systematically and consistently estimating emissions at the national and international levels is a prerequisite for evaluating the cost-effectiveness and feasibility of pursuing possible mitigation strategies and adopting emission-reduction technologies.

This chapter summarizes the sources and sinks of U.S. greenhouse gas emissions. The methods used to estimate emissions and sinks, as well as the uncertainties associated with using them, are reported in *Inventory of U.S. Greenhouse Gas Emissions and Sinks*.

greenhouse
gas inventory

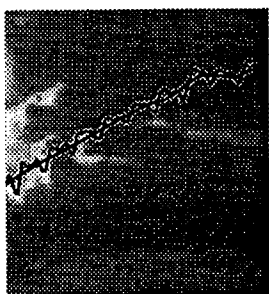


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1991–1993, a supporting document to this *Climate Action Report* (U.S. EPA 1994). Although estimates are provided for all four years, the 1990 estimates are considered the base year, because the Framework Convention on Climate Change specifies that countries should submit inventories of their greenhouse gas emissions for the year 1990.

The emission estimates presented here were calculated using the *IPCC Draft Guidelines for National Greenhouse Gas Inventories* (IPCC/OECD 1994), to ensure that the emission inventories submitted to the Framework Convention are

consistent and comparable across sectors and among nations. The United States has followed these guidelines, except where more detailed data or methodologies were available for major U.S. sources of emissions. In such cases, the United States expanded on the IPCC Guidelines to provide a more comprehensive and accurate account of U.S. emissions. *Inventory of U.S. Greenhouse Gas Emissions and Sinks for 1990–1993* documents these sources, explains the reasons for diverging from the IPCC Guidelines, and presents the uncertainties associated with each emission estimate.



Recent Trends in U.S. Greenhouse Gas Emissions

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Chlorofluorocarbons (CFCs), a family of human-made compounds, its substitute hydrofluorocarbons (HFCs), and other compounds, such as perfluorinated carbons (PFCs), are also greenhouse gases. In addition, there are other "photochemically important" gases, such as carbon monoxide (CO), oxides of nitrogen (NO_x), and nonmethane volatile organic compounds (NMVOCs) that are not greenhouse gases, but contribute indirectly to the greenhouse effect. These are commonly referred to as "tropospheric ozone precursors" because they influence the rate at which ozone and other gases are created and destroyed in the atmosphere. For convenience, all gases discussed in this chapter are generically referred to as "greenhouse gases" (unless otherwise noted), although the reader should keep these distinctions in mind. This chapter also reports U.S. emissions of sulfur dioxide (SO_2). Sulfur gases—primarily SO_2 —are believed to contribute negatively to the greenhouse effect.

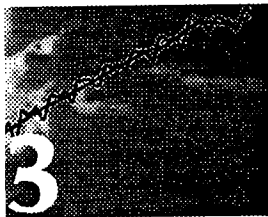
Although carbon dioxide, methane, and nitrous oxide occur naturally in the atmosphere, their recent atmospheric build-up appears to be largely the result of human activities. This build-up has altered the composition of the Earth's atmosphere and may affect future global climate.

Since 1800, atmospheric concentrations of carbon dioxide have increased by more than 25 percent, methane concentrations have more than doubled, and nitrous oxide concentrations have risen approximately 8 percent (IPCC 1992).

And from the 1950s until the mid-1980s, when international concern over CFCs grew, the use of these gases increased nearly 10 percent per year. However, the consumption of CFCs is declining quickly, as they are phased out under the 1987 *Montreal Protocol on Substances That Deplete the Ozone Layer*. In contrast, use of CFC substitutes is expected to grow significantly.

The current U.S. greenhouse gas inventory for 1990–93 is summarized in Table 3-1. For the 1990 base year, total U.S. emissions were 1,444 million metric tons of carbon equivalent (MMTCE). To be consistent with the IPCC Guidelines (IPCC/OECD 1994), this estimate excludes emissions of 22.6 MMTCE from international transport.

As the table shows, changes in CO_2 emissions from fossil fuel consumption had the greatest impact on U.S. emissions during this period. While U.S. emissions of CO_2 in 1991 were approximately 1.2 percent lower than 1990 emission levels, in 1992 they were about 1.5 percent over 1991 levels, thus returning emissions to about 1990 levels. This trend is largely attributable to changes in total energy consumption resulting from the economic slowdown in the



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U.S. economy and the subsequent recovery. Based on preliminary data for 1993, the upward trend since 1991 has continued, with 1993 CO₂ emissions from fossil fuel combustion approximately 2.4 percent greater than in 1990.

U.S. CO₂ emissions were partly offset by an

uptake of carbon in U.S. forests of 119 MMTCE. This carbon absorption was due to intensified forest-management practices and the regeneration of forest land previously cleared for cropland and pasture.

Methane, nitrous oxide, and HFCs and PFCs

Gases can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself is a greenhouse gas; indirect radiative forcing occurs when chemical transformation of the original gas produces a gas or gases that are greenhouse gases, or when a gas influences the atmospheric lifetimes of other gases. The concept of global warming potential (GWP) has been developed to compare the abilities of each greenhouse gas to trap heat in the atmosphere.

Carbon dioxide was chosen as the "reference" gas to be consistent with the IPCC's GWP values, which the Intergovernmental Negotiating Committee (INC) adopted during its 9th Session. This approach is also consistent with the GWP values used in the supplement to the *Climate Change Action Plan* (U.S. DOE, 1994).

All gases in this report are presented in units of millions of metric tons of carbon equivalent, or MMTCE. Carbon comprises 12/44 of carbon dioxide by weight.

The GWP of a greenhouse gas is the ratio of global warming—or radiative forcing (both direct and indirect)—from one

kilogram of a greenhouse gas to one kilogram of carbon dioxide over a period of time. While any time period may be selected, this report uses the 100-year GWPs recommended by the IPCC.

Besides accounting for the direct effects of methane (11) on radiative forcing, the United States has also considered

methane's indirect effects (also 11), which are believed to be comparable in magnitude to the direct effects (IPCC 1992). Using a GWP of 22 for methane is consistent with the GWP used in the supplement to the *Climate Change Action Plan* (U.S. DOE, 1994) and follows the INC's 9th Session guidelines, which request that countries include indirect effects in their emission inventories where applicable. The magnitude of the indirect effects of other gases is either zero or uncertain.

Contributions of Greenhouse Gases to U.S. Emissions in 1990

The high global warming potential of lower-emitting greenhouse gases significantly increases their contributions to the greenhouse effect. For example, over a 100-year time horizon, nitrous oxide is 270 times more effective than carbon dioxide at trapping heat in the atmosphere.

Gas	GWP ^a
(100 Years)	
Carbon Dioxide (CO ₂)	1
Methane (CH ₄)	11/22
Nitrous Oxide (N ₂ O)	270
HFC-134a	1,200
HFC-23	10,000
HFC-152a	150
PFCs	5,400

Note: The GWPs in this table are based on 1990 IPCC values. The IPCC 1994 interim assessment report, currently in review (IPCCa), is expected to provide substantially revised values for these GWPs.

Source: U.S. EPA 1994



Table 3-1

Recent Trends in U.S. Greenhouse Gas Emissions: 1991-1993 (Millions of Metric Tons)

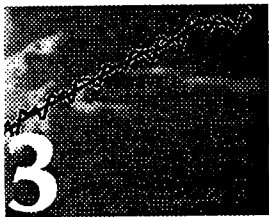
Since 1990, overall emissions of carbon dioxide have increased, while emissions of other greenhouse and photochemically important gases have remained relatively constant or have declined.

Gas/Source	Emissions (Full Molecular Weight)				Emissions (Direct and Indirect Effects; Carbon Equivalent)			
	1990	1991	1992	1993	1990	1991	1992	1993
Greenhouse Gases								
Net Carbon Dioxide (CO₂)	4,520	4,463	4,541	-	1,233	1,218	1,239	-
Fossil Fuel Combustion	4,895	4,835	4,908	5,013	1,335	1,319	1,339	1,367
Other	62	61	62	-	17	17	17	-
Total	4,956	4,896	4,970	-	1,352	1,336	1,356	-
Forests (sink)	(436)	(433)	(429)	-	(119)	(118)	(117)	-
Methane (CH₄)	27.0	26.9	27.0	-	162	162	161	-
Landfills	10.0	10.1	10.2	10.3	60	61	61	62
Agriculture	8.6	8.5	8.6	8.8	52	51	52	53
Coal Mining	4.4	4.2	4.0	-	26	26	24	-
Oil and Gas Systems	3.2	3.3	3.3	-	19	20	20	-
Other	0.8	0.8	0.8	-	5	5	5	-
Nitrous Oxide (N₂O)	0.4	0.4	0.4	-	30	32	32	-
Industrial Processes	0.2	0.2	0.2	-	14	14	14	-
Agriculture	0.1	0.1	0.1	-	9	10	10	-
Fossil Fuel Consumption	0.1	0.1	0.1	-	7	7	7	-
HFCs and PFCs	*	*	*	-	19.2	19.6	20	-
Photochemically Important Gases								
Carbon Monoxide (CO)	82.7	81.4	78.1	-	-	-	-	-
Nitrogen Oxides (NO_x)	21.4	21.2	21.0	-	-	-	-	-
Nonmethane Volatile Organic Compounds (NMVOCs)	19.1	18.7	17.9	-	-	-	-	-
Net U.S. Emissions	-	-	-	-	1,444	1,432	1,452	-

Note: The totals presented in the summary tables in this chapter may not equal the sum of the individual source categories due to rounding.

* The total of each of these gases does not exceed 0.01 million metric tons.

Source: U.S. EPA 1994



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represent a much smaller portion of total emissions than CO₂. Overall, emissions of these gases remained relatively constant from 1990 to 1992. Methane emissions from coal mining declined slightly due to small decreases in coal production and increases in coalbed methane recovery. Nitrous oxide emissions remained relatively constant, while HFC emissions increased slightly, due to increased production of HCFC-22, which induced by-product emissions of HFC-23.

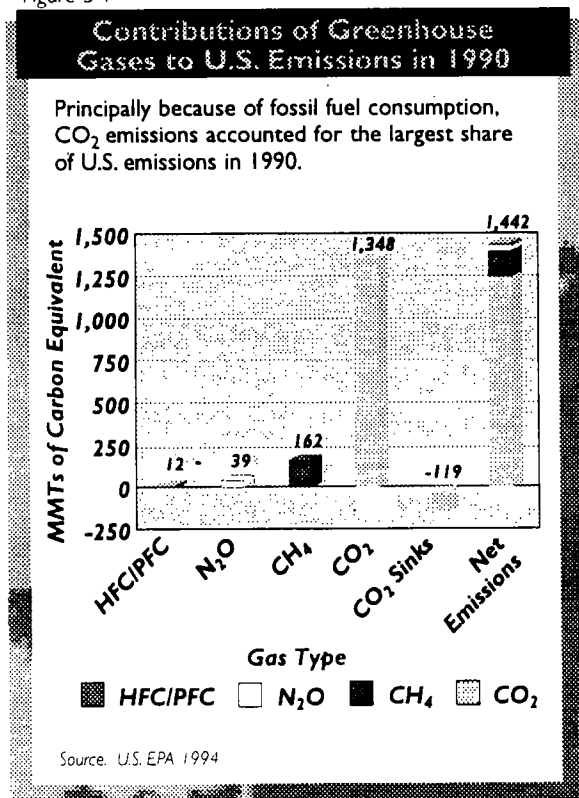
Figure 3-1 illustrates the relative contributions of the primary greenhouse gases to total U.S. emissions in 1990. These contributions were calculated based on the global warming potentials (GWPs) of these gases, as presented in the figure. Due largely to fossil fuel consumption, carbon dioxide emissions accounted for the largest share—85 percent. Methane accounted

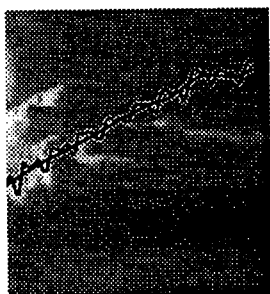
for 11 percent of total emissions, which included contributions from landfills and agricultural activities, among others. The other gases were less important, with nitrous oxide emissions comprising 2 percent of total U.S. emissions; HFCs, slightly over 1 percent; and PFCs, about 0.3 percent.

The emissions of the photochemically important gases CO, NO_x, and NMVOCs are not included in Figure 3-1 because there is no agreed-upon method to estimate their contribution to climate change. These gases only affect radiative forcing indirectly. However, the U.S. Environmental Protection Agency prepares publications that provide data and trends on annual emissions of these gases from 1940 to the present (e.g., U.S. EPA 1993b). Also, any gases covered under the *Montreal Protocol* are not included in this figure because their use is being phased out, and the IPCC Guidelines (IPCC/OECD 1994) recommend excluding gases covered by the *Montreal Protocol*.

The following sections present the anthropogenic sources of greenhouse gas emissions, briefly discuss the emission pathways, summarize the emission estimates, and explain the relative importance of emissions from each source category.

Figure 3-1





Carbon Dioxide Emissions

The global carbon cycle is made up of large carbon flows and reservoirs. Every year, hundreds of billions of tons of carbon in the form of CO₂ are absorbed by the oceans, trees, and other carbon "sinks" and are emitted to the atmosphere through natural processes. When in equilibrium, carbon flows among the various reservoirs roughly balance. Since the Industrial Revolution, however, atmospheric concentrations of carbon dioxide have risen more than 25 percent, principally because of the combustion of fossil fuels (IPCC 1992). While the combustion of fossil fuels accounts for 99 percent of total U.S. CO₂ emissions, carbon dioxide emissions also result directly from industrial processes. Changes in land use and forestry activities both emit carbon dioxide and have the poten-

tial to act as a sink for CO₂ emissions.

Table 3-2 summarizes U.S. emissions and uptake of carbon dioxide, while the remainder of

Table 3-2

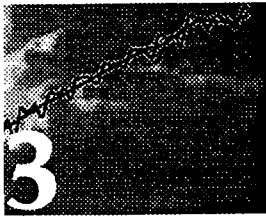
Sources of CO₂ Emissions: 1990

The combustion of fossil fuels accounts for 99 percent of total gross U.S. CO₂ emissions.

Source/Sinks	CO ₂ Emissions (Molecular Basis)	CO ₂ Emissions (Carbon Equivalent)
(Millions of Metric Tons)		
Sources	4,956.6	1,351.7
Fossil Fuel Consumption	4,895.0	1,335.0
Residential	927.0	252.7
Commercial	757.0	206.4
Industrial	1,673.0	456.3
Transportation	1,505.0	410.5
U.S. Territories	033.0	9.1
Fuel Production and Processing	6.6	1.8
Industrial Processes	55.0	15.0
Cement Production	32.7	8.9
Lime Production	11.9	3.2
Limestone Consumption	5.1	1.4
Soda Ash Production and Consumption	4.1	1.1
Carbon Dioxide Manufacture	1.2	0.3
Sinks	(436.0)	(119.0)
Forestry and Land Use	(436.0)	(119.0)
Total Net Emissions	4,520.6	1,232.7

Note: The totals provided here do not reflect emissions from bunker fuels used in international transport activities. At its 9th Session, the Intergovernmental Negotiating Committee instructed countries to report these emissions separately, and not include them in national totals. U.S. emissions from bunker fuels were approximately 24.6 MMTCE in 1990.

Source: U.S. EPA 1994



this section presents detailed information on the various sources and sinks of CO₂ emissions in the United States.

The Energy Sector

Approximately 88 percent of U.S. energy is produced through the combustion of fossil fuels. The remaining 12 percent comes from renewable or other energy sources, such as hydro-power, biomass, and nuclear energy (Figure 3-2).

As they burn, fossil fuels emit carbon dioxide due to oxidation of the carbon contained in the fuel. The amount of carbon in fossil fuels varies significantly by fuel type. For example, coal contains the highest amount of carbon per unit of energy, while petroleum has about 20 percent less carbon than coal, and natural gas has about 45 percent less.

The U.S. inventory includes carbon dioxide emissions from all fossil fuel consumption and oil and gas production and storage. Carbon dioxide emissions from biomass and biomass-based fuel consumption are reported, but are not included in the national total. This approach is consistent with the 1994 IPCC Guidelines.

Fossil Fuel Consumption

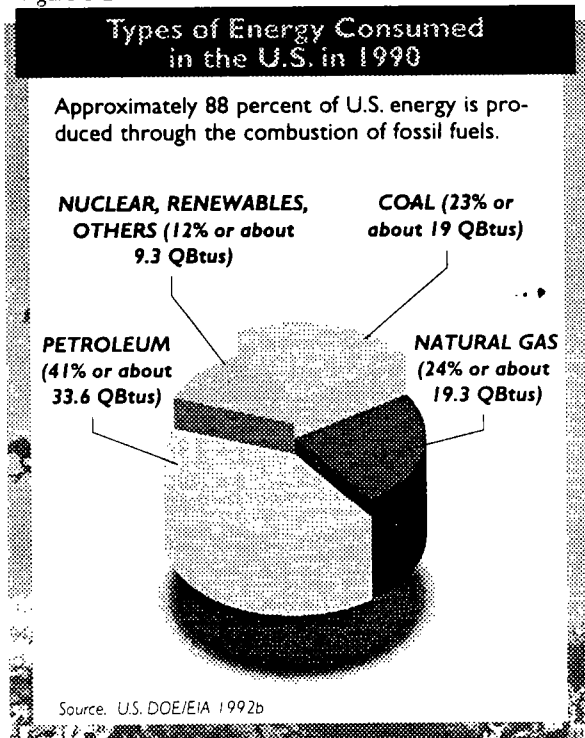
In 1990 the United States emitted a total of 1,335 MMTCE from fossil fuel combustion. (Bunker fuels, or fuels used in international transport, accounted for an additional 22.6 MMTCE.) The energy-related activities producing these emissions included steam production for industrial processes, gasoline consumption in automobiles and other vehicles, heating in residential and commercial buildings, and the generation of electricity. Petroleum products across all sectors of the economy were responsible for about 44 percent of total U.S. energy-related

CO₂ emissions, with coal accounting for 36 percent, and natural gas, 20 percent.

Industrial Sector. The industrial sector accounts for 34 percent of U.S. emissions from fossil fuel consumption, making it the largest end-use source of CO₂ emissions (Figure 3-3). About two-thirds of these emissions result from the burning of fossil fuels to meet industrial demand for steam and process heat. The remaining one-third of industrial energy needs is met by electricity for such uses as motors, electric furnaces and ovens, and lighting.

The industrial sector is also the largest user of nonenergy applications of fossil fuels, which often store carbon. Fossil fuels used for producing fertilizers, plastics, asphalt, or lubricants can store carbon in products for very long periods. Asphalt used in road construction, for example, stores carbon indefinitely. Similarly, the fossil fuels used in the manufacture of materials like

Figure 3-2





plastics also store carbon and release it only if the product is incinerated.

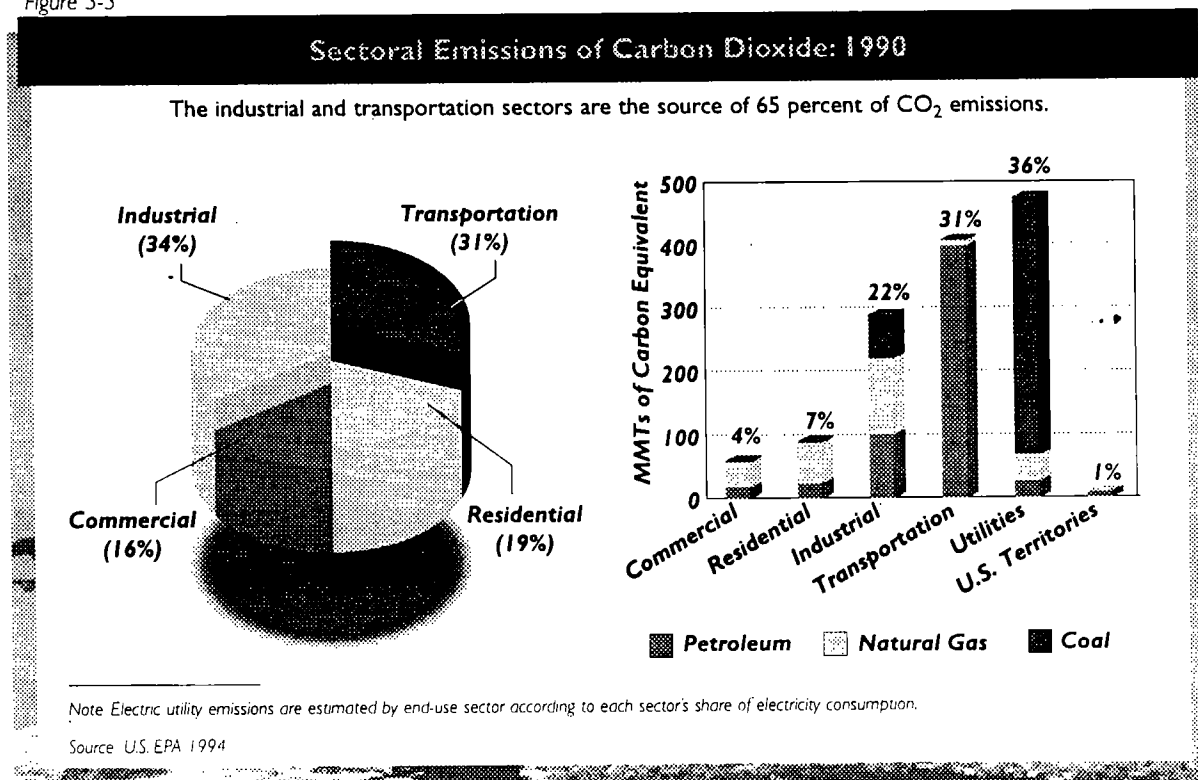
Transportation Sector. The transportation sector is also a major source of CO₂, accounting for about 31 percent of U.S. emissions. Virtually all of the energy consumed in this sector comes from petroleum-based products. Nearly two-thirds of the emissions are the result of gasoline consumption in automobiles and other vehicles, with other uses—including diesel fuel for the trucking industry and jet fuel for aircraft—representing the remainder.

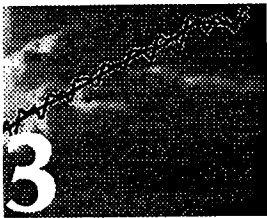
Residential and Commercial Sectors. The residential and commercial sectors account for about 19 and 16 percent, respectively, of CO₂ emissions from fuel consumption. Both sectors rely heavily on electricity for meeting energy needs, with about two-thirds of their emissions attributable to electricity consumption. End-use applications include lighting, heating, cooling,

and operating appliances. The remaining emissions are largely due to the consumption of natural gas and oil, primarily for meeting heating and cooking needs.

Electric Utilities. The United States relies on electricity to meet a significant portion of its energy requirements. In fact, as the largest consumers of U.S. energy (about 36 percent of total energy), electric utilities are collectively the largest producers of U.S. CO₂ emissions (Figure 3-3). This sector generates electricity for such uses as lighting, heating, electric motors, and air conditioning. Some of this electricity is generated with the lowest CO₂-emitting energy technologies, particularly nonfossil options, such as nuclear energy, hydropower, and geothermal energy. However, electric utilities rely on coal for 55 percent of their total energy requirements and account for about 85 percent of all coal consumed in the United States.

Figure 3-3





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Fuel Production and Processing

Carbon dioxide is produced via flaring activities at natural gas systems and oil wells. Typically, the methane that is trapped in a natural gas system or oil well is flared to relieve the pressure building in the system or to dispose of small quantities of gas that are not commercially marketable. As a result, the carbon contained in the methane becomes oxidized and forms carbon dioxide. In 1990 the amount of carbon dioxide from the flared gas was approximately 1.8 MMTCE, or about 0.1 percent of total U.S. CO₂ emissions.

Biomass and Biomass-Based Fuel Consumption

Biomass fuel is used primarily by the industrial sector in the form of fuelwood and wood waste. Biomass-based fuel, such as ethanol from corn or woody crops, is used mainly in the transportation sector. Ethanol and ethanol blends, such as gasohol, are typically used to fuel public transport vehicles, such as buses or centrally fueled fleet vehicles.

Biomass, ethanol, and ethanol-blend fuels do release carbon dioxide. However, in the long run, the carbon dioxide they emit does not increase total atmospheric CO₂ because the biomass resources are consumed on a sustainable basis. For example, fuelwood burned one year but regrown the next only recycles carbon, rather than creating a net increase in total atmospheric carbon. As a result, CO₂ emissions from biomass have been estimated separately from fossil fuel-based emissions and, as recommended in the 1994 IPCC Guidelines, are not included in national totals.

For 1990, CO₂ emissions from biomass consumption were approximately 48 MMTCE, with the industrial sector accounting for 73 percent,

and the residential sector, 25 percent. Carbon dioxide emissions from ethanol use in the United States are generally declining, due to a combination of low gasoline prices and limited ethanol supply. In 1990, total U.S. CO₂ emissions from ethanol were estimated to be 1.2 MMTCE, and mostly originated in the South and Midwest, where the majority of U.S. ethanol is produced and consumed.

Industrial Processes

Emissions are often produced as a by-product of various nonenergy-related activities. For example, in the industrial sector, raw materials are chemically transformed from one state to another. This transformation often releases such greenhouse gases as carbon dioxide. The production processes that emit CO₂ include cement production, lime production, limestone consumption (e.g., in iron and steel making), soda ash production and use, and carbon dioxide manufacture. Total CO₂ emissions from these sources were approximately 15 MMTCE in 1990, accounting for 1 percent of total U.S. emissions of carbon dioxide.

Cement Production (8.9 MMTCE)

Carbon dioxide is produced primarily during the production of clinker, an intermediate product from which finished Portland and masonry cement are made. Specifically, carbon dioxide is created when calcium carbonate (CaCO₃) is heated in a cement kiln to form lime and carbon dioxide. This lime combines with other materials to produce clinker, while the carbon dioxide is released into the atmosphere.

Lime Production (3.2 MMTCE)

Lime is used in steel making, construction,



pulp and paper manufacturing, and water and sewage treatment. It is manufactured by heating limestone (mostly calcium carbonate— CaCO_3) in a kiln, creating calcium oxide (quicklime) and carbon dioxide, which is normally emitted to the atmosphere.

Limestone Consumption (1.4 MMTCE)

Limestone is a basic raw material used by a wide variety of industries, including the construction, agriculture, chemical, and metallurgical industries. For example, limestone can be used as a purifier in refining metals, such as iron. In this case, limestone heated in a blast furnace reacts with impurities in the iron ore and fuels, generating carbon dioxide as a by-product. It is also used in flue-gas desulfurization systems to remove sulfur dioxide from the exhaust gases.

Soda Ash Production and Consumption (1.1 MMTCE)

Commercial soda ash (sodium carbonate) is used in many consumer products, such as glass, soap and detergents, paper, textiles, and food. During the manufacture of these products, natural sources of sodium carbonate are heated and transformed into a crude soda ash, in which carbon dioxide is generated as a by-product. In addition, carbon dioxide is released when the soda ash is consumed. Of the two states that produce natural soda ash, only Wyoming has net emissions of carbon dioxide, because producers in California recover the CO_2 and use it in other stages of production. U.S. emissions of carbon dioxide from soda ash production were approximately 0.4 MMTCE in 1990, while U.S. soda ash consumption generated about 0.7 MMTCE.

Carbon Dioxide Manufacture (0.3 MMTCE)

Carbon dioxide is used in many segments of

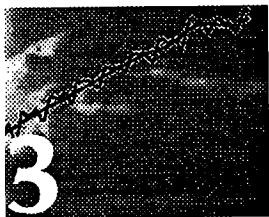
the economy, including food processing, beverage manufacturing, chemical processing, crude oil products, and a host of industrial and miscellaneous applications. For the most part, carbon dioxide used in these applications will eventually be released into the atmosphere.

Changes in Forest Management and Land Use

When humans use and alter the biosphere through changes in land use and forest-management activities, they alter the natural balance of trace-gas emissions and uptake. These activities include clearing an area of forest to create cropland or pasture, restocking a logged forest, draining a wetland, or allowing a pasture to revert to a grassland or forest.

Forests, which cover about 295 million hectares (737 million acres) of U.S. land in the contiguous 48 states (USDA/USFS 1990), are a potentially important terrestrial sink for carbon dioxide. Because approximately half the dry weight of wood is carbon, as trees add mass to their trunks, limbs, and roots, more carbon is stored in the trees than is released to the atmosphere through respiration and decay. Soils and vegetative cover also provide a potential sink for carbon emissions.

In the United States, improved forest-management practices and the regeneration of previously cleared forest areas have actually increased the amount of carbon stored on U.S. lands. This uptake of carbon is an ongoing result of land-use changes in previous decades. For example, because of improved agricultural productivity and the widespread use of tractors, the rate of clearing forest land for crop cultivation and pasture slowed greatly in the late nineteenth century, and by 1920 this practice had all but ceased.



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As farming expanded in the Midwest and West, large areas of previously cultivated land in the East were brought out of crop production, primarily between 1920 and 1950, and were allowed to revert to forest land or were actively reforested. The regeneration of forest land greatly increases carbon storage in both standing biomass and soils, and the impacts of these land-use changes are still affecting carbon fluxes from forests in the eastern United States.

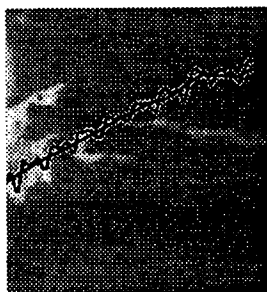
In addition to land-use changes in the early part of this century, carbon fluxes from forests in the East are affected by a trend toward managed growth on private land in recent decades, resulting in a near doubling of the biomass density in eastern forests since the early 1950s. More recently, the 1970s and 1980s saw a resurgence of federally sponsored tree-planting programs (e.g., the Forestry Incentive Program) and soil-conservation programs (e.g., the Conservation Reserve Program), which have focused on reforesting previously harvested lands, improving timber-management activities, combating soil erosion, and converting marginal cropland to forests.

As a result of these activities, the net CO₂ flux from standing biomass and vegetative cover in 1990 was estimated to have been an uptake (sequestration) of 119 MMTCE. The Northeast, North Central, and South Central regions of the United States accounted for 99 percent of the uptake of carbon, largely due to high growth rates that are the result of intensified forest-management practices and the regeneration of forest land previously cleared for cropland and pasture. Western states are responsible for a small net release of carbon, reflecting mature forests with a near balance among growth, mortality, and removals.

However, there are considerable uncertainties

associated with the estimates provided for the net carbon flux from U.S. forests. For example:

- *The impacts of forest management activities on soil carbon are very uncertain.* Since soils contain more than 50 percent of the total stored forest carbon in the United States, forest-management activities can have a large impact on flux estimates. However, because of uncertainties associated with soil carbon flux, this component is not included in the U.S. estimate at this time.
- *The United States has assumed that harvested timber effectively results in immediate carbon emissions.* This assumption is consistent with the methodology recommended by the IPCC (IPCC/OECD, 1994). However, other studies that model the product "pools" estimate a net accumulation of carbon in 1990.
- *The current estimate does not include forest land in Alaska and Hawaii or reserved timber land throughout the United States.*
- *Forest management activities may also result in fluxes of other greenhouse and photochemically important gases.* Dry soils are an important sink for CH₄, are a source of N₂O, and are both a source and a sink for CO. Vegetation is a source of several NMHCs (nonmethane hydrocarbons, a subset of NMVOCs). However, the effects of forestry activities on these gases is highly uncertain, and the possible fluxes are not included in the U.S. inventory.



Methane Emissions

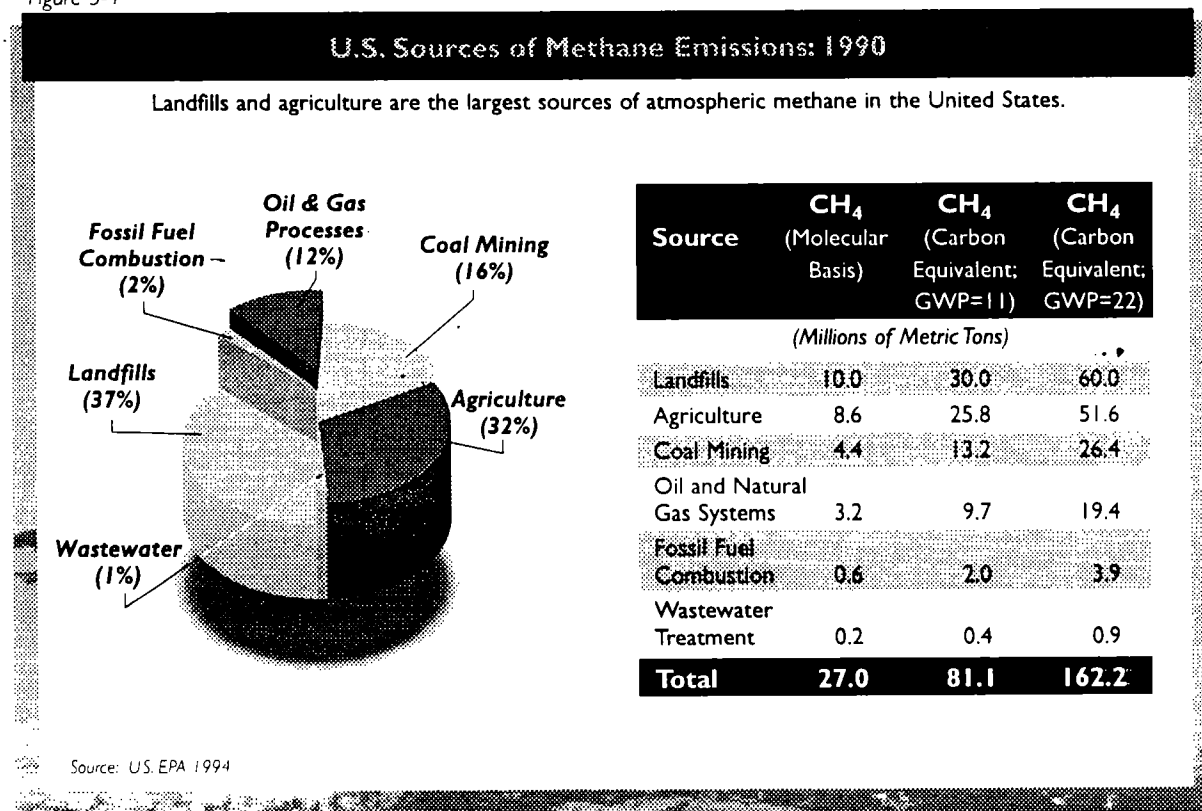
Atmospheric methane (CH_4) is second only to carbon dioxide as an anthropogenic source of the greenhouse effect. Methane's overall contribution to global warming is large because it is 11 or 22 times (counting either direct or both direct and indirect effects) more effective at trapping heat in the atmosphere than carbon dioxide over a one-hundred-year time horizon. Furthermore, methane's concentration in the atmosphere has more than doubled over the last two centuries. Scientists have concluded that these atmospher-

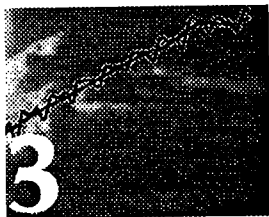
ic increases are largely due to increasing emissions from anthropogenic sources, such as landfills, agricultural activities, fossil fuel combustion, coal mining, the production and processing of natural gas and oil, and wastewater treatment (Figure 3-4).

Landfills

Landfills are the largest single anthropogenic source of methane emissions in the

Figure 3-4





United States. There are an estimated 6,000 methane-emitting landfills in the United States, with 1,300 of the largest landfills accounting for about half of the emissions.

In an environment where the oxygen content is low or nonexistent, organic materials, such as yard waste, household waste, food waste, and paper, are decomposed by bacteria to produce methane, carbon dioxide, and stabilized organic materials (materials that cannot be decomposed further). Methane emissions from landfills are affected by site-specific factors, such as waste composition, moisture, and landfill size.

Methane emissions from U.S. landfills in 1990 were 60 MMTCE, or about 37 percent of total U.S. methane emissions. Emissions from U.S. municipal solid waste landfills, which received over 70 percent of the total solid waste generated in the United States, accounted for about 90–95 percent of total landfill emissions, while industrial landfills accounted for the remaining 5–10 percent. Currently, about 10 percent of the methane emitted is recovered for use as an energy source.

Agriculture

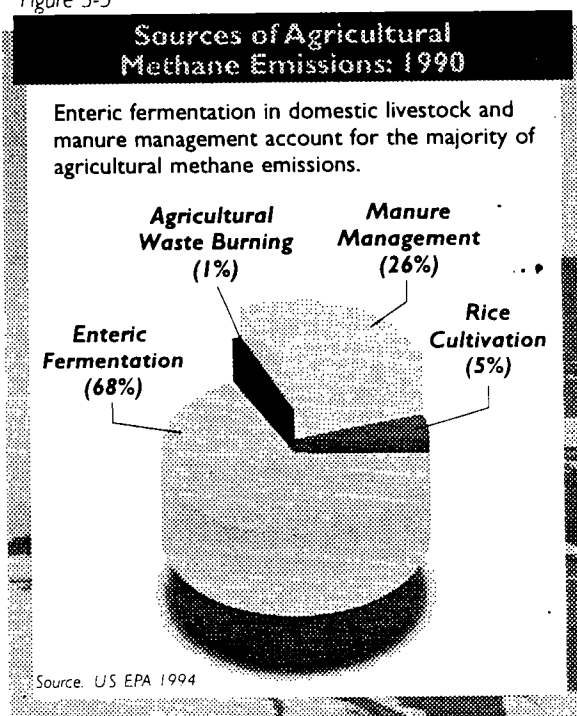
The agricultural sector accounted for approximately 32 percent of total U.S. methane emissions in 1990, with enteric fermentation in domestic livestock and manure management together accounting for the majority (Figure 3-5). Other agricultural activities contributing directly to methane emissions include rice cultivation and field burning of agricultural crop wastes. Several other agricultural activities, such as irrigation and tillage practices, may contribute to methane emissions, but emissions from these sources are uncertain and are believed to be small; therefore, the United States has not

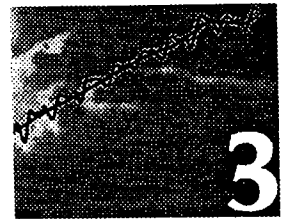
included them in the current inventory. Details on the emission pathways included in the inventory are presented in this section.

Enteric Fermentation in Domestic Livestock (34.9 MMTCE)

In 1990, enteric fermentation was the source of about 22 percent of total U.S. methane emissions, and about 68 percent of methane emissions from the agricultural sector. During animal digestion, methane is produced through a process referred to as enteric fermentation, in which microbes that reside in animals' digestive systems break down the feed consumed by the animals. Ruminants—which include cattle, buffalo, sheep, and goats—have the highest methane emissions among all animal types because they have a rumen, or large "fore-stomach," in which a significant amount of methane-producing fermentation occurs. Nonruminant domestic animals, such as pigs and horses, have

Figure 3-5





much lower methane emissions than ruminants because much less methane-producing fermentation takes place in their digestive systems. The amount of methane produced and excreted by an individual animal depends upon its digestive system (i.e., whether or not it possesses a rumen), and the amount and type of feed it consumes.

Manure Management (13.7 MMTCE)

The decomposition of organic animal waste in an anaerobic environment produces methane. The most important factor affecting the amount of methane produced is how the manure is managed, since certain types of storage and treatment systems promote an oxygen-free environment. In particular, liquid systems (e.g., lagoons, ponds, tanks, or pits) tend to produce a significant quantity of methane. However, when manure is handled as a solid or when it is deposited on pastures and range lands, it tends to decompose aerobically and produce little or no methane. Higher temperatures and moist climate conditions also promote methane production.

Emissions from manure management accounted for about 8 percent of total U.S. methane emissions in 1990, and about 26 percent of methane emissions from the agricultural sector. Liquid-based manure-management systems accounted for over 80 percent of total emissions from animal wastes.

Rice Cultivation (2.6 MMTCE)

Most of the world's rice, and all of the rice in the United States, is grown on flooded fields. When fields are flooded, anaerobic conditions in the soils develop, and methane is produced through anaerobic decomposition of soil organic matter. Methane is released primarily through the rice plants, which act as conduits from the

soil to the atmosphere.

Rice cultivation is a very small source of methane in the United States. In 1990, methane emissions from this source were less than 2 percent of total U.S. methane emissions, and about 5 percent of U.S. methane emissions from agricultural sources.

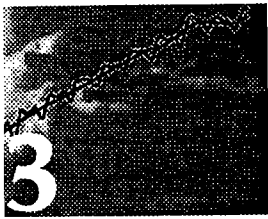
Field Burning of Agricultural Wastes (0.5 MMTCE)

Large quantities of agricultural crop wastes are produced from farming systems. Disposal systems for these wastes include plowing them back into the field; composting, landfilling, or burning them in the field; using them as a biomass fuel; or selling them in supplemental feed markets.

Burning crop residues releases a number of greenhouse gases, including carbon dioxide, methane, carbon monoxide, nitrous oxide, and oxides of nitrogen. Such burning is not considered to be a net source of carbon dioxide emissions because the carbon dioxide released during burning is reabsorbed by crop regrowth during the next growing season. However, burning is a net source of emissions for the other gases. Because this practice is not common in the United States, it was responsible for only 0.3 percent of total U.S. methane emissions in 1990, and 0.9 percent of emissions from the agricultural sector.

Coal Mining

Coal mining and post-mining activities (such as coal processing, transportation, and consumption) are the third largest source of methane emissions in the United States, behind landfills and domestic livestock. Estimates of methane emissions from coal mining for 1990



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were 26.4 MMTCE, which accounted for about 16 percent of total U.S. methane emissions.

Produced millions of years ago during the formation of coal, methane is trapped within coal seams and surrounding rock strata. When coal is mined, methane is released to the atmosphere. The amount of methane released from a coal mine depends primarily upon the depth and type of coal, with deeper mines generally emitting more methane (EPA 1993a). Methane from surface mines is emitted directly to the atmosphere as the rock strata overlying the coal seam are removed.

Methane is hazardous in underground mines because it is explosive at concentrations of 5 to 15 percent in air. Therefore, all underground mines are required to remove methane by circulating large quantities of air through the mine and venting this air into the atmosphere. At some mines, more advanced methane-recovery systems may be used to supplement the ventilation systems and ensure mine safety. The recovered methane can be used as an energy source—a practice that has been increasing in recent years.

Oil and Natural Gas Production and Processing

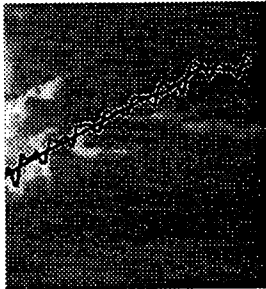
Methane is also a major component of natural gas. Any leakage or emission during the production, processing, transmission, and distribution of natural gas emits methane directly to the atmosphere. Because natural gas is often found in conjunction with oil, leakage during the production of commercial quantities of gas from oil wells is also a source of emissions. Emissions vary greatly from facility to facility and are largely a function of operation and maintenance procedures and equipment condition. Fugitive

emissions can occur at all stages of extraction, processing, and distribution. In 1990, emissions from the U.S. natural gas system were estimated to be 17.8 MMTCE, accounting for approximately 11 percent of total U.S. methane emissions for 1990.

Methane is also released as a result of oil production and processing activities, such as crude oil production, crude oil refining, transportation, and storage, when commercial gas production is not warranted due to the small quantities present. Emissions from these activities are generally released as a result of system leaks, disruptions, or routine maintenance. For 1990, methane emissions from oil production and processing facilities were 1.6 MMTCE, accounting for about one percent of total U.S. methane emissions.

Other Sources of Methane

Methane is also produced from several other sources in the United States, including energy-related combustion activities, wastewater treatment, industrial processes, and changes in land use. The sources included in the U.S. inventory are fossil fuel combustion and wastewater treatment, which accounted for approximately 4.8 MMTCE in 1990, or about 3 percent of total U.S. methane emissions. Additional anthropogenic sources of methane in the United States—such as land-use changes and ammonia, coke, iron, and steel production—are not included because little information on methane emissions from these sources is currently available.



Nitrous Oxide Emissions

Nitrous oxide (N_2O) is a chemically and radiatively active greenhouse gas that is produced naturally from a wide variety of biological sources in soil and water. Although actual emissions of N_2O are much smaller than CO_2 emissions, N_2O is approximately 270 times more powerful than CO_2 at trapping heat in the atmosphere over a 100-year time horizon.

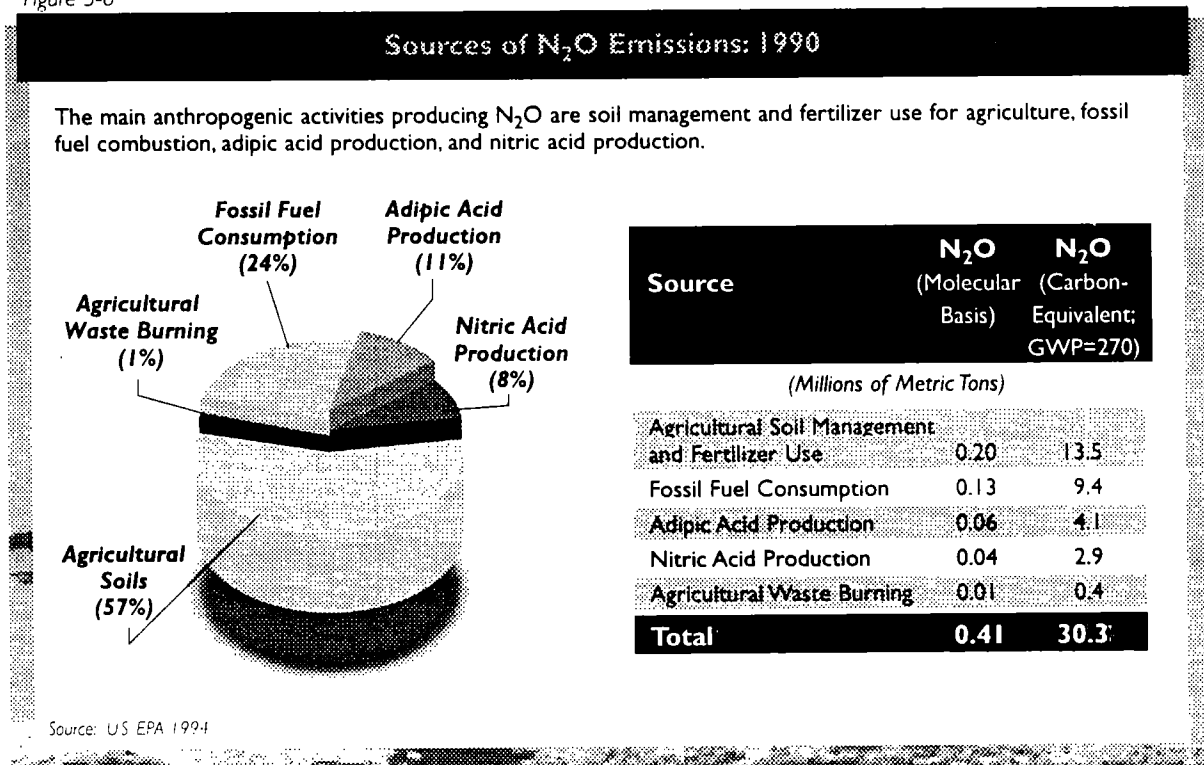
Over the past two centuries, human activities have raised atmospheric concentrations of nitrous oxide by approximately 8 percent. The main anthropogenic activities producing N_2O

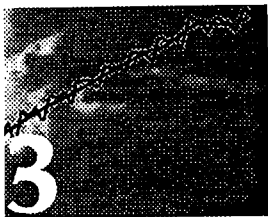
are soil management and fertilizer use for agriculture, fossil fuel combustion, adipic acid production, and nitric acid production (Figure 3-6).

Agricultural Soil Management and Fertilizer Use

The primary source of anthropogenic nitrous oxide emissions in the United States falls into the category of fertilizer use and soil-management activities. By adding nitrogen to soils, synthetic nitrogen fertilizers and organic fertili-

Figure 3-6





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zers increase N_2O emissions. Nitrous oxide emissions in 1990 due to consumption of synthetic and organic fertilizers were 13.5 MMTCE, or approximately 45 percent of total U.S. nitrous oxide emissions (U.S. EPA 1994)

Other agricultural soil-management practices—such as irrigation, tillage practices, or the fallowing of land—can also affect N_2O fluxes to and from the soil. However, because there is much uncertainty about the direction and magnitude of the effects of these other practices, only the emissions from fertilizer use and field burning of agricultural wastes are included in the U.S. inventory at this time.

Fossil Fuel Combustion

Nitrous oxide is a product of the reaction that occurs between nitrogen and oxygen during fossil fuel combustion. Both mobile and stationary sources emit nitrous oxide. Emissions from mobile sources are more significant and are better understood than those from stationary sources. The amount of nitrous oxide emitted varies, depending upon fuel, technology type, and pollution control device. Emissions also vary with the size and vintage of the combustion technology, as well as maintenance and operation practices.

For example, catalytic converters installed to reduce vehicular emissions of pollutants have been proven to promote the formation of nitrous oxide. As catalytic converter-equipped vehicles have increased in the U.S. motor vehicle fleet, emissions of nitrous oxide from this source have also increased (DOE 1993). Mobile emissions totaled 6.8 MMTCE in 1990 (22.4 percent of total N_2O emissions), with road transport accounting for approximately 95 percent of these N_2O emissions. Nitrous oxide emissions

from stationary sources were 2.6 MMTCE in 1990.

Adipic Acid Production

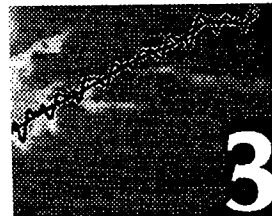
Nitrous oxide is emitted as a by-product of the production of adipic acid. Ninety percent of all adipic acid produced in the United States is used to produce nylon 6,6. It is also used to produce some low-temperature lubricants, and to provide foods with a "tangy" flavor. In 1990, U.S. adipic acid production generated 4.1 MMTCE of nitrous oxide, or 13.7 percent of total U.S. N_2O emissions.

Nitric Acid Production

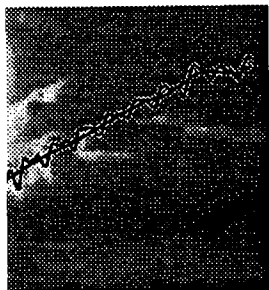
Production of nitric acid is another industrial source of N_2O emissions. Nitric acid is a raw material used primarily to make synthetic commercial fertilizer, and is also a major component in the production of adipic acid and explosives. Virtually all of the nitric acid that is manufactured commercially in the United States is obtained by the oxidation of ammonia. During this process, N_2O is formed and emitted to the atmosphere. Nitrous oxide emissions from this source were about 2.9 MMTCE in 1990, accounting for 9.7 percent of total U.S. N_2O emissions.

Other Sources of N_2O

Nitrous oxide can also be emitted during the burning of agricultural crop residues, although emissions from this source are extremely small relative to overall U.S. N_2O emissions. In 1990 nitrous oxide emissions from such burning were approximately 0.4 MMTCE, or about 1.2 percent of total U.S. nitrous oxide emissions.



Forestry activities may also result in fluxes of nitrous oxide, since dry soils are a source of N_2O emissions. However, the effects of forestry activities on fluxes of these gases are highly uncertain; therefore, they are not included in the inventory at this time. Similarly, the U.S. inventory does not account for several land-use changes because of uncertainties in their effects on trace gas fluxes, as well as poorly quantified statistics on them. These land-use changes include loss and reclamation of freshwater wetland areas, conversion of grasslands to pasture and cropland, and conversion of managed lands to grasslands.



HFC and PFC Emissions

Partially halogenated compounds (HFCs) and perfluorinated compounds (PFCs) were introduced as alternatives to the ozone-depleting substances being phased out under the *Montreal Protocol* and Clean Air Act Amendments of 1990 (see opposite page). Because HFCs and PFCs are not directly harmful to the stratospheric ozone layer, they are not controlled by the *Montreal Protocol*. However, these compounds are powerful greenhouse gases and are, therefore, considered under the Framework Convention on Climate Change. For example, HFC-134a has an estimated direct global warming potential of 1,200, which makes HFC-134a 1,200 times more heat absorbent than an equivalent amount by weight of CO₂ in the atmosphere. For this reason, emission estimates for these gases have been included in the U.S. inventory and are provided in Table 3-3.

In 1990, the use of substitutes for ozone-depleting substances was minimal. Thus, emissions of HFCs were quite small, and were largely the result of by-product emissions from the production of HCFC-22. PFC emissions were the result of aluminum-smelting activities. For example, HFC-23 is a by-product emitted during HCFC-22 production, and PFCs (CF₄ and C₂F₆) are emitted during aluminum smelting. While the use of such ozone-depleting substances as methyl chloroform, CFC-12, and HCFC-22 is declining, consumption of HFCs is increasing

markedly. Emissions of HFCs and PFCs should continue to rise as their use as replacements increases.

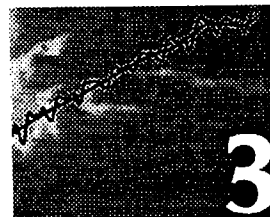
Table 3-3

Emissions of HFCs and PFCs: 1990

In 1990, the use of substitutes for ozone-depleting substances was minimal. Thus, emissions of HFCs were quite small, and were largely the result of by-product emissions from the production of HCFC-22. PFC emissions can be attributed to industries related to aluminum production.

Compound	Molecule Basis	Global Warming Potential	Carbon Equivalent
(Millions of Metric Tons)			
HFC-23a	0.00552	10,000	15.05
HFC-134a	0.0005	1,200	0.16
HFC-152a	0.0003	150	0.01
PFCs	0.0030	5,400	3.98

Sources: The GWP for HFC-23 was obtained from U.S. EPA's Office of Air and Radiation and is based on unpublished data from DuPont Chemical Company and others. The GWPs for other compounds are from IPCC 1992.



U.S. Emissions of CFCs and Related Compounds

Halogenated fluorocarbons were emitted into the atmosphere for the first time this century. This family of man-made compounds includes chlorofluorocarbons (CFCs), halons, methyl chloroform, carbon tetrachloride, methyl bromide, and partially halogenated fluorocarbons (HCFCs). These substances are used in a variety of industrial applications, including refrigeration and air conditioning; solvent cleaning; foam production; sterilization; fire extinguishing; paints, coatings, and other chemical intermediates; and in such miscellaneous products as aerosols and propellants.

Because these compounds have been shown to deplete stratospheric ozone,

they are typically referred to as ozone-depleting substances. In addition, they are important greenhouse gases because they block infrared radiation that would otherwise escape into space (IPCC 1990 and 1992).

Recognizing the harmful effects of these compounds on the atmosphere, in 1987 many governments signed the *Montreal Protocol on Substances That Deplete the Ozone Layer* to limit their production and consumption. By June 1994, 133 countries had signed

the *Montreal Protocol*. The U.S. furthered its commitment to phase out these substances by signing and ratifying the *Copenhagen Amendments* to the *Montreal Protocol* in 1992. Under these amendments, the U.S. committed to eliminating the production of all halons by January 1, 1994, and all CFCs by January 1, 1996.

The 1994 IPCC Guidelines do not require countries to report their emissions of CFCs and related compounds because their use is being phased out by the *Montreal Protocol*. Nevertheless, because the U.S. believes that no inventory is complete without these emissions, estimates for emissions of several

Class I and Class II ozone-depleting substances (ODSs) are provided in the table below.

Compounds are classified as "Class I" or "Class II" substances, based on their ozone-depletion potential, and must adhere to a distinct set of phase-out requirements under the *Montreal Protocol*. Class I compounds are the primary (ODSs) in use today; Class II compounds include HCFCs, which were developed as interim replacements for CFCs. Because these HCFC compounds are only partially halogenated, their hydrogen-carbon bonds are more vulnerable to oxidation in the troposphere and, therefore, pose only about one-tenth to one-

hundredth the threat to stratospheric ozone compared to CFCs.

Also, the effects of these compounds on radiative forcing are not provided here. Although CFCs and related compounds have very large direct global warming potentials, their indirect effects are believed to be negative and, therefore, could significantly reduce the magnitude of their direct effects (IPCC 1992). Given the uncertainties surrounding the net effect of these gases, they are reported here on a full molecular basis only.

U.S. Emissions of Ozone-Depleting Substances and Related Compounds: 1990

Compound Emissions

(Millions of Metric Tons)

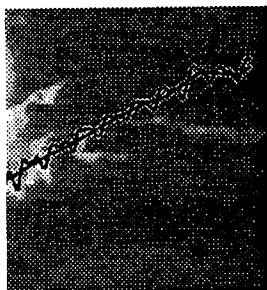
Class I ODSs

CFC-11	0.06
CFC-12	0.1
CFC-113	0.05
CFC-114	0.005
CFC-115	0.003
Carbon Tetrachloride	0.03
Methyl Chloroform	0.3
Halon-1211	0.001
Halon-1301	0.001

Class II ODSs

HCFC-22	0.08
HCFC-141b	0.002
HCFC-124	0.03

Source: U.S. EPA 1994



Emissions of Criteria Pollutants

In the United States, carbon monoxide (CO), nitrogen oxides (NO_x), nonmethane volatile organic compounds (NMVOCs), and sulfur dioxide (SO₂) are commonly called "criteria pollutants." CO is created when carbon-containing fuels are burned incompletely; oxides of nitrogen (NO and NO₂) are created from lightning, natural fires, fossil-fuel combustion, and in the stratosphere from nitrous oxide; NMVOCs, which include such compounds as propane, butane, and ethane, are emitted primarily from transportation and industrial processes, as well as forest wildfires, and nonindustrial consumption of organic solvents (U.S. EPA 1990); and SO₂ can result from the combustion of fossil fuels, industrial processing (particularly in the metals industry), waste incineration, and biomass burning (U.S. EPA 1993b).

Because of their contribution to the formation of urban smog (and acid rain in the case of SO₂), criteria pollutants are regulated under the 1970 Clean Air Act and its amendments. These gases also have an impact on global climate through their indirect radiative effects (i.e., they do not directly act as greenhouse gases but react with other chemical compounds in the atmosphere to form compounds that are greenhouse gases). Unlike other criteria pollutants, SO₂ emitted into the atmosphere affects the Earth's radiative budget negatively; therefore, it is discussed separately from the other criteria pollu-

tants in this section.

The most important of the indirect effects of criteria pollutants is their role as "precursors" of tropospheric ozone. In this role, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. For example, carbon monoxide interacts with the hydroxyl radical (OH)—the major atmospheric sink for methane emissions—to form carbon dioxide. Therefore, increased atmospheric concentrations of CO limit the number of OH compounds

Table 3-4

Emissions of CO, NO_x, and NMVOCs: 1990

Fuel consumption accounted for the majority of emissions of criteria pollutants.

Sources	CO	NO _x	NMVOCs
(Millions of Metric Tons)			
Fossil Fuel Combustion	73.65	20.36	8.94
Industrial Processes	4.35	0.72	3.49
Agricultural Waste Burning	2.76	0.12	
Waste Incineration	1.53	0.07	0.29
Fossil Fuel Production, Distribution, and Storage	0.39	0.09	0.67
Solvent Use	0.002	0.002	5.74
Total	82.67	21.36	19.13

Source: U.S. EPA 1994



available to destroy methane, thus increasing the atmospheric lifetime of methane.

Since 1970, the United States has published estimates of annual emissions of criteria pollutants. In summarizing U.S. emissions from these sources for 1990, Table 3-4 clearly shows that fuel consumption accounted for the majority of emissions of these gases. In fact, motor vehicles that burn fossil fuels comprise the single largest

source of CO emissions in the United States, contributing about two-thirds of all CO emissions in 1990. Motor vehicles also emit about one-third of total NO_x and NMVOC emissions. Industrial processes, such as the manufacture of chemical and allied products, metal processing, and industrial uses of solvents, are also major sources of CO, NO_x, and NMVOCs.

Sulfur Dioxide: Sources and Effects

Emitted into the atmosphere through natural and anthropogenic processes, sulfur dioxide affects the Earth's radiative budget through photochemical transformation into sulfate particles that (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) possibly increase the number of cloud condensation nuclei, thereby potentially altering the physical characteristics of clouds; and (3) affect atmospheric chemical composition—e.g., stratospheric ozone—by providing surfaces for heterogeneous chemical processes. As a result of these activities, the effect of these gases on radiative forcing may be negative (IPCC

1992), although the distribution is not uniform. Because their effects are uncertain and opposite from the other criteria pollutants, emissions of these gases are presented separately here.

Sulfur dioxide is also a major contributor to the formation of urban smog, which can cause significant increases in acute and chronic respiratory diseases.

Once SO₂ is emitted, it is chemically transformed in the atmosphere and returns to Earth as the primary source of acid rain. Because of these harmful effects, the United States has regulated SO₂ emissions in the Clean Air Act of 1970 and its 1990 amendments.

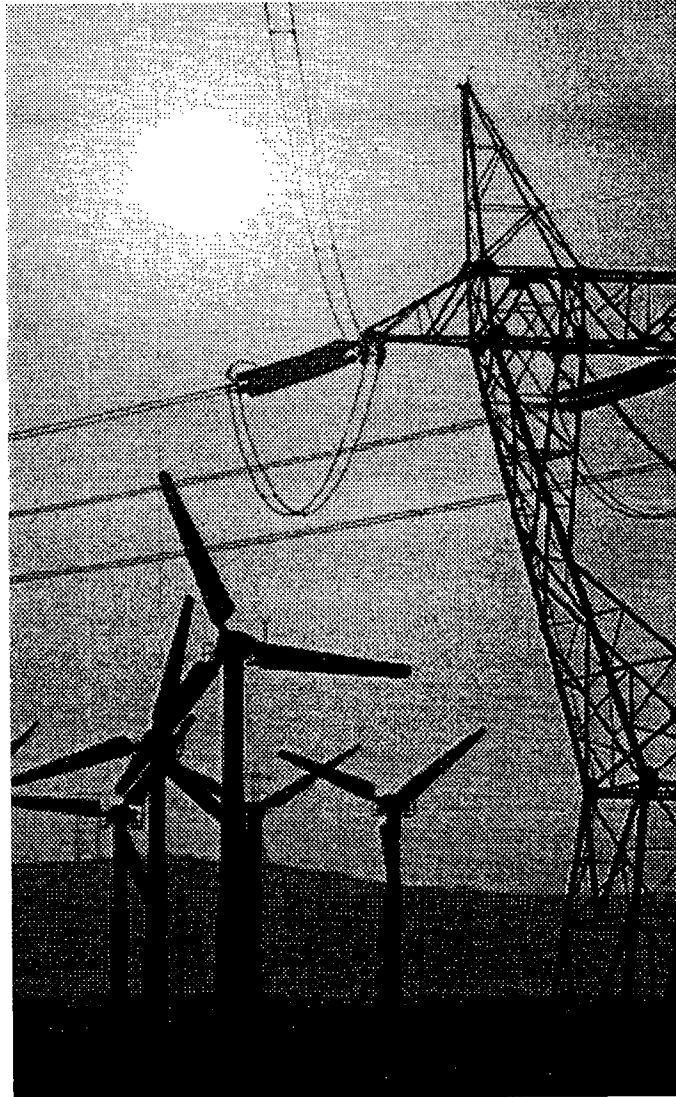
The largest source of overall U.S. emissions of SO₂ is electric utilities, accounting for about 70 percent. Coal combustion contributes nearly all of those emissions (approximately 96 percent). The second largest source is fuel combustion for metal smelting and other industrial processes, which produced about 14 percent of 1990 SO₂ emissions.

U.S. Emissions of Sulfur Dioxide: 1990

Source	Emissions
	(Millions of Metric Tons)
Fossil Fuel Combustion	22.69
Industrial Processes	1.91
Fossil Fuel Production, Distribution, and Storage	0.51
Waste Incineration	0.04
Solvent Use	0.001
Total	25.15

Source: US EPA 1993b

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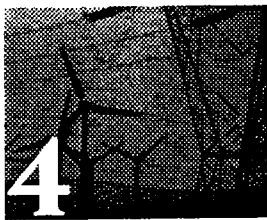
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While the Climate Convention includes no internationally binding obligations to reduce anthropogenic emissions of greenhouse gases to any specified level in any set year, each Annex I party (i.e., developed countries and countries with economies in transition) is committed to:

adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. These policies and measures will demonstrate that the developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol would contribute to such modification... (Article 4, Paragraph 2(a), FCCC).

A full-scale international response is needed to confront the climate change effort, and the United States is committed to that effort. In October 1993, President Clinton and Vice President Gore

**mitigation:
the action plan**



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announced the U.S. *Climate Change Action Plan* to cost-effectively reduce U.S. greenhouse gas emissions to 1990 levels by the year 2000 in accordance with the aim of the Climate Convention and the President's 1993 Earth Day commitment.

The Action Plan responds to the threat of global climate change and helps guide the U.S. economy toward environmentally sound economic growth into the next century. It is comprehensive, targeting all greenhouse gases and all sectors of the economy through a portfolio of nearly fifty different actions. The Plan inaugurates a new era of partnership with U.S. business to improve environmental performance while

enhancing economic growth and job creation. Because time is of the essence, the Plan is designed for rapid implementation, building on existing programs, technologies, and voluntary efforts to deliver cost-effective results. It is a coordinated federal response, involving many government agencies working together, and was developed using an interagency process with significant public input. The Plan is being actively monitored to ensure that it will meet the President's goal, and will be modified to adapt to changing circumstances. Finally, the Plan lays the foundation for an international response to climate change through the U.S. Initiative on Joint Implementation.

Differences Between Estimates in the Action Plan and Inventory

The emission estimates reported in this chapter were developed for the U.S. *Climate Change Action Plan* in October 1993. These estimates are slightly different from the official U.S. inventory reported in Chapter 3 of this report. The Chapter 3 inventory represents an update to reflect recent guidance from the Intergovernmental Negotiating Committee's (INC's) 9th Session and improvements in information developed since the Action Plan's completion.

The largest difference is due to international bunker fuel consumption, which is reported separately in Chapter 3 and is not included in U.S. totals (consistent with INC guidance). Estimates of international

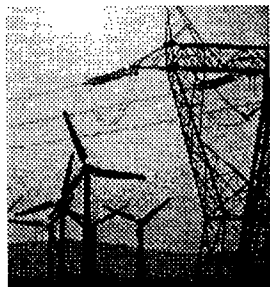
bunker fuels are included in the Action Plan projections reported in this chapter.

Other differences not reflected in this chapter include updates for forest carbon sequestration rates, improvements in fossil fuel emission coefficients, new estimates of the percent of fossil fuel feedstock sequestered in products, and a correction to the estimate of nitrous oxide emissions from fertilizer use. (A complete and transparent description of the methods and data used in developing the U.S. inventory is reported in *Inventory of U.S. Greenhouse Gas Emissions and Sinks for 1990-1993* (U.S. EPA 1994).)

Because of these differences, the 1990 inventory values

reported in Chapter 3 cannot be compared to projections of future U.S. emissions presented in this chapter to estimate changes in emission levels over time. However, each chapter is internally consistent. Our preliminary review suggests that under the assumptions made in October 1993 regarding action funding and effectiveness, economic growth, and world energy prices, the differences between the inventory and the Action Plan baseline do not affect the Plan's ability to achieve a return to 1990 emission levels in 2000.

Reconciliation of reporting methods in the Action Plan and the inventory will be addressed as part of the biennial review of U.S. actions scheduled for 1995.



The Plan and Its Development

The Action Plan builds on policies and programs already in place—notably, the Energy Policy Act (EPAct), the Clean Air Act Amendments, and the Integrated Surface Transportation Efficiency Act, described in Chapter 2. Without these policies, projected net U.S. greenhouse gas emissions would rise to 1,674 million metric tons of carbon equivalent (MMTCE) by 2000. With these measures, but without the additional steps in the Action Plan, net emissions would rise to 1,568 MMTCE by 2000.

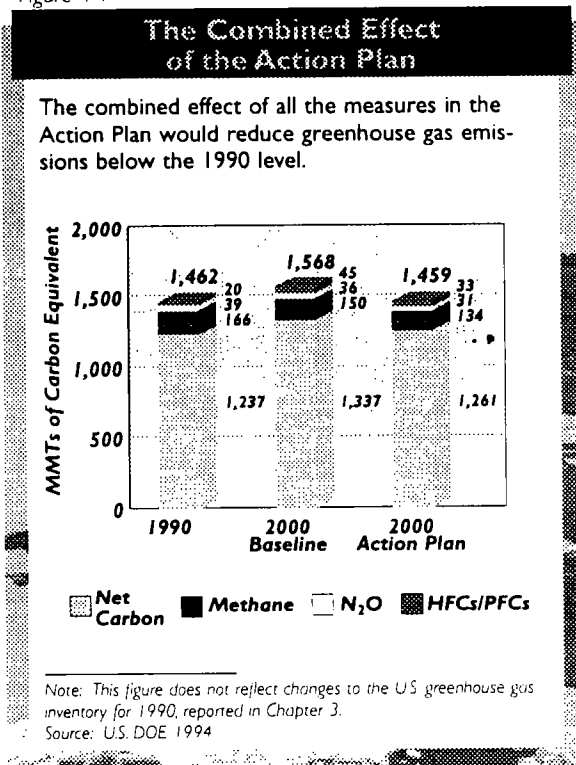
The Effects of the Plan

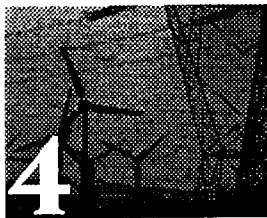
The combined effect of all the measures in the Action Plan, on the basis of the 1993 economic assumptions and also assuming full funding of all measures, would reduce emissions by a further 109 MMTCE by 2000, bringing them to 1,459 MMTCE, or slightly below the 1990 level of 1,462 MMTCE (Figure 4-1). Net carbon emissions are likely to be slightly higher in 2000—about 2 percent above their 1990 levels. The rate of increase in HFC emissions is cut in half. Offsetting these increases in emissions are even larger reductions in methane and nitrous oxide emissions. These figures are based on the global warming potentials of these gases, as provided in the 1992 IPCC Supplementary Report.

Many of the programs outlined here encour-

age individuals and firms to invest in energy-saving equipment or other technologies that yield significant cost savings over the long term. Comparing the magnitude of these investments with the value of energy savings indicates the overall cost-effectiveness of the Action Plan. While investing over \$60 billion in greenhouse gas emission reductions between 1994 and 2000, individuals and firms are projected to realize over \$60 billion in energy savings between 1994

Figure 4-1





and 2000, and continued returns in the form of an additional \$207 billion in energy savings between 2001 and 2010. By stimulating investments in cost-effective opportunities for greenhouse gas emission reductions, the Action Plan can increase the long-term profits for American business and can help consumers save money.

Since these policies and measures were first developed and their effects projected, economic growth has been more robust, and oil prices have been lower than projected in the Action Plan. These differences, as well as other data that may affect current and future greenhouse gas emission levels, are now being evaluated. A more complete discussion of the steps being taken within the United States to achieve our objective in light of changing circumstances appears in Chapter 8 of this report.

Applying a Portfolio Approach

The Action Plan targets multiple emission-reduction opportunities in all major areas: energy demand in the residential, commercial, industrial, and transportation sectors; energy supply; forestry; and methane and other gases. Notwithstanding changes in the economy, a broad portfolio of policy actions is more likely to succeed than a narrow approach. Some programs called for here will work better than expected, while others may fall short of their estimated impact. A portfolio approach reduces the risk that any specific program that does not live up to expectations will cause a substantial shortfall of emission reductions.

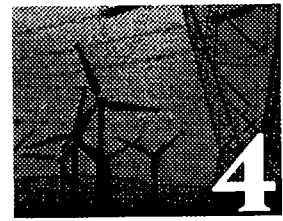
The U.S. program to reduce greenhouse gas emissions is based on a number of different approaches that combine efforts of the public sector (federal, state, and local governments) and the private sector. From the public-sector

viewpoint, these can be grouped into four main categories:

- Undertaking regulatory actions, including setting standards.
- Conducting research and development to enhance efficiency, improve supplies, and promote fuel switching.
- Enhancing market performance by developing incentives and providing information.
- Encouraging voluntary adoption of processes and technologies that make both environmental and economic sense.

The majority of the actions in the Plan are in the second half of these categories, which focus on voluntary choices and policies. The efficacy of the voluntary approach has been demonstrated by the significant commitments already undertaken within the private sector to reduce emissions. Whereas mandatory programs may take years to enact into law and are often the focus of intense and lengthy legal battles after enactment—and even, on occasion, limited compliance—voluntary measures have already resulted in rapid and significant action. The specific measures in the Action Plan are described in detail in this chapter (and in substantially greater detail in the Technical Supplement to the Action Plan [U.S. DOE 1994]); some of the Plan's highlights appear on the following page.

Various programs in the Action Plan focus on one or another of these strategies. EPA calls for advanced technologies and improved management practices to help maintain supplies of environmentally benign fuels while reducing energy demand. Voluntary programs target individual energy end use and assess barriers that are preventing fuller penetration of advanced, energy-conserving technologies into the market. The overall effect of these efforts is not to create a



binding regulatory framework, but to enhance the level of information provided to the private sector. The focus is on ensuring that consumers and corporations recognize the benefits that result—in both their financial and their environmental bottom lines—from improving energy efficiency.

While the aggregate effect of the U.S. voluntary programs cannot be precisely determined—and the modeling of the projected effects itself has been a challenge—the effort is beginning to bear fruit. Some of the voluntary programs already have hundreds of private-sector participants and are operating more effectively than even optimistic estimates originally projected. The Climate Challenge program is also enormously successful, having already attracted over 750 participants. The United States intends to build on such efforts in moving toward the future and continuing the trend of greenhouse gas emission reductions. The progress of the U.S. program—and some of the

factors that are influencing its effectiveness—are discussed in Chapter 8.

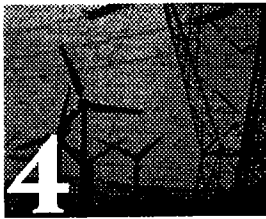
Developing the Plan: A Public Process

Following President Clinton's announcement of the nation's commitment to reduce "our emissions of greenhouse gases to their 1990 levels by the year 2000" and "to produce a cost-effective plan" to do so, the Administration began to develop a climate action strategy. One of the principal aims in the process was to maximize public participation—both as a means to draw on the ingenuity and creativity of the American people in developing a cost-effective and comprehensive program, and to ensure that those with interests most affected by such a strategy would be involved and supportive of the measures ultimately adopted.

On June 10–11, 1993, the White House-sponsored Conference on Global Climate

Highlights of the Climate Change Action Plan

- *Identifies and promotes the use of energy-efficient products.* The Action Plan provides opportunities for corporate purchasers and consumers to make educated decisions on energy use. Such educational initiatives and voluntary programs help overcome the inertia and lack of good information, which often make it difficult to adopt the most cost-effective and environmentally beneficial products.
- *Promotes large-scale purchasing of energy-efficient and renewable-energy technologies.* By helping improve economies of scale and by moving these technologies into the market, the Action Plan helps prices fall to levels equal to or below those of alternatives that result in higher greenhouse gas emissions.
- *Encourages industry to commercialize more resource-efficient technologies.* The Action Plan demonstrates that these technologies will sell by providing clear "market-pull" signals that are organized through mass-purchase initiatives and utility program coordination aimed at getting new technologies off the drawing boards and onto store shelves.
- *Promotes sensible regulatory and legal frameworks.* The Action Plan encourages cost-effective investments in energy-conservation and methane-recovery programs to ensure that companies and consumers can profit from wise use of resources leading to a more productive and less polluting economy.



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Change brought together more than eight hundred participants in a forum designed to provide an exchange of ideas among the federal government, industry stakeholders, state and local governments, and nongovernmental environmental organizations. With the aim of developing specific measures, the conference was divided into ten working groups addressing emission reductions in the following areas: energy supply; energy demand (residential, commercial, and industrial); transportation (auto/light truck, commercial, and infrastructure); methane and other gases; sinks; and joint implementation. In addition to the intensive effort put forward at the June session, many of the individual working groups met several times in the following months, continuing to develop and detail options.

Operating in parallel with the public process was a broad federal interagency program convened to consider mitigation opportunities in all sectors of the economy—a process divided into working groups identical to those in the public process. These groups were coordinated at senior levels within the government, through a coordinating body ultimately responsible for shaping the content of the U.S. Action Plan. Ideas for emission-reduction actions evolved from both internal and public recommendations. By early July 1993, the United States had assembled a list of nearly 250 measures, approximately 150 of which included detailed program descriptions, and that together covered a broad range of greenhouse gas reduction measures.

On the basis of this extensive list (which often included overlapping or similar proposals), a first cut was made to identify the most promising measures. The key criteria used to make this assessment included the size of the near-term greenhouse gas reductions (the focus being on meeting the year 2000 goal set by the President);

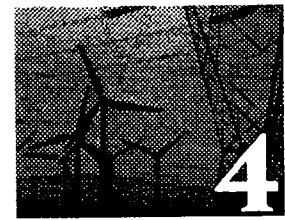
the cost-effectiveness of the measures (both the government and the private-sector costs); the long-term potential (looking at the post-2000 implications); and the ease and speed of implementing the measures. Using these criteria, the working groups narrowed the list of measures to approximately fifty.

Assessing the Effects of the Plan

An ongoing interagency analysis was a key part of the process for developing the Plan, and called for an unprecedented degree of coordination and cooperation at all levels of the government. An analytical team was established, composed of members from all relevant federal agencies. It was charged with evaluating all actions proposed, and when the list of options had been narrowed, it was called upon to provide an integrated assessment of the set of measures.

Whenever the list of measures was modified, modeling analysis had to be repeated to account for potential overlap and synergistic effects with other actions. The new emission-reduction estimates were then presented and evaluated relative to the goal of cost-effectively meeting the target of 1990 levels by 2000. For example, most of the energy policy options affect more than one sector or fuel—changes in one sector can affect fuel prices, which in turn can affect energy demand and supply in other sectors. Therefore, interactions among energy supply, demand, and policies were considered to generate the best possible estimate of overall energy and emission impacts.

Two modeling scenarios were created: an Administration Baseline and a Combined Policy Case. The former was the baseline scenario, defined to reflect expectations of private- and public-sector behavior based on all legislation



already in effect and all federal programs funded as of the date of issuance of the Action Plan. The Combined Policy Case added to the Administration Baseline the effects of the emission-reduction actions included in the Action Plan.

Baseline projections are derived from a set of specific assumptions about markets, technologies, and resources, such as growth rates in the gross domestic product (GDP) and oil and gas prices. There are four main types of assumptions underlying the projections:

- Economic factors, including GDP growth rates, world oil prices, and other economic assumptions.
- Energy resources, including proven

reserves and undiscovered resources.

- Market behavior, reflecting the demand and supply decisions of energy-market participants, as influenced by oil prices, standards, and partnership programs.
- Technology factors, which include information on the costs of energy-consuming and -producing technologies, their performance, and when they will be commercially available.

While a full description of the assumptions used in generating these scenarios is contained in the Technical Supplement to the Action Plan (U.S. DOE 1994), a partial list, including some of the most critical factors, is provided in Table 4-1.

Table 4-1

Assumptions Underlying Baseline Projections

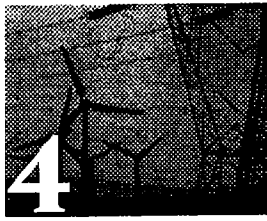
Baseline projections are derived from the following assumptions about energy markets, technologies, and resources.

Factor	1990 Value	2000 Baseline
Real GDP (billions of 1987 dollars)	4,887	6,153
Population (millions)	251	269
Residential Housing Stock (millions)	93.4	102
Commercial Floor Space (billion sq. ft.)	62.9	71.9
Industrial Production Index (1985=100)	115	147.2
Energy Intensity (BTU per 1991 dollar GDP)	14,855	13,122
Light-Duty Vehicle Miles Traveled (billions)	169.9	201.8
Heavy-Duty Vehicle Miles Traveled (billions)	138	177
New Heavy-Duty-Vehicle Fuel Efficiency (miles/gallon)	8.8	9.7
New-Car Fuel Efficiency (miles/gallon)	27.7	30.0
New Light-Duty-Truck Fuel Efficiency (miles/gallon)	21.3	24.4
World Oil Price (dollars/barrel)	22.54	22.48
Wellhead Natural Gas (dollars/1,000 cubic feet)	1.77	1.77
Minemouth Coal (dollars/ton)	22.52	26.39
Average Price Electricity (cents/kilowatt-hour)	6.8	7.1
Average Price Gasoline (dollars/gallon)	1.23	1.36

Source: U.S. DOE 1994

The Integrated Dynamic Energy Analysis Simulation (IDEAS) model was used as a tool for the integrated analysis of energy-related options. This model has elements of both top-down and bottom-up modeling. The macroeconomic effects are combined with a microeconomic, technology-specific representation of energy-service methods that link energy supply and demand through equilibrium market prices. Other sectors and gases were estimated independently.

For example, projections for carbon sequestration were based on



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two of the U.S. Department of Agriculture's (USDA's) Forest Service models that analyze the impacts of changes in forest policies in the United States. Methods for projecting CFC emissions are based on estimates developed through use of vintaging models and estimates regarding the use of substitutes for the replacement gases. Projections for nitrous oxide are based on assumptions regarding fertilizer use and production of adipic acid, as well as on fossil fuel combustion. Finally, projections for methane emissions are based on assumptions regarding all major methane sources, including landfills, coal mining, natural gas systems, fuel combustion, ruminant livestock manure, and rice production.



Carbon Dioxide

Carbon dioxide (CO₂) accounts for 83 percent of total U.S. greenhouse gas emissions. Net CO₂ emissions, primarily from energy production and consumption, stood at 1,237 MMTCE in 1990. Without the measures in the Action Plan, they are forecast to rise to 1,337 MMTCE in 2000. However, the Plan is designed to reduce this increase by 76 MMTCE, to a level of 1,261 MMTCE in 2000 (Figure 4-2).

Energy-Demand Strategies

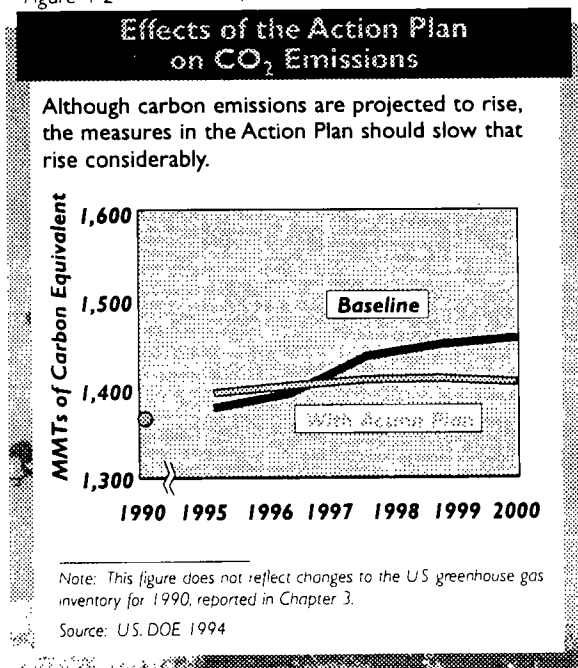
In 1990, the United States consumed nearly

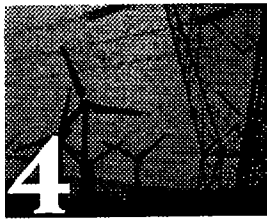
85 quadrillion Btus of primary energy, which produced 1,338 million metric tons (MMTs) of carbon. The largest end-use energy consumer in 1990 was the industrial sector, which used 32.1 quadrillion Btus (39 percent) of the primary energy supplied. Residential and commercial energy consumption comprised slightly more than one-third of primary energy supplied to end users, with the residential sector consuming about 28 percent more than the commercial sector. Transportation comprised 27 percent of primary energy (Figure 4-3). ("End-use" energy does not include the generation and distribution losses in electric generation, which on average account for almost 70 percent of the fuel input used in power plants.)

Investing in energy efficiency is the single-most cost-effective way to reduce CO₂ emissions. The Action Plan combines an array of public-private partnerships to stimulate the deployment of existing energy-efficient technologies and accelerate the introduction of more advanced technologies. These programs will cut CO₂ emissions while enhancing productivity at home and U.S. competitiveness abroad.

Technical studies have consistently shown that potentially profitable energy-efficiency investments exist in the residential, commercial, and industrial sectors. However, many of these opportunities go unrealized, frequently because of information, regulatory, financial, and institu-

Figure 4-2





tional barriers. The Action Plan includes a comprehensive strategy that applies innovative solutions to address these investment barriers—from financial reforms in residential mortgages to agreements between vehicle manufacturers and users. This Action Plan aligns market forces with the environmental imperative to reduce greenhouse gas emissions.

In the past, many federal programs have been a confusing patchwork of competing activities that were not coordinated effectively with utility or state and local efforts. By expanding existing successful programs, by combining them with new and complementary initiatives, and by linking programs with state, local, and private-sector efforts, the United States will maximize the energy-saving impacts of federal programs and their associated greenhouse gas emission reductions. The following discussion of the energy-efficiency programs and initiatives

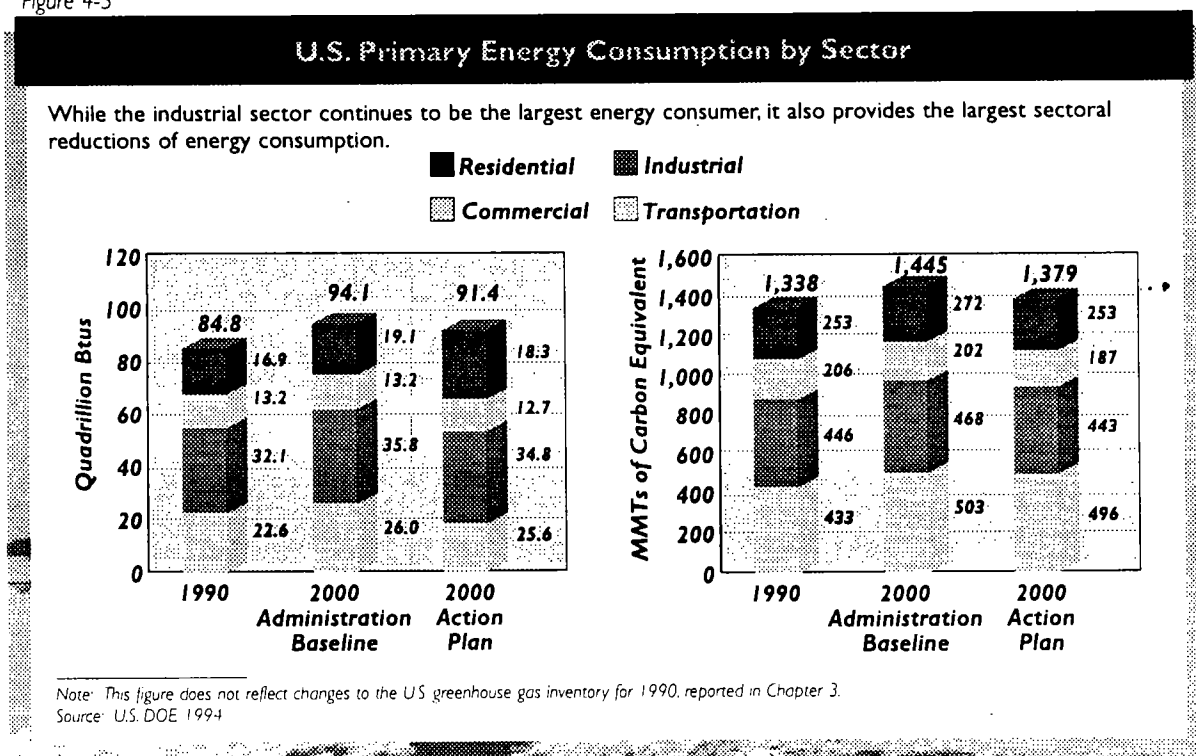
included in the Action Plan is broken out by sector. Figure 4-3 illustrates the effect of the Action Plan on carbon emissions by sector.

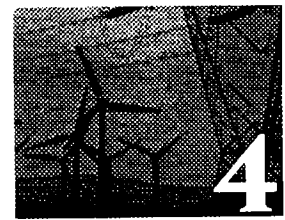
Because of the difficulty in projecting their effects, several of the major new initiatives in the Action Plan are not scored for any reductions toward the U.S. goal of 1990 levels by the year 2000; however, they are expected to provide underlying support for existing measures, as well as leading to additional emission reductions. Two of the most prominent of these are the Climate Challenge and Climate Wise programs; the third is the U.S. Initiative on Joint Implementation, described at the end of this chapter.

Climate Challenge

On April 19, 1994, associations representing 766 utilities signed a Memorandum of Understanding with the U.S. Department of

Figure 4-3





Energy (DOE), outlining their commitment to the Climate Challenge. This voluntary program is being developed jointly by the electric utility industry and DOE to reduce, limit, or avoid greenhouse gas emissions. It also builds upon Section 1605(b) of the Energy Policy Act of 1992, in which participants report emission baselines and submit periodic reports of actions taken voluntarily to cost-effectively reduce greenhouse gas emissions. These utilities represent about 80 percent of U.S. electricity generation and about 80 percent of CO₂ emissions from this sector.

Through company-specific agreements, participating utilities will have the flexibility to implement a portfolio of emission-reduction measures, including enhancing the efficiency of generation and transmission, switching to lower-carbon fuels, investing in renewable generation, enhancing the performance of existing hydro-electric and nuclear capacity, expanding demand-side management programs, undertaking forestry projects, promoting electrotechnologies that displace direct fuel use, and participating in international projects. To the extent that utilities invest in international projects to help meet their voluntary commitments, they could provide an important source of private-sector participation in the U.S. Initiative on Joint Implementation.

Climate Wise

Climate Wise is a program designed to encourage and publicly recognize voluntary efforts to reduce greenhouse gas emissions. This program establishes partnerships with business, industry, state and local governments, and other organizations that make commitments to reduce greenhouse emissions and report their results. Organizations participate by committing to

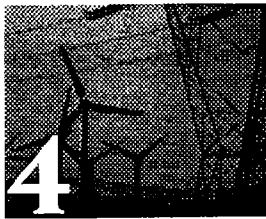
undertake specific actions to reduce greenhouse gas emission reductions and by reporting their reductions, primarily through the new Voluntary Greenhouse Gas Reduction Reporting System established under Section 1605(b) of EPAct. In return, Climate Wise will publicly recognize these commitments and will provide additional recognition—both nationally and locally—for the most successful emission-reduction efforts. As one of the foundation actions in the Action Plan, Climate Wise provides technical assistance and public outreach as an umbrella program to encourage participation in the full range of Action Plan initiatives.

Commercial Sector

Commercial buildings are complex, dynamic systems made up of numerous components and subsystems. The energy-related subsystems include the building envelope (i.e., the foundation, walls, and roof); the lighting system; and the heating, air-conditioning, and ventilation systems. The energy requirements of a building depend not only on the performance of these individual systems, but also on how they are integrated and operated in the building.

In 1990, commercial buildings accounted for nearly 11 percent of total end-use energy consumption in the United States (U.S. DOE/EIA 1993a). However, commercial buildings consumed over 30 percent of all electricity, primarily for lighting, heating, cooling, and air handling. Including the fossil fuel used to generate the electricity, the commercial sector accounts for over 15 percent of gross U.S. CO₂ emissions. (This emission figure assumes that the sector's electric utility CO₂ emissions are proportional to its share of electric demand.)

The Action Plan is supporting these efforts by expanding existing federal programs that



address specific building attributes, such as lighting, as well as those that take a whole-building approach. The Action Plan creates financial mechanisms for funding state and local efforts to conserve energy in commercial buildings and thus cut their greenhouse gas emissions. Across America, companies are investing in energy efficiency in order to improve their energy performance, lower overhead, and increase their competitiveness. By supporting these efforts in the commercial sector, the Action Plan programs are projected to reduce greenhouse gas emissions by approximately 10.6 MMTCE in 2000.

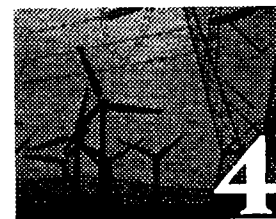
Demonstrations of Energy Technologies. The United States will initiate cost-shared demonstrations of emerging technologies in public and private buildings. These demonstrations will allow manufacturers to acquire field experience that will lower the perceived risk of using the technologies and lead to accelerated commercialization. DOE will solicit demonstration proposals that will be evaluated on the basis of technical merit, level of co-funding by manufacturers and host agencies, state and local government involvement, and information-dissemination benefits. Demonstrated technologies will include fuel-cell applications for on-site power generation; advanced windows, including electrochromic technologies; advanced building monitoring/control systems; and active and passive solar technologies. Jointly with efforts to establish the Energy Efficiency and Renewable Energy and Information and Training Programs, this action is projected to lead to greenhouse gas emission reductions of 3.8 MMTCE.

Energy Star Buildings and Rebuild America. The United States is launching new coordinated initiatives—Energy Star Buildings and Rebuild America—to improve the efficiency of heating, cooling, and air handling in commercial build-

ings. EPA and DOE will provide the product development, marketing, and technical assistance necessary for comprehensive commercial building upgrades. By bringing the most up-to-date technical knowledge to the people who need it, these voluntary programs will help companies to reduce their overhead and become more efficient, and will stimulate the introduction of more advanced commercial technologies. Projected emission reductions from this action are approximately 3.1 MMTCE.

Green Lights. Since its inception in 1991, the voluntary Green Lights program has entered into more than fifteen hundred partnerships with corporations, utilities, nonprofit organizations, and other groups who agree to analyze and, where profitable, to upgrade lighting equipment with more energy-efficient systems. These lighting-system upgrades are designed to save energy and provide positive returns on investment. For its part, EPA provides technical support to Green Lights participants through a technical hotline, a comprehensive manual, regional training workshops, up-to-date literature, and on-site implementation visits. EPA also publicly recognizes exceptional partnerships in journal articles, media venues, and by selecting a "Partner of the Year."

To date, over 4.5 billion square feet of facility space have been upgraded, representing over 5 percent of all U.S. commercial and industrial space. The United States will enhance its Green Lights efforts to reach untapped portions of the commercial lighting market. The expanded Green Lights will include new partnerships with electric utilities, a new marketing effort targeted to attract nonprofit partners, and increased technical support for program participants. The expansion is projected to yield reductions of approximately 2.5 MMTCE in 2000.



State Buildings Energy Incentive Fund. The United States will create a State Buildings Energy Incentive Fund that includes state revolving funds for public buildings. DOE will provide seed money of \$10 million per year over five years to state governments to fund, design, and start up energy-management programs for public buildings. Emission reductions are projected to be 1.1 MMTCE from this action.

Residential Sector

In 1990, America's homes consumed 15 percent of all U.S. end-use energy and accounted for 34 percent of U.S. electricity demand. Including the fossil fuels used to generate electricity for homes, the residential sector generated 19 percent of U.S. CO₂ emissions in 1990.

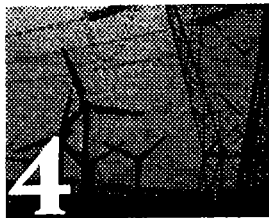
The Action Plan targets key opportunities in the residential sector—such as delivery of heating and cooling services, home appliances, lighting, and the design of the building exterior itself—and includes a mix of partnerships with businesses and utilities, economic incentives, and new standards and building codes. There are environmental and economic advantages to bringing energy efficiency to the residential sector. An energy-efficient new home that meets today's best design criteria consumes 50 percent less energy than a poorly designed alternative, while offering a lower life-cycle cost (i.e., the amortized annual cost of a product, including capital costs, installation costs, operating costs, maintenance costs, and disposal costs discounted over the lifetime of the product). A typical home built fifteen years ago can be upgraded to save 20 percent of its energy use, at a profit to homeowners.

In the aggregate, measures in the U.S. Action Plan are anticipated to lead to emission reductions of 16.3 MMTCE in the residential

sector. These will result from the combined effects of appliance improvements (yielding 11.8 MMTCE) and home improvements (providing another 4.4 MMTCE). Because of the overlapping effects of action within this sector, more precise measurement of the individual effects is impossible.

Home Energy-Rating Systems and Energy-Efficient Mortgages. The United States is launching a new national effort to market Home Energy-Rating Systems (HERS) and Energy-Efficient Mortgages (EEMs). HERS provide home buyers with information on the energy efficiency of new and existing homes (similar to the miles-per-gallon guide for automobiles). These ratings are the yardstick by which EEMs are created. EEMs recognize that the energy savings from efficient new and retrofitted housing will enable home buyers to afford larger mortgage payments. These programs allow home buyers to finance investments in energy improvements through their mortgage lender when the monthly energy savings are greater than increased monthly mortgage payments. Current federal and state ratings and finance programs are fragmented and are not readily accessible to realtors, lenders, or borrowers, and their use is not widespread. Federal agencies will coordinate an effort involving financial institutions, utilities, and contractors to ensure that a uniform EEM program reaches the intended market.

Residential Building Code. The federal government will help state governments update and enforce residential building codes by the end of 1994. EPA requires states to assess the feasibility of improving residential building standards. DOE will help states to comply with this requirement and will encourage them to adopt energy-efficient building codes. Many states



have no code enforcement, which is an effective tool to increase the energy efficiency of homes.

Cool Communities. The Cool Communities program promotes the use of strategic landscaping to shade residential and commercial buildings, and of light-colored building surfaces to reduce absorption of sunlight. In targeting 100 federal facilities and 250 new cities with minimum populations of 30,000, the program is working with homeowners, businesses, and their communities and partners to adopt these strategies to keep communities cooler during the hottest days of the summer and to reduce the demand for air conditioning. Planting trees to cool communities will also help create more sinks for absorbing carbon dioxide emissions.

New "Golden Carrot" Partnerships. The United States will form new "Golden Carrot" partnerships with nonprofit organizations, utilities, and environmental groups to accelerate the commercialization of advanced energy-efficient appliances. The Golden Carrot program creates a financial incentive for the development of more efficient appliances by combining financial resources from a variety of sources. The incentive might be a winner-take-all prize, a rebate from the utility for all new products that meet energy-saving targets, or a guaranteed number of purchases by a utility or a large purchaser.

For example, some utilities offer rebates to customers who purchase efficient appliances because the efficiency investment "on the consumer side of the meter" (i.e., the rebate) can help the utility avoid having to build an expensive new power plant. Under a Golden Carrot partnership, several utilities pool their rebates to provide a clear market signal (a guaranteed pool of rebate money) for appliance manufacturers to commercialize advanced energy-efficient appliances, such as rooftop air-conditioning units,

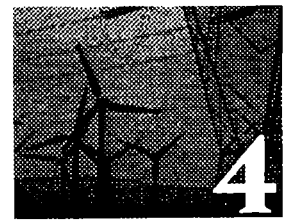
clothes washers and dryers, and water heaters. The original Golden Carrot—the Super-Efficient Refrigerator Program—pooled \$30 million in utility rebate money for the manufacturer who could commercialize a 50 percent more energy-efficient, CFC-free refrigerator.

New Residential Appliance Standards. The United States will accelerate the schedule for new standards that are required under the National Appliance Energy Conservation Act of 1987. DOE will issue new residential appliance standards for eleven product categories: central air conditioners, furnaces, refrigerators, room air conditioners, water heaters, direct heating equipment, mobile home furnaces, kitchen ranges and ovens, pool heaters, televisions, and fluorescent lamp ballasts. Cost-effective energy standards ensure that consumers will only be able to purchase appliances that are both energy efficient and affordable. Raising the energy efficiency of appliance standards will result in a measurable decline in U.S. electricity use and greenhouse gas emissions.

Industrial Sector

U.S. industries consumed 39 percent of the nation's end-use energy in 1990, including 35 percent of the electricity generated. Since two-thirds of the industrial sector's electricity use is for motors, industrial motors use over 20 percent of all U.S. electricity generation. Including the emissions from electricity generation, the industrial sector accounted for 33 percent of U.S. CO₂ emissions in 1990. A small number of major manufacturing groups—primary metals, petroleum refining, chemicals, and pulp and paper—account for about two-thirds of industrial energy use and 19 percent of the U.S. gross domestic product.

Since the 1970s, the federal government has



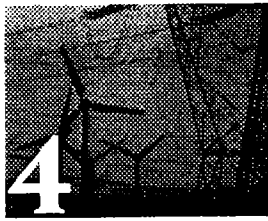
funded a large research and development program for energy-efficiency and waste-reduction technologies in the industrial sector. Following are some of the industrial measures included in the Action Plan. They establish working partnerships with American industry to help get those improvements off of the drawing board and onto the factory floor. The total projected emission reductions from this sector are 19.0 MMTCE.

Motor Challenge. The United States has launched the Motor Challenge—a voluntary, industry-driven collaborative program aimed at galvanizing U.S. business and industry into action to better understand, apply, and target energy-efficient industrial electric motor systems. DOE will work with industry to test, verify, and disseminate information on the cost-saving potential of industrial motor systems, and will obtain commitments from industry to use them. Companies will achieve increased efficiency in their motor systems through the system integration of a variety of technology and application options, including energy-efficient motors, adjustable-speed drives, and efficient motor-driven equipment (e.g., pumps, fans, and compressors). Efficiency gains will result in significant energy savings and reduced greenhouse gas emissions, particularly since motor systems being targeted for this initiative currently account for two-thirds of U.S. industrial electricity consumption. The plan projects emission reductions of 8.8 MMTCE from this program.

“Golden Carrots” for Industrial Equipment. To complement the Motor Challenge, federal agencies will create Golden Carrot programs for industrial equipment analogous to the Golden Carrot programs for residential appliances. By helping to pool financial incentives and purchas-

ing power, these programs can stimulate rapid commercialization of new energy-efficient equipment. Targeted equipment includes air compressors, fans and pumps, and other types of industrial process equipment. This program is expected to yield emission reductions of 2.9 MMTCE when evaluated jointly with a program to accelerate the adoption of energy-efficient process technologies.

Waste Management. The United States is expanding voluntary source-reduction, pollution-prevention, and product-recycling programs, and is focusing on ways to enhance the recycling of forestry products (paper and wood). Source-reduction efforts will encourage the adoption of unit pricing (charging homeowners by the amount of garbage they throw away), provide incentives and education to practice reducing waste at the source of its production, and promote the design of longer-life, repairable goods. Recycling efforts will foster “buy recycled” programs, expand access to information clearinghouses, increase the use of government loan guarantees for recycling manufacture investment, and provide technical assistance to state and local governments to improve the quality of recycled materials. Increased source reduction and recycling of paper and other municipal waste will save energy and money, increase carbon sequestration in forests, reduce greenhouse gas emissions, reduce the level of exploitation of our natural resources, and help alleviate disposal problems at landfills. This program is expected to reduce CO₂ emissions by 4.2 MMTCE in 2000 and to sequester an additional 5 MMTCE in forests—a projection that does not include the additional potential reductions from the associated methane emissions in the landfills.



Transportation Sector

The combustion of fossil fuels to move people and goods consumed 35 percent of the nation's energy in 1990 and produced over 32 percent of U.S. CO₂ emissions. The expected increase in demand for transportation services over the next decade will hamper efforts to reduce greenhouse gas emissions. It will also continue to contribute to urban air pollution and to U.S. reliance on foreign oil.

Transportation will be the fastest-growing source of CO₂ emissions through the year 2000. Following are initiatives in the Action Plan that will help to slow the growing demand for vehicle travel and enhance the market for more efficient technologies and cleaner fuels. Overall, actions in the transport sector account for reductions of 8.1 MMTCE in the year 2000. This figure represents the combined total for tire labeling (1.5 MMTCE) and parking reforms, telecommuting, and a transportation efficiency strategy (6.6 MMTCE).

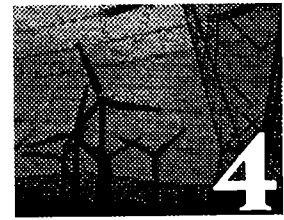
Cash Value of Parking. This action will transform an existing tax subsidy—employer-paid parking—into a powerful reward for commuters who ride public transit, carpool, or to find ways to get to work other than driving alone in personal vehicles. The Clinton Administration is proposing legislation that will give workers the option of receiving the cash value of employer-provided parking as an alternative to existing subsidized parking arrangements. Employees given subsidized parking at work will have the option of retaining the parking space or accepting a cash allowance equal to the market cost of the leased parking space minus any amount paid by the employee. While the cash reward will be considered taxable income to the employee and will generate tax revenue for the federal government, the costs of administering such as program

will be tax-deductible for the employer. Those employees who choose to use an employer-provided parking space will be unaffected. Parking cash-out is one of the most innovative programs included in the U.S. Action Plan because of its prospect as a "win-win" proposal. While it provides maximum flexibility to employers and employees, its administrative costs are minimal, and it generates revenue for the federal government.

Innovative Transportation Strategies. The Transportation System Efficiency Strategy will broaden the arsenal of strategies available to cities and states seeking to meet the joint challenges of clean air and urban mobility. The U.S. Environmental Protection Agency (EPA), in consultation with the U.S. Department of Transportation (DOT), is drafting guidance documents that identify the air-quality benefits of innovative transportation strategies to reduce the number of vehicle miles traveled.

To encourage people to drive less, the United States is aggressively advocating innovative pollution control strategies that concentrate on such market mechanisms as parking charges, emission-based fees, accelerated vehicle scrapping, and transportation subsidies. Some states have experimented with innovative programs, such as congestion pricing tolls and mass-transit finance. New technologies, such as virtual offices (completely portable communications and computing equipment), smart cars and transit vehicles, and advanced traveler-information systems, will be encouraged. This initiative will reduce the costs of complying with clean air regulations and will improve the quality of life of transportation users through increased choice and enhanced environmental quality.

Tire-Labeling Program. DOT is developing a tire-labeling program to help consumers identify



tires that have low rolling resistance and, therefore, provide better fuel economy. Consumers often purchase replacement tires that have 20 percent more rolling resistance than original-equipment tires, reducing their fuel economy by up to 4 percent. With the labeling program, consumers will readily have the information they need to make better decisions on how to save gas, save money, and protect the environment, and tire manufacturers will have greater incentive to produce low-rolling-resistance tires. This program is expected to result in the purchase of about 20 million additional fuel-efficient tires (out of a total replacement market of about 120 million units) in the year 2000.

Telecommuting Program. DOT has initiated a telecommuting program aimed at reducing commuter travel through arrangements that allow employees to work at home or at neighborhood "telework" centers. DOT has begun to implement a federal pilot telecommuting program, in collaboration with the General Services Administration (GSA), DOE, and EPA, that will both use the existing federal telework centers developed by GSA and encourage work-at-home arrangements. On April 1, 1994, the Secretary of Transportation issued a formal departmental policy on telecommuting and directed DOT to begin to identify potential candidates for this program.

Energy Supply Strategies

The energy industry is entering an era of unprecedented change due to market and regulatory shifts. The EAct and actions taken by the Federal Energy Regulatory Commission (FERC) have increased competition in a variety of energy markets, increasing the efficiency of energy supply. New requirements under the Clean Air

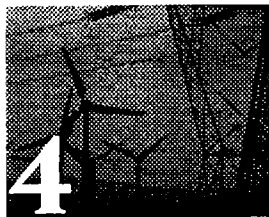
Act have prompted a shift to cleaner fuels. Federal research and development into new energy technologies continues to help the industry increase the efficiency of generating and distributing electricity and meet environmental and market challenges.

The Action Plan includes a number of new actions that build on the EAct, Clean Air Act, and FERC actions to reduce the amount of CO₂ emitted from energy production and use. The intent is to increase the use of natural gas, encourage the commercial application of renewable-energy resources, make more efficient use of our existing hydroelectric resources, and reduce the amount of energy lost in electricity transmission and distribution.

Among fossil fuels, natural gas emits the least amount of CO₂ per unit of energy provided, and renewable-energy sources—such as solar, wind, geothermal and biomass energy—release no net CO₂. Nuclear power, which currently accounts for above 20 percent of electricity generated, will continue to play a key role in limiting CO₂ emissions from electricity production. Newer technologies can also increase the efficiency of generating and distributing electricity. Increased efficiency lowers the amount of greenhouse gases emitted by reducing the amount of fuel required to generate and deliver electricity to customers. The combined effects of the U.S. energy-supply actions are projected to reduce emissions by 10.8 MMTCE in the year 2000.

Natural Gas

Natural gas, an abundant domestic fuel, emits from 30 to 45 percent less CO₂ per unit of energy provided than fuels from either oil or coal. Therefore, the Action Plan increases our use of natural gas over other fuels (Figure 4-4).



The United States is taking the following specific actions.

Clean Air Act Guidelines. Encouraging the use of natural gas as a pollution control strategy under the Clean Air Act will lower the cost of combating the severe tropospheric ozone pollution problem plaguing many of our cities in a way that also reduces greenhouse gas emissions. As part of that effort, EPA recently issued guidelines to urge state and local pollution control agencies to allow the use of natural gas in the summer in existing coal- and oil-fired power plants as a strategy for reducing nitric oxide (NO_x) emissions. EPA will examine additional regulatory options where shifts to cleaner fuels could provide environmental benefits and cost savings. This action is expected to reduce emissions by 2.8 MMTCE in 2000.

High-Efficiency Gas Technologies. The United States will accelerate the commercialization of

high-efficiency gas fuel-cell technologies, through joint ventures with utilities, research organizations, and technology developers to fund demonstrations and market-entry initiatives. Fuel cells are an ultra-high-efficiency and environmentally benign method of producing electricity and by-product thermal energy. They provide a means of converting a fuel's chemical energy into electrical energy without a combustion process. This action is projected to lead to reductions of 0.6 MMTCE in the year 2000.

Regulatory Reform. The United States will continue to facilitate the implementation of reforms that will increase the availability and use of natural gas. DOE and the FERC are working together to enhance the market orientation of an industry that previously had been characterized by excessive regulation, which unnecessarily hampered the industry's ability to serve its customers at cost-effective prices. This initiative will include an investigation of current pipeline construction rules, promulgation of incentive rate-making guidelines, and a review of the rules regarding the secondary market for pipeline transportation of natural gas. Reforms at the federal level will establish a more efficient and competitive wholesale market for natural gas and its transportation. As wholesale markets become more efficient, increased opportunities for reform of retail regulation will then exist. DOE has committed to working with state public utility commissions to reform retail regulation to create market conditions that permit increased cost-effective use of natural gas.

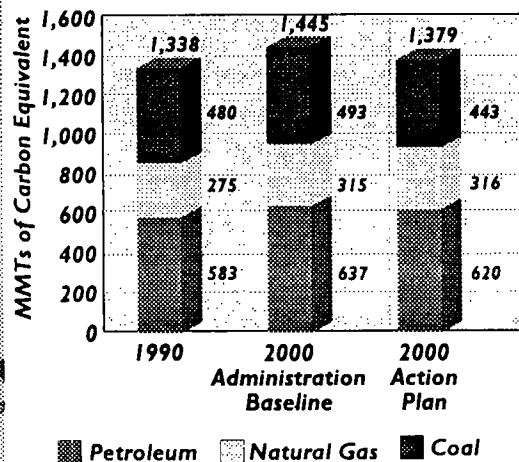
Renewable Energy

Renewable-energy sources include solar energy, biomass energy (wood, wood waste, and energy crops), geothermal energy, wind energy, hydroelectric power, and related energy sources

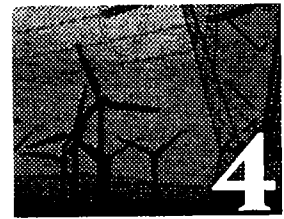
Figure 4-4

Carbon Emissions From Fossil Fuels

While carbon emissions are projected to rise, actions in the Plan slow that rise considerably.



Note. This figure does not reflect changes to the U.S. greenhouse gas inventory for 1990, reported in Chapter 3.
Source: US DOE 1994



that emit relatively little or no net greenhouse gases. Through increased funding, use of incentives included in the EAct to promote the use of renewable energy, and the removal of institutional barriers, the United States is already laying the groundwork for a future that can rely on these promising resources. The Action Plan features new initiatives to accelerate the widespread commercial deployment of renewable-energy sources. The combined effect of these initiatives is projected to lead to 2.2 MMTCE of reductions in the year 2000. Renewable energy also holds great promise for reducing greenhouse gas emissions after the year 2000.

Renewable-Energy Technology Consortium.

The United States is forming a renewable-energy technology consortium with utilities to increase the emphasis on commercialization programs for wind power, photovoltaics, biomass, and geothermal energy. By collaborating with private industry to accelerate market acceptance of renewable technologies and conducting industry cost-shared demonstrations of renewable-energy technologies, DOE will facilitate the collective purchases of nearly commercial renewable-energy technologies (including technologies in the wind, solar, and biomass areas) by states, utilities, and other interested firms. Mass-purchase strategies enable equipment manufacturers to increase their production capacity and reduce their unit costs—which will in turn further broaden the market for and increase the competitiveness of these technologies.

Profitable Hydroelectric Efficiency Upgrade.

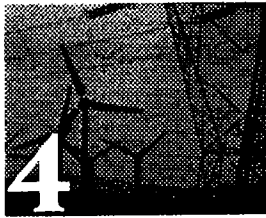
This initiative, as proposed, would enable non-federal developers to invest in environmentally sound upgrades at existing federal hydroelectric projects, and to sell the incremental power thus generated at market rates. Significant technological potential exists for increasing generation at

hydroelectric facilities, but institutional barriers have stifled efforts to make these profitable efficiency upgrades. Nonfederal investments will increase generation from hydroelectric facilities, reducing the need for fossil-fuel-fired generation. Furthermore, lease payments will help reduce the federal deficit. Implementing legislation is currently being drafted.

Electric Distribution

In 1991, about 7.4 percent of U.S. electric generation was lost while being distributed from power plants to consumers. Stemming transmission and distribution losses will decrease the amount of electricity that needs to be generated to meet electricity demands, thus reducing CO₂ emissions. FERC is currently implementing changes called for in the EAct that will foster competition and promote access to transmission systems. The Action Plan focuses on increasing the adoption of more efficient transmission and distribution equipment through the following actions, which jointly are projected to reduce emissions by 1.6 MMTCE in the year 2000.

Distribution Transformer Standards. The United States is currently determining the need for distribution transformer standards. If standards are warranted, DOE will accelerate the process of establishing test procedures, standards, and labeling. This process is based on an EAct provision that uses technological feasibility, economic justification, and level-of-energy savings as the basis for the decision. Distribution transformers reduce the distribution system voltage to a level that can be used by customers. There are approximately 50 million distribution transformers in service, with approximately 40 million units located on the utility side of the meter. Approximately 61 billion kilowatt-hours are lost per year in the delivery of electricity



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from utility distribution transformers. Losses from comparable-size distribution transformers on the customer side of the meter are significantly higher. Utilities typically use total owning cost criteria in their specifications for transformers. Initial cost is a significant factor in the sales of transformers on the customer side of the meter.

Energy Star Identification Program. The United States is implementing an "Energy Star" identification program to encourage electric utilities to invest in high-efficiency, cost-effective distribution transformers that reduce transformer losses. Participating utilities would agree to purchase only high-efficiency transformers, wherever they are cost-effective, and to accelerate the replacement of higher-loss transformers where economically warranted. EPA will distribute information regarding energy-efficient transformers to utilities and state regulatory bodies, and will help participating utilities to organize group purchases of energy-efficient transformers in order to obtain lower prices.

Electric Utilities

The energy demand and supply programs outlined above rely on an assumed private-sector response to a collection of government initiatives. The analysis of their impact assumes that a favorable climate exists for the penetration of energy-efficient technologies and that electric utilities will support the programs. To ensure that these programs deliver the estimated impacts, and to enhance the prospects for early emission reductions, DOE has begun to forge partnerships with electric utilities to limit greenhouse gas emissions through the Climate Challenge, described earlier in this chapter. In addition, DOE and EPA will expand their efforts to encourage supportive state regulatory actions.

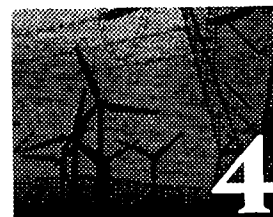
This strategy is not scored for reductions under the current plan.

Expanded Assistance for Utility Integrated Resource Planning. Integrated resource planning (IRP) stresses systematic consideration of all relevant options and uncertainties in the development of a utility's resource plan. Such options include both supply and demand actions, such as promoting renewable generating technologies; programs to help customers improve energy efficiency or use alternative fuels; utility investments to improve the efficiency of generation, transmission, and distribution equipment; purchase of electricity from nonpower producers; and electricity imports from Canada.

DOE will expand utility IRP assistance to provide a foundation for other federal and state programs, and to encourage a supportive regulatory environment for utilities signing the Climate Challenge. The expanded IRP program will focus on increasing federal technical and financial support to state regulatory commissions to make utility investments in energy efficiency as profitable as other traditional investments and for more effective demand- and supply-side planning. It will also increase federal support for removing regulatory barriers to the increased use of renewable energy and natural gas. The intent behind this initiative is to provide more planning flexibility, to lower costs for utilities over the long term, and to spur the adoption of innovative technologies and approaches, including electrotechnologies, which more than offset the increased use of electricity with reduced fossil fuel consumption.

Forestry Strategies

Atmospheric CO₂ concentrations are the net result of continuous emissions and sequestra-



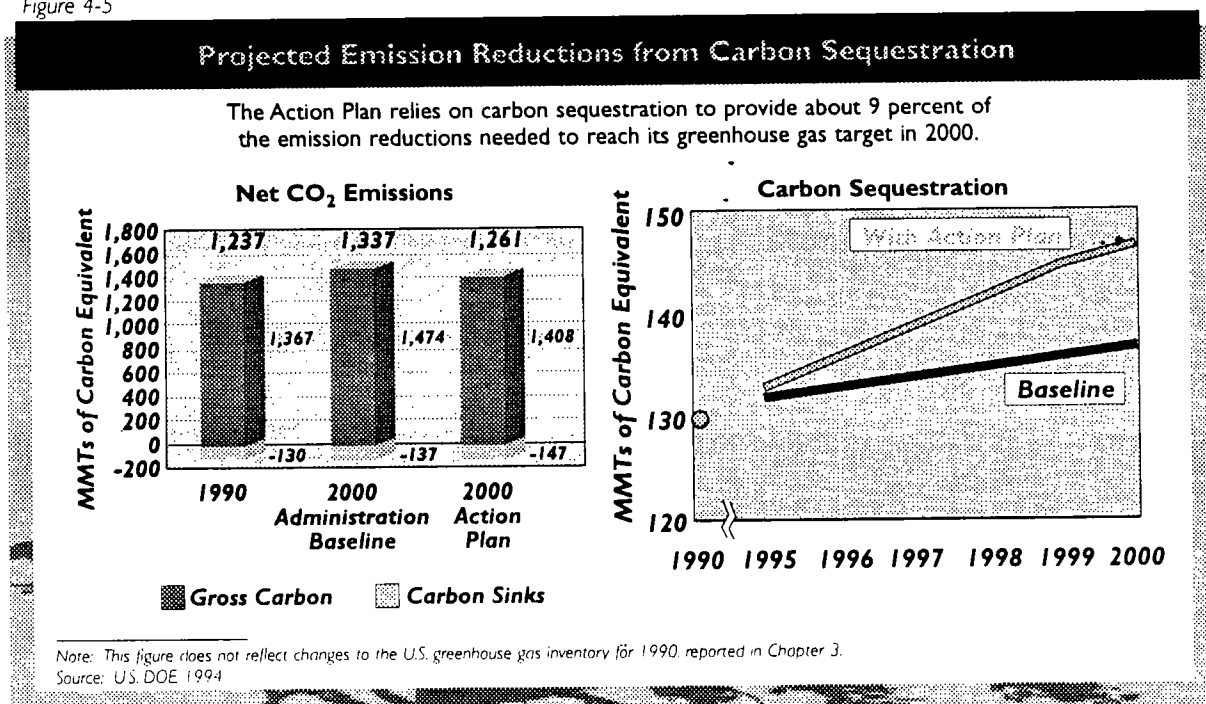
tion that occur through natural processes and human activities. Future concentrations of CO₂ in the atmosphere—the key factor of the global warming threat—can be limited both by reducing emissions and by increasing the amount of annual sequestration by natural systems, sometimes called carbon “sinks.” Trees, plants, and soils absorb and store CO₂ from the atmosphere and are a significant carbon sink. CO₂ emissions occur when the carbon stored in these sinks is released—for example, when trees are harvested and the wood is burned for energy. Protecting the carbon stored in these forest reservoirs, therefore, can prevent CO₂ emissions from occurring.

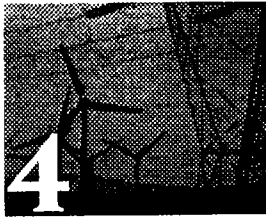
The United States has already taken significant steps to protect carbon sequestered in forests. Lower harvests in old-growth forests help prevent CO₂ emissions, even if accompanied by increased harvests elsewhere, because old-growth forests have higher carbon densities

than second-growth forests. The shift toward ecosystem management also favors timber harvest methods that inflict less damage, and helps retain carbon on forest lands. Sink-protection actions are very cost-effective methods for limiting net CO₂ emissions.

The Action Plan includes several programs to maintain carbon sequestered in forest ecosystems, which provide about 9 percent of the emission reductions needed to reach the greenhouse gas target in 2000, or a total of approximately 10.0 MMTCE. Figure 4-5 illustrates the expected impact of these actions on net CO₂ emissions. In addition to the two programs described below, several other actions detailed above lead to increased carbon sequestration in U.S. forests. In particular, efforts to enhance recycling will extend the useful life of forest products, thus reducing demands on rapidly growing forest stands and enhancing biological carbon reservoirs. Concurrently, the Cool Communities pro-

Figure 4-5





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gram will encourage the planting of shade trees to improve home energy efficiency, which will also serve as a carbon sink, contributing to the overall carbon reservoir, both above and below ground.

Reduce Depletion of Nonindustrial Private Forests

The United States will enhance the health of private forests by providing technical and economic assistance to nonindustrial private forest landowners to aid them in making silviculturally and financially sound timber-harvesting decisions that are consistent with landowner objectives and good forest stewardship. USDA's Forest Service will carry out this action in cooperation with state foresters and private consulting foresters who will prepare stand evaluations that describe the owner's timber (tree species composition, age, stocking, growth rate, and approximate volume and value) and recommend management options for the next ten years. Nonindustrial private landowners generally do not manage their holdings intensively. As a result, about 16 percent of these forests are in poor health, and many are harvested for short-term economic gain without adequate regard for the future condition of the forest. Large increases in the ability of forests to capture and store carbon can be achieved by reducing harvesting practices that leave forests in an understocked and depleted condition. This measure is projected to reduce net emissions by sequestering an additional 4 MMTCE in the year 2000.

Accelerate Tree Planting in Nonindustrial Private Forests

This program aims to increase tree planting on poorly stocked and nonstocked nonindustrial private forest land by 233,000 acres within five years. To accomplish this, the federal government will expand management assistance under the Stewardship Incentive Program by funding additional free technical consultations and management plans for nonindustrial private landowners. Technical assistance and up to 75 percent federal cost-sharing will be provided by the Forest Service in cooperation with respective state foresters. Accelerated planting programs increase carbon uptake and provide significant economic and environmental benefits over the long term. This program is expected to lead to reductions of approximately 0.5 MMTCE in 2000.



Methane and Other Gases

Methane comprises about 12 percent of the U.S. greenhouse gas emissions. The primary sources of methane emissions in the United States are landfills, domesticated livestock, coal mines, and natural gas systems. The U.S. Action Plan includes specific measures for each of these. The total greenhouse gas emission reductions achieved from methane-related actions amount to 16.3 MMTCE.

The United States has also developed emission-reduction strategies for hydrofluorocarbons and perfluorocarbons and for nitrous oxide.

Methane Recovery and Reduction Strategies

In many cases, methane that would otherwise be emitted to the atmosphere can be captured and used to generate power, or can be significantly reduced through the use of cost-effective management methods. Therefore, methane-control options offer tremendous opportunities to reduce greenhouse gas emissions at low cost or even at a profit (Figure 4-6). The Action Plan builds on several U.S. programs that are already delivering cost-effective methane reductions, and establishes new initiatives to reduce methane emissions from all of the major methane sources.

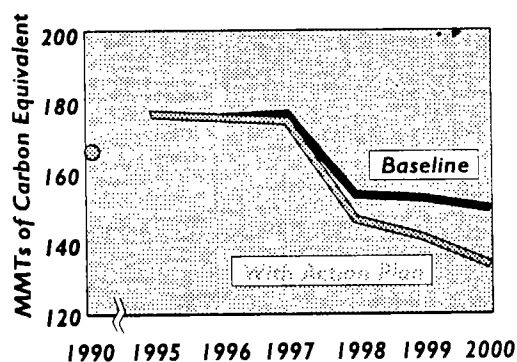
Natural Gas STAR

The new Natural Gas STAR program will set an industrywide performance benchmark for leakage and emission control throughout the entire natural gas system. EPA will expand the existing Natural Gas STAR partnership with the natural gas industry to include additional transmission and distribution companies and production companies. Key 1994 milestones for this initiative include (1) the completion of a full analysis of the barriers companies face in implementing emission-control practices and (2) the launching of a marketing campaign for gas pro-

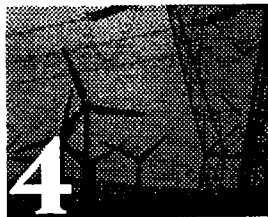
Figure 4-6

Effects of the Action Plan on Methane Emissions

The Plan establishes new initiatives to reduce methane emissions from all of the major methane sources.



Note: This figure does not reflect changes to the U.S. greenhouse gas inventory for 1990, reported in Chapter 3
Source: US DOE 1994



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ducers and processors.

Increase Stringency of Landfill Rule

This action will increase the amount of organic compounds that must be recovered and destroyed at landfills and will result in additional methane recovery. EPA will formulate a more stringent rule to reduce methane emissions from landfills under Section 111 of the Clean Air Act. This rule, which will be promulgated in 1994, is expected to affect about the largest 10 percent of the more than 6,000 landfills in the United States.

Expand Coalbed and Landfill Outreach Program

New outreach and technical assistance programs for landfill and coal mine owners will promote energy recovery rather than the minimum requirement of flaring the methane. Studies indicate that many coal mine owners could make a profit by using or selling the methane they currently emit to the atmosphere. However, most mines have not installed recovery systems because of institutional, regulatory, and financial barriers and a lack of technical support. This voluntary program will significantly reduce methane emissions. DOE and EPA will work to broaden the range of cost-effective technologies and practices for recovering methane associated with mining. They will expand an outreach program with key coal utilities and state agencies to raise awareness of these cost-effective, emission-reduction opportunities.

AgSTAR Partnerships

Cattle are currently responsible for over 30 MMTCE of methane emissions per year. AgSTAR is a partnership effort designed for dairy and swine farmers to provide on-farm ener-

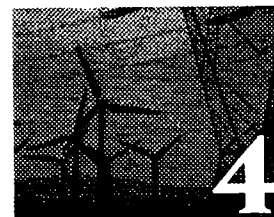
gy needs with methane produced from animal manure. An outreach program by EPA and USDA will promote practices that improve production efficiency and reduce methane emissions per unit of beef, pork, or milk produced.

HFC and PFC Control Strategies

Due to their high global warming potentials, long atmospheric lifetimes, and increasing emissions, hydrofluorocarbons (HFCs) are a growing contributor to the climate change problem. HFCs are produced commercially as a substitute for ozone-depleting CFCs and are also emitted as a by-product of HCFC-22 production (another CFC substitute). Perfluorocarbons (PFCs), emitted primarily during aluminum smelting, are also potent greenhouse gases.

The United States is the first nation to articulate a national strategy to control the emissions of HFCs and PFCs. HFC and PFC emissions are projected to grow from 20 MMTCE in 1990 to 45 MMTCE in 2000 without the Action Plan; with the Plan, increases in emissions from these gases are expected to be substantially smaller (Figure 4-7). The Plan uses a combination of partnership efforts and regulatory mechanisms to minimize the future contribution of HFCs and PFCs to global warming, without disrupting the orderly and cost-effective transition away from CFCs.

The United States will use both regulatory and voluntary approaches to limit HFC and PFC use. EPA will use its authority under the Clean Air Act to narrow the scope of uses allowed for HFCs with high global warming potentials where better alternatives exist, and to initiate rulemaking early in 1994. In addition, EPA will establish a partnership with chemical manufac-



turers to assist their efforts to limit by-product emissions of HFCs from their manufacturing operations by 50 percent. Another partnership, with aluminum producers, will identify opportunities to reduce PFC emissions by up to 50 percent.

duct of field experiments regarding bacterial denitrification and the testing of management options to improve the efficiency of nitrogen use. Demonstration projects and an outreach campaign using nationwide USDA outlets will begin by 1996.

Nitrous Oxide Strategy

Nitrous oxide emissions, mostly from fertilizer and chemical manufacture, accounted for 39 MMTCE in U.S. greenhouse gas emissions in 1990, and are projected to decline to 36 MMTCE even without the actions in the Plan. With the Plan, a further decline, to 31 MMTCE, is projected (Figure 4-7).

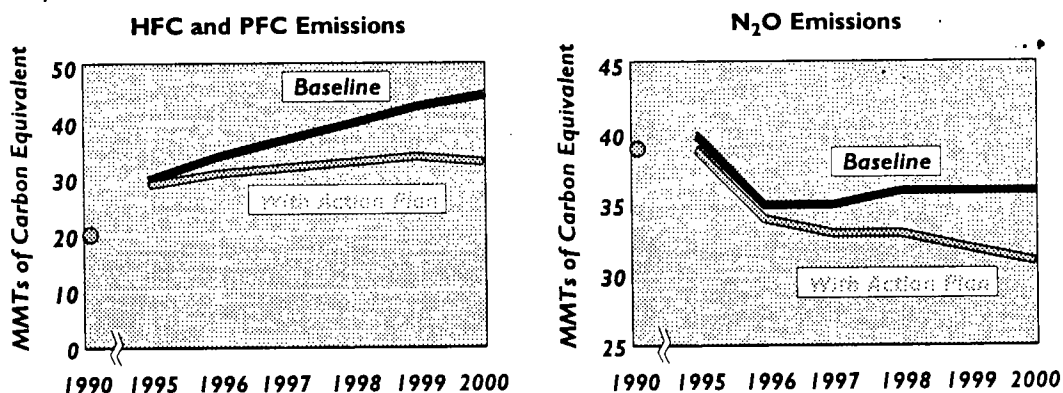
Improved Fertilizer Management

A new partnership with American farmers to improve the efficiency of fertilizer management will result in lower emissions of nitrous oxide from soil. This initiative will begin with the con-

Figure 4-7

Effects of the Action Plan on Emissions of HFCs, PFCs, and Nitrous Oxide

With the Plan's actions, increases in emissions of HFCs and PFCs and of nitrous oxide are expected to be substantially smaller.



Note: This figure does not reflect changes to the U.S. greenhouse gas inventory for 1990, reported in Chapter 3.
Source: U.S. DOE 1994

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State and Local Outreach

To facilitate all the actions in the Plan, state government agencies and federal officials are developing new working relationships. The intent is for the federal government to provide support to states and localities to build expertise in climate change policy issues and to provide a central federal point of contact for greenhouse gas mitigation efforts. States have been involved in the implementation planning process from the beginning, bringing their considerable expertise to these issues, particularly as related to energy efficiency and renewable technologies.

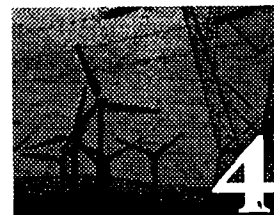
The federal government is coordinating efforts to work with states and localities through a variety of mechanisms. DOE has been holding a series of Regional Roundtable discussions for stakeholders, including state and local government officials, to obtain input and feedback on the DOE initiatives. DOE has established a centralized point-of-contact staff, known as the "Green Room" for climate-related activities, and has been working closely with state energy office staff to ensure internal and external coordination. EPA's State and Local Outreach Program is geared toward energy offices, environmental agencies, and public utility commissions to provide technical and financial assistance in understanding climate change impacts and reducing greenhouse gas emissions.

Industrial and Commercial Efficiency Programs

Thirty-five states currently operate industrial and commercial efficiency programs. They have significant expertise working with builders, manufacturers, utilities, public utility commissions (who regulate utilities and natural gas distribution companies), and building owners. For example, many utility demand-side management programs have been initiated through the joint efforts of utilities and state energy offices. State programs have helped hundreds of industrial and commercial energy users to convert from fossil fuels to low-cost biomass and other renewable technologies, have organized photovoltaic technologies to work in new applications, and have coordinated with state regulatory commissions and utilities to implement integrated resource planning, opening up new opportunities for efficiency and renewable technologies.

EPA's State and Local Outreach Program

EPA's "one-stop-shopping" efforts are designed to encourage states and localities to develop and implement cost-effective greenhouse gas-reduction strategies, in addition to those identified in the Action Plan. The outreach program builds capacity in climate change issues.



and helps the targeted groups integrate the Action Plan with other efforts, such as the Clean Air Act, the Energy Policy Act, and the Internodal Surface Transportation Efficiency Act. The program provides technical and financial assistance to states and localities to conduct greenhouse gas inventories, to develop state "action plans" to reduce greenhouse gas emissions, to study the impacts of climate change, and to demonstrate innovative mitigation policies. Other efforts include providing training workshops and guidance documents.

To date, eight states have completed inventories and are developing action plans, and nearly twenty states and localities have completed projects that range from telecommuting demonstrations to studies of the impact of sea level rise on land use and development policies. Nearly fifteen states will begin greenhouse gas inventories in 1995.

Agricultural Outreach Programs

Ongoing programs within the U.S. Department of Agriculture transfer technical assistance in the management of forest and agriculture carbon sinks to state and local jurisdictions. For the most part, these programs have been in place for the past fifty years at the county level in every state, providing over three thousand locations for on-site assistance in resource conservation and judicious land use. Through its offices in each county in the United States, the U.S. Soil Conservation Service works with locally elected officials and with farm and forest land owners in local soil- and water-conservation districts.

The State Agricultural Extension Service fully complements federal assistance through the County Agricultural Extension Agents, which

are funded jointly by county, state, and federal programs. In addition, private, nonindustrial woodlot and forest owners receive resource management technology through the State and Private Forest Division of the U.S. Forest Service, which coordinates technical assistance from forestry experts at the local, county, and state levels and provides overall guidance for consistency in management designs and practices.



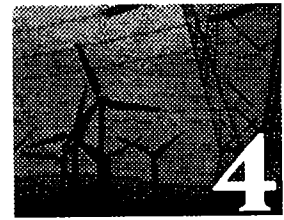
Joint Implementation

Efforts undertaken cooperatively between countries or entities within them to reduce net greenhouse gas emissions—called joint implementation—hold significant potential for combating the threat of global warming and promoting sustainable development. Joint implementation is recognized under the Framework Convention on Climate Change as an approach open to all parties to the Convention.

Joint implementation could achieve greater emission reductions than would be possible if each country pursued only domestic actions, and could achieve these reductions more cost effectively. Joint implementation could also spur technology cooperation—increasing developing countries' access to energy-efficient and renewable-energy technologies, including providing countries with additional operational capability, while stimulating export markets for industrialized countries. At the same time, significant questions arise about what kinds of actions might take place under the rubric of joint implementation: whether these would produce "real" reductions, whether they would be "new and additional" to ongoing development assistance or private business transactions, how to measure and track net emission reductions achieved, how to ensure that reductions in one place do not give rise to increases in another, and how to ensure that reductions will not be lost or reversed through time.

The U.S. *Climate Change Action Plan* was developed to achieve the goal of emission reductions to 1990 levels by the year 2000 through domestic actions alone. However, recognizing the enormous potential for cost-effective greenhouse gas emission reductions in other countries, the United States chose to develop ground rules for joint implementation, which would allow the promise of these measures to be realized. Published in final form in the June 1, 1994, *Federal Register* after an extensive domestic review process, the ground rules establish a pilot program, the intent of which is to evaluate possible approaches to joint implementation domestically, including the development of methods to measure and verify the achievements of the projects, and to help serve as a model for international consideration of this important tool to combat climate change. The final ground rules for the U.S. Initiative on Joint Implementation (IJI) include the following key features:

- The IJI provides a mechanism for investments by U.S. firms, to be evaluated for net greenhouse gas emission reductions.
- The IJI includes an interagency Evaluation Panel, co-chaired at senior policy levels by DOE and EPA, to certify net emission reductions and to approve projects for inclusion in the program.
- The IJI will adhere to strict criteria to

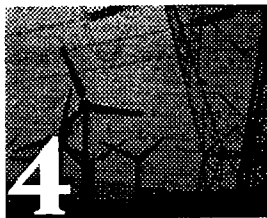


evaluate potential emission reductions in order to maximize international acceptance.

- Net emission reductions achieved as a result of projects developed under the IJI will be measured, tracked, and scored, and an accounting of the reductions will be part of the Action Plan.

The Evaluation Panel, which has formally begun its work and is now supported by a Secretariat, is in the process of developing guidelines for the day-to-day operations of the Initiative, including both application and review procedures for project proposals. The Panel will accept its first project applications by mid-November 1994, will evaluate them within ninety days, and will select the first portfolio of projects by early February 1995.

At this time, it is envisioned that the participants in the program will be given technical assistance to reduce the transaction costs associated with IJI projects. Such costs might include those involved in working with host country governments, and identifying appropriate methodologies to perform specific tasks. While the program is still in a pilot phase, IJI participants will receive public recognition for their efforts to combat global warming and contribute to sustainable development.



Ground Rules for the U.S. Initiative on Joint Implementation

Section I—Purpose

The purpose of the U.S. Initiative on Joint Implementation pilot program shall be to:

- (1) Encourage the rapid development and implementation of cooperative, mutually voluntary, cost-effective projects between U.S. and foreign partners aimed at reducing or sequestering emissions of greenhouse gases, particularly projects promoting technology cooperation with and sustainable development in developing countries and countries with economies in transition to market economies.
- (2) Promote a broad range of cooperative, mutually voluntary projects to test and evaluate methodologies for measuring, tracking, and verifying costs and benefits.
- (3) Establish an empirical basis to contribute to the formulation of international criteria for joint implementation.
- (4) Encourage private-sector investment and innovation in the development and dissemination of technologies for reducing or sequestering emissions of greenhouse gases.
- (5) Encourage participating countries to adopt more complete climate action programs, including national inventories, baselines, policies, and measures, and appropriate specific commitments.

Section II—Evaluation and Reassessment of Pilot Program

The pilot program shall be evaluated and reassessed within two years of its inception or within six months of adoption of international criteria for joint implementation by the Conference of the Parties to the United Nations Framework Convention on Climate Change, whichever is earlier.

Section III—Eligible Participants

A. Domestic

- (1) Any U.S. citizen or resident alien.
- (2) Or any company, organization, or entity incorporated under or recognized by the

laws of the United States, or group thereof.

- (3) Or any U.S. federal, state, or local government entity.

B. Foreign

- (1) Any country that has signed, ratified, or acceded to the United Nations Framework Convention on Climate Change.
- (2) Or any citizen or resident alien of a country identified in B(1) of this section.
- (3) Or any company, organization, or entity incorporated under or recognized by the laws of a country identified in B(1) of this section, or group thereof.
- (4) Or any national, provincial, state, or local government entity of a country identified in B(1) of this section.

Section IV—Evaluation Panel

A. An Evaluation Panel is hereby established.

B. The Evaluation Panel shall consist of eight members, of whom:

- (1) One shall be an employee of the U.S. Department of Energy, who shall serve as Co-Chair.
- (2) One shall be an employee of the U.S. Environmental Protection Agency, who shall serve as Co-Chair.
- (3) One shall be an employee of the U.S. Agency for International Development.
- (4) One shall be an employee of the U.S. Department of Agriculture.
- (5) One shall be an employee of the U.S. Department of Commerce.
- (6) One shall be an employee of the U.S. Department of the Interior.
- (7) One shall be an employee of the U.S. Department of State.
- (8) One shall be an employee of the U.S. Department of the Treasury.

C. The Panel shall be responsible for:

- (1) Advising and assisting prospective U.S. and foreign participants on the technical parameters (including with respect to baselines, mea-

Ground Rules for the U.S. Initiative on Joint Implementation, continued

- (1) Reviewing and tracking) of projects submitted for inclusion in the USJFJ.
- (2) Accepting project submissions from eligible U.S. participants and their foreign partners.
- (3) Reviewing and evaluating project submissions, including baseline projections.
- (4) Approving or rejecting project submissions for inclusion in the USJFJ, based on criteria contained in section V.
- (5) Providing written reasons for its decisions, which shall be made publicly available, within 90 days of receipt of a complete submission or resubmission.
- (6) Certifying emissions reduced or sequestered estimated to result from projects.
- (7) Developing operational modalities for the implementation of the Program.
- (8) Preparing an annual report of its activities, including a summary of approved projects.
- (5) Contains adequate provisions for tracking the greenhouse gas emissions reduced or sequestered as a result of the project, and on a periodic basis, for modifying such estimates and for comparing actual results with those originally projected.
- (6) Contains adequate provisions for external verification of the greenhouse gas emissions reduced or sequestered by the project.
- (7) Identifies any associated nongreenhouse gas environmental impacts/benefits.
- (8) Provides adequate assurance that greenhouse gas emissions reduced or sequestered over time will not be lost or reversed.
- (9) Provides for annual reports to the Evaluation Panel on the emissions reduced or sequestered, and on the share of such emissions attributed to each of the participants—domestic and foreign—pursuant to the terms of voluntary agreements among project par-

Section V—Criteria

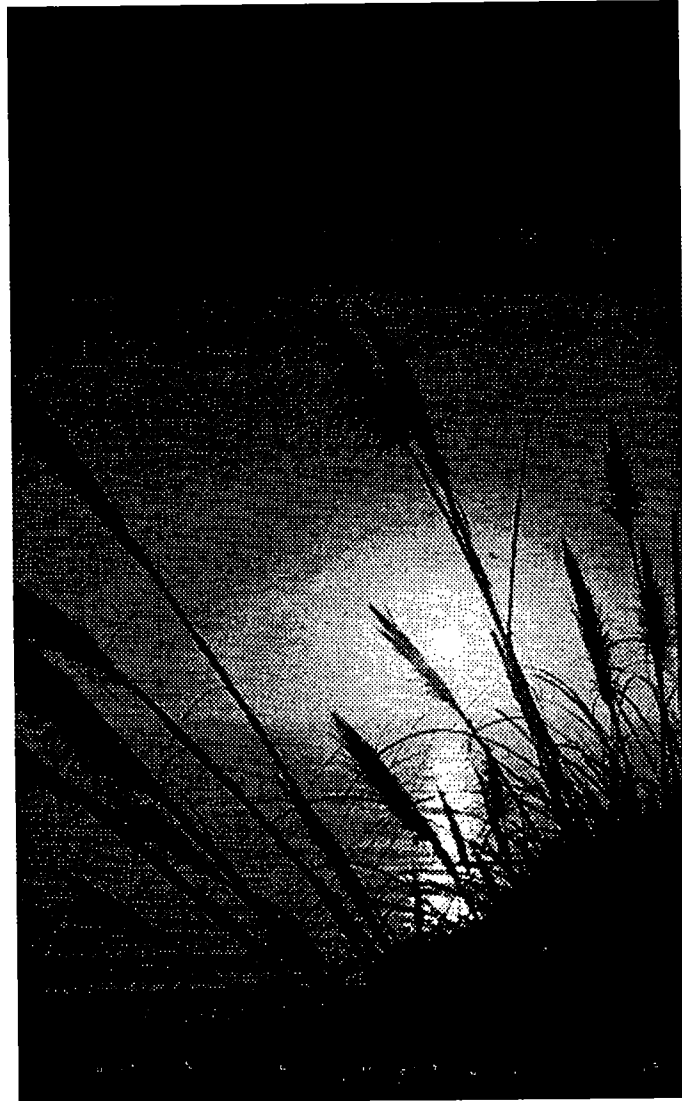
A. If a project submission is to be included in the USIII, the Evaluation Panel must find that it:

- (1) Is acceptable to the government of the host country.
- (2) Involves specific measures to reduce or sequester greenhouse gas emissions initiated as the result of the U.S. Initiative on Joint Implementation, or in reasonable anticipation thereof.
- (3) Provides data and methodological information sufficient to establish a baseline of current and future greenhouse gas emissions:
 - (a) in the absence of the specific measures referred to in A(2) of this section, and
 - (b) as the result of the specific measures referred to in A(2) of this section.
- (4) Will reduce or sequester greenhouse gas emissions beyond those referred to in A(3)(a) of this section, and if federally funded, is or will be undertaken with funds in excess of those available for such activities in fiscal year 1993.

B. In determining whether to include projects under the USIJI, the Evaluation Panel shall also consider:

- (1) The potential for the project to lead to changes in greenhouse gas emissions elsewhere.
- (2) The potential positive and negative effects of the project apart from its effect on greenhouse gas emissions reduced or sequestered.
- (3) Whether the U.S. participants are emitters of greenhouse gases within the United States and, if so, whether they are taking measures to reduce or sequester such emissions.
- (4) Whether efforts are under way within the host country to ratify or accede to the United Nations Framework Convention on Climate Change, to develop a national inventory and/or baseline of greenhouse gas emissions by sources and removals by sinks, and whether the host country is taking measures to reduce its emissions and enhance its sinks and reservoirs of greenhouse gases.

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The bulk of scientific evidence suggests that greenhouse gases emitted over the last century will eventually warm the Earth 1–2°C (1.8–3.6°F). While the Framework Convention on Climate Change can greatly affect future emissions and the magnitude and rate of additional climate change, it cannot offset all change. Both adverse and beneficial consequences of climate change are plausible, with the overall effect depending on the rate and magnitude of change and the vulnerability or sensitivity of natural and human systems to such changes. Thus, society and nature may have to adapt to rising sea levels, more variable precipitation patterns and periods of temperature extremes, changes in water supplies, disruption of ecosystems, and changes in many other climate-sensitive natural resources.

For example, sea level rise could lead to higher storm surges, increased erosion of coasts, and accelerated loss of coastal wetlands. Shifts in precipitation patterns could cause more floods, droughts, water-supply disruptions, hydropower reductions, and ground-water overdrafts, especially in the arid

impacts and
adaptation



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West. The ideal range for agricultural crop varieties and other plant species might move north as temperatures increase, and prolonged droughts could become more frequent. Forests could experience more frequent fire and diebacks driven by drought, insects, and disease. Retaining unique assemblages of plants and ani-

mals in preserves could become extremely difficult as the climate to which they are adapted effectively shifts northward or to higher elevations. And regional drying could eliminate some prairie potholes that support local wetland ecosystems and transcontinental wildlife migration.

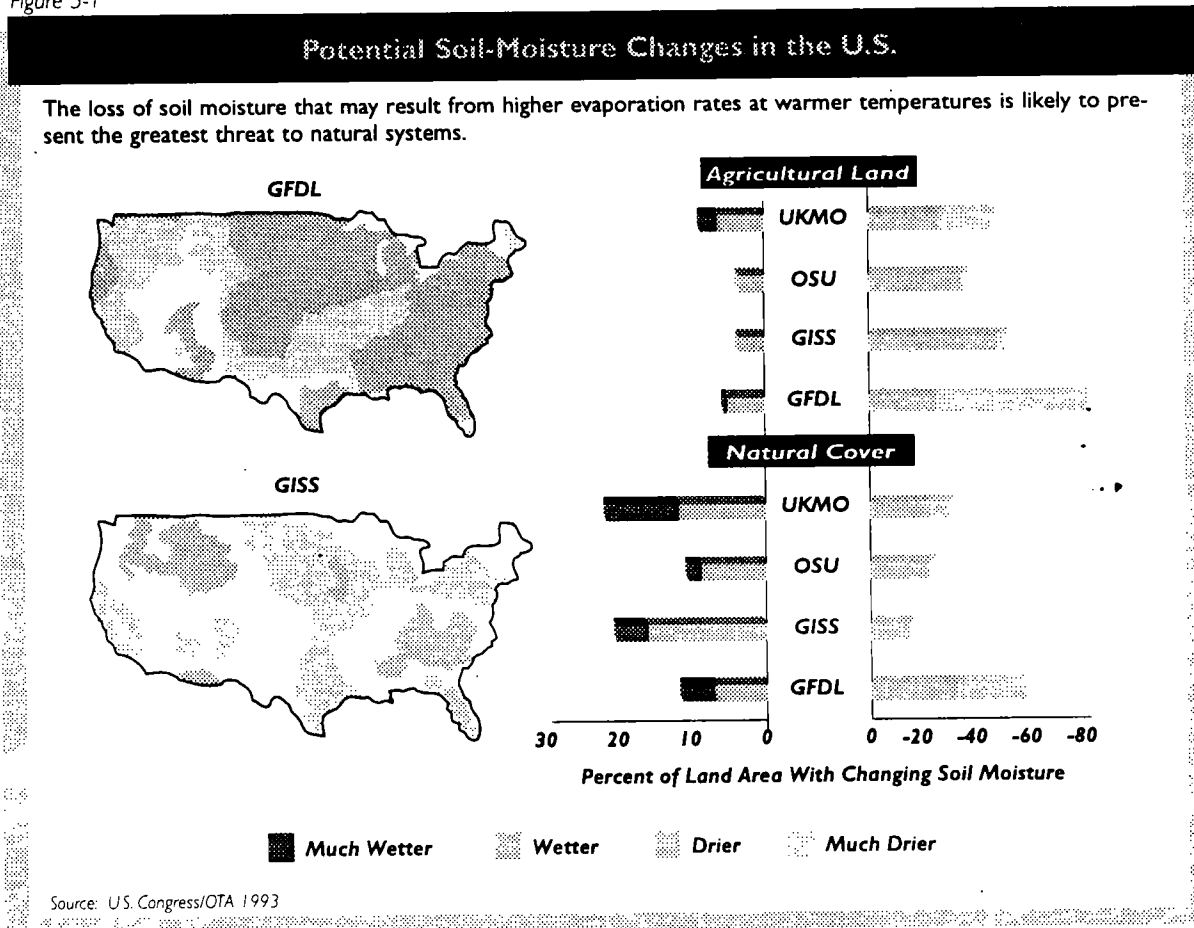


The Adaptability of Natural Systems

The loss of soil moisture that may result from higher evaporation rates at warmer temperatures is likely to present the greatest threat to the present composition and structure of natural systems. Figure 5-1 shows the areas of the United States that may undergo significant changes in soil moisture based on climate

changes projected by two global change models that assume a doubling of CO₂ emissions. The Goddard Institute for Space Studies (GISS) scenario suggests that large areas face moderate drying. However, the Geophysical Fluid Dynamics Laboratory (GFDL) scenario shows more severe drying across much of the eastern

Figure 5-1





and central United States. While there is substantial uncertainty in the models, their projections suggest that much of the nation's natural resource base may face at least moderate drying, which is likely to increase stress on current vegetation and crop varieties.

Atmospheric concentrations of carbon dioxide—the main greenhouse gas—are changing thirty to one hundred times faster than shown in ice-core records, which go back millennia. The projected rates of temperature change exceed the estimated rates for the past fifteen thousand years, which averaged about 1°C (1.8°F) per thousand years. Under a changing climate, temperatures could rise 1.5–to 4.5°C (2.7–8.1°F) within one hundred years. These changes may be too rapid to allow forest ecosystems to effectively migrate.

It is impossible to estimate with any confidence the costs to society of climate change. Estimates of the costs to the United States resulting from an average temperature increase of 2–3°C (3.6–5.4°F) range from 0.3 percent to 2.0 percent of the gross national product—corresponding to billions of dollars per year.

Adaptation can include any adjustment to altered conditions—biological, technical, institutional, regulatory, behavioral, or economic. It encompasses passive adjustments (e.g., gradual change in human behavior and tastes, or biologically driven changes in communities); deliberate reactive responses (e.g., management responses after climate change effects are observed); and anticipatory actions (e.g., planning, engineering, or regulatory responses taken in advance of observed climate change). Ongoing adaptation-related efforts in the United States fall into this last category. Most have been initiated because they will increase the nation's ability to cope with existing threats to natural resource systems,

such as those related to climate extremes and fragmentation of natural habitat.

Overall, various strategies for coping with climate change can be identified for managed natural resources, such as coastal zones, agriculture, and water resources. For these, active technological measures (such as building sea walls, fertilizing soils, applying genetic breeding techniques, or transferring water) exist to some extent today. For unmanaged natural systems, however, such technological options do not currently exist. For example, we are limited by our fundamental understanding of what maintains an ecosystem as it is, and we don't know how to transplant existing ecosystems or facilitate migration.

The Committee on Science, Engineering, and Public Policy of the National Academy of Sciences and the National Academy of Engineering and Institute of Medicine recently studied this problem and presented its findings (Table 5-1). It concluded that the sensitivity and adaptability of both human systems and natural, unmanaged ecosystems vary considerably, although they do not account for potential nonlinear changes. In industry, the Committee found that decision-making horizons and building schedules are shorter than the time frame within which most climate changes would emerge, so adaptation can occur as change occurs. The Committee categorized human migration and water resources as "sensitive to climate change" but "adaptable at some cost." Unmanaged natural ecosystems, however, respond relatively slowly, making their ability to adapt to climate change more questionable and "problematic" than that of managed cropland or timberland. The EPA report *The Potential Effects of Climate Change* similarly concluded that natural ecosystems have only limited ability to adapt rapidly to climate change, and suggested that



"managed systems may show more resilience."

U.S. Ecosystem Management Initiative

The goal of ecosystem management is to restore and maintain the health, sustainability, and biological diversity of ecosystems while supporting sustainable economies and communities. Ecosystem management is important to ameliorate today's problems as well as to help us adapt to new environmental challenges, such as global change. Many factors, such as piecemeal monitoring, incompatible data bases, a lack of research on ecosystem function, inconsistent planning and budgeting cycles, and differing agency organizational structures have hampered the development of a coordinated U.S. approach

to actively maintaining or restoring the health of ecosystems, which are the cornerstones of sustainable economies.

One of the most far-reaching environmental recommendations of Vice President Gore's National Performance Review was to develop a "proactive approach to ensuring a sustainable economy and a sustainable environment through ecosystem management." An interagency Ecosystem Management Task Force has been established to implement an ecosystem approach to environmental management. The Task Force, which consists of Assistant Secretaries from twelve federal departments and agencies, as well as representatives from several White House offices, is in a unique position to advance a consistent approach to environmental management by establishing overarching goals for all agencies,

removing barriers that frustrate more efficient, effective interagency cooperation, and learning from large-scale, ecosystem-based management efforts. One of the group's most important tasks is to examine major areas that influence the effectiveness of ecosystem management, such as the budget process, legal authorities, and information management, and to make recommendations for improvements.

The Task Force has selected eleven ecosystems for attention and

Table 5-1

Sensitivity and Adaptability of Human Activities and Natural Resources

The sensitivity and adaptability of both human systems and natural, unmanaged ecosystems vary considerably.

Human Activity and Nature	Low Sensitivity	Sensitive: Adaptation at Some Cost	Sensitive: Adaptation Problematic
Human Activities			
Industry	✓		
Health	✓		
Farming		✓	
Managed Forests and Grasslands		✓	
Tourism and Recreation		✓	
Settlement and Coastal Structures		✓	
Human Migration		✓	
Political Tranquillity		✓	
Nature			
Water Resources		✓	
Natural Landscapes			✓
Marine Ecosystems			✓

Source: NAS/NAE/IM 1992



has divided them into two categories: (1) "Survey and Assist" case studies—ecosystems where ecosystem-based activities are already ongoing, and (2) "New Initiatives" laboratories—locations where the interagency, ecosystem-based activities are not as well developed but where the development of new, integrated approaches holds great promise.

The ecosystems identified as case studies are parts of the Great Lakes, the coastal Louisiana wetlands, the South Florida ecosystem, the southern Appalachian highlands, Pacific Northwest forests, Prince William Sound, and the Anacostia River watershed in the Washington, D.C., area. The Task Force is currently assessing the ecosystem-based activities of the case study ecosystems to elicit lessons and identify opportunities to assist those efforts, and will make its initial recommendations by late 1994. The "New Initiative" laboratories will be the West Mojave Desert, Monterey Bay, and the Great Plains.

Contingency Planning

Climate change alters the baseline against which future actions are gauged. Our way of life relies on a dependable, consistent, and sustainable supply of water, food, and other things society values from natural resources. Our institutions and infrastructure presume that the past is a reasonable surrogate for the future. When designing reservoirs, for example, engineers assume historic rainfall patterns provide a good indication of the range of future patterns. A farmer plants knowing that at times weather conditions will cause a crop to fail, but—based on past climate—expects the crop will succeed in most years.

Climate change poses two potential prob-

lems for current management strategies for resources: (1) increased unpredictability resulting from changing climate averages, and (2) increased risk of surprises or large-scale losses. These, together with the "background" of increasing population, greater future demand, and growing competition for the use of scarce resources, make the need to improve the nation's ability to deal with an uncertain climate all the more important.

The goal of contingency planning is to minimize losses from natural disasters or accidents by preparing in advance to take appropriate actions. Contingency planning is important where the threat of significant losses is high in the absence of preparation and prompt response—as is the case with floods, forest fires, droughts, and hurricanes.

Our response to such events has often proven to be expensive and reactive rather than anticipatory. Almost \$4 billion in federal payments went to farmers suffering crop losses during the 1988 drought. Hurricane Hugo cost the federal government about \$1.6 billion. Hurricane Andrew topped \$2 billion in federal disaster payments, and expected damages from the Mississippi River flooding in 1993 range from \$5 billion to \$10 billion, with federal disaster payments of about \$3 billion. Climate change makes preparedness perhaps even more important than it is now. With a rising sea level, storm surges will reach property further inland, and erosion will increase, even if the frequency or intensity of extreme events remains constant.

Given the current inability to predict accurately where, when, and how much change will occur, decision makers must plan for natural and managed systems in light of considerable uncertainty. A critical first step in contingency planning is improving our understanding of these



uncertainties. Accordingly, impacts and adaptation issues are receiving increased attention within the U.S. Global Change Research Program (described in Chapter 6).

Nonetheless, uncertainty does not mean we cannot position ourselves better to cope with the broad range of impacts possible under climate change. Delaying anticipatory measures may leave the United States poorly prepared to deal with the changes that do occur and may increase the possibility of impacts that are irreversible or substantially increase the cost of adaptation. Options that can be justified for other reasons today and that can make us more flexible or

resilient to the changes posed by the threat of climate change are particularly desirable.

Floodplain Management

In response to the Mississippi floods in 1993, the President established a Floodplain Management Task Force to assess how to reduce vulnerability to damages and how to create a balance among natural and human uses of floodplains and their related watersheds that would meet the social and environmental goals of the nation. Initial recommendations promote a regional approach of avoidance, minimization, and mitigation; increased use of natural buffers,

such as wetlands, and decreased emphasis on structural solutions.

Following the flood, the first priority for federal mitigation funds was buyout of structures. The federal government bought out over four thousand structures, mostly in areas of recurring flood damage. The buyouts not only eliminated the need for future disaster relief, but in many instances also removed poor-quality, lower-value housing. The Clinton Administration's commitment to buyout measures marks the first time that this strategy has been used on such a large scale.

A report of the interagency review to the Management Task Force envisions future floodplain



EOSAT Corp. 1993, reproduced with permission

Extremes in precipitation—a possible consequence of climate change—may lead to more frequent droughts and floods. Shown here is the Mississippi River during the 1988 drought (above) and 1993 flood (below).



use in which human activity is attuned to flood cycles. Development in commonly flooded areas would be curtailed and gradually replaced with recreational areas. Critical infrastructure, such as roadways and water-treatment facilities, would be elevated, protected, or otherwise designed to withstand a flood. Larger urban areas would remain protected behind large levees, but would incur a greater proportion of expenses for maintenance.

The Committee concluded that better use of science and technology—from creating a computerized data base of flood-prone structures to developing hydrologic, hydraulic, and hydrometeorologic models—would be a part of this future vision of floodplain management. Such models would improve the government's ability to both avoid and mitigate the damage from such a natural disaster.

Predicting El Niño Events

Abnormal interannual climate variability, such as El Niño/Southern Oscillation (ENSO) events, dramatically change world weather patterns, with some areas of the world experiencing severe droughts, while others suffer from floods. The ENSO cycle is an oscillation of relatively warm and cold waters, with a variable period of two to seven years in the tropical Pacific Ocean, which causes concomitant response of the global atmosphere. The cycle influences the onset and intensity of the Asian and Indian monsoons, the frequency and severity and paths of storms in the Pacific, the viability of commercial fisheries off the coast of South America, and the occurrence of short-term regional drought and floods in many parts of the world, including the United States. The El Niño of 1986–87 is hypothesized to have been a key factor in the severe nationwide drought of 1988, which is estimated to

have cost the U.S. economy tens of billions of dollars.

Recent scientific results have demonstrated the ability to predict the onset of El Niño events and to estimate rainfall in equatorial regions one to two years in advance. These predictions are already being used with success in many tropical countries to affect decisions on crop selection, planting schedules, and water resource allocations. For example, in 1987, agricultural production in northeastern Brazil dropped by 85 percent when rainfall fell to 70 percent of the historic average. In 1992, however, agricultural production was near normal, despite a similar decrease in rainfall, because farm-management practices were adapted on the basis of the forecast.

Current global change research is directed at extending the forecasts to middle latitudes—e.g., to North America. Improved seasonal and interannual climate forecasts could result in potential annual savings to the United States of several billion dollars.

Federal Interagency Coordination: CENR

On November 23, 1993, President Clinton established the National Science and Technology Council by executive order. This cabinet-level council is the principal means for the President to coordinate science policies across the federal government and to identify clear goals.

One of the Council's nine committees is the Committee on Environment and Natural Resources. CENR aims to enhance the nation's ability to anticipate and respond to environmental change by:

- Developing a balanced, comprehensive



environmental and natural resource research and development program that provides the scientific and technical basis for national and international policymaking, including the global environmental conventions (stratospheric ozone depletion, global climate change, loss of biological diversity, and desertification).

- Strengthening research on: (1) the socioeconomic aspects of environmental changes; (2) the impacts of environmen-

tal changes on human health, ecological, and socioeconomic systems; and (3) adaptation to and mitigation of environmental changes.

- Creating an interagency organization that improves the way that the federal government plans and coordinates environmental and natural resource research and development activities.
- Developing the tools needed for policy formulation—e.g., integrated models and risk assessments.

Key Issues for the Committee on Environment and Natural Resources

The CENR has subcommittees in key environmental policy areas: global change, biodiversity and ecosystem dynamics, resource use and management, water resources and coastal and marine environments, air quality, toxic substances and solid and hazardous waste, risk of natural disasters, socioeconomic issues, and environmental technology. Each subcommittee is explicitly considering:

- *The depth of understanding of the issue.* How well do we observe, understand, and predict the physical, chemical, geological, and biological states of the natural system and how human activities are affecting it?
- *The socioeconomic driving forces of environmental change.* What are the social and economic forces that lead to anthropogenic changes in the environment? These forces include the organization and functioning of human society, population growth and migration, consumption patterns, and economic systems.
- *The impacts of environmental change.* What changes to human health, the structure and functioning of unmanaged ecosystems, and the productivity and structure of managed systems (agriculture, forestry, fisheries, energy systems, transportation, etc.) occur in response to single and multiple socioeconomic and environmental stresses?
- *Mitigation of environmental change.* What technologies can be developed to mitigate environmental change, and what research should be conducted to analyze the barriers and opportunities for the diffusion of these technologies into the marketplace, both nationally and internationally?
- *Adaptation to environmental change.* How can the United States best position itself to respond in a timely, cost-effective way to both short-term and long-term environmental changes? (This includes development of methodologies and strategies designed to adjust to the consequences of environmental change.)
- *Assessment of the state of the knowledge.* The United States will provide a mechanism to perform national assessments and to involve the U.S. scientific and technical communities in the international assessments—e.g., of ozone depletion, climate change, and biological diversity.



Many U.S. government agencies are involved in planning for response to natural disasters. Through the CENR's Subcommittee on Natural Disaster Reduction, the federal government is promoting "strategic coordination and advancement of programs and research to reduce the social, environmental, and economic costs of natural hazards among federal agencies and among the various levels of government for responding to disasters."

All the federal agencies are participating in the CENR effort. The Committee has developed a draft environmental research and development strategy across all areas, has vetted it in a public forum held by the National Academy of Sciences in February 1994, and is preparing an implementation plan to address the near-term priorities. Under the full Committee are subcommittees developing strategies and implementation plans in the areas of global change, biodiversity and ecosystem dynamics, resource use and management, water resources and coastal and marine environments, air quality, toxic substances and solid and hazardous waste, natural disasters, risk, socioeconomic effects, and environmental technologies. Each of these subcommittees is reviewing where federal dollars are being spent and how near-term priorities can be augmented despite fiscal constraints. The subcommittees are attempting to build on agency program strengths and to eliminate redundancies where they may exist. Through this effort, the full federal environmental and natural resource budget can be coordinated, and agreed-upon priority areas can be pursued efficiently.



Resource Adaptation Strategies

Using the framework described above, the United States is analyzing the vulnerabilities of key resource and ecological systems to climate change: water, coastal areas, agricultural land, forests, and lightly managed ecosystems. At the same time, it is developing strategies to facilitate the adaptation of these resources and systems to a changed climate.

Water Supplies

Water is an indispensable component of life on Earth: its abundance or scarcity is a key factor in the development of ecosystems in any given location. Human communities are dependent on water not only for consumption, but also for industry, transportation, and energy.

Vulnerability

Many factors are straining U.S. water resources and leading to increased competition among a wide variety of different uses and users of water. Human demands for water are increasingly in conflict with the needs of natural ecosystems, which has led to significant water-quality and water-quantity problems. In addition, water infrastructure in many urban areas is aging.

Climate change may heighten the competition for water in water-short areas and may affect the social and economic well-being of communi-

ties in those areas. Regions traditionally considered to be rich in water may also be directly affected by climate change because of increased demand for water for domestic and agricultural uses. Changes in precipitation and higher levels of evapotranspiration can affect surface-water and ground-water supplies, the frequency of floods and droughts, and hydropower production. Arid basins could experience the largest relative change in water flow from climate change—even small reductions in water availability could be significant. The drawing down of ground-water levels may result in land subsidence, saltwater intrusion into freshwater aquifers, and the loss of surface-water systems and associated wetlands. Reduced surface flow may impede or even render unviable current transportation routes and waste-disposal practices.

Numerous studies have been conducted on the relative vulnerability of the major U.S. river basins to flooding and drought, supply disruptions, hydropower reductions, ground-water overdrafts, and extreme events. They conclude that the water-resource regions most vulnerable to some or all of these events are the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande, and Lower Colorado (Figure 5-2).

Adaptation Strategies

Many institutional arrangements for manag-

ing and allocating water resources have evolved over the past 150 years as agricultural, hydropower, and industrial development supported an expanding economy. Policies were developed for managing potential water scarcity, and the industrial, hydroelectric, and agricultural sectors greatly increased the efficiency of their use of water, while meeting several external environmental needs as well. Primary among the water-resource use issues is the realignment of

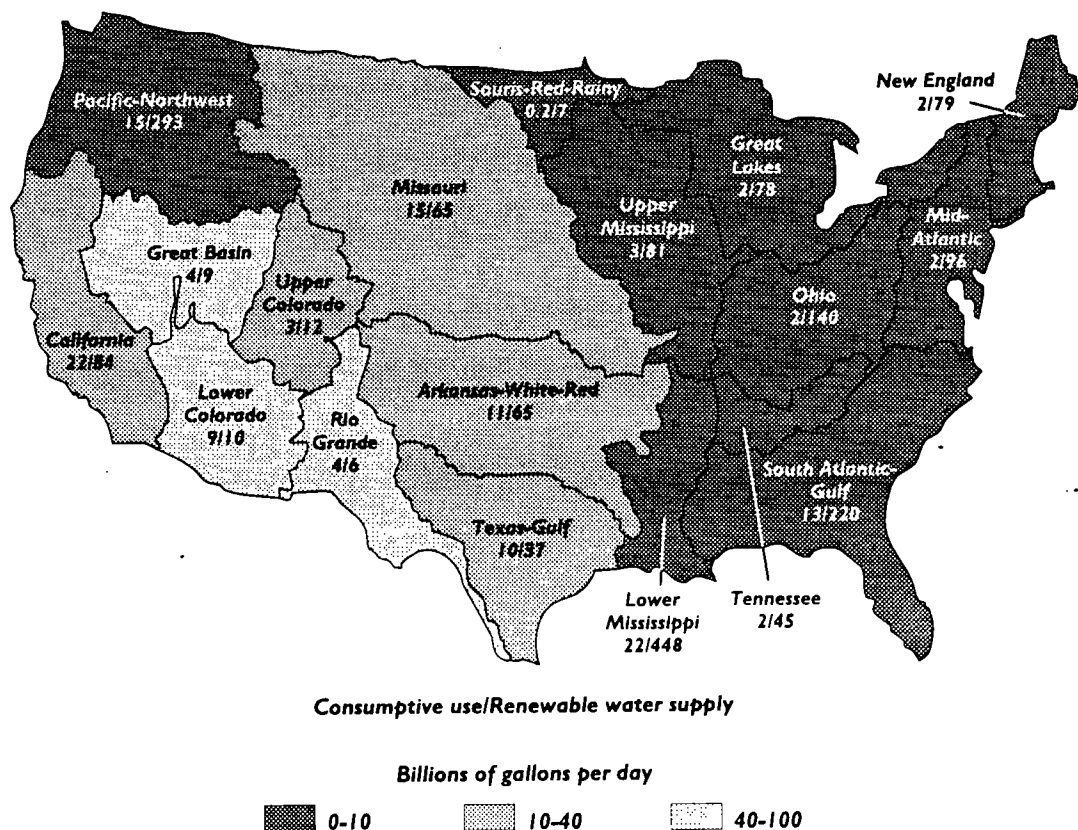
incentives to conserve water as more efficient delivery and use systems are developed.

Many of the existing predictive tools (climate, watershed, and aquatic/ecosystem models) are not yet sufficiently developed to predict potential water shortages or potential system responses to them. Virtually all techniques of hydrologic analysis are based on the assumption of an unchanging climate. Water-resource managers require improved methods for assessing the

Figure 5-2

Water Withdrawals and Consumption in the Conterminous U.S.

The U.S. water-resource regions most vulnerable to climate change are the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande, and Lower Colorado.



Source: Solley, Pierce, and Perlman 1993



sensitivity of the systems they manage to seasonal and longer-term variations in weather and climate. Equally important is the ongoing development of methods for evaluating the risk or uncertainty associated with such assessments.

The federal government is attempting to facilitate adaptation of its water resources to climate change by building ever-improving capabilities for predicting supplies of and demand for water resources and the effects of climate change on them. Comprehensive aquatic/ecosystem models are just now being developed. Improved understanding will help private and public decision makers as they consider management and policy alternatives to protect and enhance water supplies and associated ecosystems, to encourage pollution prevention and cleanup, and to guard against water hazards.

To facilitate adaptation to changes in water resources caused by climate change, the federal government, in cooperation with state and local agencies, is focusing on encouraging five types of activity: improving demand management through conservation and market-oriented pricing; improving supply management (by improving coordination, jointly managing ground- and surface-water supplies, and improving the management of reservoirs and reservoir systems); facilitating water marketing and related types of water transfers; improving planning for floods and droughts; and promoting the use of new analytical tools that enable more efficient operations.

The following first steps toward improving water-resource planning and management both help relieve existing stresses and make sense for climate change.

Development of New Analytical Tools. Further development, dissemination, and use of new modeling and forecasting tools will greatly

enhance water-resource management. Joint research projects between federal agencies and private industry related to the creation of a new generation of technologies for developing river basin models have just been initiated, and new models are expected to be used in the arid West within five years.

Adoption of Demand-Management and Water-Conservation Practices. The Energy Policy Act of 1992 requires each federal agency to implement by 2005 all water-conservation measures that have a payback period of ten years or less. Proposed legislative changes being considered in the reauthorization of the Clean Water Act will enable the states to improve their water use, primarily by ensuring that private ownership of water resources carries with it incentives toward wise use.

Basinwide Management of Reservoirs. Pilot programs are under way in the Tennessee Valley Authority and the upper Colorado River system to operate reservoirs within the same basin as a single system, rather than individually. The objective is to greatly improve the efficiency and flexibility of water quantity and quality.

Improved Information and Models. The CENR is coordinating programs to determine the impact of climate change on water resources. Studies are aimed at developing a capability to predict the hydrometeorological and water-resource responses to climate variability and change across the range of environmental conditions existing in the United States. This involves integrating meteorological and climate factors with stream-flow, ground-water recharge, and sea level changes. Additional studies emphasize understanding the hydrologic processes and the interactions among snow accumulation and melt, soil moisture and freezing, distribution of precipitation, evapotranspiration, ground-water



recharge, and stream-flow management. The U.S. Army Corps of Engineers has begun a study of decision making about water resources, given the uncertainty of climate change.

Coastal Zones

The U.S. coastal zone includes 9,000 square kilometers (15,000 square miles) of coastal wetlands, 1,500 square kilometers (2,500 square miles) of developed barrier islands, and 4,800 square kilometers (8,000 square miles) of dry mainland areas within one meter (3.28 feet) of mean high water. Traditional farming and fishing areas are already under assault from increased development and water pollution. The wetlands provide habitat for numerous species of birds, are a nursery ground for many commercial fish and shellfish, and play a vital role in extracting nutrients and toxic chemicals from water. The developed barrier islands are primarily recreational communities. Although the mainland areas include some cities, they are mostly farms and forests. All of the lowlands are threatened by a rise in sea level; estuaries are also threatened by potential hydrologic changes.

Vulnerability

Population growth in U.S. coastal regions is more rapid than anywhere else in the country. At present, more than 50 percent of the population lives within 80 kilometers (133 miles) of an ocean or Great Lake. This growth and increased use of the coastal zone are stressing coastal systems and place them at particular risk of several potential climate change impacts.

Coastal land (including buildings, transportation infrastructure, and recreational and agricultural areas) is vulnerable to inundation and increased erosion as a result of sea level rise.

Heightened storm surge could increase the rate of erosion. The highest-risk areas are those currently experiencing rapid erosion rates and with very low relief, such as the southeastern United States and the Gulf Coast. Because most recreational beaches in developed areas are less than 50 meters (164 feet) wide, they would be completely lost from under the "low" IPCC sea level rise scenario. The 50-centimeter (20-inch) rise, which recent studies suggest is more likely, would inundate 1,320–3,660 square kilometers (2,200–6,100 square miles) of dry land and could necessitate spending \$50–\$200 billion for coastal protection. Coastal systems would also be highly vulnerable to the increased occurrence of hurricanes, as well as to increased or decreased freshwater and sediment flux from river systems.

Coastal wetlands are already eroding in most states, particularly Louisiana and Maryland. They require a delicate balance of fresh and salt water and are particularly vulnerable to inundation and erosion as a result of sea level rise. Coastal wetlands are also vulnerable to decreased flux of fresh water and sediment if upstream areas become more arid. Wetlands naturally migrate as land subsides and sediment supply changes, but migration has been limited in several areas by the encroachment of urban areas with sea walls and other protective structures. In addition, the possible rate of sea level rise predicted by some climate change models is more rapid than the natural rate of wetland migration. A 50-centimeter (19.7-inch) rise by 2100 would inundate or erode 20–45 percent of U.S. coastal wetlands.

Fragile systems, such as coral reefs, are highly susceptible to temperature increases. Reefs in many parts of the world have undergone episodes of bleaching (particularly in the 1980s),



apparently as a result of local surface temperature increases. Some of these episodes appear to be associated with the El Niño effect. Fisheries in estuaries and the coastal ocean are also vulnerable to changes in water temperature and freshwater inflow. The loss of coastal wetlands has already been implicated in the decline of shrimp harvests in Louisiana, and would also be likely to reduce yields of crab and menhaden. In the open ocean, increased temperatures could result in the migration of certain species. In estuaries, decreased freshwater inflow could result in increased salinity and, in turn, a replacement of some freshwater species by saltwater species. Increased salinity has already contributed to the decline of oyster harvests in Delaware and Chesapeake Bays.

Adaptation Strategies

Adaptation approaches in coastal regions include two strategies. The first is to gain a better understanding of the coastal ecosystems at risk to climate change to be able to anticipate the magnitude of impacts from the change. This includes determining (1) the flexibility of wetlands or coastal systems, to enable them to modify or move under changing climate conditions, and (2) the robustness of systems to accommodate a greater range of conditions. Coastal barriers and low-lying coastal regions are susceptible to increased erosion and damage from major storms. Adaptation can be facilitated by identifying areas at high risk, improving understanding of the processes that build and erode shorelines, and developing integrated coastal ocean-prediction systems.

The second strategy is to take these concerns into account in the integrated coastal resource management programs at the various governmental levels to take precautionary mea-

sures that will minimize the potential damage caused by climate change. The Federal Coastal Zone Management Act was amended in 1990 to require states to consider in their programs the problems of climate change and sea level rise. Many states have already taken considerable measures to ensure that growth in the coastal zones and the potential loss of resources will be planned for and managed accordingly. Examples include specific policies addressing sea level rise, setback zones, standards for infrastructure development, research, and education.

In highly urbanized and high-use recreational areas, coastal beaches are nourished with imported sand and are protected by structures. A better understanding of the effectiveness of various beach nourishment and protection methods is needed. Improved planning for catastrophic events, improved building codes in high-risk coastal regions, widespread public education about the risks of living in coastal zones, and limiting certain kinds of development in high-risk zones are additional adaptation strategies. In the San Francisco Bay area, for example, regulations passed in response to projections of sea level rise now require additional elevation on newly reclaimed land.

Coastal wetlands naturally migrate in response to changes in sediment supply and relative sea level. It is unknown if the rate at which wetlands can naturally migrate is sufficient for the possible rates of sea level rise that would accompany climate change. Establishing locations for wetlands to migrate to by expanding reserves and protected areas adjacent to current coastal wetlands can facilitate adaptation. Maine explicitly requires that development will be removed to allow the landward migration of coastal wetlands in dune areas, and a few states recognize "rolling easements" along ocean shores



to permit natural dune systems to migrate inland. Other states have decided that protecting private property from erosion has a higher priority than allowing wetlands to migrate and have guaranteed landowners the right to erect a bulkhead.

Creation or restoration of wetlands is another adaptive strategy, which requires the development of effective methods for restoring coastal wetlands and for measuring the effectiveness of those restoration efforts.

CENR is currently coordinating several wetland activities—including studies of recent changes in wetland systems along the eastern Gulf of Mexico and southern Atlantic coasts, and studies of changes documented in the Mississippi Delta—which should establish credible limits on the ability of coastal wetlands to adapt to sea level rise by vertical growth. Other CENR research related to the vulnerability and adaptation of coastal systems includes space-based geodesy studies to distinguish the long-term trends in sea level change due to glacial melting and ocean expansion from effects of post-glacial rebound and active tectonics; studies that test existing geological models of coastal erosion processes; and studies of the frequency, magnitude, and tracks of storms. In addition, the U.S. Global Change Research Program is developing and validating methodologies for estimating the effects of global climate change on regional fishery resources, and is examining the reproductive dynamics of the sardine, anchovy, and mackerel stocks off the coasts of California, Chile, Spain, and West Africa.

The United States is developing a Coral Reef Initiative. This effort promotes the conservation and sustainable use of coral reefs and related ecosystems (mangroves and sea-grass beds), both within the United States and

throughout the world. The initiative will attempt to integrate the research, assessment, monitoring, and management of reef ecosystems through better coordination of existing activities and the creation of new programs. Among other activities, this program would focus on developing a better understanding of how reef ecosystems are affected by global climate change.

Agricultural Land

Agriculture in the United States is an intensively managed, market-based activity. Throughout the world, agriculture has adapted continuously to the risks associated with normal climate variability, just as it has adapted to changes in economic conditions. For example, the American agricultural sector continues to respond to new technologies, new environmental regulations, and changes in population and market demands. Market forces continue to be the principal catalyst for rewarding and encouraging rapid adaptation, and the domestic agricultural sector—which is already well attuned to these forces—is expected to be able to adapt to climate change.

Vulnerability

The possible effects of climate change on agriculture are difficult to predict. Agricultural productivity is likely to be affected worldwide, which would lead to alterations in both national and multinational regions, redistributing agricultural activities and changing farming intensity. In the United States, the range over which major U.S. crops are planted could eventually shift hundreds of miles to the north. For American farmers, who are already facing increasingly competitive and growing world markets, any relative change in regional productivity compared



with the rest of the world would mean market-driven incentives to adapt to the changes. Some individual farmers might benefit through locally improved yields or higher prices, while others might suffer because of relatively severe local climate changes requiring significant economic investment to adjust farming systems. Rapid geographical shifts in the agricultural land base, brought about by very rapid climate changes, could disrupt rural communities and their associated infrastructures. Shifts in climate can also be expected to shift the distribution and extent of many agricultural pests and pathogens, which could also influence changes in regional productivity.

Adaptation Strategies

Climate change adds to the importance of government efforts to improve the knowledge and skills of farmers, to remove impediments to farmers' ability to adapt and innovate, and to expand the array of options available to farmers. Efforts to increase the diversity of crops and of farm technologies ensure against a future in which existing crop varieties or farming systems cannot cope with change. Similarly, efforts to speed the rate at which appropriate farming systems can be adopted lower the potentially high financial and human costs of adjusting to climate change.

The opportunities for adjusting to climate change are numerous. Oversubscribed water demands will limit the potential for compensating adjustments in certain regions, however. The uncertainty of climate change makes effective response difficult to project, as does lack of experience and knowledge about alternative crops and agricultural practices suitable for rapid adaptation to such changes. The decline in the federal government's support for agricultural

research and for technology development, demonstration, and education will require refocusing existing resources to meet projected needs to enhance adaptability.

Certain agricultural programs may increase the costs associated with a changing climate. Because the commodity programs link support payment to maintaining production of a particular crop, such support programs could inadvertently discourage farmers from making the necessary switch to other crops. Disaster-assistance programs will become increasingly costly under a harsher climate and, if not well designed, may tend to reduce the incentive for farmers to take appropriate precautionary actions to reduce their exposure to climate risks. In contrast, water-resource planning and changes to state and regional laws regarding the marketing of conserved water are already enhancing incentives for efficient use of scarce water resources in agriculture.

The U.S. Congress is beginning to evaluate agriculture's future needs as it starts the process of revising the U.S. omnibus farm bill, which occurs every five years. Congress is expected to consider modifying commodity-support programs, which have traditionally focused on individual commodities. One approach would be to develop greater flexibility in crop support within any farm unit, enabling more rapid adaptation to the most efficient farming systems accommodating environmental changes.

The most pressing tasks that the federal government is currently undertaking with regard to agriculture and climate change are:

- Improving technology and information transfer to farmers in order to speed adaptation and innovation through the development of a nationwide telecommunications system.

- Strengthening research, development, and pilot programs for computerized farm- and ranch-management systems.
- Supporting research and technology that will ensure that the agricultural sector can deal successfully with the various challenges of the next century, through the continuing development of new crops and crop varieties to meet the needs of farmers due to changes in soil, water, pest, climate, and processor requirements.

A wide range of U.S. agricultural research programs can support adaptation to climate change. Ongoing programs include the development of salt-tolerant crop varieties, strengthening of the plant germplasm repositories and long-term germplasm storage, the plant genome mapping program, and biological engineering research in pest resistance. The potential for a fertilization effect from enhanced CO₂ is also being examined under conditions of low and high nutrient availability. Further, The U.S. Global Change Research Program is developing research on management tools for responding to the potentially undesirable effects of climate change on agricultural productivity domestically and worldwide. These research tools include methods for aggregating plant-scale models to predict regional-scale effects. Current research programs also focus on the needs of production systems, long- and short-term storage and post-harvest protection systems, food safety and quality, processing technologies, transportation technologies, and market systems.

An "Integrated Farm Management System" that will provide for the development and broader use of technologies is under way, with significant potential to enhance farming efficiency and to increase the flexibility with which farmers can

respond to climate change.

Forests

Forests cover roughly one-third of the U.S. land area, shaping much of the natural and urban environment and providing the basis for a substantial forest products industry. These forests are enormously variable, ranging from the complex juniper forests of the arid interior West to the humid and highly productive forests of the coastal Pacific Northwest and the Southeast. Besides being the source of one of the nation's most important agricultural crops—timber, the nation's forests provide essential fish and wildlife habitat, livestock forage, watershed protection, attractive vistas, and an array of recreational opportunities.

Vulnerability

Climate change will present a wide array of adaptation challenges for forests, particularly forests that are not intensively managed for timber or pulp production. At the very extreme, within a century, climate change might shift the optimum growing range for some North American forest species more than three hundred miles to the north (Figure 5-3). Such a shift would almost certainly exceed the ability of less intensively managed forests to migrate. Forest species stranded outside their optimum climate range could suffer from declining growth rates and increased mortality from climate-related stresses, such as insects, disease, and fires. Some forests may rotate rapidly through a change in dominant canopy species, similar to the change that took place when the American chestnut was removed from the forest canopy in the 1920s. Certain species and unique populations would most likely become isolated if climate change is



too rapid, and may become rare or extinct. In many cases, adaptation—or ecosystem resilience—will depend on the availability of a wide genepool within the species.

The most vulnerable forest resources are in those regions where moisture stress may increase significantly, as in the already arid continental interior. Forests on coastal margins may also be at risk—from rising sea levels with the threat of flooding and saltwater intrusion, or from increases in damaging cyclonic storm events. Forest communities with small or highly fragmented ranges may be lost, such as those at the upper elevations of mountains with no clearly discernible migration routes. While evidence of survival of pockets of temperate species throughout previous ice ages indicates that relic communities may survive radical climate change, models are not sufficiently sophisticated to enable scientists to predict such events. Forests in locations already subject to droughts, fire, and

wind damage will be highly vulnerable to rapid depopulation or change in species composition and structure if the frequency or intensity of these stressors is increased.

Adaptation Strategies

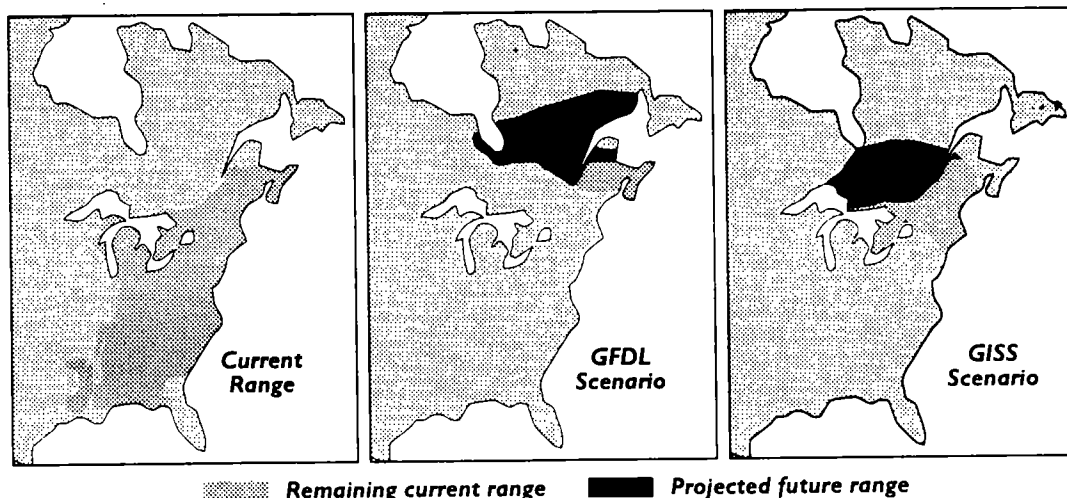
Government intervention to facilitate adaptation may be impractical or limited. Even timber-industry forests are not intensively managed by the standards of annual agricultural crops. Furthermore, on large areas of public forest lands, such as wilderness areas, even a minimal management response may itself be viewed as incompatible with the goals for which the forest is held. The challenge is to find unobtrusive and cost-effective means to ensure that the health and primary services of U.S. forest resources will not be severely eroded under a changed climate.

The federal government is considering several programs that will enable U.S. forests to respond to long-term climate changes. Research

Figure 5-3

Current and Projected Ranges of Beech Trees in the U.S.

At the very extreme, within a century, climate change may shift the optimum growing range for some North American forest species more than three hundred miles to the north.



Source: Adapted from Davis and Zabinsky 1992



focusing on the development of high-quality forest product species continues to develop suites of varieties adapted to greater levels of stress, both in the intermountain West as well as the Southeast. Studies are under way to determine how atmospheric deposition affects tree growth and how to increase the U.S. carbon sink. Improved technologies for managing forest pests are being developed, and forest seed banks and tree nurseries are being expanded to meet a growing demand for trees for planting on marginal cropland or thinned forest stands. This expanding research will enable species more adapted to projected harsher environmental conditions to be propagated and planted as needs arise. The economic impacts of climate change scenarios on forest inventories in the southern United States are also being modeled under the U.S. Research Program.

“Lightly Managed” Ecosystems

Ecosystems are structurally and functionally interrelated groups of living things and their physical environment. Effective ecosystem management recognizes the importance of understanding how each of the living and nonliving parts of an ecosystem contributes to, and is affected by, the health of the whole system and how the system responds to stress. Lightly managed ecosystems are those natural systems with little or no management. They include wilderness areas, preserves, wetlands, some coastal systems, alpine tundra, and some economically marginal forests.

Vulnerability

Ecosystems are always changing and would continue to do so without climate change. Many natural systems, however, are already degraded

by pollution and geographic fragmentation. Changes in the availability and quality of surface and ground water, and changes in atmospheric deposition, may further stress ecosystem function and limit productivity. Natural areas are being effectively dissected into smaller and smaller parts, which leaves them more vulnerable to other stresses that could degrade habitat quality, ecosystem health, and species mobility.

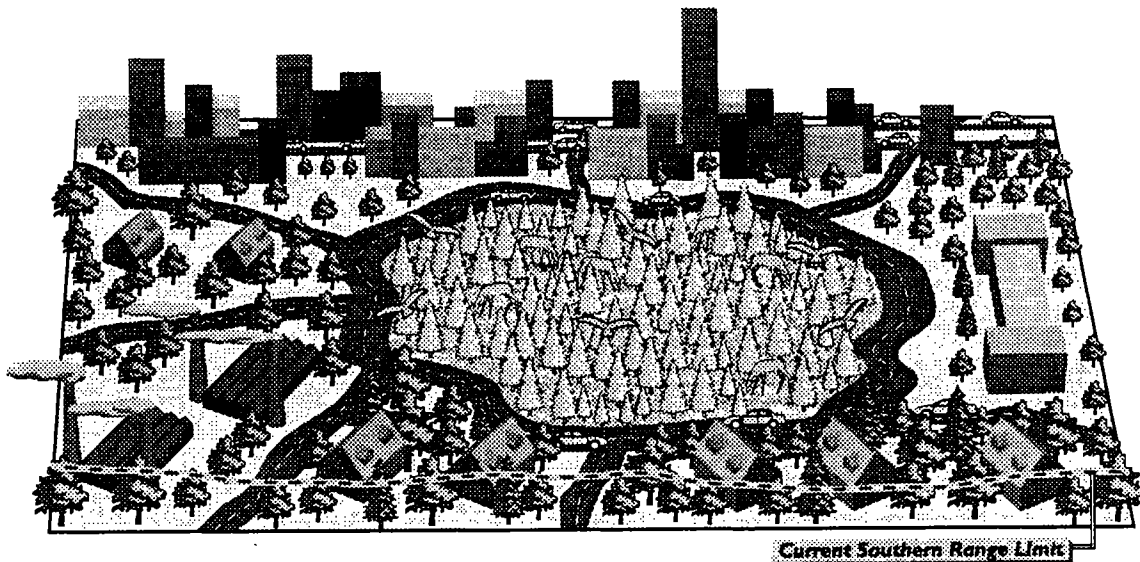
Federally protected natural areas have become repositories for some of the nation's rarest species and play a role in conserving in-situ biological diversity. However, these areas are subject to increased stress from activities that occur both within and outside their boundaries. Certain general characteristics of lightly managed ecosystems—such as being small, isolated, fragmented, or already under considerable stress, and containing sensitive species or ecosystems—make them extremely vulnerable to climate change.

Climate change could realign the environmental boundaries that have shaped existing natural areas, while the boundaries that define the management and degree of protection for these areas will remain fixed (Figure 5-4). As a result, the biological makeup of the protected natural areas will change. Some natural areas may become incapable of providing the benefits or serving the functions for which they were originally established, such as maintaining their unique or distinctive character, providing protection for rare species and other biological resources, and maintaining the quality and availability of other services, such as nature study or certain kinds of recreation. For example, climate change could lead to shifts in climate zones that may exceed the ability of flora and fauna to adapt through migration. Potential climate change impacts on forests and terrestrial vegeta-

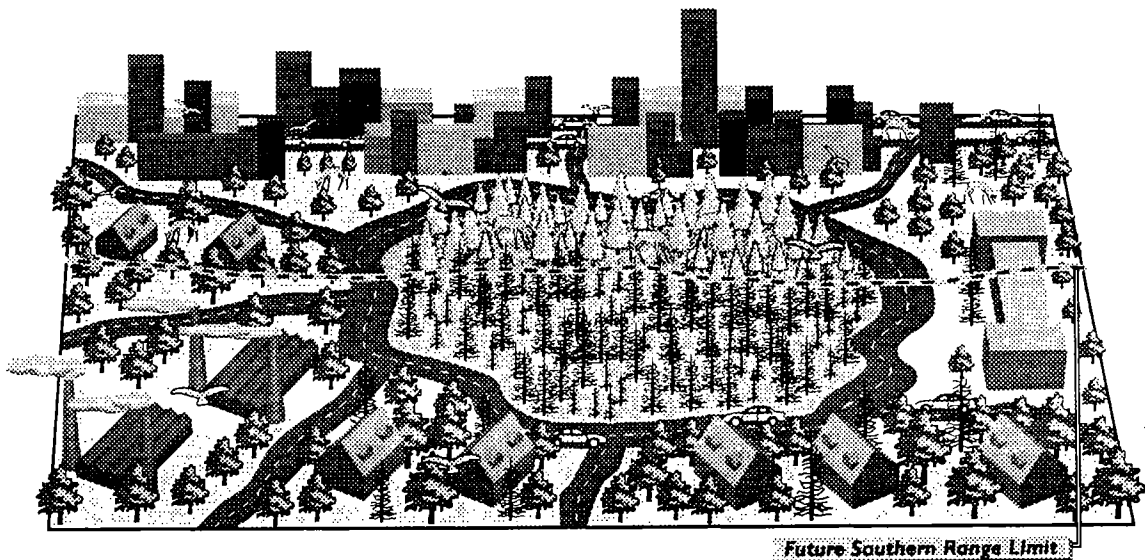
Figure 5-4

Vulnerability of Ecosystem Preserves to Climate Change

Climate change could realign the environmental boundaries that have shaped existing natural areas, while the boundaries that define the management and degree of protection for these areas will remain fixed.



As a result, some natural areas may become incapable of providing the benefits or serving the functions for which they were originally established, and isolated species may find themselves in climate zones no longer suitable for their survival.



Source: Adapted from U.S. Congress/OTA 1993

tion include migration of vegetation, geographical change in inhabited range, and altered ecosystem composition.

Potential climate change impacts on species include loss or changes in composition or structure of diversity, migration of species, and rise in dominance of new species. If climate change accelerates habitat change or proceeds so quickly that some species cannot adapt quickly enough, the rate of extinction of species may rise, and overall biodiversity may decline. Isolated species may find themselves in climate zones no longer suitable for their survival.

Adaptation Strategies

The ability of humans to adapt the composition and structure of species diversity to climate change is currently limited. Little information exists about the probable timing, rate, or geographical extent of climate change. Likewise, there is limited understanding about which species are most sensitive to climate change, which could be saved, how to recreate habitats or entire ecosystems elsewhere, and what lands will be most valuable as preserves under varying climate change scenarios. Despite the recent removal of the American bald eagle from the Endangered Species list, much remains to be learned about restoring species and their natural habitat.

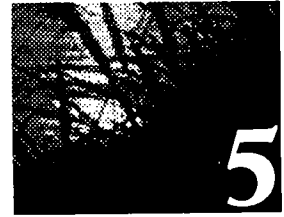
The U.S. government is involved in several efforts to facilitate adaptations to climate change in natural areas, by coordinating information gathering (including research, inventory, and monitoring options) and by evaluating management measures. Two CENR subcommittees (Biodiversity and Ecosystem Dynamics, and Resource Use and Management) will coordinate research on species sensitivity to climate change, restoration and translocation ecology, the design

and effectiveness of migratory corridors or protective buffer zones, the development of ecological models, and the effect of elevated CO₂ concentrations on plants and animals. Under the U.S. Global Change Research Program, contributing research on the adaptation of natural ecosystems to global change includes forest health monitoring, studies on threatened, endangered, and sensitive species, and research into the physiological basis of resistance to drought, ultraviolet radiation, and other stresses.

The United States, through the U.S. Man and the Biosphere Program, is also assisting in the development of the Biosphere Reserve Integrated Monitoring Network in Europe and North America. This pilot program establishes electronic linkages among the 170 biosphere reserves in Europe and North America for monitoring biodiversity and global change. If this pilot program is successful, it will be expanded to other biosphere reserves throughout the world.

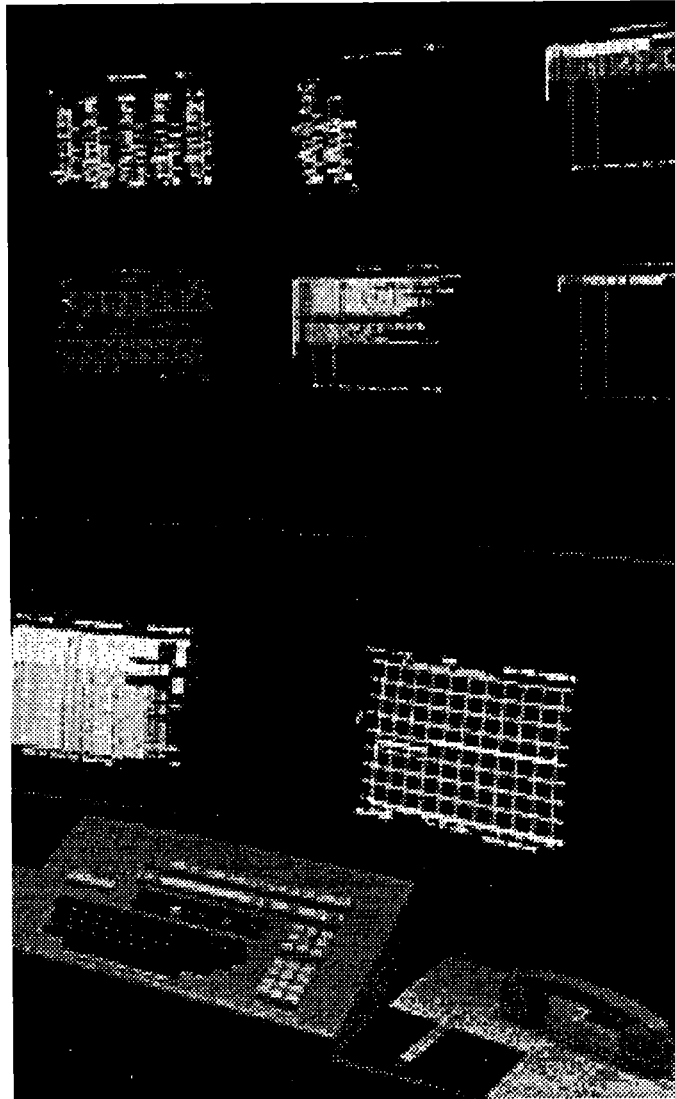
In addition, federal agencies are developing programs to fill key gaps in the understanding of ecosystem functions and how they may be protected, restored, and enhanced. The South Florida Initiative exemplifies this approach. In addition, the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program is (1) estimating the current condition of U.S. ecological resources, (2) monitoring indicators of pollutant exposure and habitat, and (3) providing ecological status and trends reports to managers and the public. The U.S. Fish and Wildlife Service's Gap Analysis Project aims to preclude species extinctions by promoting protection of species-rich areas and unprotected vegetation types before they are threatened.

The National Science Foundation is conducting a Long-Term Ecological Research



Program that focuses on seventeen sites and five core research categories: primary productivity, nutrient cycling, site disturbance, population distribution, and organic matter accumulation. The spatial and temporal scales of these processes—decades to centuries—make this program's activities especially important for climate change and adaptation-related research.

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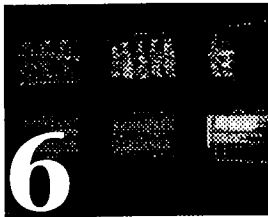


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Key to successfully mitigating and adapting to climate change is a better understanding of the global climate system and the deleterious impacts human activities have on it. Besides requiring further study of the magnitude, timing, and regional and local impacts of climate change, acquiring this understanding also involves substantial additional research on and dissemination of information to enable society to better prevent or—as some change is unavoidable—to accommodate climate change. In short, it calls for programs in both research and public education.

The United States has several programs that address these needs. The U.S. Global Change Research Program is a nationally integrated effort that seeks to expand our knowledge of the processes that affect climate change and to develop integrated models to predict these effects. The U.S. initiative, the largest climate change research program in the world, not only supports a domestic effort, but also is linked to numerous international organizations and global research and assessment programs. In addition to its focus on basic science, in an effort to understand and monitor changes in the climate system, the

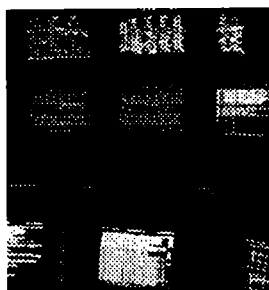
**research and
public education**



United States is promoting research in all economic sectors—including industry, transportation, housing, and agriculture—to develop strategies to reduce greenhouse gas emissions.

Ultimately, of course, the public is the true arbiter of national response strategies and policies. Thus, the public must have a solid understanding of global change science, particularly the consequences of policy options. To promote

this understanding, the United States has programs for general education, communication, and dissemination of climate change information. These activities are coordinated broadly under the U.S. Research Program, with the key agencies involved with climate change each having outreach programs, many of which now are being extended from a purely domestic focus to include international activities.



The U.S. Global Change Research Program

Scientists and governments around the world agree that continuing anthropogenic emissions of carbon dioxide, methane, chlorofluorocarbons, and other greenhouse gases are expected to lead to significant global warming, shifts in precipitation patterns, and rising sea levels. However, uncertainties remain in quantifying the magnitude, timing, and regional patterns of climate change, and the implications for socioeconomic and ecological systems. Despite these uncertainties, the United States has responded to the concern over climate change through negotiating, signing, and ratifying the Framework Convention on Climate Change, developing the 1993 *Climate Change Action Plan* to reduce the nation's emissions to their 1990 levels by the year 2000, and increasing and reorienting aid to developing countries to fund the transfer of energy-efficient technologies. To better predict and assess the magnitude, timing, and regional patterns of climate change, the

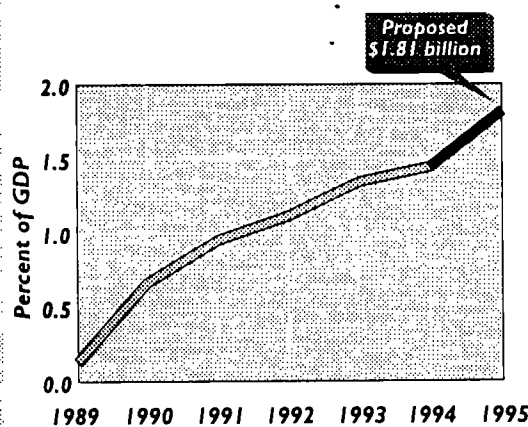
United States supports a major research program in global change, funded at \$1.4 billion in Fiscal Year 1994, with a proposed budget of \$1.8 billion for Fiscal Year 1995 (Figure 6-1).

The U.S. Global Change Research Program makes a major scientific contribution to international research and assessment efforts. Funding for research conducted through this program has accounted for almost half of that spent worldwide on global change research to date. Climate change assessments coordinated by the Intergovernmental Panel on Climate Change (IPCC)—which draws upon hundreds of scientists from more than fifty countries—not only have provided information requested by governments, but also have served to identify components of the climate change issue that deserve priority attention from the international research community. Participation of U.S. scientists as lead and contributing authors in IPCC assessments is particularly strong

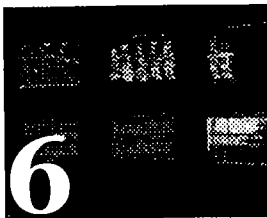
Figure 6-1

U.S. Research Program Budget

As a reflection of its importance to the policy-making process, the budget for the U.S. Research Program has increased steadily since 1990.



Source: NSTC 1994



because of the many activities supported by the U.S. Research Program. The Research Program also supports the Secretariat for IPCC Working Group II, which is coordinating the development of an assessment on the impacts, adaptation, and mitigation of global change, due in 1995.

The United States has been conducting research into global change issues for many years. By adopting the Global Change Research Act in 1990, the U.S. Congress established the U.S. Global Change Research Program to combine and coordinate the global change research and policy development interests of all U.S. departments and agencies. The Research Program is coordinated through the National Science and Technology Council's Committee on Environment and Natural Resources. The Council is chaired by the President.

In accordance with its importance to the policymaking process, the budget for the Research Program has increased steadily since 1990 (Figure 6-1). These funds support a wide range of policy-relevant research programs that provide scientific insight into the causes and effects of changes in the Earth system—especially those related to human activities—and the evaluation of options for responding to such changes.

The Research Program focuses on trace atmospheric species and their effects on climate, the role of terrestrial and marine ecosystems in climate change and the impacts of climate change on these ecosystems, the socioeconomic and policy implications of climate change, and potential responses to and mitigation of climate change. As the depth of our understanding of these systems and their feedbacks grows, the research results will provide increasingly valuable input to support national and international

policy responses to system changes, and to evaluate the impacts and effectiveness of those responses.

Atmospheric Constituents Important to Climate Change

While human activities have long influenced a community's local environment, over the past few decades observations of increasing concentrations of greenhouse gases and aerosols in the atmosphere have shown that human activities are significantly influencing the global environment. Reconstructions of past climate change, analyses of volcanically induced changes in recent years, and theoretical models suggest that the changes in atmospheric composition will lead to global warming. The measured rise in global temperatures, however, is less than and different in timing from the rise expected from greenhouse gas increases alone, suggesting the additional influence of sulfate aerosols, ozone depletion, and other factors. These complexities emphasize the importance of understanding all human influences, as well as the natural variations that may be either offsetting or enhancing the warming that is expected from greenhouse gases in both the short and the long terms.

The Research Program's work on radiative trace species that influence climate focuses on: (1) the growth rates of the common greenhouse gases and why they are changing; (2) the global warming potentials (GWPs) of greenhouse gases, with particular emphasis on the GWPs of the proposed substitutes for ozone-depleting substances; (3) the climate role of "emerging" greenhouse gases, such as perfluorocarbons; (4) the abundance, trends, variability, chemistry, and role of tropospheric ozone in the climate system, including the impacts of the ozone precursors

(e.g., carbon monoxide, hydrocarbons, and reactive nitrogen species); (5) the impact of lower stratospheric ozone depletion on the climate system; and (6) the effect of human-induced aerosols on offsetting and masking the warming trend of greenhouse gases. Recent findings from this research have led to the following policy-relevant information about these trace species.

Carbon Dioxide

The atmospheric concentration of carbon dioxide has increased by more than 25 percent since preindustrial times. This increase is responsible for more than half of the enhancement of the trapping of infrared radiation due to human activities. Over the past two years, there has been an apparent pause in the rate of increase in CO₂ concentrations. It is speculated that enhanced

Organization of the U.S. Research Program

The development of a predictive understanding of how human activities are affecting and are affected by the Earth's climate system is among the most complex of all scientific undertakings. The activities of the U.S. Research Program are organized into the following elements:

■ **Observations:** (1) Establishing an integrated, comprehensive, long-term program of land-, ocean-, satellite-based, and in-situ observations on a global scale that monitor and describe the current state of the Earth system, and (2) assembling and analyzing observations on recent and past social and environmental changes in the Earth system.

■ **Data and Information Management:** Assembling, processing, storing, and distributing data and information that document the state of the global system, and the conditions of both the natural and the societal systems that are influencing and are influenced by global environmental changes.

■ **Process Research:** Conducting a program of focused studies to measure, analyze, and investigate the physical, chemical, biological,

and geological processes and societal influences that govern Earth-system behavior and the interactions of human activities with the global environment.

■ **Predictions:** Developing, testing, and applying integrated conceptual and predictive models of the coupled Earth system in order to provide insights and projections of the response of the atmosphere, oceans, and land surface to natural and human influences and to reconcile predicted and observed Earth-system behavior.

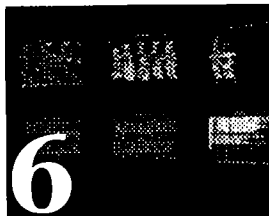
■ **Analyzing Consequences:** Evaluating and interpreting the environmental, human health, and societal consequences and impacts of global change and understanding the potential for natural and technology-enhanced adaptation to and mitigation of global change.

■ **Assessing Policies and Options:**

Researching social and economic interactions and decision frameworks (especially those that include decision making under uncertainty), and developing policy and economic tools to examine the relative strengths and weaknesses of the various choices for responding to global change.

■ **International Cooperation:** Encouraging and promoting cooperation with other nations in developing scientific understanding and establishing the institutional framework necessary for broad-based consideration of global change issues.

■ **Education and Public Awareness:** Preparing materials and organizing activities that promote consideration of global change and its human dimensions as part of both public awareness and educational processes.



sinks for carbon are responsible for the recent slowdown, but the exact cause remains unexplained. Lately, the rate of increase appears to be returning to prior rates observed in the 1980s.

Recent evidence suggests that in the short term, at least, the CO₂ sinks provided by lands in the temperate zone may be larger than previously thought. Anomalies in surface temperature and precipitation may have allowed terrestrial ecosystems to accumulate more carbon during 1991–93 than normally would have been the case. New research is ongoing to monitor CO₂ exchange between the atmosphere and vegetation and soils.

Chlorofluorocarbons

Because CFCs destroy lower stratospheric ozone, which is also a greenhouse gas, the net effect of CFCs as greenhouse gases is less potent than previously believed. The indirect offset of the hydrochlorofluorocarbon substitutes, however, may be smaller than that of the CFCs. Observations show the rate of increase of CFCs in the atmosphere to be slowing, consistent with international emission controls. Stratospheric ozone depletion, however, continues because of the long residence time of CFCs in the atmosphere. And in 1993, the observed springtime ozone depletion in the Antarctic was the largest ever recorded. Because the depletion of ozone in the lower stratosphere has a negative radiative-forcing effect on the climate system, characterization of these ozone trends and processes is a requirement for improved understanding and interpretation of surface temperature trends.

Very-Long-Lived Greenhouse Gases

Laboratory and modeling studies have shown that the lifetimes of fully fluorinated ("perfluorinated") carbons (PFCs)—potent

greenhouse gases—exceed millennia. Understanding the chemistry and lifetimes of PFCs (such as CF₄, C₂F₆, C₆F₁₄) is critical to predicting climate change, because some have been proposed as CFC substitutes, while others are emitted as trace products of industrial processing, including aluminum production.

Methane

The atmospheric lifetime of methane—an especially potent greenhouse gas—has recently been determined to be 25 percent longer than previously thought, which raises its global warming potential. However, following the guidelines set by the Intergovernmental Negotiating Committee (UN/INC 1994), the United States uses the 1990 IPCC global warming potential values in its emissions inventory.

Over the last few years, the rate of increase of atmospheric methane has slowed. In 1992, the rate of increase was sharply reduced, but current measurements indicate that the rate of increase of atmospheric methane is returning to the earlier values measured before the slowdown. Continued research is planned to understand whether the reduced rate was due to decreased human emissions or to an enhancement of sinks.

Ozone

Calculations suggest that increases in ozone in the upper troposphere substantially augment radiative forcing. Field measurements have shown that a significant amount of tropospheric ozone over the temperate north Atlantic Ocean is derived from transported emissions of North American precursors (nonmethane hydrocarbons and reactive nitrogen compounds). Although the precursors of tropospheric ozone are increasingly being controlled in industrialized countries, more research is necessary to

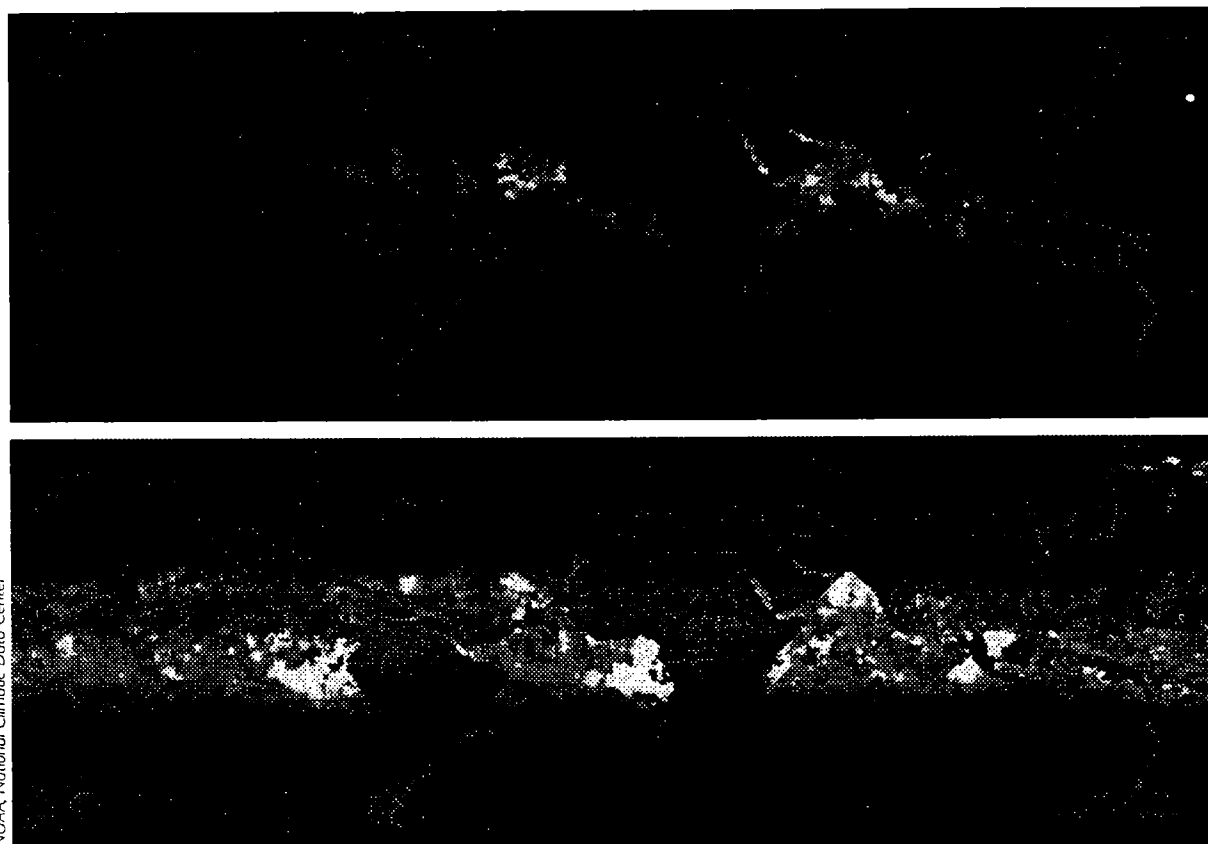
understand the global contribution of tropospheric ozone to radiative forcing.

Aerosols

Emissions into the atmosphere of aerosols (airborne particles or collections of particles) and of gases that chemically react to form aerosols can have direct effects both on the global radiation balance and on global atmospheric chemistry. These direct effects can then have subsequent effects on climate and surface radiative fluxes (e.g., of ultraviolet radiation), which could offset and mask a portion of the greenhouse warming.

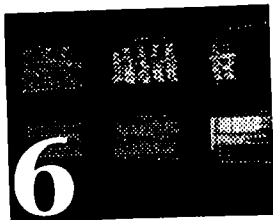
Research on the radiative effects of sulfate particles formed in the lower troposphere, main-

ly as a result of emissions from coal and oil combustion and from industrial processes, is important to understanding whether they may be counterbalancing the enhanced greenhouse warming of carbon dioxide, as hypothesized. For aerosols emitted by biomass burning, the effect is less certain and depends on the amount of black carbon in the aerosol. The absence of measurements confirming the predicted increase in land surface temperatures in the United States appears to be most closely related to recent increases in the frequency of cloud cover. Recent studies suggest that the hemispheric asymmetry in this century's warming may be due—at least in part—to the higher concentrations of aerosols in the Northern Hemisphere.



NOAA, National Climatic Data Center

Volcanic eruptions emit enormous quantities of aerosols, which scientists believe may offset some of the climate changes caused by greenhouse gases. The aerosols ejected into the atmosphere following the Mount Pinatubo eruption in June 1991 circled the Earth and remained in the atmosphere for months after the eruption.



Aerosols ejected into the stratosphere from volcanic eruptions can have very significant short-term effects on climate. Observed climatic responses to the Mt. Pinatubo eruption have included tropospheric cooling, stratospheric warming, and an overall drop of about 0.5°C (1°F) in the global average surface temperature. During 1993, measurements from satellites and the surface showed that these volcanic aerosols are finally settling out of the atmosphere, leading to a return of the global average temperature to levels typical of the 1980s, and to a small recovery from the sharply increased rate of ozone depletion in the lower stratosphere, which studies suggest was caused by volcanic aerosols.

Understanding the Carbon Cycle

There is a natural cycling of carbon in the environment, causing a large exchange of carbon among the atmosphere, the land vegetation and soils, and the oceans and marine biosphere. Evidence from ice-core data suggests that this natural cycle was roughly in balance, with only minor variation, from about 10,000 years ago until recently. Over the past two centuries, however, the concentration of carbon dioxide has risen from preindustrial levels at an increasing rate. Although the anthropogenic emissions are only about 5 percent as large as the natural fluxes, the rising concentration indicates that emissions from changes in land use (e.g., deforestation, biomass burning, and agricultural expansion) and from fossil fuel combustion (i.e., the use of coal, oil, and natural gas) have become increasingly larger than can be accommodated by natural removal processes. Projections of these trends unabated suggest that the atmos-

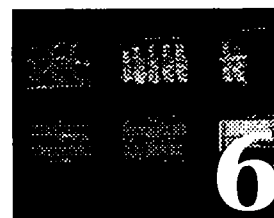
pheric CO_2 concentration may reach double its preindustrial value by the middle of the next century, leading to an average global temperature increase of $1.5\text{--}4.5^{\circ}\text{C}$ ($2.5\text{--}8^{\circ}\text{F}$).

Research has shown that interannual fluctuations in climate can modify natural removal processes, such as carbon uptake and release by respiration. Other studies suggest that mid-latitude forests may be taking up more carbon than previously estimated and, hence, that this natural removal process could be enhanced through reforestation and land-management practices. The U.S. Research Program continues to support these efforts to better understand the global carbon cycle, which is vital to understanding and predicting climate change, and assessing potential response options.

Terrestrial and Marine Ecosystems

The Research Program supports the study of marine and terrestrial ecosystems and their role in climate change. There is particular interest in studying the exchange of carbon among the land vegetation and soils, the oceans and marine biosphere, and the atmosphere. Understanding the carbon balance is critical for predicting future concentrations of carbon dioxide in the atmosphere and, hence, greenhouse warming. Recent regional measurement of CO_2 uptake by forest vegetation suggests that the net uptake of carbon worldwide could account for "missing" carbon in the global carbon budget. Confirmation of these results with other natural vegetation studies would support the use of forest management (including reforestation) as an interim mitigation strategy.

The U.S. Research Program supports research designed to enhance the fundamental



understanding of the physiological and ecological responses of plants and animals to global changes of climate, atmospheric gas concentrations, and increased ultraviolet radiation. These studies include research on the effects of climate change on agriculture, forestry, marine resources, biodiversity, and areas with special vulnerabilities, such as coastal regions. Some of the projected impacts of climate change follow.

Effects on Agriculture

Prospective shifts in precipitation patterns could cause dramatic changes in world agricultural regions and in the availability of water resources, disrupting long-established patterns of land use. Recent research has shown that for a moderate scenario of climate change, projected to accompany a doubling of greenhouse gases, the global agricultural production potential may not be seriously threatened. At the regional level, however, agricultural production losses, particularly in developing countries, are likely to be severe.

Although the growth rate of some plants has been shown to increase in the presence of additional CO₂, altered precipitation patterns due to climate change could threaten the viability of agricultural regions. Also, increasing population pressures and misguided land-management practices may cause shifts in flora and fauna greater than those that have occurred in response to natural climatic fluctuations. The U.S. Research Program is increasing efforts to understand the vulnerabilities and resilience of these systems to change, and their adaptive capabilities.

Effects on Forests

Studies are currently being conducted to determine how climate change may affect tree growth. Potentially altered precipitation pat-

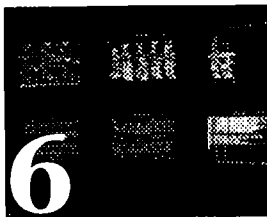
terns and changes in regional hydrology due to climate change may threaten forest health. Elevated CO₂ has also been shown to influence host-pest relationships in a way that can reduce forestry yields. The Research Program is using existing data on fire history, lake sedimentation, and climate to refine models that predict how ecosystems respond to changes in temperature, precipitation, and atmospheric composition. The Research Program is also studying the potential economic impacts of climate change scenarios on forest inventories in the southern United States.

Effects on Biodiversity

New research in this area will focus on the potential effects of climate change on the species diversity, genetic diversity, and habitat diversity of managed and unmanaged ecosystems and, in turn, how changes in biodiversity will affect the functions of ecosystems.

Effects on Aquatic Ecosystems and Fishery Resources

The U.S. Research Program contributes substantially to Global Ocean Ecosystems Dynamics, an international program that is examining how climate change may affect the relationship between the oceanic physical and biological processes that govern the health of marine fish. For example, research is under way to study the effects of climate on the reproductive dynamics of fishery resources, such as sardine, anchovy, and mackerel stocks. Studies are also assessing the influence of increased ultraviolet radiation, due to ozone depletion, on the oceanic carbon cycle and, hence, on the rate of global warming. Methodologies for estimating the regional effects of global climate change on environmental conditions in lakes and freshwater



fisheries are being developed and validated.

Regional Effects

Efforts have been initiated to evaluate the potential effects of climate change at the regional level. Recent modeling efforts have successfully simulated winter precipitation at the local scale for a high-elevation, high-water-yielding mountain watershed in western Colorado by coupling regional- and local-scale atmospheric models to watershed models. These models also simulated the increase in temperature surrounding several federally managed reservoirs in western U.S. watersheds that might result from doubling of atmospheric CO₂. After coupling global-, regional-, and local-scale models for watersheds with three-year current climate

records, the models predicted an average temperature increase of 3.8°C (6.8°F) in areas surrounding several reservoirs in the model watersheds with doubled CO₂ in the environment. Water temperatures were also predicted to increase.

Coastal areas are particularly vulnerable to climate change. Warming of the oceans, coupled with land-surface warming in high latitudes, may melt icecaps and glaciers, which would raise the level of the sea. The amount of sea level rise could be tens of centimeters over the next century (several times the rate of rise in the recent past). In addition, climate change may increase the frequency of severe storms and hurricanes and, hence, the potential for increased natural disasters.

Socioeconomic Issues Related to Climate Change

International Population Trends and the Human Condition

- What are the interactions between population growth/migration and environmental change?
- What demographic and social factors are particularly relevant for assessing the vulnerability of societies to environmental change?
- How do the human health impacts of climate change, such as the potential for changing patterns in the incidence of diseases, affect health-care needs?

Patterns of Trade and Global Economic Activity

- How do world economic growth and international trade patterns affect the use and value of environmental resources, such as wetlands, coastal zones, and forests?
- What effects might large-scale, debt-for-nature swaps have on global environmental resources?
- How will the development and diffusion of technology affect the impacts of global change?
- What effects might such changes as political and economic liberalization have on the use of environmental goods?

Adaptation and Mitigation, Including Environmental Resource Use and Management

- Under what conditions in the past have people adapted to environmental stresses?
- What are the costs and benefits of various policy approaches that influence the use of key resources, such as land, energy, water, and coastal zones?
- How do institutional and legal rules affect the use of common-property resources?
- What international mechanisms and processes can be used to build the international coalition needed to stabilize concentrations of greenhouse gases?



Socioeconomic and Policy Implications of Climate Change

The problems associated with climate change have highlighted the need to understand the fundamental relationships between policy goals and the social processes that contribute to achieving those goals. The U.S. Research Program is increasing its focus on the socioeconomic impacts of climate change, including studies on human health, water quality and supply, the availability of food and fiber, and the potential impacts of change on social, political, and economic systems.

An important new area of emphasis in the U.S. Research Program is the development of decision tools and analytic approaches that will assist both the short- and long-term needs of decision makers. These new tools will enable decision makers to address competing objectives and to analyze potential trade-offs among available options. Many of these tools are designed for addressing local responses to global change. Particularly high demand has been expressed for new decision tools that can be used in coastal zone management. Issues like fisheries, flooding, erosion, water quality and allocation, and sea level rise in coastal settings require adaptive strategies, which must be considered in the context of complex human/environmental interactions over varying time scales, despite high degrees of uncertainty.

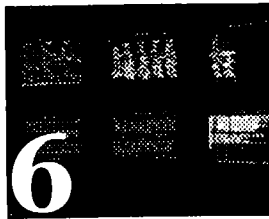
Integrated assessments are especially important tools for assisting the policy process. Methodologies for conducting integrated assessments are being developed to bring research results from natural, social, and policy sciences into a framework that can help decision makers formulate and evaluate actions to respond to potential environmental change.

Recent successes in the refinement of decision-support tools have been made possible through advances in knowledge of critical natural processes. As more complete understanding is gained of the frequency and scale of physical phenomena, decision tools have been refined to reduce uncertainties about the socioeconomic consequences of environmental changes. One example of these improvements is the enhanced predictive accuracy of the El Niño/Southern Oscillation (ENSO) phenomenon. Research suggests that although ENSO is a naturally occurring, short-term climatic variation, the frequency of ENSO events may be intricately linked to long-term climate change. Because the impacts of ENSO may be significant at regional levels, continued research in this area is important. Using the recently developed ability to provide more accurate ENSO forecasting, resource managers have been able to alter management strategies with respect to water use and agricultural practices and, hence, avert potentially significant adverse consequences.

Research on Mitigating Climate Change

Research on mitigation focuses on reducing greenhouse gas emissions into the atmosphere and increasing the sinks for these gases. The U.S. Research Program is reviewing progress under the 1993 *Climate Change Action Plan* on a biennial basis to report on current trends and to adapt existing programs to evolving circumstances. The actions being reviewed, which are described in detail in Chapter 4 of this document, involve all economic sectors, including industry, transportation, homes, office buildings, forestry, and agriculture.

U.S. funding for mitigation research to



develop energy-efficient technologies for reducing greenhouse gas emissions from all sectors has increased by about 40 percent in the past year. Some research topics include energy supply and fuel use in the utility, industrial, commercial, and residential sectors; manufacturing processes and operations in energy-intensive industries, such as primary metals, chemical and petroleum, cement, and pulp and paper; transportation fuels and their efficiency, as well as transportation modes and influences of urban planning; energy consumption, biomass-burning practices, and fertilizer use in the agriculture and forestry industries; afforestation/reforestation efforts; coal-mining practices; and CFC alternatives and new refrigeration, air-conditioning, and fire-retarding technologies.

The U.S. Research Program is providing information relevant to the greenhouse gas reduction programs outlined in this document by contributing to: (1) the development and continuation of worldwide CO₂ and CH₄ emission data bases needed to document country-level emissions and to evaluate overall emission-reduction performance; (2) the understanding of the capacity for natural vegetation to sequester carbon and the potential influence of a changing climate on that capacity; (3) the development of national data bases for evaluating forestry actions that could enhance carbon sinks through assessing experimental data and models on the carbon balance of natural and managed ecosystems; and (4) evaluation of the ozone-depleting potentials and the global warming potentials of proposed CFC substitutes.

Coordination With International Research Efforts

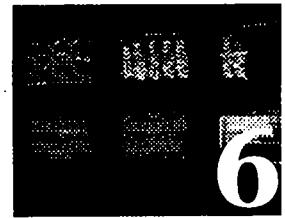
To be most effective, global change research

must be a global effort in which scientists from different countries work together to assess, evaluate, and build on one another's research. The primary vehicle for this cooperation is the Intergovernmental Panel on Climate Change (IPCC), in which the United States and the U.S. scientific community are deeply involved. The United States also plays a major role in other international efforts to understand and assess the state of knowledge about global change through multilateral organizations, bilateral research projects, and internationally coordinated research programs involved with climate change.

Multilateral Organizations

Besides working with the IPCC to assess climate change mitigation and adaptation strategies, the United States provides substantial financial and technical support to the World Meteorological Organization and the United Nations Environment Program. These organizations provide important international underpinning to the international global climate change effort, including support for global climate modeling and the full and open exchange of global climate data and information.

World Meteorological Organization. The United States provides significant support to the World Meteorological Organization (WMO), which coordinates, standardizes, and improves world meteorological activities and encourages the efficient exchange of meteorological information among countries throughout the world. As part of its activities, WMO has been actively engaged in various aspects of climate and climate change, with such programs as the World Climate Research Program and the World Climate Impacts Program. Along with the United Nations Environment Program, WMO has helped sponsor the scientific assessments of



both climate change and ozone depletion. WMO has long been one of the principal organizations upon which the United States relies for providing needed international coordination for these programs.

U.N. Environment Program. The United States is also an active supporter of the United Nations Environment Program (UNEP). One of UNEP's major climate change activities is the design and implementation of a Global Environment Monitoring System with a Global Resources Information Data Base component. This program links more than twenty-five major global monitoring networks, a number of which are established and supported by U.S. agencies. Along with WMO, UNEP has been a key sponsor of the scientific assessments of climate change and ozone depletion.

Intergovernmental Panel on Climate Change. In 1988, WMO and UNEP established the IPCC to assess the information in the professional literature related to various components of the climate change issue. The IPCC does not sponsor research, although it does encourage its lead authors to synthesize results and apply insights from the literature in novel ways. U.S. scientists, both within the government and in the academic research community, have been instrumental in assisting these efforts.

Specific U.S. contributions to the IPCC include the following:

- The United States and Zimbabwe co-chair the IPCC Working Group II, which is assessing potential impacts of climate change and adaptation and mitigation measures. In addition, the United States is providing financial sponsorship for several of the lead authors for the Second Assessment Report, whose contributions will be in the areas of energy

supply, energy demand, transportation, and human settlements (IPCCb, in preparation). The United States is also helping to prepare an appendix on Energy Technology Characterizations.

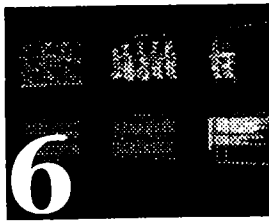
- U.S. scientists are participating in the IPCC Working Group I, which is assessing the state of science with respect to the functioning of the climate system and possible anthropogenic changes to it.
- U.S. scientists are also supporting the IPCC Working Group III, which is focusing on cross-cutting issues, including the economic implications of climate change and of available emission scenarios.
- Participation of U.S. scientists as lead and contributing authors is particularly strong, due to the many activities supported by the U.S. Research Program and individual U.S. government agencies.

Bilateral Research Cooperation

The United States is engaged in a number of global change research activities in cooperation with countries and regions around the globe. Examples of these activities follow.

Brazil. The United States participates in the Brazilian Rain Forest Pilot Project, which the Government of Brazil initiated in 1990 in cooperation with the G-7 countries to improve the knowledge and understanding of Amazonian ecosystems, promote sustainable natural resource management, and encourage the application of environmentally friendly technologies to improve human conditions in the region.

Canada. The Boreal Ecosystem-Atmosphere Study (BOREAS) is a coordinated ground, air-



craft, and satellite study of how Canada's boreal forests exchange energy, heat, water, CO₂ and other trace gases with the atmosphere. A joint U.S.-Canadian project involving over eighty-five teams of scientists from around the world, BOREAS seeks to better understand the role of boreal forests in climate change, and how a warmer climate may affect the composition of the boreal forests and their role as carbon sinks.

Indonesia. The U.S. Research Program is working closely with the Indonesian National Institute of Aeronautics and Space to study the flow of water from the Pacific to the Indian Oceans, a poorly understood but critical factor in global ocean circulation. Complementary studies of coastal and terrestrial ecologies and their responses to global change are also proposed.

Japan. The United States has several bilateral agreements with Japan involving global change research. The U.S.-Japan Science and Technology Agreement covers more than forty-seven global change projects. The Global Observation Information Network initiative met twice during 1993 to identify existing and planned networks, to propose candidate data sets and prototype demonstrations, and to draft a two-year work plan.

Russia. A bilateral agreement with Russia supporting joint research on environmental change covers several dozen activities, such as a study using paleoclimatic data (especially from the large land areas of the two countries) to attempt to determine how past changes in atmospheric composition, solar insolation, and other naturally changing factors have affected the Earth's climate. The U.S. Research Program, in cooperation with the Russian Academy of Sciences, is supporting an analysis of the biospheric role of the Siberian forests and their

influence on global change. Other joint research includes the use of remote-sensing and ground-sampling data in a geographic information system to monitor catastrophic changes in the boreal environment.

Informal International Coordination Groups

U.S. federal science agencies that support global change research also coordinate their efforts with their counterpart agencies in other countries through informal arrangements.

The International Group of Funding Agencies for Global Change Research serves as a forum for exchanging information on national global change research programs, for supporting programs and facilities, and for considering the integration and phasing of global change research in light of available resources.

The Committee on Earth Observation Satellites serves as the focal point for international coordination of global change activities related to space-based Earth observations and data. Comprising government agencies with funding and program responsibilities for satellite observations and data management, the Committee has contributed significantly to global change research through improved coordination among Earth-observing satellite operators in payload planning, calibration and validation, networking, data management, and data policy.

International Research Programs

The U.S. Research Program is a major contributor to international global change research programs. Many nations, both developed and developing, are involved in this international cooperative research, primarily through three major international programs: (1) the World



International Global Change Research Programs

World Climate Research Program

Created in 1979 to confront the problem of global warming and to use climate information to benefit national socioeconomic development, assists countries in applying climate knowledge and provides information on possible future climate variations and change. The Program is affiliated with WMO, UNEP, UNESCO/IOC, FAO, UNDP, and ICSU and is organized into four major subprograms:

■ **World Climate Data and Monitoring:** Increases the availability of reliable data for the World Climate Research Program by maintaining and enhancing national observational networks and facilitating data processing and exchange.

■ **World Climate Applications and Services:** Enhances the use of climate information to reduce the vulnerability of societies to

extreme climate events by transferring application techniques and associated training to the developing world.

■ **World Climate Impact Assessment and Response Strategies:** Studies the socioeconomic and environmental impacts of climate variability and change, and of potential options for response strategies.

■ **World Climate Research:** Improves understanding of the physical basis of climate to determine the extent to which climate can be predicted and the extent of human influence on climate through major research on the global atmosphere, the oceans, the cryosphere, and the continental land surfaces.

Global Climate Observing System

Builds on both existing and developing observational networks to measure variations and changes in the world's climate

more comprehensively. This includes the Global Ocean Observing System and the Global Terrestrial Observing System.

International Geosphere-Biosphere Program

The biological and chemical counterpart to the World Climate Research Program, investigates the biogeochemical cycles vital to understanding greenhouse gases and their exchanges among the atmosphere, oceans, and land.

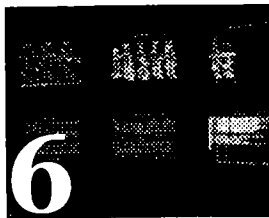
Human Dimensions (of Global Environmental Change) Program

Studies the effect of human use on land cover over the past three hundred years, and the likely effects over the next fifty years, as well as major human causes of land-use changes and the effects of climate and biogeochemical change on land use and land cover.

Climate Research Program (WCRP), (2) the International Geosphere-Biosphere Program (IGBP), and (3) the Human Dimensions (of Global Environmental Change) Program (HDP).

International programs are coordinated at a series of levels, including scientist-to-scientist, agency-to-agency, and government-to-government through a broad range of multilateral and bilateral organizations and arrangements. Many of these arrangements involve United Nations agencies concerned with global change research,

including WMO, UNEP, and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. The International Council of Scientific Unions (ICSU) provides strong leadership for scientific planning for many of these key international programs, especially the WCRP and the IGBP. The United States shares in funding ICSU's coordination of these activities, and U.S. scientists and agencies participate in and interact regularly with ICSU, its Secretariat, and various related committees. U.S.



scientists have chaired many of the international scientific steering groups for the major international global change research programs. Moreover, the U.S. Research Program supports the international offices of the IGBP Task Force on Global Analysis, Interpretation, and Modeling, as well as the IGBP regional field programs.

Leading international economic organizations are also now considering how global change may affect economic development and are identifying global change research-related issues. These include the Organization for Economic Cooperation and Development (OECD), which in 1993 convened an experts' meeting on global change that recommended greater scientific input from the social science community to the policy process, and the Asia-Pacific Economic Cooperation (APEC) organization, whose Marine Resource Conservation Working Group is reviewing the effects of global change on the Asia/Pacific region.

International Institutes and Networks for Global Change Research

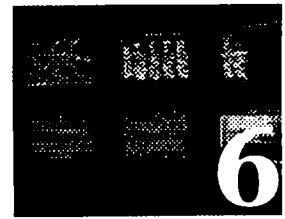
The United States is currently placing special emphasis on the creation of networks and institutes to promote the development of regional capabilities to conduct global change research. The agreement establishing the Inter-American Institute for Global Change Research (IAI) entered into force on March 11, 1994. The IAI Conference of the Parties will meet for the first time in September 1994. The United States is working closely with the other parties to the agreement to ensure that the IAI adopts a broad regional scientific program that also contributes to global objectives.

The United States is also working with key countries in Europe, Asia, and other regions to

promote the establishment of complementary, broadly based international networks in those regions. The European Union and the countries of Central and Eastern Europe and of Africa are developing regional global change research agendas for the European Network for Research in Global Change (ENRICH). This network is intended to improve the coordination of global change research in three regions: Western Europe, Central and Eastern Europe, and Africa. The European Union has established a central ENRICH office in Brussels, with liaison offices in each of the three regions. Japan is leading efforts to develop an Asia-Pacific Network for Global Change Research (APN), which will focus on regional issues, such as tropical and coastal processes in the Pacific.

The United States will continue its active support for the establishment of a multinational network of centers to develop and issue experimental seasonal-to-interannual climate predictions. The purpose of this network is to improve understanding of the global climate system, to advance our ability to predict ENSO-related climate variability on seasonal-to-interannual time scales, and to produce and systematically disseminate regionally tailored climate forecasts for use in a wide range of economic and social planning activities.

The international commitment to build indigenous capacities for global change research in the developing world is reflected in the SysTem for Analysis, Research and Training (START), a joint effort of the HDP, IGBP, and WCRP to develop regional research networks for global change research that will be linked to the three more broadly based regional networks (IAT, ENRICH, and APN). The START regional research networks promote focused research and training on regional issues of global importance,



integrate and synthesize the research results, and provide input to decision makers at national and regional levels. The U.S. Research Program supports the operations of the START Secretariat and the participation of U.S. scientists in the development of the START scientific agenda.

U.S. Support for National Inventories

The United States has provided substantial technical and financial support for the development of guidelines and specific default methods for calculating and reporting national inventories of greenhouse gas emissions and sinks. The IPCC, with the assistance of the Secretariat of the OECD, initially released draft guidelines and reporting instructions in 1991 through the OECD (IPCC/OECD 1991). During the past three years, the IPCC/OECD joint program has devoted considerable effort to improving the methodologies and addressing major limitations and areas of uncertainty in methods for high-priority greenhouse gases and sectors. A major update of the methods and reporting guidelines was released for review by the IPCC and Intergovernmental Negotiating Committee (INC) processes in December 1993 and was adopted by the INC in February 1994 (UN/INC 1994).

The United States has funded a \$25-million Country Studies program (of which \$18 million is funded through the U.S. Research Program) to assist developing countries and countries with economies in transition to generate inventories of greenhouse gases, assess their vulnerability to climate change, and evaluate strategies for reducing net emissions of greenhouse gases and adapting to the potential impacts of climate change. (Chapter 7 of this document describes the Country Studies program in further detail.)

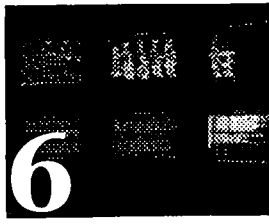
The United States also provides funding for

the Tropical Forestry and Climate Change Research Network, which is working with researchers in about ten countries worldwide to improve estimates of the greenhouse gas emissions from forestry activities in key countries and to develop plausible policy scenarios to slow these emissions. Methods developed by the Network have been adopted by the U.S. Country Studies program for analysis of climate change mitigation through forestry and by several countries for use in preparing their national climate change reports.

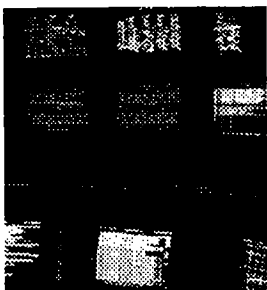
Data and Information Dissemination

To increase worldwide access to climate change data and information, the United States has developed a policy of full and open access for all countries to U.S. global change data. The Global Change Data and Information System, being developed through the U.S. Research Program, provides the infrastructure for linking global change data bases and information available within the various agencies of the federal government.

An integral component of the System is the Global Change Research Information Office, which opened in 1993 to provide the international community easier access to the data. The mission of the Information Office is to determine what global change information holdings and disseminations are being used by various agencies and to develop the means of conveying that information to end users; to facilitate information access by developing an on-line capability to point to and retrieve, or store and disseminate, global change research information; to provide customer service to end users with varying levels of technological competence; and to evaluate the effectiveness of the system for disseminating global change information.



The Information Office has already made good progress in its task by identifying world-wide sources of data and information to satisfy requests about global change topics. The Internet provides the primary access to these tools, and most are available at no charge to the user. The Information Office provides easy-to-use, on-line data and information services to access these data. For example, the Information Office has implemented a CIPHER menu system on the Internet, which identifies available resources and allows the user to connect to many on-line systems.



Public Education and Communications

The challenge of U.S. education and communications activities is to determine how to best:

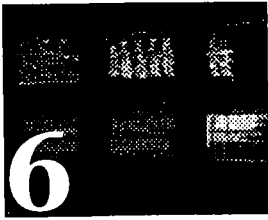
- Involve the public and institutional decision makers in planning programs and examining policies and choices.
- Expand public awareness of global change: the prominent issues, their scientific complexity, and needed research, including predicting consequences and evaluating policy options for responding.
- Train future scientists and educators by promoting understanding among educators and decision makers about the multidisciplinary nature of global change issues and solutions.

The effective conduct of the U.S. Research Program depends on effective dialogue among its various constituencies. The Research Program has undertaken specific initiatives to meet this objective. The private sector—including academia, industry consortia, and environmental groups—currently conducts significant research in the areas of environmental and natural resources. Some of this research is taking place in conjunction with federal agency programs. The U.S. Research Program encourages private-sector and government agency interactions to minimize duplication, to focus on key problems and issues, and to bring working-level researchers together.

Educational Outreach

Member agencies of the U.S. Research Program have longstanding programs for developing educational materials for primary and secondary school levels. They have developed monographs, resource guides, curricula, and other supporting teaching materials on global change, which are distributed to science teachers nationally. The Research Program recognizes the need to strengthen the human resource base in science and technology and to provide the United States with highly trained professionals. Thus, at the inception of the U.S. Research Program, the agencies augmented this foundation to respond to the cross-disciplinary aspects of global change.

The major emphasis of these educational programs has been to award competitive graduate-level and postdoctoral fellowships for developing the interdisciplinary problem-solving skills that are necessary for addressing global change science, technology, and policy issues. Both postdoctoral and graduate-level fellows are encouraged to interact with the scientific staff of the various federal research organizations. The postdoctoral fellows sponsored by the Research Program conduct research at agency laboratories, which may be outside their supporting organization, and as a part of university research projects.



The GLOBE Program

The GLOBE program (Global Learning and Observations to Benefit the Environment) brings together school children, educators, and scientists throughout the world to monitor the global environment. The program's objectives are to enhance the world's awareness of environmental problems, to increase scientific understanding of the Earth, and to help all students reach higher standards in science and mathematics education.

The GLOBE program consists of a worldwide network of K-12 students making environmental observations at or near their schools, providing data useful to environmental scientists, and sharing the resulting global environmental images and knowledge with each other. Scientists involved in the program's design and implementation will help determine what types of measurements students are most capable of making and where students can make the greatest contributions.

The data acquired by the students are expected to help both students and environmental researchers in a wide range of fields better understand Earth systems, including climate systems. The student data will be quality-controlled during GLOBE processing prior to their use in producing environmental images and publicly available data. The GLOBE program will use an international information network—initially, the Internet—direct satellite transmission, and television to acquire, transmit, and distribute data and environmental images.

The actual operation will begin on April 22, 1995, the twenty-fifth anniversary of Earth Day. Over two hundred schools—fifty of which will be in the United States—will participate in the start-up. Over the next few years, the program will expand to include thousands of schools,

both in the United States and abroad.

Over forty countries have already expressed interest in becoming involved in the GLOBE program. Foreign governments and nongovernmental sources both in the United States and abroad are expected to fund over 90 percent of the long-term GLOBE expenditures. Foreign governments will pay for their own country's participation to the extent they are able, and a nonprofit organization will be the focal point for U.S. private-sector contributions to GLOBE.

Project Earthlink

To complement the U.S. government agency programs, the Research Program has launched an interagency initiative called Project Earthlink. The mission of this initiative is to establish a long-term educational effort on global environmental change by: increasing the understanding of global change issues, based on IPCC and similar scientific assessments; describing the effects of human actions on the global environment; and fostering access to and use of scientific data sets and information technologies for informed decision making and policy formation. Six audiences will be targeted: community leaders, informal educators, teachers, students, journalists, and the general public.

Project Earthlink will develop materials targeted to specific audiences, including resource guides for teachers and journalists, a data set directory, a manual on using information technologies, and classroom activities for students. Topics include natural variability, the greenhouse effect, sea level rise, ozone depletion, ecosystem response, health effects, and decision making under scientific uncertainties.

This initiative is being carried out in coordination with other White House initiatives,



including the President's Council on Sustainable Development and Global Learning and Observations to Benefit the Environment. Project Earthlink is evidence of the continuing U.S. commitment to develop and nurture a scientifically and environmentally literate citizenry in the belief that improving the human partnership with the natural Earth system is essential to our future. The primary goal of this initiative is to enhance long-term global change educational efforts that reach multiple audiences and become part of every education and outreach program.

Earthlink and Formal Education

Through various innovative efforts, Project Earthlink will be formally introduced to the U.S. educational system.

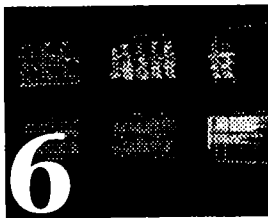
- Originally funded by the National Science Foundation, the JASON Project is an innovative science-education program that uses state-of-the-art technology to transport students to research sites around the world for "live" explorations. The April 1995 "expedition" will focus on global change issues and will use the *Global Change Education Resource Guide* in training workshops for the ten thousand teachers associated with the twenty-five JASON downlink sites.
- The International Science and Engineering Fair will add global change as a fifteenth category for science fair projects. Students in every school district in the United States and around the world will be encouraged to design experiments related to global change research.
- In August 1994, member teams from nearly every state came to Washington, D.C., for the U.S. Global Change

Education Conference. The teams, which included educational policy leaders, classroom teachers, informal educators, and global change research specialists, began to develop statewide action plans to incorporate global change information and research into school and community programs.

Earthlink and Informal Education

Informal educators have educational responsibilities in museums, aquaria, nature centers, and extension and outreach programs.

- The National Oceanographic and Atmospheric Administration (NOAA) established four pilot regional workshops on global change in 1993-94. A national video conference on global change for informal educators is scheduled for November 1994.
- Global change will also be one of the features of the Ocean Planet Exhibit, which will open in April 1995 at the National Museum of Natural History. Collaboration with Project Earthlink includes developing informational materials and training workshops.
- A *Global Change Specialist Resource Directory* will include a list of research specialists in global change interested in education.
- The National Science Foundation's Science and Technology Week in April 1995 will feature "Building a New World," a year-long educational project that will culminate in the construction by students of a forty-two-foot scale model of the globe showing vegetation, precipitation, and soil types.



Earthlink and the General Public

To provide editors and broadcasters with accurate and timely scientific information on global change, NOAA is supporting a *Guide on Global Environmental Change*, along with a series of accompanying workshops taking place in 1994. A national video conference in April 1995 for community leaders will focus on global change issues, with a four-hour workshop that will bring local decision makers together to discuss global change issues, regional impacts, and local actions. The informal educators who participated in the training workshops will serve as site facilitators for the eighty downlink sites covering every state and major metropolitan area. These downlink sites will also host a prime-time interactive town hall meeting with the President.

The Earthlink Resource Guide

The *Global Change Education Resource Guide* is a multimedia collection of materials for assisting educators in conducting activities and programs on global change. Based on the IPCC assessments, it includes fact sheets from the UNEP-WMO Information Unit on Climate Change, available in several languages; graphic representations of research data on full-color slides; definitive articles for nontechnical audiences; classroom activities for multiple age levels; and a bibliography of resources. Topics include natural variability, the greenhouse effect, sea level rise, ozone depletion, ecosystem response, and decision making under scientific uncertainty. The *Resource Guide* will be provided to participants in the informal educator training workshops, the video conference for teachers, the JASON expedition, and the U.S. Global Change Education Conference.

Individual Agency Efforts

As an example of individual agency efforts, the U.S. Environmental Protection Agency's (EPA's) Office of Air and Radiation is involved in educating individuals and organizations about the benefits of energy-efficient computers, lighting, building systems, and residential appliances, as well as best management practices in natural gas pipelines, improving ruminant productivity, and methane recovery and reduction from coalbeds and landfills. Voluntary programs include Green Lights, Energy Star Computers, Energy Star Buildings, AgSTAR, Natural Gas STAR, and coalbed and landfill outreach.

In these and other programs, EPA is increasing public understanding and awareness of the pollution-prevention and economic benefits of these programs by distributing monthly newsletters, annual reports, fact sheets and brochures, posters, videotapes, and technical guidance; by participating in conferences, media briefings, seminars, and implementation workshops; by placing public service advertisements; and by incorporating the pollution-prevention message into popular cable television productions for children, such as "Captain Planet." In addition, participants in EPA's voluntary programs actively contribute to employee and customer awareness through newsletter articles, brochures, videotapes, and building tours.

The U.S. Agency for International Development supports activities in developing countries and countries with economies in transition that address climate change and promote sustainable economic growth. An integral component of many of these programs is assistance in training, public awareness, and education, particularly with regard to improving the collection, exchange, and dissemination of information on

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energy and environmental issues, as described in
Chapter 7.

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International cooperation is critical to the success of the Framework Convention on Climate Change and the attainment of its goal. While the efforts of each individual country to control its own greenhouse gas emissions are important, they will be ineffective if all countries do not work together. To foster closer international cooperation on climate change, the United States is engaged in a variety of activities, both bilaterally and internationally. Some are designed to encourage the private sector to bring innovative technologies to developing countries and economies in transition, while others provide government-to-government assistance.

In particular, much closer cooperation is needed between developed countries, which have historically had the highest greenhouse gas emissions, and developing countries, whose emissions are growing rapidly, and who will require still more energy in the coming years to fuel their growth. However, developing countries can benefit from the experience of the United States and other OECD countries, which have attained impressive—and ever-improving—levels of efficiency in their energy use.

**international
activities**



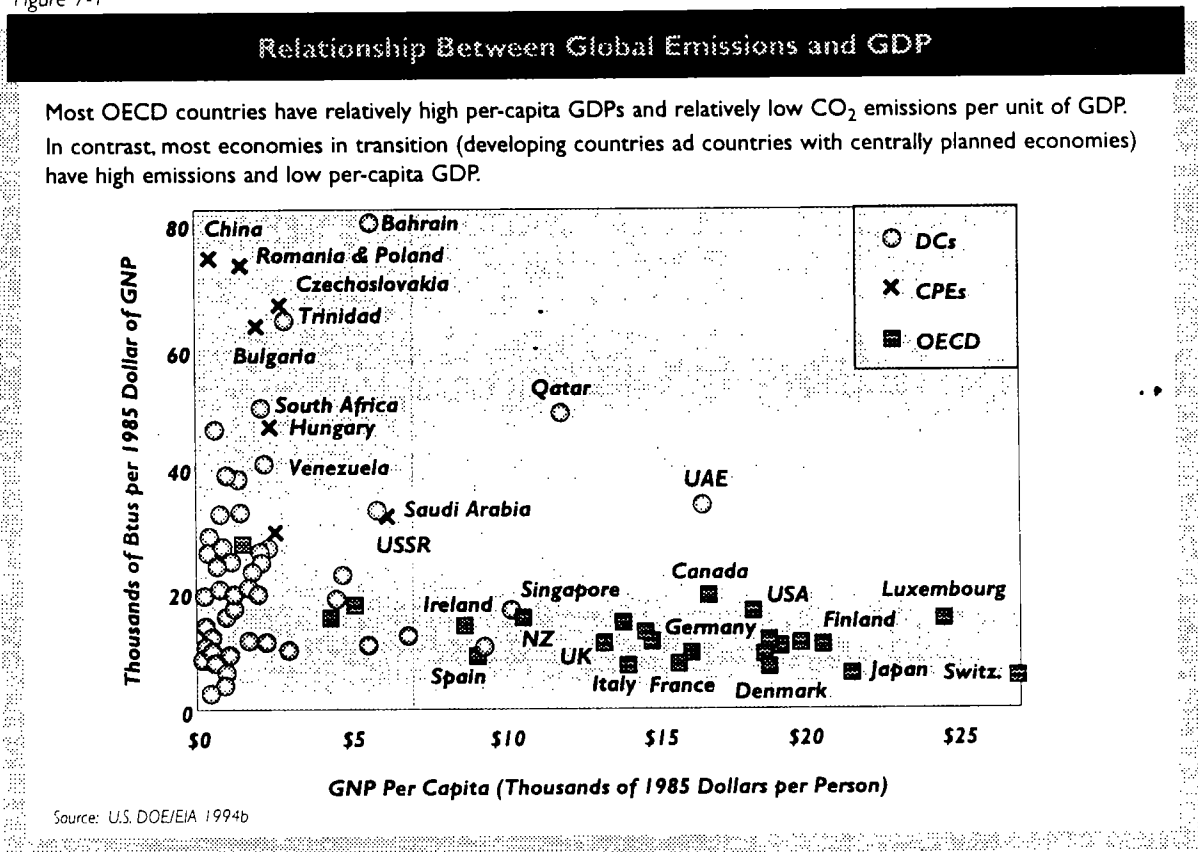
Figure 7-1, which plots emissions against per-capita gross domestic product (GDP), demonstrates this point. Most OECD countries are toward the right of the graph, with relatively high per-capita GDPs and relatively low CO₂ emissions per unit of GDP. In contrast, most economies in transition are in the upper left corner, with high emissions and low per-capita GDP. Most developing countries are clustered in the lower left corner, with low emissions and low per-capita GDPs. The challenge for all signatories to the Climate Convention is to work together to help both developing countries and countries with economies in transition move toward higher efficiency and lower emissions through technology transfer and cooperation.

The United States is committed to facilitating the commercial transfer of energy-efficient

and renewable-energy technologies that can help developing countries achieve sustainable development. In addition, the United States is engaged in a number of other projects to help countries mitigate and adapt to climate change. This chapter outlines some of the most significant U.S. efforts in this area, in the hope that our experience may spark further ideas for such cooperation in the wider international community.

However, bilateral efforts are not enough; climate change is a global threat that requires cooperation worldwide. The United States has played a leading role in international efforts to address the climate change issue, by its participation in climate convention negotiations, as well as in other multilateral fora, where it has used its influence to place the climate change issue squarely on the agenda and to foster policies that can help to mitigate climate change.

Figure 7-1





Technical Assistance and Technology Transfer

The United States provides technical assistance and facilitates the transfer of energy-efficient technologies through its Country Studies program, bilateral mitigation projects, information sharing and trade facilitation, and bilateral assistance for adaptation projects.

Country Studies

The Climate Convention requires all signatory countries to communicate a national inventory of greenhouse gas emissions by sources and removals by sinks and describe the steps they are taking to implement the Convention, including adaptation and mitigation measures. To assist developing countries in meeting this commitment, and to fulfill in part its own obligations under the Convention to provide new and additional financial resources to help developing countries meet their obligations, the United States initiated the Country Studies program in 1992.

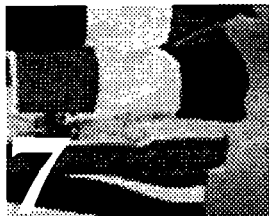
The studies are a first step for countries seeking to meet their national reporting and other obligations under the Framework Convention. In its first phase, this \$25-million program is providing technical and financial support to developing countries and countries with economies in transition (the Newly Independent States and Eastern Europe) to help them prepare studies to address climate change. The primary objectives

of the program are:

- To enhance the abilities of countries and regions to inventory their greenhouse gas emissions, assess their vulnerabilities to climate change, and evaluate strategies for mitigating emissions and adapting to the potential impacts of climate change.
- To enable countries to establish a process for developing and implementing policies and measures to mitigate and adapt to climate change, and for reexamining these policies and measures periodically.
- To develop information that can be used to further regional, national, and international discussions of climate change issues.

Developing and transition countries are eligible to participate if they: (1) have signed the Framework Convention on Climate Change, (2) pledge to adopt the results of the study officially and to share them widely in appropriate international fora, and (3) establish appropriate institutional structures to direct the study and to develop and implement further climate change policies.

Technical support is a major element of the Country Studies program. In addition to funding studies directly, the program devotes approximately 25 percent of its budgeted resources to



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Activities Supported by the U.S. Country Studies Program

U.S. support for country studies provides an analytical basis upon which countries can develop national plans and actions to address climate change. The Country Studies program supports the following activities:

- Preparation of greenhouse gas inventories.
- Assessment of vulnerability to the potential impacts of climate change and evaluation of adaptive responses to cope with those impacts.
- Analysis of mitigation options to reduce emissions and expand sinks.
- Development of national plans.
- Public education and outreach activities.

training, development of analytic tools, and other technical support for participants from developing and transition countries. The U.S. Global Change Research Program has provided technical support to train over 150 analysts, engineers, and scientists from Africa, Asia, Europe, and Latin America. The Country Studies program has developed and distributed methodological handbooks, as well as reference materials and models. These materials provide a common and transparent technical framework for assessing climate change vulnerability and adaptation measures and for evaluating mitigation response options. In addition, the Country Studies program distributed to participating countries IPCC/OECD guidance documents and software in multiple languages on how to inventory their greenhouse gas emissions.

Approximately thirty countries expressed interest in the Country Studies program in its first year. Following a programmatic and technical review, twenty-six of those countries received financial assistance to conduct studies: Algeria,

Bulgaria, the Central American region (Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama), Chile, Czech Republic, Egypt, Ethiopia, The Gambia, Kazakhstan, Marshall Islands, Mexico, Micronesia, Mongolia, Nigeria, Oman, Peru, Poland, Russian Federation, Venezuela, and Zimbabwe. These ongoing studies are implemented under cooperative agreements, and most countries are completing technical tasks as scheduled.

In the program's second year, over forty-five additional countries applied for financial support. The United States expects to conclude cooperative agreements in September 1994 with approximately thirty of those countries (Figure 7-2).

Twelve U.S. government agencies have pooled their resources to implement this program. A Country Studies Management Team, with full-time personnel drawn from six different federal agencies, conducts the day-to-day operations and oversees projects in conjunction with individual U.S. agency project officers. The program complements programs implemented by other donors (e.g., the United Nations Development Program, the United Nations Environment Program, the Global Environment Facility, and individual countries). The United States coordinates financial and technical support activities with other donors through several venues, including the CC.Info project (formerly CLIMEX) of the INC Secretariat.

The potential effects of the Country Studies program are far-reaching. Emission inventories and climate vulnerability studies developed as a result of the program will point governments to cost-effective projects to mitigate climate change. Countries will develop the institutions and the technical expertise to capitalize more fully on commercial technology transfer, as well

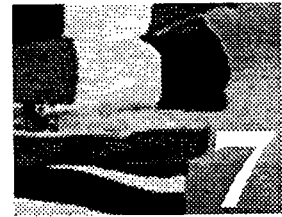
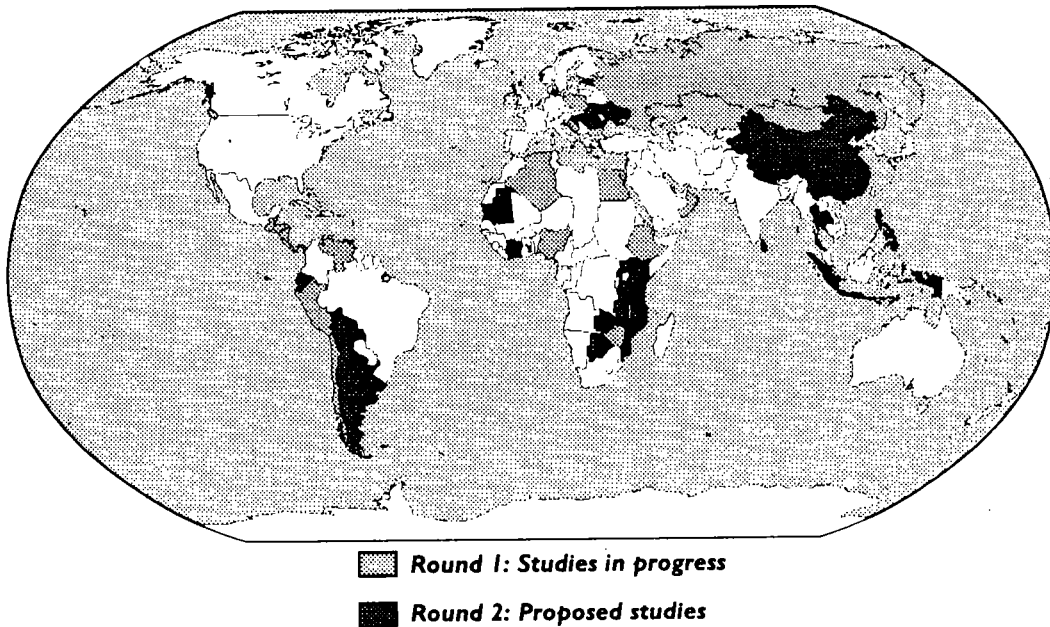


Figure 7-2

The U.S. Country Studies Program

The United States is supporting studies in twenty-six countries, and is reviewing the applications of forty-five additional countries for financial support to conduct country studies.



as on bilateral assistance.

Bilateral Mitigation Projects

U.S. bilateral mitigation projects are based on the core principles of the U.S. development assistance strategy. These principles support economic growth and social development that:

- Protect the resources of the host country.
- Respect and safeguard the country's economic, cultural, and natural environments.
- Create many incomes and chains of enterprises.
- Are supported by a favorable policy and institutional framework.

- Build indigenous institutions that involve and empower the citizenry.

The U.S. government is supporting a host of bilateral projects aimed at mitigating climate change by reducing greenhouse gas emissions or sequestering greenhouse gases. In this area, the federal government works primarily through the U.S. Agency for International Development (USAID), but also through other U.S. government departments and agencies involved in climate change issues—notably, the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the U.S. Department of Agriculture (USDA). Partnerships among various government agencies, nongovernmental organizations, private industry, and international organizations charac-



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terize many of these projects.

As the principal international development agency of the U.S. government, USAID has identified the mitigation of climate change as one of two global environmental priorities. The Agency is committed to assisting key developing countries and countries with economies in transition to reduce the rate of growth of net greenhouse gas emissions through approaches that also contribute to economic growth and local environmental protection. USAID will particularly emphasize partnerships with countries that are or that will become significant contributors to total greenhouse gas emissions, including Brazil, India, Indonesia, Kazakhstan, Mexico, Philippines, Poland, Russia, Ukraine, and Central Africa (as a region). The Agency will collaborate with these countries to develop and implement plans that reduce sources and

enhance sinks of greenhouse gases.

Future USAID projects and programs to mitigate climate change will advance three objectives:

- Promoting energy efficiency, renewable energy, and low-carbon-emitting energy systems by: (1) promoting institutional reform and private-sector approaches that improve the efficiency of delivered energy, services; (2) supporting the development of environmentally sound technologies; and (3) leveraging multi-lateral and private sources of capital to promote energy efficiency.
- Fostering sound forestry and natural resource management practices that limit deforestation and other carbon-emitting, land-use changes.
- Improving the collection, exchange, and dissemination of information on energy and environmental issues.

The U.S. bilateral mitigation projects described in this chapter received funding in 1993–94. They include efforts in the following general categories:

Energy Demand. Reduce end-user energy demand through conservation and energy efficiency, resulting in lower fuel consumption and emissions.

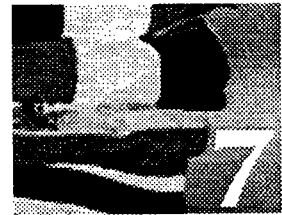
Generation. Increase the efficiency of power generation, thereby expanding effective generating capacity without additional fuel consumption.

Distribution. Reduce losses in transmission and distribution processes, especially in rural networks, thus increasing effective capacity without additional fuel consumption.

Renewables. Encourage the adoption of renewable-energy technologies to replace fossil fuels or to increase capacity without increasing

The Role of Joint Implementation

The U.S. Initiative on Joint Implementation, described in detail in Chapter 4 of this report, offers the potential for expanding on the international activities outlined in this chapter. Although bilateral—and even multilateral—aid funds are limited, the initiative ultimately is expected to harness the technological and financial resources of the U.S. private sector, with the aim of reducing net greenhouse gas emissions as a complement to the bilateral mitigation projects described in this chapter. These efforts—particularly those that focus on mitigation and information sharing and trade facilitation—lay the foundation for the initiative by demonstrating beneficial projects and results, by creating a favorable institutional climate, and by facilitating the exchange of information necessary to bring parties together in joint implementation projects.



fossil fuel consumption. Many renewable-energy technologies are particularly appropriate for rural use.

Clean Coal. Use clean-coal technology, which can cut emissions by up to 25 percent, to achieve significant immediate greenhouse gas emissions in countries where coal is widely used.

Privatization. Support privatization, on the assumption that the private sector generally makes more rational use of energy resources than do government-owned or -subsidized monopolies. Open existing power-grid systems to sales from private producers to provide a market incentive for the development of nonconventional renewable-energy resources.

Clean Air. Reduce air pollution, thereby decreasing greenhouse gases as an ancillary benefit.

Methane. Reduce methane emissions through coalbed methane recovery and other technologies. Methane recovery not only lowers emissions of methane—a potent greenhouse gas—but also provides an additional clean-burning fuel source with low greenhouse gas emissions.

Forestry. Enhance carbon sinks through forestry projects that reduce deforestation, or support reforestation or afforestation of degraded lands.

Many projects are not so easily categorized, however, for they cut across two or more of these categories, as shown in Table 7-1. Following are the descriptions of the projects, along with their time frames, total U.S. funding levels over the indicated time frame, responsible agency or agencies, and host country or region.

Energy Efficiency Project

EEP strives to combat climate change by introducing environmentally sound, energy-effi-

cient technologies and by promoting related policy reforms, investment incentives, and energy management and planning. Specifically, EEP (1) mitigates energy-related greenhouse gas emissions, (2) addresses energy-sector policy and institutional reform issues, (3) promotes private-sector involvement, (4) expands U.S. technology transfer, and (5) promotes energy information dissemination through outreach and training. EEP works cooperatively with groups inside the United States and in developing and emerging countries, such as universities, research centers, and nongovernmental organizations.

EEP emphasizes the following three strategic elements: building institutional partnerships, promoting technology cooperation between U.S. and local firms, and leveraging major financing. To build local capacity, which is critical to sustaining development efforts, all EEP activities involving specific countries have an institutional counterpart to assist in carrying out project objectives. On the technology front, EEP promotes innovative, market-driven technology cooperation between U.S. and developing-country organizations. In the financing arena, EEP leverages funding from the multilateral development banks by providing initial design and start-up efforts that will lead to projects being funded by these institutions. •

■ *USAID, \$22.8 million from 1992 to 1998, Worldwide*

Philippines Demand-Side Management

This parallel-financed USAID/Global Environment Facility project seeks to reduce future greenhouse gas emissions by developing demand-side (conservation and energy-efficiency) resources to meet a portion of the power sector's needs in the Philippines. It comprises a three-pronged strategy of (1) assessing the potential for demand-side management (DSM),



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Table 7-1

U.S. Bilateral Mitigation Projects

The U.S. government is supporting a host of bilateral projects aimed at mitigating climate change by reducing greenhouse gas emissions or sequestering greenhouse gases.

Project Name	Agency	Location	Project Type	Total \$ (thousands)	Years
Energy Efficiency Project	USAID	Worldwide	Energy Demand, Generation, Distribution	\$22,800	6
Philippines Demand-Side Management	USAID	Philippines	Energy Demand	\$4,500	3
Thailand Demand-Side Management Program	EPA	Thailand	Energy Demand	\$120	1
Energy Demand Management	USAID	Morocco	Energy Demand	\$8,600	6
Energy Efficiency and Market Reform Project	USAID	Newly Ind. States	Energy Demand, Generation, Distribution, Privatization	\$272,500	4
Integrated Transportation Planning	EPA	Worldwide	Energy Demand	\$265	1
Program for the Acceleration of Commercial Energy Research	USAID	India	Energy Demand, Renewables	\$20,000	8
Energy Management Consultation and Training	USAID	India	Energy Demand, Generation, Distribution, Privatization	\$20,000	5
Power-Sector Support Program	USAID	Egypt	Generation, Distribution, Renewables	\$661,000	7
Energy Technology Innovation Project	USAID	Worldwide	Energy Demand, Generation, Distribution, Clean Coal, Clean Air, Methane	\$20,000	8
Energy Training Program	USAID	Worldwide	Energy Demand, Generation, Distribution	\$29,500	10
Energy-Efficient CFC-Free Refrigeration	EPA	China	Energy Demand	Major Multinational Grant	
Renewable Energy for Rural Electrification	USAID	Guatemala, Honduras, Costa Rica, Nicaragua	Renewables	\$500,000	2
Nepal Private Hydropower for Rural Electrification	USAID	Nepal	\$2,000	Renewables	3
Windpower for Island and NGO Development	USAID	Indonesia	\$3,000	Renewables	2
Rural Electrification	USAID	Philippines	Distribution	\$40,000	6
Renewable Energy Applications and Training	USAID	Worldwide	Renewables	\$25,000	10
Biomass Energy Systems and Technology	USAID	Worldwide	Renewables	\$13,000	7
Puspiptak Energy Research Laboratory	USAID		Generation, Renewables, Energy Demand	\$12,000	8
Philippines Assistance Support Project	USAID	Philippines	Renewables	\$3,750	5
Electrification for Sustainable Development	USAID	Bolivia	Renewables	\$2,500	5
Greenhouse Gas Pollution Reduction Project	USAID	India	Renewables, Generation	\$19,000	4
Krakow Energy Projects	USAID, DOE	Poland	Clean Coal, Energy Demand, Generation, Clean Air	\$29,800	3
Private-Sector Energy Development Project	USAID	Worldwide	Privatization, Renewables	\$6,000	3
Regional Energy Efficiency	USAID, DOE	Eastern Europe	Energy Demand, Generation, Distribution, Privatization, Renewables	\$96,000	5
Improved Public-Sector Environmental Services	USAID, EPA	Eastern Europe	Clean Air, Energy Demand	\$68,000	5
Russian Air Management Program	USAID, EPA	Russia	Clean Air	\$325,000	4

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Table 7-1, continued from previous page

U.S. Bilateral Mitigation Projects					
Project Name	Agency	Location	Project Type	Total \$ (thousands)	Years
Coalbed Methane Projects	EPA, USAID	Russia, Poland, Czech Republic, China	Methane	\$2,000	6
Polish Coalbed Methane Project	DOE, TDA, EPA	Poland	Methane	\$1,000	2
GAZPROM Working Group	EPA, DOE	Russia	Methane	\$100	1
Ruminant Livestock Methane-Reduction Projects	EPA	Bangladesh, Brazil, China, India, Tanzania	Methane	\$100,000	1
Russia-USA Forestry and Climate Change Project	EPA	Russia	Forestry	\$250	1
Forest Service Project in Brazil and Russia	USDA, USAID	Brazil, Russia	Forestry	\$1,500	1
Forestry Planning and Development	USAID	Pakistan	Forestry	\$30,000	10
Community-based Natural Resources Management	USAID	Senegal	Forestry	\$25,000	6
Environment/Global Climate Change	USAID	Brazil, Mexico	Forestry, Energy Demand	\$30,000	6
EGGCC, Mexico Renewable Energy Component	USAID	Mexico	Renewables	\$4,350	6

(2) providing technical assistance for DSM regulatory frameworks, and (3) designing and implementing a pilot industrial-sector DSM program to demonstrate targeted project benefits and working models for follow-on development and replication. To maximize the program's impact, USAID and the Asian Development Bank (ADB) are planning a coordinated effort, whereby USAID is providing grant-funded technical assistance and technical services, and the ADB will provide specialized project finance for Philippine DSM investments.

■ USAID, \$4.5 million from 1994 to 1997, Philippines

Thailand Demand-Side Management Program

In the Thailand DSM program, the United States is working with the International Institute for Energy Conservation and the Government of Thailand to design and implement a national energy utility DSM program and energy-conservation fund. The fund is intended to reduce emissions of greenhouse gases and other pollutants, to lower energy costs, and to reduce Thailand's

dependence on foreign sources of fuel.

■ EPA, \$120,000 from 1993 to 1994, Thailand

Energy-Demand Management

The Energy Demand Management project has focused on reducing energy waste and improving the efficiency of energy use in Morocco by introducing energy-demand management techniques into important sectors of the Moroccan economy, including agro-industry, construction materials, and hotels. In its six years of operation, the project has provided such technical support as energy audits, boiler tune-ups, and electric bill analyses to more than 200 Moroccan firms. The annual monetary savings, which are in excess of \$7.5 million, also translate into significant reductions in greenhouse gas emissions.

■ USAID, \$8.6 million from 1988 to 1994, Morocco

Energy Efficiency and Market Reform Project

This project seeks (1) to improve efficiency and performance in electric power, refineries,



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industries, and buildings; (2) to support energy-sector privatization and market reform; and (3) to reduce safety risks at nuclear power plants. Energy-efficiency and demand-management efforts are under way in Russia, Belarus, Ukraine, Armenia, Kazakhstan, and Kyrgyzstan in cooperation with the multilateral development banks and through U.S. private-sector contracts. These efficiency improvements, using state-of-the-art U.S. technologies, have resulted in annual energy savings of \$4.5 million, when calculated at world energy prices. This project is also engaged in cooperative efforts to reduce greenhouse gas emissions from natural gas flaring in Russia, to rehabilitate gas-distribution system designs in four major Russian cities, and to develop a strategy for restructuring Russia's electric utility sector.

■ *USAID, \$272.5 million from 1992 to 1996, Newly Independent States*

Integrated Transportation Planning

Increased energy demand to meet transportation needs also contributes to projected increases in greenhouse gas emissions. Accordingly, the ITP aims to design and implement integrated planning tools for developing countries, in order to encourage the development of transportation infrastructure that takes into account the social, economic, and environmental impacts of rapid growth in automobile use and allows comparison of alternative modes of transportation on an equal basis.

■ *EPA, \$265,000 from 1993 to 1994, Worldwide*

Program for the Acceleration of Commercial Energy Research

PACER promotes the commercialization of emerging energy technologies, administers a revolving fund for research awards and grants,

and encourages Indo-U.S. joint ventures. Since its inception in 1987, PACER has assisted more than twenty projects in developing and validating energy technologies, including technologies for renewables and energy conservation.

For example, PACER is providing matching funds totaling \$2 million for an Indo-U.S. joint venture in developing energy-efficient technologies with industrial applications. PACER also has ongoing projects in the development of an energy-efficient regenerative burner; a 500-kilowatt biomass gasifier-based, power-generation system; and continuous-fluidized-bed furnaces for heat treatment. In addition, the Program for the Advancement of Commercial Technology, which aims to accelerate technology innovation through U.S.-Indian joint ventures, has helped projects develop energy technologies that reduce greenhouse gas emissions.

■ *USAID, \$20 million from 1987 to 1995, India*

Energy Management Consultation and Training

The EMCAT project provides technical assistance to improve the ability of Indian public enterprises and private businesses to manage the generation, transmission, and use of energy throughout the power sector. USAID has worked through EMCAT to leverage \$1.5 billion in multilateral and Indian financial resources to promote the development of efficient power projects and improvements in energy efficiency. The project is also improving the efficiency of energy use by developing the capability to design, manufacture, and implement energy-efficient technologies.

■ *USAID, \$20 million from 1991 to 1996, India*

Power-Sector Support Program

This program aims to rehabilitate electricity-



generating capacity, increase efficiency, and stimulate energy conservation. It is reducing greenhouse gas emissions through infrastructure investments and technical and policy assistance.

The modernization of the Cairo West thermal power station's boilers and turbine generators, as well as the modification of the boilers to burn both natural gas and mazout oil, is expected to increase the plant's capacity from 300 to 350 megawatts, while decreasing its fuel-consumption rate from 275 to 260 grams per kilowatt-hour. These actions should greatly reduce the power station's greenhouse gas emissions.

The Power Sector Research Program is also assisting the Egyptian government in adopting environmentally sound practices and reducing electricity subsidies that discourage conservation. In partnership with the World Bank, the Egyptian government developed a national Environmental Master Plan that identified Egypt's environmental problems and outlined an action plan to address them. The New and Renewable Energy Authority, recently established under the Power Sector Support Program, will help carry out the government's action plan and meet future demands for environmentally sound energy by promoting new and renewable sources of energy. The program is also helping to expand the operating data-collection capability of the National Energy Control Center, which will enhance the reliability and efficiency of the overall national power system.

■ USAID, \$661 million from 1989 to 1996, Egypt

Energy Technology Innovation Project

The purpose of ETIP is to introduce innovative and environmentally sound technologies and management techniques that promote efficient, sustainable, and cost-effective production of electricity generation, transmission, and dis-

tribution systems in developing countries. ETIP focuses on increasing energy efficiency in industries and utilities. It has supported such activities as clean-coal technology missions to Indonesia and Thailand, and improved efficiency in power generation from power plants in Armenia and the Philippines. In the Newly Independent States, the project has provided technical support to reduce the amount of natural gas and natural gas liquids flared to the atmosphere, and has identified solutions to improve the safety and efficiency of natural gas distribution systems and to reduce methane leakage.

■ USAID, \$20 million from 1990 to 1998, Worldwide

Energy Training Program

This program offers a unique opportunity for qualified energy and environmental professionals from developing countries to receive practical hands-on training, either in the United States or in the host country. The resulting increase in local institutional capacity to resolve energy-sector problems can improve energy efficiency and mitigate the effects of climate change, while increasing the potential for economic growth. U.S.-based courses are designed to provide mid-level engineers, planners, and other specialists with the skills needed to implement new technologies, policies, or procedures.

In-country courses are custom-designed to provide senior-level policymakers and executives with the information they need to make informed decisions on new energy and environmental technologies, policies, and procedures. A study-tour program brings senior-level, energy-sector professionals to the United States to observe new energy technologies, policies, and procedures in action.

■ USAID, \$29.5 million from 1987 to 1997, Worldwide



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Energy-Efficient CFC-Free Refrigeration in China

EPA is cooperating with the Chinese National Environmental Protection Agency and the National Council of Light Industry to spur the production of energy-efficient, CFC-free refrigerator models in China. So far, energy savings of more than 50 percent have been achieved on a widely distributed model. EPA will work to transfer the technology throughout China. Methods and results will be relevant to other developing countries as well.

■ EPA, major multinational grant application under way, China

Renewable Energy for Rural Electrification

This project is a component of the larger Central American Rural Electrification Support Program. It is designed to increase rural use of appropriate renewable-energy technologies in order to help the people of Central America address their energy needs in an economically and environmentally sustainable manner. The program disseminates renewable-energy technologies; provides training in system design, installation, operation and maintenance of renewable-energy technologies; and conducts pilot activities in national park areas and buffer zones in Guatemala, Honduras, Costa Rica, and Nicaragua.

■ USAID, \$500,000 from 1993 to 1995, Guatemala, Honduras, Costa Rica, and Nicaragua

Nepal Private Hydropower for Rural Electrification

This four-year program seeks to help the private sector and the Government of Nepal establish and sustain private investment in small-to-medium hydropower projects and in

innovative rural electrification facilities based on hydropower. The program focuses on two major activities: (1) technical assistance for development of private power regulations, implementing procedures and institutional capacity, as well as for qualified private hydropower projects; and (2) private pilot initiatives in hydropower-based rural electrification with a local consortium comprised of nongovernmental organizations.

■ USAID, \$2.2 million from 1993 to 1996, Nepal

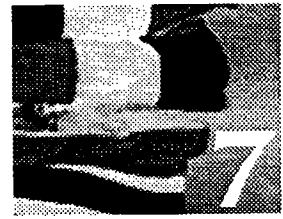
Windpower for Island and Nongovernmental Development

This three-year, parallel-financing USAID/GEF project will help Indonesian nongovernmental organizations (NGOs) demonstrate, manage, and transfer small-scale wind-energy systems in the eastern islands of Indonesia. It is designed to secure the involvement and commitment of NGOs in demonstrating an alternative approach to energy supply in rural communities. The project is composed of two basic components: (1) an assessment of wind resources and establishment of demonstration projects, and (2) strengthening the technical and institutional capacity of NGOs to design and implement wind-energy projects.

■ USAID, \$2.9 million from 1993 to 1995, Indonesia

Rural Electrification

This project aims to help selected Philippine rural electric cooperatives achieve commercial viability by addressing the institutional, policy, and technical weaknesses of the rural electrification system. It targets energy efficiency by rehabilitating distribution systems at the rural and national levels and by taking steps to reduce technical and nontechnical energy losses. Several of the participating cooperatives, which previously experienced line losses of up to 50



percent, have already attained the project's target of a "15 percent or under" system loss rate.

■ *USAID, \$40 million from 1988 to 1994, Philippines*

Renewable Energy Applications and Training

REAT is designed to bring about investments in renewable-energy systems that contribute significantly to the solution of development problems, while reducing greenhouse gas emissions. It promotes investments in renewable-energy technologies as alternatives to fossil fuel generation, conducts country-specific feasibility analyses of alternative energy sources, and develops and disseminates country investment portfolios and energy-sector case studies. Financing for investment opportunities identified by the project is organized in collaboration with the U.S. private sector and multilateral development banks.

In Asia, Africa, Latin America, and the Caribbean, REAT has developed and tested solar, wind, and small hydro systems to meet the energy needs of rural populations and villages. REAT funding also helps support VITASAT, a satellite system that has allowed an Indonesian utility and a collaborating U.S. company to monitor and optimize a pilot project by which small, hybrid-generation power plants provide electricity to remote island villages.

■ *USAID, \$25 million from 1985 to 1995, Worldwide*

Biomass Energy Systems and Technology

BEST is designed to reduce the technical, financial, economic, and institutional risks associated with biomass energy systems so that public- and private-sector interests (both U.S. and indigenous) will invest in commercially proven energy-conversion systems in target countries. The BEST project has been dedicated to pro-

moting the use of certain biomass fuels (namely, crops and crop residues). For example, biogas technologies can be used to increase the efficiency of energy production, while such technologies as cogeneration can turn biomass waste products into energy. Both approaches reduce greenhouse gas production.

In India, BEST conducted a biomass fuel assessment in Tamil Nadu and Maharashtra, focusing on three sugar mills; as a result, one private mill is planning significant investments in cogeneration. BEST also supported a study of cogeneration from sawmill waste in Honduras, a cost-shared feasibility study of biogas-fired electric power generation at a swine-production and dairy installation in the Philippines, and a two-year biomass energy project in Mexico.

■ *USAID, \$13.1 million from 1989 to 1996, Worldwide*

PUSPIPTEK Energy Research Laboratory

This project has assisted the Government of Indonesia in developing the PUSPIPTEK Energy Research Laboratory, which conducts research on efficient energy technologies other than oil, gas, and nuclear power. U.S. technical assistance was provided for developing the organization, for short-term training of staff, and for the design of research facilities. The project also procured analytical chemistry laboratory equipment, a pilot rice husk fluidized bed gasifier, efficient coal-combustion research facilities, and workshop equipment to support the Laboratory. Research activities include solar energy, biomass energy, energy audits for factories and buildings, and coal characterizations and combustion research. Other donors that provided assistance to the Laboratory include the World Bank, for long-term training, Japan, for solar energy and coal gasification, the Netherlands and Germany, for solar energy and biomass gasification, and



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the EU, for energy audits.

■ *USAID, \$12.25 million from 1981 to 1993, Indonesia*

Philippines Assistance Support Project, USAID/GEF Renewable Energy Component

This project is a multi-donor effort to help the Philippine government develop economic infrastructure and stimulate investment. Project activities include studies, operational support to the Committee on Official Development, and funding of a private-sector, pre-investment facility. The USAID/GEF renewable-energy component will help the Philippines demonstrate and test innovative financing approaches for renewable energy in economic development. This program will finance projects to supplant some 15–18 megawatts of fossil energy systems directly and will help with indirect assistance for another estimated 20–25 megawatts, with corresponding reductions in greenhouse gas emissions.

■ *USAID, \$3.75 million from 1990 to 1995, Philippines*

Electrification for Sustainable Development, USAID/GEF Renewable Energy Component

Part of a larger project, this component is designed to promote the reduction of greenhouse gas emissions through the use of renewable-energy systems in rural areas in Bolivia. This component will demonstrate innovative mechanisms for sustainable financing and integration of renewable-energy systems in Bolivia's electrification process. It will include financing for solar, wind, small hydro, and biomass energy projects in order to integrate renewable-energy technologies within the broad electrification planning policy in Bolivia.

■ *USAID, \$2.5 million from 1991 to 1996, Bolivia*

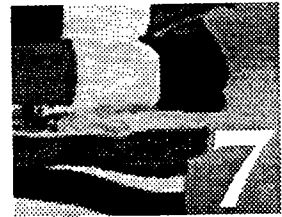
Greenhouse Gas Pollution-Reduction Project

This project in India represents a two-pronged strategy to reduce greenhouse gas emissions from energy production. The first component is a near-term strategy to increase the efficiency of coal use through the introduction of coal-conversion efficiency measures in existing power plants and state-of-the-art coal-conversion technologies. The second component is part of a longer-term strategy to reduce dependence on greenhouse gas-emitting fossil fuels by using alternative bagasse (sugar cane waste) cogeneration technologies (which produce no net greenhouse emissions) to exploit currently unused biomass resources. Both components are designed to address the major market, financial, and institutional obstacles to the introduction of these technologies and thereby to demonstrate their competitiveness with other sources.

■ *USAID, \$19 million from 1994 to 1998, India*

Krakov Power Plant Retrofit and Clean Fossil Fuels and Energy-Efficiency Projects

This initiative involves two complementary projects: (1) the \$9.8-million Krakow Power Plant Retrofit Project, which has installed a high-efficiency scrubber on a power plant in Krakow, Poland; and (2) the \$20-million Krakow Clean Fossil Fuels Energy Efficiency Project, which is designed to stem the low-level emissions of small boilers and home furnaces in and around the city of Krakow. Emission reductions are gained through the use of clean-coal technology and efficiency improvements in the district heating system and heat end use. The project supports the testing, introduction, and commercialization of new cost-effective fuels and technologies, and the implementation of the



policy and regulatory changes needed to stimulate the commercial market.

Pilot plant demonstrations in Phase I have shown a significant reduction in pollution, with a concomitant 20 percent increase in operating efficiency, thereby significantly reducing carbon emissions. Phase II, a 50–50 cost-sharing program with U.S. and Polish industry, will promote the commercialization of cost-effective fuels and technologies through eight joint ventures. This will boost the efficiency of boiler houses and other sources of pollution in Poland, thereby reducing CO₂ emissions by about 15 percent.

■ *USAID and DOE, \$29.8 million from 1991 to 1994, Poland*

Private-Sector Energy Development Project

PSED promotes the private ownership, financing, and operation of electric-power facilities in selected developing countries. Because private power developers operate more efficiently than government-owned and subsidized utilities, their operations consume less fuel to satisfy current demand levels, thus reducing greenhouse gas emissions.

PSED originally concentrated on familiarizing U.S. companies and foreign governments with the benefits and opportunities of private-power-sector development. PSED activities now include facilitating participation by private-power developers in the development and implementation of environmentally acceptable, economically sound, power-generation technology.

Private-sector participation also helps the power sector use its resources more effectively, capitalize on the technical and managerial expertise of private energy companies, and gain access to new sources of capital. This participa-

tion helps alleviate the power shortages that restrict economic growth, as well as provides much-needed capital infusion and relief of the capital burden placed on governments, freeing up funds for environmental or health programs.

Furthermore, opening existing power-grid systems to sales from private producers is often the most effective incentive for the development of nonconventional renewable-energy resources. About 70 percent of the projects approved under the PSED Feasibility Study Fund use alternative or renewable fuels.

■ *USAID, \$6 million from 1991 to 1994, Worldwide*

Regional Energy Efficiency

The Regional Energy Efficiency project provides technical assistance, training, and equipment to accomplish three strategic objectives in the Central and Eastern European region: (1) improve energy efficiency and pricing; (2) support energy-sector restructuring, privatization, and modernization; and (3) improve nuclear safety. Through this project, U.S. government agencies and private organizations, in coordination with the World Bank and other donors, are working to improve the climate for private investment in the modernization and increased efficiency of energy systems, as well as to establish local private energy-service and equipment-supply companies.

Specific program components include: (1) a grant to the International Energy Agency to carry out regional and country-by-country energy policy reviews in Poland, Hungary, the Czech Republic, Slovakia, Romania, and the Baltic countries to improve energy efficiency; (2) regional technical assistance to promote policy and institutional reform within the energy industry, develop rational and environmentally sound energy-investment programs, and enhance the



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business climate for energy industries and infrastructure in Central and Eastern Europe; (3) an Electric Utility Partnership program that links U.S. electric utilities and industries with counterparts in Central and Eastern Europe to facilitate economic and technical reform of national utility systems, introduce modern management concepts, and expose Central and Eastern European industrial leaders to U.S. energy and environmental technologies and practices with a view to future technology transfer; and (4) a Technology Cooperation program that takes advantage of specific DOE capabilities with respect to renewable energy, energy efficiency, clean-coal technology, and nuclear safety.

■ *USAID and DOE, \$96 million from 1991 to 1996, Central and Eastern Europe*

Improved Public-Sector Environmental Services

This project provides technical assistance and training and technology-transfer opportunities to improve environmental quality in Eastern Europe and strengthen Eastern European governments' capacity to provide public-sector environmental services. Although targeted primarily at industrial and municipal pollution reduction and regulation, and at environmental risk assessment, the project has also reduced greenhouse gas emissions and has encouraged energy-efficiency improvements.

Through the application of "low-cost or no-cost" process changes, environmental audits, recycling, waste minimization, and efficient use of raw materials and natural resources, the project is promoting pollution prevention and is installing equipment at specific industrial facilities. Environmental Management Training Centers are being established in Bulgaria and Poland, and a "twinning" program fosters long-

term relationships between government ministries and EPA's regional offices in the United States for information exchange and technical assistance.

■ *USAID and EPA, \$68.8 million from 1991 to 1996, Central and Eastern Europe*

Environmental Policy and Technology, Russian Air Management Program

Part of an overall environmental policy project, RAMP is designed to demonstrate how improved institutions, policies, and practices in air-quality management can help solve air pollution problems in Russian cities. RAMP also aims to identify activities that will reduce greenhouse gas emissions. It has begun by assisting Russian officials in a short-term study of Volgograd's air-quality problems and in identifying low- and no-cost emission-reduction measures. Using experience gained in Volgograd, RAMP will then help Russians define and implement appropriate changes to national, regional, and local approaches to air-quality management. Through training, technology transfer, and policy development, RAMP will assist Russians in drafting air-quality legislation and regulations, establishing standards, and setting emission limits and permit requirements.

■ *USAID and EPA, \$35 million from 1992 to 1996, Russia*

Coalbed Methane Projects in China, Czech Republic, Poland, Russia, and Ukraine

Several ongoing projects reduce emissions of methane from coal mines by identifying and assessing profitable opportunities for coal mines to expand methane recovery in conjunction with coal mining. The efforts include assessments of coalbed methane resources, specific project



opportunities, and the applicability of different U.S. technologies for methane recovery under local mining conditions; assistance to the United Nations Development Program's coalbed methane demonstration project in China; and establishment of Coalbed Methane Centers to disseminate information about investment opportunities to recover coalbed methane.

■ EPA, USAID, \$2 million from 1990 to 1996; Czech Republic, Poland, Russia, Ukraine, China (EPA only)

Polish Coalbed Methane Project

Three U.S. agencies are cooperating with the Polish Ministry of Environmental Protection in a \$1-million project to demonstrate a new technology for recovering methane emissions from coal-mining operations. The U.S. Trade and Development Agency will fund a feasibility study for the project, in which three Polish coal mines will participate. The recovered methane will be enriched and used for domestic consumption and export. It will also serve as the fuel source for an expanded brine disposal plant.

■ DOE, TDA and EPA, \$300,000 from 1993 to 1995, Poland

GAZPROM Working Group

This working group aims to identify and assess project opportunities to reduce methane emissions from Russia's natural gas system through the application of U.S. technologies. Approximately twenty U.S. companies are participating in this effort, together with EPA, DOE, and GAZPROM (the Russian natural gas company). Working group members have identified a number of potentially profitable projects that could improve the efficiency of Russia's natural gas system and reduce methane emissions. They are now working on obtaining support for demonstration projects and joint-venture devel-

opment.

■ EPA and DOE, \$100,000 in 1994, Russia

Ruminant Livestock Methane-Reduction Projects

EPA has conducted prefeasibility studies in several key countries—including India, China, Bangladesh, Brazil, and Tanzania—to identify cost-effective opportunities for reducing methane emissions from large ruminant livestock. The studies focus on ways to improve the diets of animals, thereby reducing methane emissions per unit of meat or milk produced. The information developed is used for the design of pilot extension projects to help small-scale producers learn how to implement various improved nutritional management practices, such as molasses-urea supplements, ammoniation of straw, and improved grazing/forage management techniques. Studies are also planned for Ukraine and Nepal.

■ EPA, \$100,000 in 1994; Bangladesh, Brazil, China, India, and Tanzania

RUSSAFOR (Russia-USA Forestry and Climate Change Project)

This pilot project designed is to demonstrate the viability of attracting private investment from the United States and Europe to sequester carbon through tree planting and improved forest management. A cooperative venture among U.S. and Russian governmental and nongovernmental organizations, RUSSAFOR expects to attract one to three U.S. private electric utilities to invest in forest plantations in Russia. The project should provide useful experience for the U.S. Initiative on Joint Implementation and the Climate Convention's Joint Implementation component.

■ EPA, \$250,000 in 1993, Russia



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Forest Service Project in Brazil and Russia

The purpose of this project is to develop research capabilities to measure the release of greenhouse gases from biomass burning in tropical and boreal forests and savanna ecosystems. In Brazil, the project includes training in fire detection and suppression, while in Russia work has progressed to providing technical assistance and funds for forest planning and policy development, fire and pest management, protection of preserves, and forest regeneration.

■ *USDA and USAID, \$1.5 million in 1994, Brazil and Russia*

Forestry Planning and Development

This project aims to achieve local energy self-sufficiency and to reduce deforestation in Pakistan by increasing national abilities to design and implement forest and fuelwood development strategies. It also demonstrates the feasibility of producing tree crops on private farm and range lands.

■ *USAID, \$30 million from 1983 to 1993, Pakistan*

Community-based Natural Resources Management

This project aims to improve forest resource management in Senegal through direct participation by rural communities and the private sector in land-use planning and conservation. Building on a 1991 reforestation project in which 43,000 participants planted trees on 1,300 hectares (3,212 acres) of land, the follow-on project includes continued tree-planting and forest-regeneration activities to instill in the population a sense of stewardship for natural resources. The project aims to work with community groups and farmers to plant three million trees, and to protect and manage natural forest regeneration

on 200,000 hectares (424,200 acres) of land. A related policy and institution-strengthening component will work through Senegal's national environmental plan process to ensure that these gains are sustained.

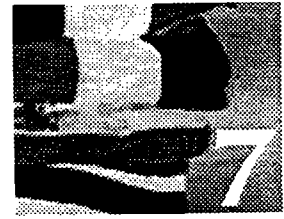
■ *USAID, \$25 million from 1993 to 1999, Senegal*

Environment/Global Climate Change

This project is designed to reduce greenhouse gas emissions in Latin America by promoting policy reforms and encouraging environmentally sound technologies and practices for the sustainable, efficient use of forest and energy resources, especially in Brazil and Mexico. Because the primary source of greenhouse gases in the region stems from the destruction of tropical forests, this project focuses heavily on the sustainable use of forest resources.

In Brazil, the project is providing training, management assistance, and basic infrastructure needs to local nongovernmental organizations (NGOs) in the region. This assistance aims to increase NGO capacity to influence policy by working with government research agencies and carrying out demonstration field projects. To give added value to the existing forests, the project is supporting research and pilot demonstration activities for new nontimber forest products and for improving the cultivation of traditional products, such as Brazil nuts and rubber. The activities also include environmental education, impact assessments, and components to improve timber management and management of protected areas.

Working with NGO partners, the project has used \$2 million to purchase and conserve critical forested areas in Belize and Paraguay. In Mexico, the project is helping the government analyze its policies and legal and institutional structures that encourage destruction of tropical



USAID Bilateral Forest Conservation Programs

USAID has an extensive portfolio of forest-management and -protection projects that help conserve existing carbon sinks. Global loss of biomass from tropical deforestation produced an estimated 4.1 gigatons of CO₂ annually between 1981 and 1990 (UN/FAO 1993). Conserving tropical forests avoids net release of CO₂ when carbon sequestered in biomass and soil is oxidized during agricultural burning and decomposition processes associated with deforestation. The same policies and institutional capacity that countries require to sustainably manage their natural resources will also equip them to assess their vulnerability and adapt to climate change.

In fiscal 1993, USAID forestry conservation assistance totaled \$86 million. These projects are designed to protect forests' biodiversity and improve the societal well-being by maintaining sustainable forest industries, nontimber forest products, fertile agricultural lands, and intact watersheds.

While the Latin America and Caribbean region contains over half the world's remaining forests, it also has the world's highest rate of deforestation—by far the major source of greenhouse gas emissions in the region. In 1994, USAID plans to commit over \$21 million to forest-protection and sustainable-use projects in the region. Major bilateral projects are ongoing in Belize, Bolivia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, and Panama. Other programs, such as the Parks in Peril Program with The Nature Conservancy, operate throughout the region.

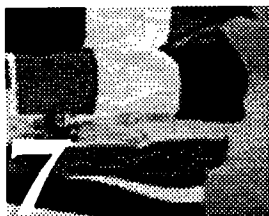
In Asia, USAID is funding forest-conservation programs in Indonesia, Nepal, the South Pacific Islands, and the Philippines. For example, in the Philippines, the \$125-million Natural Resources Management Program initially focused on national forest policy reforms and setting up an endowment—through a debt-swap—to fund the conservation activities of local nongovernmental organizations. After the passage of major policy

reforms, attention has turned to implementation and investment in community-based forest management. The program expects to place at least 500,000 hectares (1,255,500 acres) of open-access forests under sustainable management by local and indigenous cultural communities, cooperatives, or private corporations in producer relationships with communities.

In several African countries, USAID has worked with other donors to analyze forestry and natural resource management and economic policies through the National Environmental Action Plan process. In 1993, USAID committed \$19.1 million to forest-conservation projects in the Congo, Ghana, Kenya, Madagascar, Mali, Niger, and Uganda.

These programs, and many smaller activities worldwide, are supported by such global programs as the Forestry Support Program II. This \$25-million collaboration among USAID, the U.S. Forest Service, and the Peace Corps seeks to ensure a sustainable forest and natural resource base in developing countries and countries with economies in transition. It promotes the contribution of trees to sustainable development; strengthens the capacity of institutions that manage forestry and natural resources in developing countries; and provides technical assistance, training, private-enterprise development, and facilitation of donor collaboration. Similar programs include the Conservation of Biological Diversity Project; the Forestry, Fuelwood, and Resource Development Project; the Environmental Planning and Management Project; and the Environment and Natural Resources Policy and Training Project.

USAID is currently reviewing its forestry activities in light of its commitment to mitigating climate change. New Forestry/Climate Change programs are being planned for the Russian Federation and central Africa. USAID is also developing methods to better monitor and evaluate the impact of its forestry assistance on enhancing carbon sinks, in order to maximize the impact of its programs in terms of climate change mitigation.



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and temperate forests. It is also working to consolidate and manage eight protected areas and their buffer zones, covering more than ten million acres in southern Mexico. The Mexican activities also include some energy assistance through training in demand-side management and in energy-efficient and renewable-energy technologies. An additional major renewable-energy component is described in the next section.

■ *USAID, \$30.1 million from 1990 to 1996, Latin America (primarily Brazil and Mexico)*

Environment/Global Climate Change, Mexico Renewable Energy Component

In collaboration with DOE's Sandia Laboratories, this project is supporting the expansion of the Government of Mexico's non-conventional rural electrification program and other renewable-energy activities. It will focus on socially productive uses of renewable energy, including water pumping for potable water supply, livestock watering, and small-scale irrigation. The principal renewable-energy technologies will be photovoltaics, wind-power-driven electric turbines, and hybrid systems combining these two technologies. Installation of off-grid renewable-energy systems will avoid the greenhouse gas emissions of the equivalent fossil-fuel-generated electricity, while providing for sustainable development in Mexico.

■ *USAID and DOE, \$4.4 million from 1990 to 1996, Mexico*

Projects That Indirectly Reduce Greenhouse Gas Emissions

Many projects with other focuses achieve reductions in greenhouse gas emissions as an ancillary benefit. For example, the Mexico City

Air Quality Initiative, a nine-year, \$9.1-million joint DOE-Méxicanos Petróleos project to reduce air pollution in Mexico, has reduced greenhouse gas emissions through the implementation of energy-efficiency initiatives. The Energy Conservation and Efficiency project in Egypt, which is a subproject of Science & Technology for Development, promotes the use of energy-efficient industrial and commercial technologies in both the public and the private sectors in Egypt. By using portable gas analyzers to tune fifty-four boilers in eighteen companies, the project has reduced fuel use by about 10 percent and greenhouse gas emissions by 15–30 percent.

Information Sharing and Trade Facilitation

A critical element of technology transfer is making information about available technologies easily accessible to foreign government agencies and private-sector firms, and helping them secure financing for beneficial technologies. The benefits of effective information-sharing and trade-facilitation programs in promoting the transfer of technologies that can mitigate greenhouse gas emissions are far greater than their relatively modest funding levels might indicate.

Often the only obstacle to successful technology transfer is lack of information. Project planners in developing countries may not have ready access to information about the latest energy-efficient or renewable-energy technologies. Similarly, U.S. companies, especially smaller firms engaged in developing renewable-energy technologies, may lack information about international market opportunities for these technologies. Furthermore, traditional project financing has been geared toward large-scale, new-generation projects, rather than toward smaller-scale



renewable or demand-side projects.

Accordingly, the United States has established an array of information clearinghouses aimed at stimulating the flow of information about technologies and opportunities to reduce greenhouse gas emissions, and trade-facilitation programs aimed at promoting the most beneficial of U.S. exports: technologies to reduce emissions of the greenhouse gases that threaten our shared climate.

Committee on Renewable Energy, Commerce, and Trade

CORECT is an interagency project that facilitates the use of U.S. renewable-energy products and services worldwide by bringing together potential foreign customers and decision makers, funding sources, and U.S. industry.

■ 14 U.S. agencies, \$2 million in 1994, Worldwide

America's 21st Century Program

As the initial implementation of CORECT's

Central African Regional Program for the Environment

As the world's second-largest area of tropical forests, the Congo Basin is a major carbon sink and repository of biological diversity. Because deforestation and unsustainable land-use practices are rapidly destroying the natural resources in the region, USAID is recommending a new ten-year project, called the Central African Regional Program for the Environment (CARPE). The proposed project will identify and establish some of the conditions and practices required for the conservation and sustainable use of the natural resources in the region, in a manner that addresses local, national, regional and global concerns, including climate change.

CARPE will stress African participation in program design and implementation, and will work through regional institutions, national governments, and nongovernmental organizations

(NGOs). It will draw from project implementation experience gained through USAID-funded initiatives in the Korup Forest of Cameroon, the northern forest of the Congo, and the Dzanga-Sangha area of the Central African Republic, as well as extensive analytic and implementation work carried out by others in the region.

Activities of the proposed project will seek to:

- Improve the understanding of the ecology and biodiversity of the Congo Basin biosphere, the threats to the ecosystem, and the potential impacts of degradation of the environment, in order to guide development strategies in the region.
- Document and test field approaches to slow deforestation in the region.
- Assist in the development of a cadre of trained and com-

mitted environmentally conscious development specialists within the governmental and nongovernmental sectors of countries of the region.

- Support networks of researchers, NGOs, practitioners, and others working to conserve the natural resources of the Congo Basin.
- Develop partnerships among NGOs, researchers, governments, and the international community that permit discussion of overlapping interests in the sustainability of the region's natural resources.
- Evaluate and, if feasible, establish a Congo Basin Foundation to manage an endowment for the sustained support of conservation efforts of African NGOs and researchers in the region.



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regional strategy for the Western Hemisphere, "A21" aims at building a strong business and industrial capacity through renewable-energy products and services. It seeks to identify and evaluate project opportunities and technical assistance needs to develop a framework to conduct sustainable projects, to provide limited cost-sharing of project expenses, and to aggregate projects into portfolios for financing by multilateral development banks.

■ 14 U.S. agencies, \$3.25 million in 1994, Western Hemisphere

Committee on Energy Efficiency and Trade

COEECT is an interagency program that facilitates the export of U.S. energy-efficient technologies worldwide by bringing together potential foreign customers and decision makers, funding sources, and U.S. industry.

■ 14 U.S. agencies, \$700,000 in 1994, Worldwide

Energy Efficiency and Sustainable Development Centers

This project has established centers in Bulgaria, the Czech Republic, Poland, Russia, and Ukraine to facilitate the transfer of U.S. renewable-energy and energy-efficient technologies. The centers arrange contacts with regional energy decision makers and provide marketing assistance for U.S. business representatives, while serving as local centers of expertise and information for the host country. These nonprofit, independent local organizations promote economic policy reform and transfer of energy-efficient technologies through their advocacy work, demonstration projects, sectoral studies, seminars, and business partnership events.

For example, the center in Prague, named

"SEVEN," has conducted seminars in integrated resource planning, has established a data base of energy-efficient products, and has launched a local association for energy managers. To stimulate business networking for energy-efficiency services, "SEVEN" sponsors an annual "Business Week" event to encourage business partnerships and the transfer of energy-efficient technologies, products, and services.

■ DOE, USAID, \$500,000 in 1994, Eastern Europe and Newly Independent States

International Fund for Renewable Energy and Energy Efficiency

IFREE is a nonprofit corporation founded in 1992 to increase the deployment of renewable and energy-efficient technologies in developing countries and countries in transition. IFREE helps private companies obtain financing for potential alternative-energy projects by sharing the costs of prefeasibility and/or feasibility studies, performing market assessments, and supporting market-development activities.

■ EPA, DOE, USAID, \$3.55 million in 1994, Worldwide

Coal and Technology Export Initiative

This initiative is designed to help foreign countries that use coal widely to reduce their greenhouse gas emissions, while continuing to meet their energy needs by developing efficient, economic, and environmentally acceptable coal projects using U.S. clean-coal technologies. By producing comparable amounts of power using less fuel, these technologies can reduce CO₂ emissions by 20–25 percent, while cutting acid-rain emissions that can degrade forest carbon sinks.

■ DOE, TDA, SBA, \$1.7 million in 1994, Asia, Eastern Europe, Newly Independent States



Bilateral Assistance for Adaptation

Aware of the vulnerability of many developing countries to rising sea levels, drought, increased frequency and severity of storms, flooding, and other effects of climate change, the United States is also engaged in efforts to help countries adapt to these effects. Some of these adaptation programs address current problems, such as flooding in Bangladesh, coral reef degradation, and desertification in the Sahel. Although not currently attributable to climate change, these problems are likely to become more severe with climate change. USAID is working to better integrate vulnerability and adaptation issues into its current and planned assistance to developing countries. The United States is also engaged in a number of research projects aimed at developing drought- or heat-resistant crops to alleviate the potential effects of climate change on agriculture. In addition, the U.S. Country Studies program offers specific assistance to countries seeking to assess and minimize their vulnerability to climate change.

Coastal Resources Management

This project supports the sustainable use and protection of coastal systems through integrated approaches to local, national, and regional planning. Initial efforts focused on pilot projects in Ecuador, Sri Lanka, and Thailand, and the lessons gleaned from these projects are being widely disseminated.

The project's strength lies in a two-track approach: strengthening government agencies while empowering local communities. The project's extension and training have allowed the development of public-private-sector partnerships, with broad participation by communities in planning and decision making. This enhanced

capacity for planning will be crucial if coastal communities are to prepare for adaptation to sea level rise or other potential impacts of climate change.

■ USAID, \$13.8 million from 1985 to 1995; Ecuador, Sri Lanka, Thailand

Environment and Coastal Resources

This project is promoting partnerships among public, private, and community organizations to conserve and manage coastal resources in the eight island-nations of the Organization of Eastern Caribbean States (Antigua and Barbuda, the British Virgin Islands, Dominica, Grenada, Montserrat, St. Kitts-Nevis, St. Lucia, and St. Vincent and the Grenadines). Through its environmental monitoring, public awareness and training, and local site management components, the project is helping to build the regional capacity for environmental management that will help these countries plan for adaptation to potential impacts of climate change.

■ USAID, \$13 million from 1991 to 1998, Eastern Caribbean

Sahel Regional Institutions

This project provides support to the countries of the Inter-state Committee for Drought Control in the Sahel (CILSS). It is assisting CILSS and its member states with donor coordination and implementation of their joint work plan in food security and natural resource management. Although targeted to current land-use changes in the region, these activities will help countries prepare for similar impacts that may result from global climate change.

■ USAID, \$25 million from 1987 to 1997, Sahel Region

Famine Early-Warning Systems

These projects aim to ensure food security in



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famine-prone African countries by developing a famine early-warning system within USAID, improving early-warning capacity in host countries, and increasing cooperation among international donors. Institutional capacities being developed, including surveillance and reporting methods, would be important adaptive mechanisms under a changed climate, especially one with lower and less reliable rainfall. The current project will reinforce existing African early-warning programs for food and nutrition problems and famine, and will develop or expand warning systems in semi-arid and drought-prone countries outside the Sahel. It will also explore ways to link and apply early-warning technology and experience to food security and other agricultural development issues.

■ USAID, \$9.2 million from 1990 to 1992 and \$40 million from 1993 to 1999, Africa

Sahel Water Data and Management III and IV

This project aims at improving water-resource management in the Sahel, which had below-normal rainfall in the 1980s and early 1990s. It is supporting the regional Agro-meteorological/Hydrological program by providing computer hardware and software, technical assistance, and training. With this assistance, this program will be able to collect, analyze, and disseminate climatic, hydrologic, and meteorologic information to forecast crop production.

The regionwide water-resource monitoring, data-gathering, and dissemination capabilities built up by this long-term project constitute an important underpinning for observing and coping with future climate change and attendant weather variability. Current areas of concentration are: (1) institutional capacity leading to

Sahelianization; (2) new products and applications in famine early warning, agricultural production, and natural resource management; and (3) pilot activities, especially using geographic information system applications.

■ USAID, \$21.23 million from 1987 to 1994 and \$12.82 million from 1994 to 1997, Sahel Region

Collaborative Research Support Program—Beans and Cowpeas

This program aims to develop an ongoing, multidisciplinary, multi-institutional research and training effort to increase bean and cowpea production and use in East and West Africa, Latin America, and the Caribbean, where these crops are a staple. The project has identified and provided to the West African region short-growing-season varieties of cowpeas that reduce the risk of crop failure.

■ USAID, \$32.75 million from 1980 to 1991

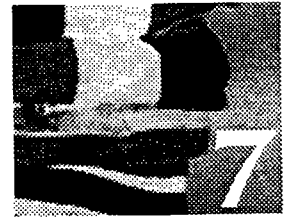
Disaster Preparation and Mitigation in Niger

This project is intended to minimize the negative impact of natural disasters on economic development through (1) policy and legal reform and institutional development, and (2) an Emergency Fund and companion project-assistance component, which will strengthen Nigerian abilities to assess, mitigate, and successfully respond to disasters. The Emergency Fund will allow for disaster early warning, preparedness, mitigation, and effective relief.

■ USAID, \$18 million from 1992 to 1996, Niger

Irrigation Support for Asia and the Near East

Initially aimed at providing irrigation assistance to boost food production and farm income, this project now includes flood manage-



ment and other broad water-resource issues. In particular, this project is developing nonstructural means of limiting flood damage to life, crops, and structures through its technical support for the World Bank-funded Bangladesh Flood Action Plan. These means of coping with recent flooding of the low-lying Gangetic floodplain and delta represent responses and capabilities that may be needed on a continuing and more widespread basis in Bangladesh and other low-lying deltaic plains as sea levels rise.

■ USAID, \$20.1 million from 1987 to 1992, Regional—Asia and the Near East

Senegalese Southern Zone Water Management

Lower than normal rainfall in the 1980s resulted in extended tidal flooding of low-lying deltaic rice farms, as the coastal wetlands—which normally were saturated with rain water and thus kept the sea at bay—absorbed the sea water. This scenario could become widespread in West Africa with sea level rise and, in semi-arid areas, with less rainfall.

Aiming to increase cereal production in southern Senegal by improving farmer recovery of land and use of water for agricultural production, this project includes environmental monitoring and construction of water-retention structures and tidal barrages in cooperation with village water-management committees. Activities such as these are what may be required on a more general basis to protect coastal deltas in the face of drier climates and sea level rise.

■ USAID, \$18 million from 1988 to 1996, Senegal

Program for Applied Development Research in the Sahel

This project is designed to help countries in the region improve their analysis, formulation,

coordination, and research in agricultural production, food security, and natural resource management. The project will be implemented by the Sahel Institute, a regional organization dedicated to collecting, analyzing, and disseminating scientific and technical information in the Sahel.

■ USAID, \$8.5 million from 1993 to 1998, Sahel Region

National Environmental Action Plan Support

Since 1987, USAID has pursued a program of support for African countries in the design and preparation of National Environmental Action Plans. At present, USAID Missions in Africa are supporting interventions in seven countries totaling over \$300 million in assistance related to African National Environmental Action Plans. The Multi-Donor Secretariat, housed at the World Bank and funded by USAID, has been directly involved with the design or implementation of almost all of these programs, many of which include managing dry-land resources and other planning that will be the basis for successful adaptation strategies in Africa.

■ USAID, \$450,000 from 1993 to 1995, Africa



Multilateral Fora

Multilateral fora are critical to international action on global climate change policy matters, and the United States plays a major leadership role and carries heavy financial responsibilities in them. The United States takes this role very seriously, and often goes beyond what is required to provide additional support for special projects that we believe can have significant payoffs. This section describes the U.S. role in, and contributions to, some of the chief financial and policy-making bodies relevant to the climate change issue, such as the Intergovernmental Negotiating Committee, the Global Environment Facility, the multilateral development banks, and other fora.

Framework Convention on Climate Change

The Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change successfully negotiated and concluded the present Convention, under the terms of which this document is submitted.

In addition to actively participating in the INC, the United States has provided substantial financial resources to the INC and to its special voluntary fund, which supports the travel of delegates from developing countries to the negotiations. In 1994, U.S. financial support totaled \$x, or xx percent of the total INC budget.

The United States has shown its commitment to move forward with the rapid implementation of the Climate Convention by promptly ratifying it on October 15, 1992 (the fourth country to do so), and by developing its own *Climate Change Action Plan* to reduce greenhouse gas emissions to 1990 levels by the year 2000. In addition, the United States has put forward the U.S. Initiative on Joint Implementation to assist in the development of an international joint implementation program under the terms of the Convention. The United States is also playing a major role in developing alternatives within the Convention framework to address the climate change threat in the next millennium.

Other Relevant Conventions and Agreements

The United States is also a party to several other international agreements that control greenhouse gases:

- The 1985 Vienna Convention for the Protection of the Ozone Layer and its 1987 *Montreal Protocol on Substances That Deplete the Ozone Layer*.
- The Geneva Convention on Long-Range Transboundary Air Pollution and its NO_x Protocol.
- The U.S.-Canada Air Quality Agreement.



- The Commission on Sustainable Development.

Global Environment Facility

The Global Environment Facility (GEF) was established in 1991 as a three-year pilot program to help developing countries meet the global challenges of climate change and ozone depletion, the loss of biodiversity, and the pollution of international waters. The pilot GEF was administered under a tripartite agreement among the World Bank, the United Nations Development Program (UNDP), and the United Nations Environment Program (UNEP). The United States participated in the process of restructuring and replenishing the GEF, through which governments, after reviewing the results of the pilot phase, decided that the mandate of the GEF should be preserved, but decided that its management structure needed fundamental redesign to make it more transparent, accountable, and participatory.

The restructured GEF will retain the services of the World Bank, UNDP, and UNEP, but a Secretariat that is functionally independent from the three agencies will manage the operations of the Facility, and a council composed of thirty-two countries will determine policy guidance. Membership in the GEF will be universal, and all member countries will convene periodically to review its progress. The GEF will provide for full public disclosure of all nonconfidential information, and will ensure that local communities and nongovernmental organizations are involved in all phases of project development and implementation.

The United States believes that the GEF should serve as the financial mechanism for the climate change and biodiversity conventions. To

support this vital endeavor, the United States has pledged \$430 million (out of a \$2 billion total) to the GEF's replenishment. U.S. bilateral programs will continue to strengthen collaboration with the restructured GEF as a complement to U.S. contributions to the core fund.

USAID Parallel-Financed GEF Activities

The U.S. government supported the first three-year Pilot Phase of the GEF with over \$150 million in parallel-financed GEF projects managed by the U.S. Agency for International Development (USAID) and with cofinancing of other GEF activities. Parallel-financed projects were developed by USAID, rather than by the GEF, but adhere to GEF guidelines. Six of the parallel-financed GEF projects are in the GEF climate change focal area.

USAID is assisting the Government of India in developing a pace-setting \$19 million GEF Greenhouse Gas Pollution-Reduction Project to promote efficient coal combustion and to increase the use of renewable biomass in the power sector. In the Philippines, the parallel GEF Demand-Side Management Project will provide technical assistance and financing to help establish and sustain commercial energy-conservation investments and service mechanisms in the industrial sector. USAID is also working cooperatively with four Latin American and Asian countries in developing renewable-energy projects that catalyze the cooperation of governmental and nongovernmental organizations. These projects are described in further detail earlier in this chapter.

Core-Funded Projects

In addition to these parallel projects, USAID has worked with the GEF in developing several GEF core-funded climate change projects. These



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include preinvestment assistance for the Costa Rica Grid-Integrated Windpower and Mexico Electric Power End-Use Efficiency Projects.

Analytical Support

USAID also provided instrumental start-up funding to the Program for Measuring Incremental Costs for the Environment, which is designed to provide operational guidance on how to resolve a number of methodological issues on incremental costs fundamental to the GEF and to the climate and biodiversity conventions, to which the GEF is linked. The results of this project will provide the technical underpinning for the development of financing policies and project-selection criteria for the next phase of the GEF.

Multilateral Development Banks

The United States believes that the multilateral development banks represent a powerful tool for implementing environmental policy goals. Thus, the United States is committed to providing leadership in developing the international consensus required to achieve these policy goals. In the area of climate change, the United States has had considerable success in promoting an environmental agenda.

The United States continues to urge the multilateral development banks to increase their lending, their staff positions in, and their emphasis on the areas of renewable energy and energy efficiency. The United States also encourages the banks to consider the impacts of their lending on global climate through the use of enhanced environmental impact assessments.

African Development Bank

The African Development Bank focuses on

capacity development in borrowing countries to build up the institutional, statutory, and regulatory framework necessary for the implementation of an integrated least-cost planning approach that encompasses energy supply and efficiency, and the environment. The African Development Bank is also working on the development of renewable- and alternative-energy sources.

Asian Development Bank

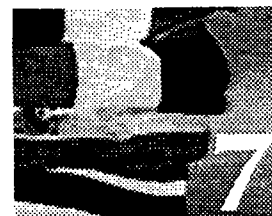
The Asian Development Bank is allocating more resources to focus on energy efficiency and conservation, nonconventional energy resource development, and intensified environmental initiatives. The Asian Development Bank's policies concentrate on moderating energy demand, improving efficiency in resource allocation, and strengthening institutions for national energy-conservation activities, with greater focus on policy analysis.

European Bank for Reconstruction and Development

The European Bank for Reconstruction and Development's energy operations aim primarily at improving energy efficiency, both in supply, by reducing conversion and distribution losses, and in demand. To address these aims, the Bank promotes pricing reform, improved standards for insulation, and the introduction of more energy-efficient technologies. Bank assistance will be based on least-cost energy plans or, preferably, an integrated resource planning strategy. The Bank plans to hire an energy-efficiency expert to work solely on expanding Bank efforts in this area.

Inter-American Development Bank

As part of its recently concluded capital-



replenishment agreement, the Inter-American Development Bank (IDB) undertakes to promote the conservation and efficient use of energy in its projects. The IDB will continue to assist borrowing countries in adopting energy-development strategies that are environmentally sustainable by: (1) elaborating on integrated least-cost energy-development plans and, where such plans do not exist, supporting their development; (2) promoting the efficient use of energy in all economic sectors; and (3) developing and carrying out regional energy-integration programs.

World Bank

World Bank policy states that energy lending will be based on integrated least-cost energy plans, with emphasis on energy efficiency, demand-side management, and the exploitation of renewable-energy sources. The World Bank is also playing a major role in the GEF, where it is responsible for the majority of GEF investment operations to reduce greenhouse gas emissions.

Organization for Economic Cooperation and Development

The Organization for Economic Cooperation and Development (OECD) has played a crucial role in helping to ensure consistency in national communications under the Framework Convention on Climate Change. Its efforts have included the joint development, with the Intergovernmental Panel on Climate Change (IPCC), of consistent guidelines for developing greenhouse gas inventories, and the evaluation of options for the preparation and review of national communications.

National Inventories

Since 1990, OECD has coordinated the

development of guidelines for reporting greenhouse gas inventories for IPCC's Working Group I. The United States has supported this project since its inception. The three-volume "Draft IPCC Guidelines for National Inventories" was released in December 1993 (xxx). The Intergovernmental Negotiating Committee (INC) adopted the guidelines, with minor revisions, as the methods to be used to report greenhouse gas inventories (UN/INC 1994). The guidelines include simple default methods and assumptions covering the major sources and sinks of greenhouse gases, and also discuss optional, more detailed methods. The guidelines are expected to be finalized in September 1994. OECD is continuing to work with experts from around the world to improve the methodologies and to address gases and sources other than those now included.

National Communications

With strong U.S. support, OECD has governed a series of expert workshops for Annex I Party representatives to develop guidelines for the preparation and review of national communications. The OECD project has substantially enhanced the ability of countries to prepare national communications by producing guidelines for Annex I Parties, which INC subsequently adopted at its Ninth Session in February 1994, with only a few minor changes. The submissions by Parties of comparable national communications under the Framework Convention is being greatly facilitated through this fair, technically sound, and constructive process.

International Energy Agency

The IEA is an autonomous body established in 1974 within the OECD framework to cooper-



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ate in energy matters. To support its members in their commitments to reduce their greenhouse gas emissions, the IEA is engaged in a growing number of activities related to climate change. These range from a study on transport, energy, and environment for the Intergovernmental Panel on Climate Change to an assessment of the comparability of national climate policies for use by the INC. Environmental considerations carry over into the work programs of virtually every sector of the IEA. The United States has funded several initiatives under the auspices of IEA and other energy-related fora.

The Information Initiative on Greenhouse Gas Technologies

Known as GREENTIE, this initiative aims to identify energy technologies that mitigate greenhouse gas emissions and have the potential for international deployment, that increase the awareness of potential decision makers and users by disseminating information on those technologies to specific target areas and groups, and that engage the relevant industries in international technology deployment. The United States contributed \$130,000 to GREENTIE in 1994.

Center for the Analysis and Dissemination of Demonstrated Energy Technologies

CADDET was established under an IEA agreement to disseminate information on demonstrated energy-efficiency and renewable-energy technologies among CADDET member countries. CADDET has recently offered associate membership to East European and developing countries. U.S. funding for CADDET was \$500,000 in 1994.

Greenhouse Gas R&D Program

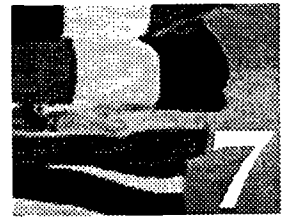
Sponsored by fourteen countries, this IEA program is currently conducting full fuel-cycle analyses of conventional and advanced power-generation systems, sponsoring conferences, and evaluating novel strategies to reduce CO₂ emissions. U.S. funding for this program was \$200,000 in 1994.

Asia-Pacific Economic Cooperation

APEC is a ministerial-level agreement to promote the economic and social well-being of the Asia-Pacific region through economic cooperation. The United States has the lead in the energy-efficiency area, which focuses on workshops and seminars on energy-efficiency technologies and practices, and develops programs for mitigating greenhouse gas emissions using energy technology. The United States contributed \$200,000 to APEC in 1994.

Other Fora

The United States actively participates in the work of numerous other international organizations and agreements related to climate change. The U.S. role in the IPCC, which evaluates and assesses the available scientific literature on climate change, is detailed in Chapter 6 of this report, together with U.S. contributions to the World Meteorological Organization and UNEP. Other organizations with climate change activities include the International Atomic Energy Agency, and the United Nations Food and Agriculture Organization.



Nongovernmental Efforts

This chapter has described in some detail the many activities that the U.S. government is engaged in to assist other countries in our common effort to combat global warming. This description is incomplete, however, without a mention of the many activities that nongovernmental organizations are engaged in overseas, especially in the areas of renewable energy, energy efficiency, and adaptation. The contribution of these organizations—in terms of both the actual projects they sponsor and their expertise and ideas—is invaluable.

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This document outlines the steps the United States is taking, domestically and internationally, to address climate change. These include a *Climate Change Action Plan* (described in Chapter 4) to mitigate the effects of climate change by reducing U.S. emissions and enhancing sinks of greenhouse gases. The measures in the Action Plan—with assumptions current when it was developed, regarding economic growth, oil prices, and program implementation—would fulfill the President's commitment to return greenhouse gas emissions to their 1990 levels by the year 2000.

This chapter addresses two additional issues: (1) the uncertain effectiveness of current actions to meet the domestic commitment in the face of changing circumstances, and (2) the long-term actions that must be taken to address global warming—as greenhouse gas emissions will continue to rise well beyond the turn of the millennium.

the future



Meeting Year 2000 Commitments

Since the *Climate Change Action Plan* was published in October 1993, the United States has been actively implementing its programs and measures. Individual agencies within the federal government are developing performance indicators and progress milestones for the programs under their management.

Significant progress has been made in meeting these milestones—with some being exceeded within the first six months of calendar year 1994. Highlights of the current effort include both the expansion of existing programs and the launching of new efforts:

- To date, more than seven hundred utilities have pledged their intent to reduce greenhouse gas emissions in their service territories as participants in the Climate Challenge.
- Climate Wise, which provides recognition for an organization's cumulative greenhouse gas reductions, has recruited several large U.S. corporations as pledge participants, representing approximately 2 percent of U.S. industrial energy use.
- Now in its third year, the Green Lights program is still growing rapidly and has recruited over fifteen hundred new participants and 4.5 billion square feet of commercial building floor space (more than 5 percent of all U.S. industrial space).
- Since its start-up in June 1994, the Energy Star Showcase Buildings program has exceeded its initial recruitment goal by signing on twenty-five members.
- Both the Coalbed Methane Program and AgSTAR (the partnership with livestock producers to reduce and recover methane emissions) were launched in April 1994.
- Provisions for parking cash-out have been proposed.
- Mobility partners have funded and distributed case studies, and guidance documents under review are scheduled for completion by the end of 1994.
- Review of the transportation efficiency strategy Congestion Mitigation and Air Quality Management is under way, and reviewers have begun to visit program participants in the field.
- Since the creation of the Waste Wise program in December 1993, over 280 companies have made significant commitments to reduce solid waste and increase recycling.

However, in spite of these efforts, it is impossible to predict precisely the future effect of the U.S. program. Uncertainties in meeting commitments to future levels of greenhouse gas emissions and sequestration arise from several



sources:

- The actual relationships between energy use, energy prices, and economic activity levels may differ from those embodied in the forecasts used to predict future emissions.
- Future conditions may diverge from the projections made regarding economic growth rates, world oil prices, and the costs and performance of technologies used on the supply and demand sides of the energy market.
- Short-term fluctuations in the weather in 2000 relative to 1990 could disguise underlying trends in energy consumption.
- The actual impact of actions identified in the plan may differ from their projected effects—some actions not currently scored at all (e.g., the Climate Challenge and Climate Wise programs, and state and local outreach programs) may yield significant reductions, while some actions may yield lower-than-expected returns because they are not fully funded or are not fully effective for other reasons.
- Future legislative and administrative actions that address environmental, energy, agricultural, and forest concerns could significantly increase or decrease net greenhouse gas emissions.
- Changes in the scientific understanding of the relative global warming potentials of different gases could change the estimates of the effectiveness of the Plan in terms of carbon-equivalent emissions.
- Improvements in the understanding and management of agricultural and forest soil carbon as they relate to the domes-

tic carbon sink could change the net emissions baseline and the effectiveness of actions.

Changes in Modeling Assumptions

Examining changes in projections regarding economic growth rates and future oil prices in the baseline for carbon emissions demonstrates, for example, the effect of uncertainty regarding future conditions. Economic growth rates determine the future gross domestic product (GDP), which reflects the level of various economic activities (e.g., commercial activity, industrial production, resource use, personal consumption, and travel). All of these economic activities influence the emissions of greenhouse gases. In general, a higher GDP has been associated with higher net emissions of greenhouse gases. A sensitivity case developed during preparation of the *U.S. Climate Change Action Plan* with GDP growth rates 0.5 percent per year lower than the assumptions ultimately used in the Plan's baseline reduces projected U.S. carbon emissions in 2000 by 29 million metric tons (MMTs) below the levels projected in the Plan.

Projections about the world oil price over time are based on assumptions about the availability of world petroleum supplies and world oil demand. For instance, larger-than-expected petroleum production could translate into lower world oil prices in the future, which, in turn, could raise consumption significantly. A sensitivity case in which real oil prices remain constant from 1992 through 2000—instead of increasing by an average of 3.0 percent annually, as in the base case—increases carbon emissions in 2000 by 16 MMTs above the level projected in the Plan.



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Another uncertainty in the projection of the effects of emissions relates to the global warming potential (GWP), a metric that allows comparisons between measures taken for different gases. The GWPs used in developing the Action Plan were those of the 1992 IPCC Assessment Report. However, more recent data on GWPs suggest that the values for methane and other greenhouse gases are substantially higher than those proposed in the 1992 report (IPCCa). Were these new values to be used in projecting emission reductions under the Action Plan, the U.S. program would reduce emissions below the 1990 target in the year 2000.

Responses to Changing Circumstances

One of the key provisions of the Action Plan is a process for monitoring, evaluating, and adjusting the U.S. greenhouse gas mitigation effort to identify and remedy potential shortfalls in emission reductions.

Monitoring

There are several mechanisms for monitoring emissions and sequestration trends. The U.S. Department of Energy, the Energy Information Administration, the U.S. Environmental Protection Agency, and the Federal Energy Regulatory Commission continuously gather and analyze data on energy production and consumption and greenhouse gas emissions. The U.S. Department of Agriculture gathers data on forest inventories and agricultural production. The Clean Air Act Amendments of 1990 require that electric utilities undertake continuous monitoring of CO₂ emissions. Companies participating in the Energy Policy Act's Section 1605(b) voluntary reporting program will supply timely

information regarding their efforts to reduce greenhouse gas emissions. This will include utilities that voluntarily undertake the Climate Challenge, and industrial firms that—also voluntarily—report under the Climate Wise program. Finally, companies participating in the U.S. Initiative on Joint Implementation will provide information on the progress of overseas projects that are expected to yield measurable emission reductions.

Evaluation

The greenhouse gas projections reported in this document were developed for the President's *Climate Change Action Plan* and were based on information provided by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency, and other federal agencies in 1993. Complete documentation of the assumptions used for the projections is provided in the *Climate Change Action Plan: Technical Supplement* (U.S. DOE 1994), a supporting document to this report. According to these 1993 estimates, the U.S. program would achieve the reductions necessary to return emissions to 1990 levels by the year 2000.

Interagency Program Tracking System

U.S. agencies are finalizing a program tracking system to record progress in meeting established milestones. The tracking system will ensure consistent and coordinated reporting on the implementation of the measures in the *Climate Change Action Plan*. This system will be used to produce periodic reports on the accomplishments of the interagency programs. In addition, the information from the tracking system, along with updated national greenhouse gas inventories and biannual evaluations of future emission trends, will provide the information



required to assess the Action Plan's success.

The previously discussed sources of uncertainty about the ability of the *Climate Change Action Plan* to meet its commitments fall into two general categories: (1) the effectiveness of the measures in the plan in reducing emissions, and (2) estimates of the level of emissions in projections for the year 2000. With respect to the latter category, there are indications that these projections are subject to considerable change. For example, the latest information collected by DOE (for publication in 1995) is expected to suggest a higher baseline level of CO₂ emissions from energy consumption than predicted in the projections used in developing the U.S. program of actions.

In addition to its *Annual Energy Outlook*, DOE's Energy Information Administration periodically publishes a *Short-Term Energy Outlook*, which provides forecasts of energy used over the next six to eight quarters. The August 1994 *Short-Term Energy Outlook* provides new short-term estimates of energy consumption through the year 1995 (U.S. DOE/EIA 1994a). When converted to carbon emissions, these estimates indicate that emissions are above the level used in developing the October 1993 *Climate Change Action Plan*. U.S. energy consumption in 1994 converts to 1,408 MMTCEs, which is 25 MMTs greater than the Action Plan's projected maximum emissions of 1,383 MMTs, which was to be reached in 1997.

The discrepancy between the *Short-Term Energy Outlook* forecast for 1995 and the baseline used in developing the *Climate Change Action Plan* is particularly striking in two areas: the projected level of industrial energy use and share of coal in total electricity generation are significantly higher in the *Short-Term Energy Outlook*. The explanation for this is that the *Energy Outlook* forecasts

are very short term—that is, they end in 1995. Thus, they cannot be used to make comparisons with year 2000 projections. Furthermore, *Short-Term Energy Outlook* forecasts do not account for structural changes, including impacts from the Action Plan and EPAct. In addition, fluctuations around the trend line are expected to occur between now and the year 2000. For example, the *Annual Energy Outlook* for 1995 could indicate lower trends for greenhouse gas emissions due to higher oil prices or slower U.S. economic growth. Nevertheless, the new data suggest there may be a need to modify the Action Plan should these phenomena persist.

Adjustment

The United States will review progress under the Action Plan on a biennial basis to report on current trends, to adapt existing programs to evolving circumstances, and to pursue additional policy initiatives, if necessary. The Action Plan is not a one-time policy development exercise, but rather begins a process of continual improvement in energy, environmental, and economic policy. In developing future steps, the United States will continue to seek out opportunities for emission reduction that provide for economic growth and job creation.

An interagency task force, chaired by the White House Office on Environmental Policy, will evaluate the progress made under the Action Plan and will recommend revisions as necessary. Updates to this *Climate Action Report* will be prepared by this task force in coordination with the U.S. Department of State; these updates will occur every two years, or when called for by the Conference of Parties to the Framework Convention on Climate Change.



Post-2000 Actions

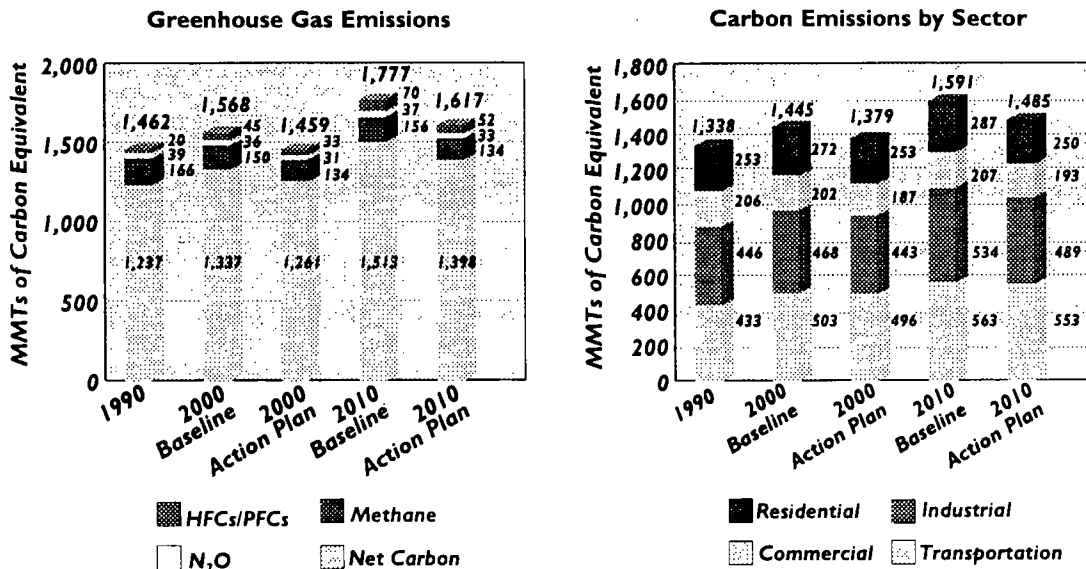
The initiatives in the 1993 *Climate Change Action Plan* to mitigate climate change will have long-term effects well beyond the year 2000. However, assuming reasonable economic growth, the current set of measures—even with the diffusion of existing technologies, and new technology development—is unlikely to be sufficient in the longer term to meet the ultimate objective of the Convention (Figure 8-1). The

United States recognizes the need to develop additional measures to combat the longer-term trend of rising emissions. Policies must address the development of new technologies of energy supply and use and must promote long-term market transition away from activities, fuels, and technologies that generate large emissions of greenhouse gases. Policies must also address enhancing forest carbon sinks.

Figure 8-1

Projected Impacts of the Action Plan on Greenhouse Gas Emissions

Action Plan measures are projected to have a substantial impact in the post-2000 period; however, emissions are still expected to exceed 1990 levels in 2010, unless additional measures are taken.



Source: U.S. DOE 1994



Technology Research and Development Strategy

The policies contained in the U.S. Action Plan are aimed at information transfer and the creation of an effective market for investment in existing or nearly commercially available technologies that cost-beneficially reduce greenhouse gas emissions. The core of a long-term strategy must ensure that a constant stream of such improved technology is available and that market conditions favoring its adoption are not impeded. While the current U.S. Action Plan is likely to stimulate an acceleration in technology development, this impact is not readily quantifiable. However, such gains will lay the foundation for the development of technologies that can contribute to significant reductions in greenhouse gas emissions and protection of carbon sinks in both the United States and abroad. A long-term accelerated technology strategy is under development and is expected to underpin progress in continued greenhouse gas emission reductions in the next century.

Research and development of technologies that could contribute to cost-beneficial greenhouse gas emission reductions will be a critical part of the long-term effort. Research priorities to reduce energy demand include advanced building systems, transportation equipment systems, and manufacturing technologies to reduce energy and material requirements. Research priorities for lower-carbon, energy-supply technologies could include sustainable biomass energy systems, advanced natural gas turbines, fuel-cell technologies, more efficient clean-coal technologies, cogeneration systems, improved efficiency of energy-distribution and -storage systems, renewable-energy technologies, hydrogen fuel systems, and continued research into

nuclear safety and waste disposal options that could maintain commercial nuclear power.

The United States is also committed to a continuing evaluation of the budgetary, technological, and economic policies that directly or indirectly affect future greenhouse gas emission trends. Mitigation of greenhouse gas emissions—and protecting and increasing existing carbon sinks—are becoming a fundamental consideration in developing and implementing U.S. economic, energy, environmental, and international policies.

The Transportation Sector

As much of the anticipated growth in greenhouse gas emissions will come from the transportation sector, additional measures will be required to address expected increases in transportation needs. Thus, the U.S. government has established a process to develop measures to reduce greenhouse gas emissions from personal motor vehicles, including light cars and trucks. The process involves key government agencies, the automobile and fuel industries, labor, state and local governments, and the environmental community in a formal advisory committee. The participants will examine a full range of cost-effective options, including vehicle use, vehicle technology, alternative fuels, and other options to reduce total greenhouse gas emissions attributable to personal motor vehicle use, while meeting or exceeding applicable vehicle safety and clean air requirements. The committee is to make recommendations in mid-1995 on policies that would lead to consensus on cost-effective returns to 1990 levels of greenhouse gas emissions from personal motor vehicles by the years 2005, 2015, and 2025, with no upturn thereafter.

In another initiative directed at the trans-



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portation sector, the United States established an historic partnership between the federal government and U.S. automobile manufacturers in 1993. The goal of this partnership is to produce a new generation of world-competitive automobiles that would achieve three times the fuel efficiency of conventional cars of today and, thus, a significant decrease in CO₂ emissions. Such cars would continue to meet all safety and conventional pollution emission standards, and would retain the performance characteristics and affordability of today's cars. The partnership is committed to the development of one or more production prototypes within a decade.

A Long-Run Strategy

In addition, the United States has established a long-run strategy working group to examine all policies that could affect greenhouse gas emission levels beyond the year 2000. Jointly chaired by the White House Offices on Environmental Policy and Science and Technology Policy, and the National Economic and National Security Councils, this group is expected to prepare its initial recommendations by the end of 1994. The working group is addressing:

- The conceptual framework, establishing a context for considering future actions.
- The international approach, establishing a context for global solutions.
- A range of budget, technology, R&D, regulatory, and economic policies that could affect greenhouse gas emission levels.

To develop these approaches, the group has formed a number of subgroups that will examine alternatives in: (1) biomass and renewables; (2) ultra-efficient residential and commercial sys-

tems; (3) carbon sequestration—focusing mostly on forest offsets, but also examining options for marine sequestration and soil/biomass sequestration; (4) pricing—looking at options for changing activities that lead to high greenhouse gas emissions through market incentives; (5) non-energy policies—focusing on non-CO₂, non-energy options for greenhouse gas reductions; (6) nonpersonal transportation—looking at commercial transport as well as urban and rural mass-transit options; (7) natural gas—looking at ways to enhance natural gas consumption, which is a less carbon-intensive fuel than either oil or coal; (8) technology diffusion—looking at ways to stimulate the introduction of new greenhouse gas-reducing technologies in all countries; and (9) joint implementation—continuing to develop the U.S. Initiative on Joint Implementation to promote cost-effective actions to reduce greenhouse gas emissions. Results from each of these subgroups will be analyzed to evaluate the costs and the effectiveness of each of the most attractive policies and measures in reducing emissions. These may then become part of the initial recommendations of the working group at the end of this year.



International Process

In addition to the domestic process outlined for developing next steps to reduce greenhouse gas emissions, the United States has been, and will continue to be, an active participant in international negotiations under the United Nations Framework Convention on Climate Change. Entry into force of the Convention in March 1994 triggered the requirement to prepare this document, and the Convention's provisions established an "aim" that Annex I countries (OECD countries and countries with economies in transition to market economies) return their emissions to 1990 levels by the year 2000.

In the most recent discussions to prepare for the first meeting of the Conference of the Parties (scheduled for Berlin, March 28–April 7, 1995), the United States, as well as the majority of the other countries involved in this effort, agreed that while adequate as a first step, the actions called for by the Convention are not adequate to address the threat of global climate change, particularly in the post-2000 period. Accordingly, the international community is currently developing appropriate next steps under the Convention.

[NOTE: THIS SECTION WILL BE FURTHER ELABORATED AFTER THE AUGUST CONSULTATION AND FOLLOWING THE AUGUST INC SESSION.]

International Regime

In addition to the domestic process outlined for developing next steps to reduce greenhouse gas emissions, the United States has been, and will continue to be, an active player in the international negotiations under the Framework Convention on Climate Change. Entry into force of the Convention in March 1994 triggered the requirement to prepare this document, and the Convention's provisions established a non-binding "aim" that Annex I Parties (OECD countries and countries with economies in transition to market economies) return their emissions to 1990 levels by the year 2000.

In international discussions in February 1994 to prepare for the first meeting of the Conference of the Parties to the Climate Convention (scheduled for Berlin, March 28 to April 7, 1995), the United States, as well as many other countries involved, agreed that, while adequate as a first step, the actions called for by the Convention are not adequate to address the threat of global climate change, particularly in the post-2000 period. Accordingly, the Parties to the Climate Change Convention are considering the development of appropriate next steps under the Convention.

U.S. views on next steps were further elaborated at the 10th session of the Intergovernmental Negotiating Committee, in August of 1994. In the U.S. view, the top priority for the next stage is the negotiation of a new "aim", which would provide for international commitments beyond the year 2000. Setting a new aim would anchor the post-2000 regime, focus efforts, and help galvanize national and international action. Along with the development of a new aim for the Convention should come the development of common actions, possibly in the form of a menu of options, agreed measures or processes designed to help reduce greenhouse gas emissions to meet the agreed aim.

In promoting this view internationally, the United States has indicated that the regime should have several characteristics, and should be:

Comprehensive: Covering all greenhouse gases in all sectors, as well as sources and sinks

Flexible: Allowing countries to tailor national efforts to fit national circumstances and to adopt the most cost-effective alternatives

Cooperative: Encouraging joint action to empower all countries to respond to the threat of climate change, particularly through capacity building and technology diffusion

Sustainable: Facilitating the use of renewable, and the efficient use of non-renewable resources

Innovative: Facilitating the development and dissemination of efficient new technologies to deal with the long-term threat of climate change

Beneficial: Promoting an aim and actions whose costs are justified in light of the range of potential consequences of climate change

Equitable: Engaging all countries in the global effort while recognizing differences in national circumstances and capabilities, and

Pragmatic: Recognizing emissions trends, and likely economic growth, in developed and developing countries

Links between Science and Policy

The United States is committed to continue its strong emphasis on improving the scientific basis for future national and international policy decisions regarding climate change. In view of the policy needs outlined above, several research foci will be emphasized, including characterizing a broader suite of greenhouse gases (e.g. tropospheric ozone and its precursors), better quantifying the role of clouds and oceans for the improved prediction of the timing and magnitude and regional patterns of greenhouse warming, describing, and where possible quantifying, the impacts of climate change on natural and managed ecosystems and human health, and integrating the assessments of the science, economics and social factors to support informed decision-making. Further, the U.S. will facilitate the use of this information by the Intergovernmental Panel on Climate Change and continue its assistance with the coordination of this important assessment activity.

Establishing an New “Aim”

The United States has urged internationally that the objective should be to establish a new aim to guide efforts at adopting policies and corresponding measures to mitigate climate change in the immediate post-2000 period. In this post-2000 period, progress toward the Convention’s ultimate objective of stabilizing atmospheric concentrations of greenhouse gases at a level that would prevent dangerous anthropogenic interference with the climate system must be made. Moreover, it is critical to establish milestones to gauge progress and focus efforts; the Convention’s current aim for the year 2000 serves as the first milestone.

The Convention established a non-binding “aim” for the pre-2000 period, but each Annex I Party can individually determine the path it will take to meet the aim. Annex I Parties have been working, since adopting the Convention, to develop specific policies and measures to meet the current aim. However, it may be time to begin considering common actions -- some of which may more easily be taken collectively than individually.

Common Actions and Technology Initiatives

Such actions could draw on the experience of all countries’ efforts in meeting the current aim (or fulfilling other environmental objectives) to determine whether these offer possibilities that others might use to advantage. In this way, countries could agree -- within or outside the

Convention -- to a set of measures that will help each of them reduce emissions. It may be possible to develop a menu of agreed options from which countries could choose in seeking to meet their commitments. Such a menu could help define the scope and degree of international efforts, while preserving national flexibility. This would ensure greenhouse gas reductions and enable countries to go a substantial distance toward meeting a new aim>

The United States has also suggested the possibility of broad-based and specific technology initiatives, including incentives or disincentives to promote technologies that reduce greenhouse gas emissions and to reduce barriers to their deployment. Based on future emissions scenarios, it is clear that all nations will need to employ new technologies to achieve their economic development and GHG emission reduction goals. Technology development and diffusion is thus a promising candidate for international cooperation.

Finally, the United States has also suggested the possibility of development of international norms to guide and encourage manufacturers in adopting lower emitting technologies. Such norms could encourage competition to increase the efficiency of various products without imposing standards through regulations and potentially locking countries into yesterday's technology.

Joint Implementation

The United States strongly endorses the concept of joint implementation, and, in particular, its application to future global greenhouse gas emissions reductions. Under the U.S. Initiative on Joint Implementation (USIJI), and similar programs in other countries, international understanding of the potential for joint implementation should emerge. Convention Parties, on the basis of this information -- and the confidence it generates -- will be able to develop appropriate criteria for a mature program. A rapid, credible design of the Convention's joint implementation regime will assist parties in developing the next steps under the Convention for expanded and innovative -- as well as cost-effective -- agreements for reducing greenhouse gas emissions.

The dimensions of an international joint implementation program -- including the development of methodologies for monitoring progress, reporting on projects and verifying emissions reduced or sequestered -- have not yet been defined. The United States intends to remain active in the development of the international operational modalities for joint implementation, both through the example of the USIJI, and through full participation in the Climate Convention, the Parties to which will have the ultimate responsibility for their adoption.

Enlisting Public and Private Sector Expertise

Large numbers of public and private sector experts have participated in the process of helping to shape U.S. policy on this issue. To date, however, their role has largely been confined to observing the discussions, to making occasional, collective interventions, and to lobbying in the corridors.

To expand the dialogue with the public sector about the potential for technologies and to discuss possible internationally agreed common actions, the United States has urged that public and private sector experts be brought more centrally into this work. Technical advisory panels in other international fora (such as the Montreal Protocol on Substances that Deplete the Ozone Layer) have proven highly effective at identifying specific options and alternatives and at gauging the opportunities for implementing them. Tapping public and private sector expertise in pursuit of solutions could help forge new partnerships between and among experts from developed and developing countries. These new partnerships could hasten our efforts to promote technology development and diffusion.

Strengthening the Convention Process

As the United States attempts to build an international consensus to establish a new aim and common actions to help meet it, efforts are also continuing to strengthen the convention process. Progress in this area is vital in building confidence that Parties are fulfilling their commitments, in ensuring the integrity of national plans, in demonstrating the cost-effectiveness of emissions reductions through joint implementation, in assisting parties in better understanding the plans of others, and leading to better plan design. A stronger process, enabling us to monitor progress and to verify the results of actions taken, will assure that efforts under the Convention will be taken seriously both within governments and by the public.

Finally the U.S. recognizes that emissions will grow rapidly in many countries and that there is a need for broad international effort to examine opportunities for all countries to contribute to the effort to combat climate change. In this regard the U.S. will seek to encourage rapidly advancing developing countries in particular to assume a leadership role in future climate change actions.

While the steps in the U.S. policy described here may not be easy to adopt or to implement, it is only this kind of process that will ultimately assure that the potential threat of dangerous climate change impacts is not realized. The United States will continue to be an active participant in the international negotiating process -- both under the auspices of the Intergovernmental Negotiating Committee and the Conference of the Parties -- as critical next steps are developed, refined and agreed.

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