REQUEST FOR APPOINTMENTS

To: Officer-in-charge
Appointments Center
Room 060, OEOB

Please admit the following appointments on December 2, 19 92

for D. Allan Bromley (NAME OF PERSON TO BE VISITED) of OSTP (AGENCY):

BERNTHAL, Frederick	1/10/43
BISSELL, Richard	1/25/46
DAWSON, Christine	6/28/52
LAWLESS, James	8/18/42
MORGENSTERN, Richard	~~4/10/53~~ 4/26/44
REIFSNYNDER, Daniel	4/6/50
REINSTEIN, Robert	9/3/40
SPRADLEY, Julian R.	12/7/46
STILLINGS, Bruce	5/18/37
WHITMAN, Carol	10/20/53
PERSHING, Jonathan	2-25-59
GRUENSPECHT, Howard	10/21/54

MEETING LOCATION

Building OEOB
Room No. 472
Time of Meeting 4:15p

Requested by Ruth Fisher
Room No 431 Telephone 6202
Date of request 12/1/92

Additions and/or changes made by telephone should be limited to five (5) names or less.

APPOINTMENTS CENTER: SIG/OEOB – 395-6046 or WHITE HOUSE – 456-6742

UNITED STATES SECRET SERVICE

SSF 2037 (03-81)

395 7214
Leaf 472

Ruth:

Global Change

. Please call the offices of the members of the Strategy Task Force and determine their availability for a STF meeting for Wednesday, December 2

Please check 2 times (for a 1 hour meeting):

~~1:30~~ ~~3:00p~~ 4:15p

When you get a list of who is available and when, let me know and we will finalize it.

(1) Purpose of the meeting: To discuss the <u>US National Action Plan</u> and decide how it is to be handled

(2) A copy of the most recent version, containing agency comments/edits, will be messengered to STF members tomorrow morning.

(3) A memo and agenda will be sent out later today on the meeting

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

December 1, 1992

NOTE FOR NANCY MAYNARD

FROM: **RUTH FISHER**

RE: **GLOBAL CHANGE STRATEGY TASK FORCE MEETING**

As of c.o.b. today, the following offices have responded affirmatively regarding attendance at the Global Change Strategy Task Force meeting on December 2, 1991, 4:15 p.m., in Room 472 OEOB.

AGENCY:	**Fred Bernthal**	**NSF**
	Daniel Reifsnyder	**STATE**
	Robert Reinstein	**STATE**
	Christine Dawson	**STATE**
	Frank Bracken	**INTERIOR**
	Carol Whitman	**AGRICULTURE**
	Bruce Stillings	**AGRICULTURE**
	J. R. Spradley	**NOAA**
	Richard Morgenstern	**EPA**
	Linda Stuntz	**ENERGY**
	James Lawless	**NASA**
EOP:	**Mike Deland**	**CEQ**
	John Elkind	**CEQ**
	David Bradford	**CEA**
	Jonathan Weiner	**CEA**
	Theresa Gorman	**OPD**
	Jim Fitzhenry	**OCA**
	Boyden Gray	**WHO**
	Paul Gilman	**OMB**
	Vicki Sutton	**OSTP**

THE WHITE HOUSE

WASHINGTON

November 30, 1992

MEMORANDUM FOR THE GLOBAL CHANGE STRATEGY TASK FORCE

FROM: **D. ALLAN BROMLEY**

SUBJECT: **Strategy Task Force Meeting**

There will be a Global Change Strategy Task Force meeting on Wednesday, December 2, 1992, at 4:15 p.m. in Room 472 of the Old Executive Office Building.

The purpose of the meeting is to discuss policy issues related to the United States Climate Change National Action Plan and the release of the plan at the December meeting of the Intergovernmental Negotiating Commitee (INC).

The final draft of the plan, which incorporates agency comments submitted to OMB during the recent policy review of the document, will be sent by messenger to your office tomorrow morning, December 1, 1992, for your reference.

THE WHITE HOUSE

WASHINGTON

GLOBAL CHANGE STRATEGY TASK FORCE

AGENDA

December 2, 1992

1. **United States Climate Change National Action Plan**

   - o **Background and Status**
   - o **Overview and Assessment of the Plan**
   - o **Policy Issues**
   - o **Intergovernmental Negotiating Committee (INC) Meeting December 7, 1992**

2. **Other Business**

Introduction

In June 1992, President Bush signed the United Nations Framework Convention on Climate Change on behalf of the United States and invited other signatories to join the United States in a prompt start on its implementation. Toward this end, he proposed that countries meet by January 1993 to present and review their national action plans. In his remarks to world leaders assembled in Brazil at the United Nations Conference on Environment and Development, the President also highlighted U.S. interest in cooperating with other nations to share U.S. programs and to learn about other efforts proposed and adopted to address the issue of climate change.

In the negotiations that led to the Convention, the United States strongly supported an approach to global action that focused on the development of national policies and measures to mitigate and adapt to climate change, recognizing that only concrete actions will enable the world community to effectively address climate change, and that measures and policies must be rooted in specific national circumstances and fashioned from a comprehensive set of options addressing all sectors, sources, and sinks of greenhouse gases. Under the Convention, the Parties will closely monitor the evolving science of climate change and will continually assess the consequences of the global response. As uncertainties are resolved, and as nations are better able to assess and compare the effects of specific policies and measures, the Parties to the Convention will be better able to determine whether, and to what extent, global concern about climate change may call for additional action. The Convention established precisely this kind of action-oriented process.

The Convention is scheduled to enter into force once it is ratified by fifty countries. However, as negotiators of the Convention noted, an early and effective start is important to the process. To this end, at the final negotiating session in May 1992, the International Negotiating Committee adopted a resolution calling for a series of interim arrangements to begin as soon as possible. One of the principal recommendations was to invite "States and regional economic integration organizations entitled to sign the Convention to communicate as soon as feasible to the head of the Secretariat information regarding measures consistent with provisions of the Convention pending its entry into force."

This document represents the United States' first communication to the Secretariat. It is made in the spirit of moving forward with the complex task of beginning the implementation phase of the Convention. This Plan identifies the types of programs, policies, and measures the United States is taking to address the issue of global climate change. As such, it is merely representative of the variety of actions the United States has undertaken. It is not—nor could it truly be—an exhaustive list of all measures.

In addition, this document does not seek to identify or recommend additional policies and measures that might be taken. In this sense, this document and the process in which it has been prepared are not intended to be substitutes for existing or future decision-making processes, whether administrative or legislative, or for additional voluntary initiatives developed by or with the private sector. Rather, the compendium of actions identified in this document should assist in measuring and evaluating existing policies and measures and in establishing a basis for considering future actions.

The United States anticipates that its National Action Plan, like those of other Parties to the Convention, will be reviewed and discussed in the Convention process. Critical to this exercise will be the development and implementation of comparable methods for inventorying sources and sinks of greenhouse gases and, more particularly, for estimating the effects of specific actions. Such methods do not yet exist. However, their development and implementation should be facilitated by early development and review of the kinds of information and the methods and assumptions presented in this document.

In accordance with the provisions of the Convention, the United States intends this document to represent the first iteration in a series of regular reports. The current National Action Plan was preceded by the *U.S. Climate Change Action Agenda*, presented at the first session of the Intergovernmental Negotiating Committee in February 1991. An update in the spring of 1992 (*U.S. Views on Global Climate Change*) added a wide range of additional actions to reduce net greenhouse gas emissions. As continuing worldwide research on the science and economics of global change (more than half of which is currently funded by the United States) generates new information and resolves existing uncertainties, as new policies and measures are formulated in response to this information and to the assessment of existing policies and measures identified in this document, and as national circumstances (e.g., economics, demographics and legal relationships) continue to evolve, they will be reflected in future iterations of the National Action Plan.

Overview of U.S. Actions

The United States is taking numerous actions to address potential climate change. These include prudent steps to strengthen the ability of economic, social, and ecological systems to adapt to adverse change; concrete measures to mitigate the risk of potential climate change by limiting net greenhouse gas emissions; aggressive research to improve understanding of climate, climate change, and potential responses; and international cooperation to broaden the global effort in each of these areas.

These actions are based on the fundamental tenets of the U.S. approach to climate change, which are reflected in the Convention. This National Action Plan is the working demonstration of the U.S. view that a successful global climate change strategy must be:

- *Action-oriented.* The Action Plan is comprised of concrete measures, rather than rhetorical declarations, and emphasizes detailed reporting of the underlying policy tools and methods used to implement and quantify real achievement.
- *Comprehensive.* The Action Plan addresses mitigation and adaptation responses in all sectors. It fashions a cost-effective mix of policy actions that limit sources and protect and enhance sinks (e.g., forests) of greenhouse gases. This flexibility is estimated to reduce substantially the costs of achieving any given reduction in future warming potential, for the United States and for many other countries as well. The Plan also incorporates a full-accounting inventory of both sources and sinks of all greenhouse gases, ensuring that the environmental benefits of limiting the emissions of one gas or source are not erased by unreported increases in other emissions.
- *Long term.* The Plan takes into account the full range of social, economic, and environmental consequences of potential climate change, and potential responses, for present and future generations. The costs and benefits of trying to prevent such change are extremely difficult to measure, particularly because good predictions of new technology and of the local patterns of losses and gains due to changing climate are lacking. Nevertheless, assessments regarding an optimal policy strategy conclude that the best approach is to take low-cost actions now, without any overarching targets and timetables, and further recommend reassessing those actions in the year 2000, based upon vigorous research conducted in the intervening years.
- *Flexible.* The National Action Plan captures the variation in cost-effectiveness of different actions—both nationally (through the use of incentive-based instruments) and internationally (through the opportunity for joint implementation). Such actions are readily responsive to new information generated by robust research. The opportunity for international flexibility via joint implementation is estimated to reduce the global costs of emission limits substantially, while offering developing countries an opportunity to earn needed income.
- *Integrated.* The Action Plan is designed to be part of a global effort, engaging all nations while dynamically reflecting each nation's unique circumstances.

These concepts are reflected in the actions enumerated in the following chapters on adaptation, mitigation, research, and international activities.

Mitigation

The United States is pursuing numerous actions to mitigate the risk of potential climate change by limiting net greenhouse gas emissions. The sum total of the effects of these measures cannot be accurately quantified because of uncertainties about technology, policy effects, prices, and baseline economic growth rates. The United States estimates that by the year 2000, these actions will reduce domestic emissions by 125-200 million metric tons (MMTs) of carbon equivalent (in terms of contribution to radiative forcing), or between 7 and 11 percent of 1990 levels, implying a projected net emission of carbon equivalent in 2000 of only 1.4 to 6 percent above 1990 levels.

Adaptation

The United States is engaged in a variety of efforts to facilitate natural and societal adjustment to the environmental, social, and economic implications of potential climate change and response strategies. While many of these programs are still being developed, several are already under way. Areas of particular focus include sectors of the economy that deal with water resources, natural systems, forests, and agriculture.

Research

The United States is extremely active in promoting research essential to the understanding of the science, social dynamics, and economic implications of climate change and response strategies. Toward this end, the United States will have spent more than $2.7 billion for global change research for the three fiscal years 1990-1992, and the President's fiscal year 1993 budget requests nearly $1.4 billion for global change research—an increase of $260 million (24 percent) over the fiscal year 1992 level.

International Activities

During the next century, developing countries and other countries with economies in transition to market economies will be the primary source of greenhouse gas emissions. The United States strongly supports technology cooperation with these countries. Such cooperation should address technology needs both for hardware and for technical knowledge and capability. It includes—in addition to "technology transfer" in the traditional sense of the phrase—such priority concerns as technology needs assessment, technology and practices development, technical assistance, training, and institution or capacity building.

In calling for a cooperative process, the United States recognizes that the successful transfer of knowledge, know-how, or equipment depends on a two-way relationship based on mutual interests and benefits. Such a process also recognizes and relies heavily on the creativity and dynamism of the private sector. However, it is not possible yet to assess the net effect of this international effort either on greenhouse gas emission reductions or on improvements in the capacity of other nations to adapt to the potential impacts of climate change.

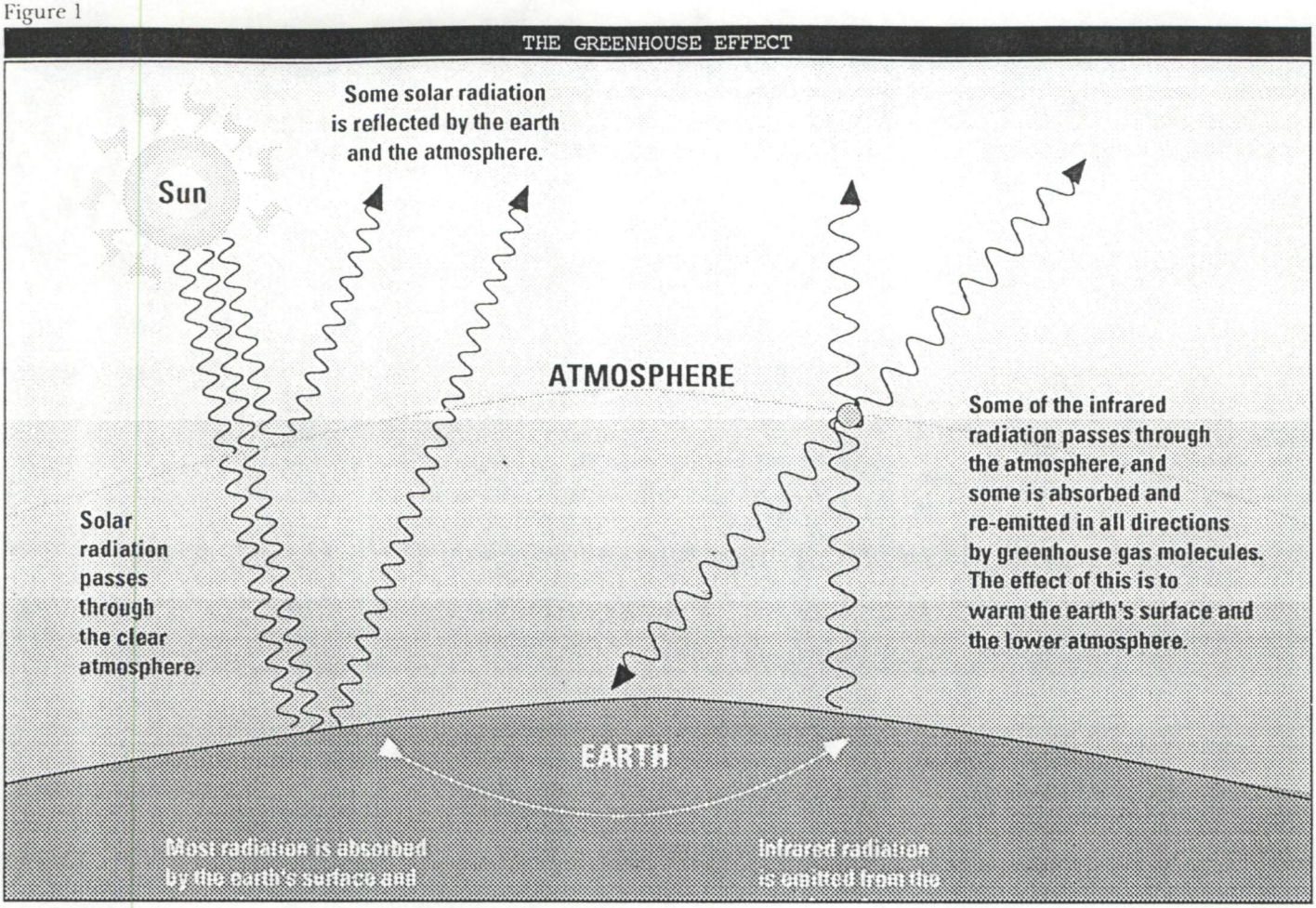
Scientific Background

As the actions described in this Plan ultimately depend on our understanding of the science of climate and climate change, it is useful to review this fundamental information. For some time, the scientific community has warned of the potential for human activities to contribute to global climate change, while recognizing that there is still much uncertainty surrounding this issue. However, in spite of the uncertainties, a broad international consensus regarding the science of the climate system and climate change has been developed over the past several years.

As shown in Figure 1, solar radiation, trapped by gases in the atmosphere acts to warm the earth. These gases, known as greenhouse gases, include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), chlorofluorocarbons (CFCs), and ozone (O_3). While water vapor has the largest "greenhouse effect," on a global scale its concentrations are not directly affected by human activities. Although, with the exception of CFCs, all of these gases occur naturally, human activities have contributed significantly to increases in these atmospheric concentrations.

Generally accepted theory indicates that increasing concentrations of greenhouse gases most likely will ultimately raise atmospheric and ocean temperatures and will alter their associated circulation and weather patterns. However, the magnitude, timing, and regional details of these changes cannot now be predicted with

Figure 1



much certainty. Climate models predict that equilibrium change in the average temperature of the globe's atmosphere as a consequence of a doubling of CO_2 or its equivalent is unlikely to lie outside of the range of 1.5°C–4.5°C (34.7°F–40.1°F), with a best estimate, based on model results and taking into account the observed climate record, of 2.5°C (36.5°F). It is expected that actual realized temperatures would lag by several years behind the equilibrium value. Sea level rise associated with such doubling has been estimated to range between a few centimeters and one meter (several inches to approximately 3 feet) with a best estimate of approximately 20 cm (7.9 in.) by 2030.

These analyses are admittedly imprecise, with no adjustments yet made for known confounding factors, such as the cooling effects of aerosols, changes in stratospheric ozone, or the cooling and warming effects of changing concentrations of CFCs. A further complicating factor in interpreting the data is that the warming predicted by the models over recent years, while within the range of that observed, is also about the same magnitude as that of natural variability, making it impossible to definitively determine whether human-induced climate change is yet occurring. Indeed, most of the observed warming of the past hundred years occurred in the first half of this century—before increasing greenhouse gas concentrations would have taken effect.

The best scientific information indicates that if greenhouse gas concentrations continue to increase as a result of human activities, global climate will eventually change. However, current analyses are unable to predict with confidence the timing, magnitude, or regional distribution of such change. Therefore, evaluating the specific costs of potential actions, as well as the possible benefits of taking steps to control atmospheric concentrations of greenhouse gases, is subject to a high degree of uncertainty.

Framework Convention on Climate Change

The issue of climate change has moved steadily from the purely scientific realm into the policy arena over the last several years. In 1988, the United Nations General Assembly began to take a significant interest in the issue, adopting a resolution that recognized climate change as "a common concern of mankind." Also, in 1988, the World Meteorological Organization and the United Nations Environment Programme established the Intergovernmental Panel on Climate Change (IPCC) to assess the science, impacts, and potential response options to mitigate and adapt to climate change.

The IPCC's First Assessment Report (1990) set the stage for the Second World Climate Conference in November 1990, whose ministerial declaration called for negotiations on a framework convention. The United Nations took up the climate issue again in 1989, and in 1990, when it formally established the Intergovernmental Negotiating Committee (INC) to develop a framework convention on climate change, and set its first meeting to be in Chantilly, Virginia, in February 1991.

The Convention, negotiated over a period of nearly two years, was opened for signature in Rio de Janeiro in June 1992. As of December 1992, it had been signed by 157 countries (including the United States) and one regional economic integration organization, and was ratified by six countries (of which the United States was the fourth). The Convention represents a delicate balance of many interests. It embodies a comprehensive approach embracing all greenhouse gases and their sources and sinks, and promotes action to modify net emission trends of all greenhouse gases not controlled by the Montreal Protocol on Substances that Deplete the Ozone Layer. It supports an action-oriented approach to net emission reductions that takes into account specific national circumstances. It provides the basis for assessing the impacts and effectiveness of different national responses in light of existing scientific and economic information and new developments. And the Convention encourages cooperative arrangements by providing for joint implementation between and among Parties under mutually agreed terms.

The ultimate objective of the Convention 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."

Parties to the Convention undertake a series of commitments to achieve this objective, which are described in several articles, most particularly, Articles 4 and 12. The relevant portions of these two articles are cited on the following pages.

ARTICLE 4: COMMITMENTS

1. All parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives, and circumstances, shall:

(a) Develop, periodically update, publish, and make available to the Conference of the Parties, in accordance with Article 12, 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;

(b) Formulate, implement, publish, and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change by addressing anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and measures to facilitate adequate adaptation to climate change;

(c) Promote and cooperate in the development, application, and diffusion, including transfer, of technologies, practices, and processes that control, reduce, or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors; including the energy, transport, industry, agriculture, forestry, and waste management sectors;

(d) Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests, and oceans, as well as other terrestrial, coastal, and marine ecosystems;

(e) Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources, and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods;

(f) Take climate change considerations into account, to the extent feasible, in their relevant social, economic, and environmental policies and actions, and employ appropriate methods, for example, impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health, and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change;

(g) Promote and cooperate in scientific, technological, technical, socioeconomic, and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude, and timing of climate change and the economic and social consequences of various response strategies;

(h) Promote and cooperate in the full, open, and prompt exchange of relevant scientific, technological, technical, socioeconomic, and legal information related to the climate system and climate change, and to the economic and social consequences of various response strategies;

(i) Promote and cooperate in education, training, and public awareness related to climate change and encourage the widest participation in this process, including that of nongovernmental organizations; and

(j) Communicate to the Conference of the Parties information related to implementation, in accordance with Article 12.

2. The developed country Parties and other Parties included in annex I commit themselves specifically as provided for in the following:

(a) Each of these Parties shall adopt national[1] 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 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, and taking into account the differences in these Parties' starting points and approaches, economic structures, and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of these Parties to the global effort regarding that objective. These Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention and, in particular, that of this subparagraph;

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[1] *This includes policies and measures adopted by regional economic integration organizations.*

ARTICLE 4: COMMITMENTS (continued)

(b) In order to promote progress to this end, each of these Parties shall communicate, within six months of the entry into force of the Convention for it and periodically thereafter, and in accordance with Article 12, detailed information on its policies and measures referred to in subparagraph (a), above, as well as on its resulting projected anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol for the period referred to in subparagraph (a), with the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol. This information will be reviewed by the Conference of the Parties, at its first session and periodically thereafter, in accordance with Article 7;

(c) Calculations of emissions by sources and removals by sinks of greenhouse gases for the purposes of subparagraph (b) above should take into account the best available scientific knowledge, including the effective capacity of sinks and the respective contributions of such gases to climate change. The Conference of the Parties shall consider and agree on methodologies for these calculations at its first session and review them regularly thereafter;

(d) The Conference of the Parties shall, at its first session, review the adequacy of subparagraphs (a) and (b) above. Such review shall be carried out in the light of the best available scientific information and assessment on climate change and its impacts, as well as relevant technical, social, and economic information. Based on this review, the Conference of the Parties shall take appropriate action, which may include the adoption of amendments to the commitments in subparagraphs (a) and (b) above. The Conference of the Parties, at its first session, shall also take decisions regarding criteria for joint implementation, as indicated in subparagraph (a) above. A second review of subparagraphs (a) and (b) shall take place not later than 31 December 1998, and thereafter at regular intervals determined by the Conference of the Parties, until the objective of the Convention is met;

(e) Each of these Parties shall:

(i) coordinate as appropriate with other such Parties, relevant economic and administrative instruments developed to achieve the objective of the Convention; and

(ii) identify and periodically review its own policies and practices which encourage activities that lead to greater levels of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol than would otherwise occur;

(f) The Conference of the Parties shall review, not later than 31 December 1998, available information with a view to taking decisions regarding such amendments to the lists in Annexes I and II as may be appropriate, with the approval of the Party concerned;...

ARTICLE 12: COMMUNICATION OF INFORMATION RELATED TO IMPLEMENTATION

1. In accordance with Article 4, paragraph 1, each Party shall communicate to the Conference of the Parties, through the secretariat, the following elements of information:

(a) A national inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, to the extent its capacities permit, using comparable methodologies to be promoted and agreed upon by the Conference of the Parties;

(b) A general description of steps taken or envisaged by the Party to implement the Convention; and

(c) Any other information that the Party considers relevant to the achievement of the objective of the Convention and suitable for inclusion in its communication, including, if feasible, material relevant for calculations of global emission trends.

2. Each developed country Party and each other Party included in annex I shall incorporate in its communication the following elements of information:

(a) A detailed description of the policies and measures that it has adopted to implement its commitment under Article 4, paragraphs 2 (a) and 2 (b); and

(b) A specific estimate of the effects that the policies and measures referred to in subparagraph (a) immediately above will have on anthropogenic emissions by its sources and removal by its sinks of greenhouse gases during the period referred to in Article 4, paragraph 2 (a).

3. In addition, each developed country Party and each other developed Party included in annex II shall incorporate details of measures taken in accordance with Article 4, paragraphs 3, 4, and 5.

The United States strongly supports the Convention, which establishes a forum and a process to engage all countries in responding to climate change concerns over the long term. The United States sees in the Convention an international process focused on actions. Industrialized countries are first required to develop emission inventories using a common methodology. In addition, they must develop national action plans containing specific measures that would have the effect of mitigating and/or adapting to climate change. In this process, industrialized countries will indicate actions they will take consistent with national circumstances and will provide estimates of the impacts of their actions over an agreed time period, relying on agreed methodologies for estimating these impacts.

By reporting on actions in an open and transparent process, all Parties are able to share information and experience and learn from each other. Public scrutiny provides a strong incentive for taking meaningful actions with maximum benefits for climate and other related areas. Under the Convention, these reviews will take place at agreed intervals.

This process will begin a global response to what is clearly a global problem. Focusing on sound actions will produce meaningful results. Recognizing and respecting diverse national circumstances will help ensure broad participation. Providing technology cooperation and support for countries in need will promote a cooperative approach, strengthening efforts to build the global partnerships that are needed as the world moves toward the next century.

As the Convention is comprehensive, covering all sources and sinks of greenhouse gases, so too are the programs outlined in this National Plan, covering all sectors of economic activity, and examining measures both to mitigate the effects of and to adapt to any potential changes in climate. As the Convention highlights the need for cooperative research to develop our understanding of the technical and scientific uncertainties surrounding the issue of global warming, so too does this Plan highlight U.S. research programs designed with these particular goals. And as the Convention specifically urges developed nations to support and promote actions by developing countries, this report discusses the international aspects of U.S. involvement with climate change, examining not only the U.S. role in multilateral financial institutions, but also providing examples of bilateral actions the United States is taking to support the participation of developing countries.

Preparation of the National Plan

The National Action Plan has been prepared in a broad interagency process, incorporating data from all relevant sectors and programs. In the early stages of preparation, a preliminary version of the Plan outline was circulated to nongovernment organizations (both environmental and private-sector organizations) for their review and comment. Where possible, suggestions received were incorporated into this text. However, while the Plan is the result of a large-scale, government-wide effort at the federal level, the information in it has not had the full public scrutiny that is anticipated in the preparation of subsequent iterations.

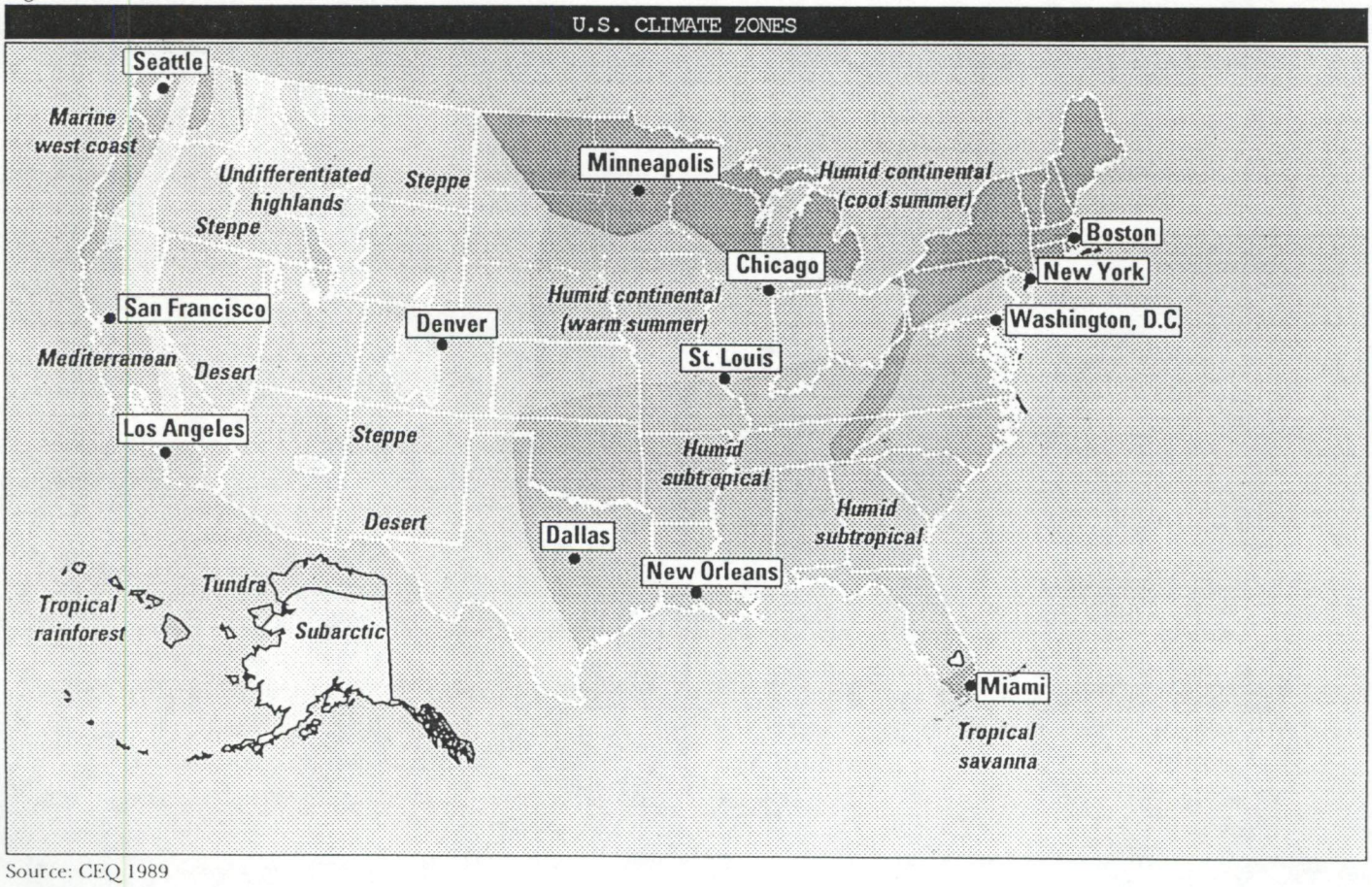
National Circumstances

The way in which climate change affects a particular country, the nature and amount of greenhouse gas emissions a country may contribute to the global situation, and the relative feasibility of various options a country may have to either mitigate or adapt to climate change all depend upon the country's specific national circumstances. Paragraph 2(a) of Article 4 of the Framework Convention on Climate Change explicitly acknowledges these differences in noting that the contributions of various industrialized countries to the aim of returning GHG emissions to earlier levels will take into account numerous biophysical, socioeconomic, political, and institutional factors affect a nation's ability to undertake various climate change policies. Many of these factors are interrelated. Some of them facilitate specific options for addressing climate change, while others restrict those options. This chapter examines several of these factors from five broad perspectives: (1) climate, (2) population and demographics, (3) land use, (4) economics and energy use, and (5) political and institutional systems. It reviews pertinent conditions, trends, and policies and their implications for climate change issues.

U.S. Climate Zones

The climate zones of the United States are representative of all the major climate regions of the world, except ice cap. Very few of the fifty states lie within a single climate zone. Indeed, as Figure 2 shows, some

Figure 2



Source: CEQ 1989

states encompass as many as five distinct climate types. This diversity poses a serious challenge to policymakers, especially with regard to energy and water policies and adaptation to possible climate change.

4Figure 3 provides a thirty-year record of heating- and cooling-degree days for some major U.S. cities. Heating- and cooling-degree days are calculated from a base of 65° Fahrenheit (18.3° Celcius), providing an indicator of heating and cooling needs in the United States. As the figure makes clear, average ambient temperature across the United States varies substantially. It also indicates that a large portion of the United States and many U.S. population centers depend on heating and cooling systems to maintain temperatures conducive tq both economic efficiency and comfort. Figure 4 shows historical temperature data for the United States, indicating both substantial year-to-year changes and broader cycles.

Precipitation across the United States is also far from uniform. Major portions of the nation receive less than 50.8 cm (20 in.) of precipitation a year, while other parts of the country receive over 152.4 cm (60 in.) (Figure 5). Equally important is a high degree of natural variation in water supplies from season to season and year to year. This type of uncertainty makes long-term planning difficult and underlies the importance of water storage, transfer, and irrigation systems.

Figure 3

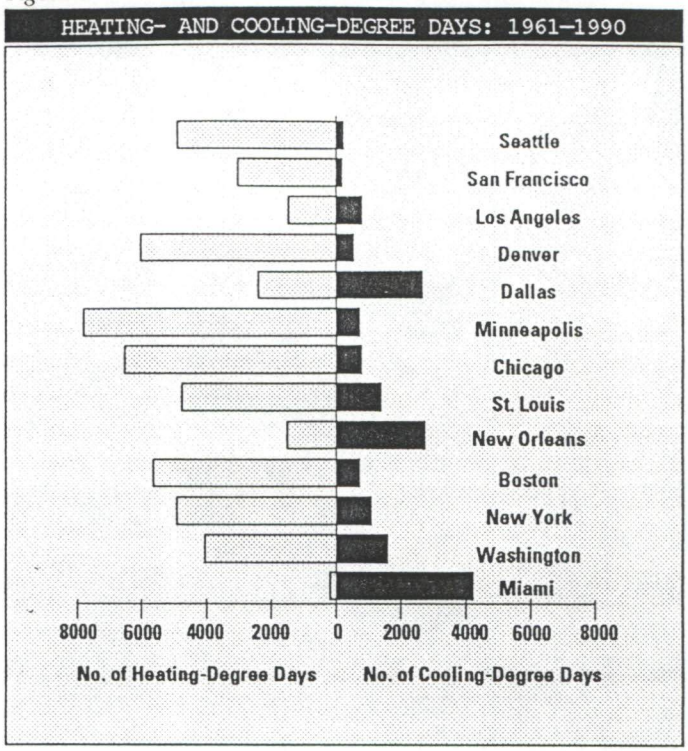
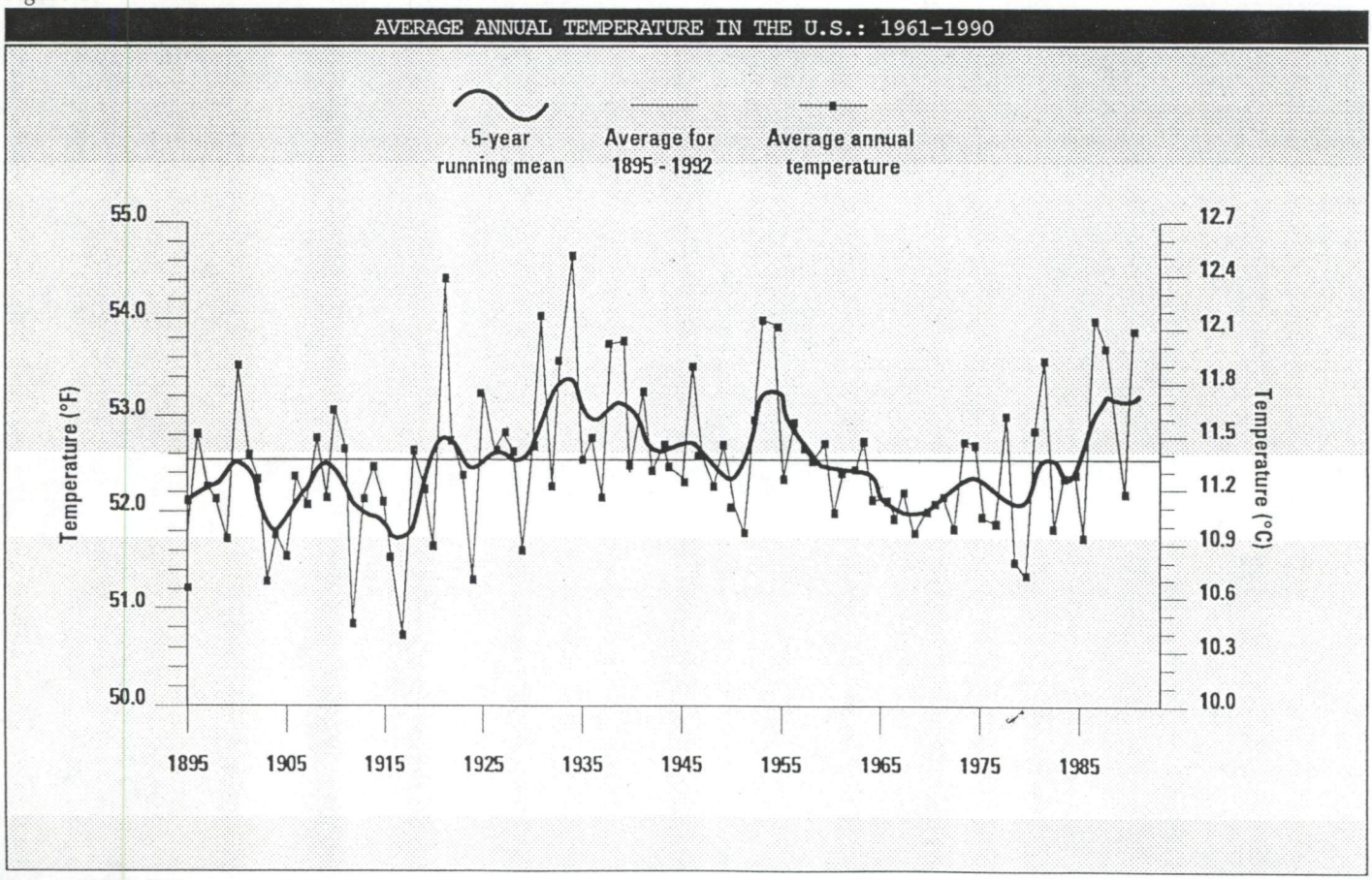
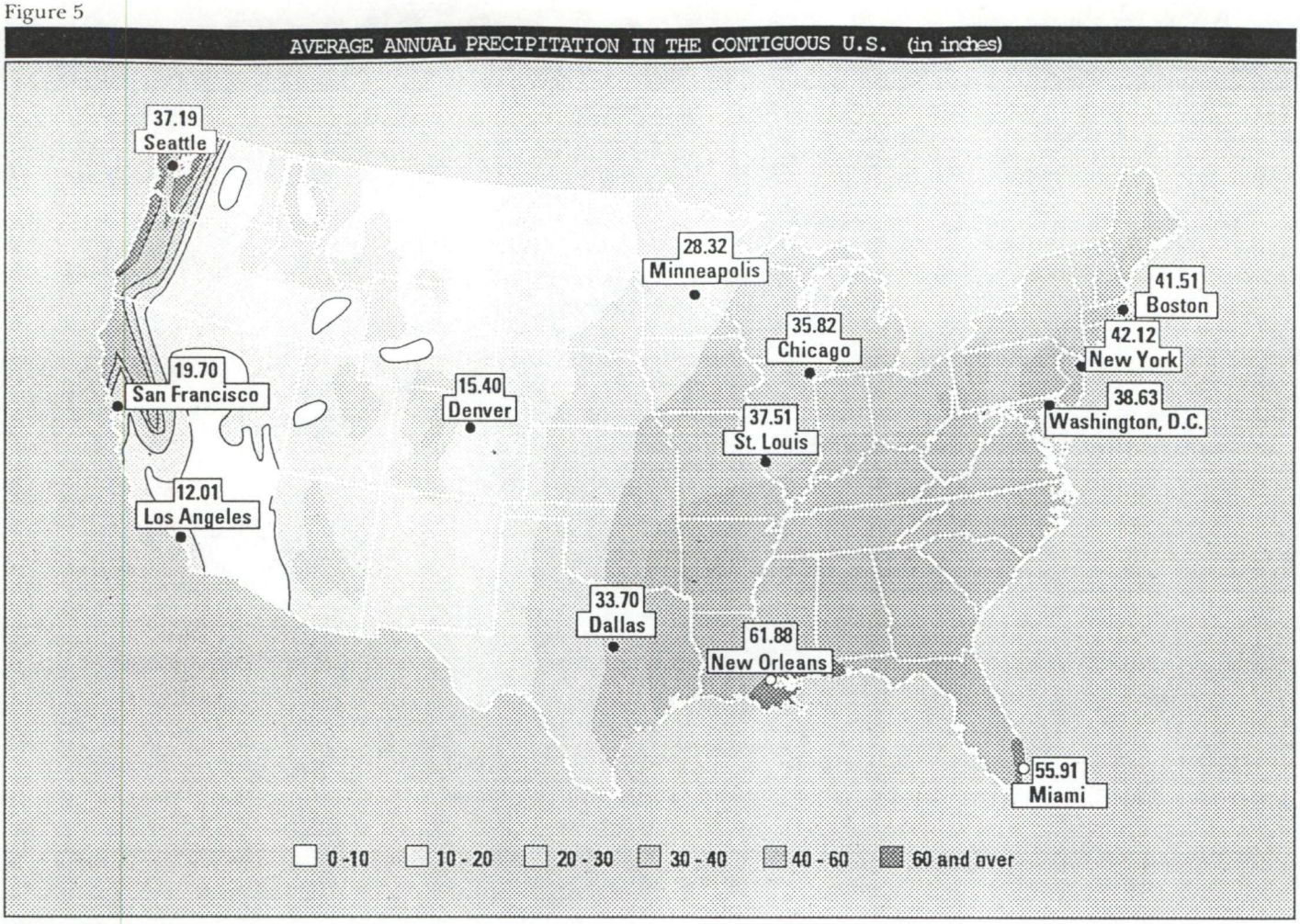


Figure 4



Source: NOAA 1991

Figure 5



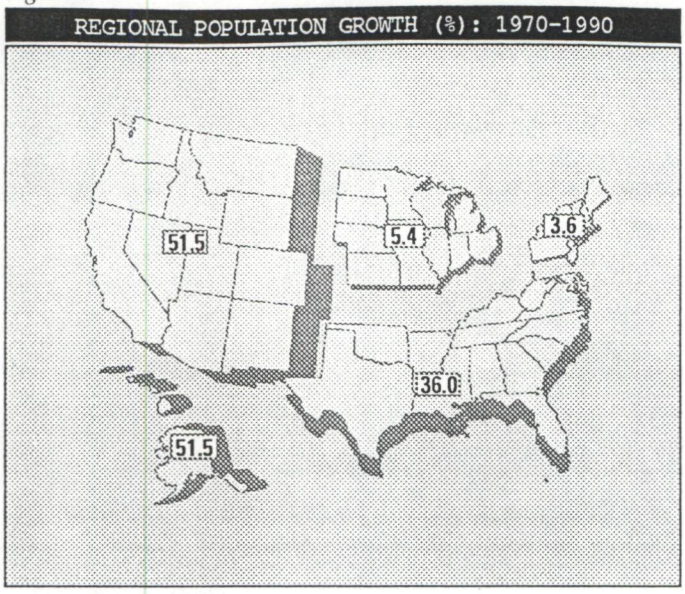
Source: El-Ashry 1988

Demographics and Population

Population Distribution and Density

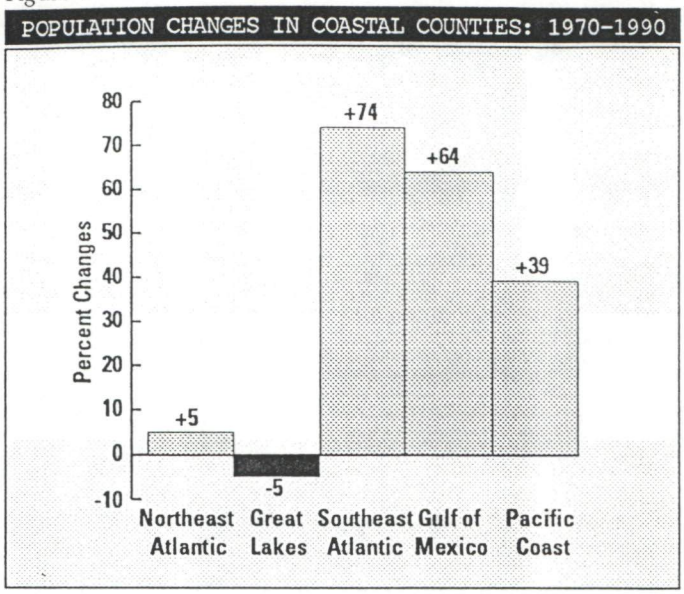
The environment and other quality-of-life issues are strongly influenced by population growth and density. Population growth drives a nation's consumption of resources and energy, while settlement patterns and population density strongly affect transportation modes and corridors and the availability of land for natural habitat, agriculture, forestry, and other uses. With a total population of approximately 250 million in 1990, the United States was the fourth most populous country in the world, after China, India, and what was then the Soviet Union, although it only has a population density of 27 people per square kilometer (excluding Alaska). Because of this low density and large expanse, people and goods are frequently transported over long distances.

Figure 6



Source: CEQ 1992b

Figure 7



Source: CEQ 1992b

During the past twenty years, while overall U.S. population growth was moderate and steady, regional population growth varied widely (Figure 6). Several major trends account for the redistribution of population within the United States over the past forty years. The increase in population has been due partly to health care improvements resulting in longer life expectancy, but more importantly, to increases in net immigration, which has always been an important factor in U.S. population.

Urbanization

In 1987, the United States was far more metropolitan (77 percent) than it was in 1950 (56 percent). Large numbers of people moved from small towns and rural areas to large cities and their suburbs, creating areas of urban sprawl. The percentage of the U.S. population living in the larger metropolitan areas (over one million population) grew from 29 percent in 1950 to 50 percent in 1990.

Sunbelt Growth

Much of the U.S. population distribution in recent decades has shifted from the North-Central and Northeast industrial belt to the Sunbelt states, which enjoy a warmer climate. The Sunbelt includes the southern tier of states stretching from Florida to California. Nine of the twelve fastest-growing metropolitan areas in 1990 were located in Florida.

Coastal Growth

Coastal populations have continued to increase, especially in the Southeast and Gulf regions. About 110 million people currently live in counties in the coastal areas of the United States. In 1988, the population density of coastal counties was more than four times greater than the overall U.S. average of 27 people per square kilometer. In over 20 percent of the nation's coastal counties, density exceeds 192 people per square kilometer, with the urban centers surrounding New York, San Francisco, Boston, and Philadelphia exceeding 3,846 people per square kilometer. Figure 7 compares the population growth rates of the five major U.S. coastal regions over the past twenty years.

Birth and Death Rates

The average life expectancy at birth in 1990 in the United States was 75.4 years. The average infant mortality rate in 1990 was 9.1 deaths per 1,000 live births. This is half the rate of twenty years ago, and only about one-fifth the infant mortality rate of 1940.

Although the current 0.7 percent annual growth rate of the U.S. population is significant, it is far below that experienced during the 1946-64 "baby boom," when 75 million people were added to the U.S. demographic profile. During the 1950s, the average growth rate was slightly less than 2 percent per year. The median age of the U.S. population rose by about four years from 1972 to 1989: in 1989 the median age was 32.6 years—31.5 years for males and 33.8 years for females.

U.S. fertility has decreased significantly over the last thirty years. This change is frequently attributed to the greater participation of women in the labor force and the widespread use of effective contraception among both males and females. In 1957, the total fertility rate peaked at 3.7 births per woman. Today, American women are bearing an average of about two children,

and this rate is projected to decline slightly over the coming years. However, the rate of natural increase (the excess of births over deaths) for the U.S. population has held steady at about 0.7 percent. The U.S. Census Bureau estimated in a January 1989 report that the U.S. population could increase from current levels to about 471 million by 2080.

Immigration/Emigration

Despite a low rate of natural increase, the U.S. population has grown by 22 percent from 1970 to 1991. Net immigration accounted for approximately 29 percent of the population growth in the 1980s. This compares with 11 percent during the 1950s, and perhaps 40 percent during the peak immigration years of 1900-10.

During 1981-90, 38 percent of the immigrants who entered the United States were of Asian origin, 29 percent were of Latin American origin, 14 percent were of European origin, and 12 percent were of Caribbean origin. Immigration has increased steadily since the end of World War II, averaging about 450,000 annually in the 1970s and over 600,000 annually in the 1980s.

Natural Resources

The natural and environmental resources of the United States are vast and varied. Its diverse climate zones, topography, and soils support many ecological communities and supply renewable resources for many human uses. The nature and distribution of these resources has had a critical role in the development of the U.S. economy, and therefore indirectly on the pattern of U.S. GHG emissions.

About 60 percent of the total U.S. land area is privately owned (70 percent, excluding Alaska). Although the private sector has played a primary role in developing and managing U.S. natural resources, federal, state, and local governments are also important in managing and protecting these resources through regulation, economic incentives, and education, as well as by directly managing much of the other 40 percent, which includes the nation's forests, parks, wildlife preserves, resource development and rangeland, recreational areas, and open space. Underlying these efforts have been private citizens demanding more environmental protection and management, seeking to be better informed about environmental risks, and influencing decisions in an open public process that is grounded in both tradition and law.

Environmental organizations and other U.S. public- and private-interest groups frequently influence the development, implementation, and timing of state and federal programs. Groups active in environmental and resource management issues include long-established national conservation organizations and newer public-interest groups, as well as business, labor, and other groups and associations.

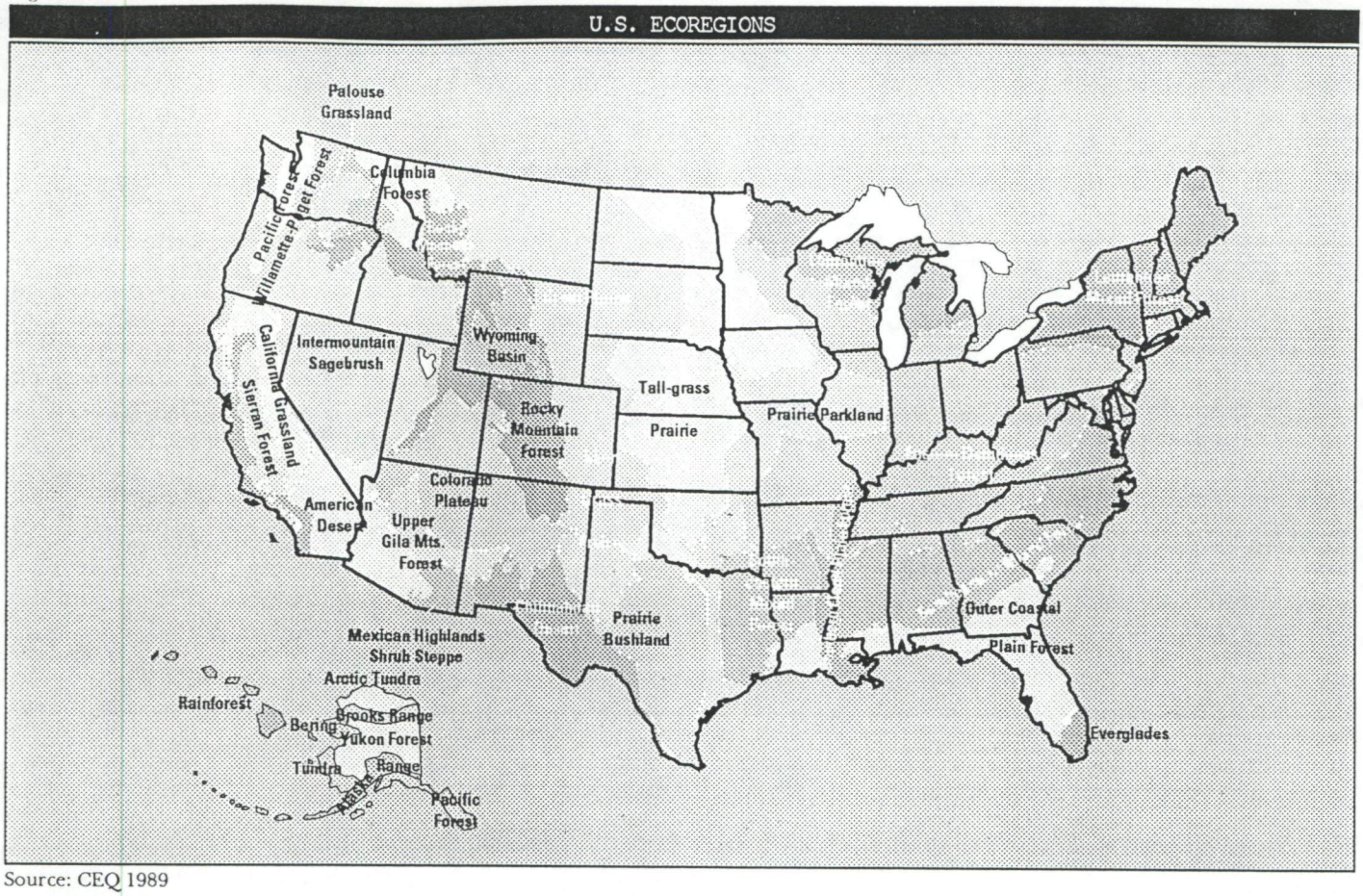
Land Resources

The United States has a large and diverse land area of approximately 931 million hectares (2.3 billion acres). About 20 percent of the land is in crop land; 26 percent is in grassland, pasture, and range; and 29 percent is forested. About 12 percent of the land area is not classified (but includes wetlands, tundra, and urban areas), and the remaining 12 percent is classified under special purposes, including transportation routes, surface-water reservoirs, parks and wildlife refuges, and national defense (Figure 8).

Forests

Forestland has great potential to alter, and be altered by, the climate system. Forests not only act as sinks of greenhouse gases, but also are home to a diversity of biota on which climate change could have a significant impact. U.S. forests vary from the scrub forests of the

Figure 8



Source: CEQ 1989

arid interior West to the highly productive forests of the Pacific Coast and the Southeast. In 1987, forests occupied about one-third (296 million hectares, or 731 million acres) of the total U.S. land area. Of this total, two-thirds were timberland, most of which (72 percent) is privately owned (Table 1).

By most measures, the productivity of U.S. timberland has been increasing. In part, this reflects management inputs over the past several decades. 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, although old-growth forests have continued to decline over the same period.

GRASSLANDS

Grasslands are relevant to climate change because of their potential to absorb significant quantities of greenhouse gases. In the United States, grasslands, including both range and pasture, accounted for about 324 million hectares (800 million acres) in 1987. Grassland is characterized as land on which the native vegetation in the climax or natural potential community is predominantly grass, grass-like plants, forbs, or shrubs suitable for grazing or browsing. Rangelands include native grasslands, savannas, alpine meadows, tundra, many wetlands, some deserts, and areas seeded to introduced species but managed like native rangeland.

The total area of pasture and range has declined by approximately 10 percent in the last decade. Some of the net decrease in range involved federal lands that were withdrawn for parks, wilderness, and similar areas or that were reclassified as unsuitable for grazing; ecologically, these lands remain grasslands. Among the reasons for decline in forested grazing land are fewer farms and less land in farms, changes in forest species, increases in stand density, and improvements in both livestock feeding and forest management practices.

In general, more than half of U.S. pasture and rangeland is classified as having poor to fair nutritional value for livestock grazing. These lands provide lower-quality forage, but good wildlife habitat and watershed protection. Sites having better-quality forage for livestock are usually also less prone to erosion problems. A site's condition can be improved by properly managing the vegetation and by controlling the duration, seasonal timing, and intensity of livestock use. Federal and state land management agencies have been working with private landowners and tenants to set long-term goals and plans for range improvement, focusing first on sensitive range environments.

Table 1

OWNERSHIP OF U.S. TIMBERLAND: 1952–1987

Year and Region	Total Forest Land	Timberland Ownership[1]				
		All ownerships	Federally owned or managed[2]	State, county, municipal	Private	
					Total	*Percent of total*
	(millions of acres)					
1952	*664*	*509*	*125*	*27*	*356*	*70.0*
North	209	158	13	18	127	80.0
South	197	205	15	3	187	91.4
West	258	146	97	6	42	29.1
1962	*759*	*515*	*125*	*27*	*363*	*70.4*
North	178	160	13	18	130	80.9
South	220	209	15	3	191	91.4
West	360	146	97	6	42	28.9
1970	*754*	*504*	*122*	*29*	*354*	*70.2*
North	186	158	13	18	127	80.5
South	212	203	15	3	185	90.9
West	355	143	94	7	42	29.2
1977	*737*	*491*	*113*	*31*	*347*	*70.6*
North	178	157	12	19	126	80.4
South	207	198	15	3	180	90.6
West	352	136	85	9	41	30.1
1987	*731*	*483*	*103*	*34*	*347*	*71.8*
North	170	158	13	19	126	79.6
South	203	195	16	4	176	89.9
West	358	130	74	11	45	34.9

[1] Timberland is forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation. Areas qualifying as timberland have the capability of producing in excess of 20 cubic feet per acre per year of industrial wood in natural stands. Currently inaccessible and inoperable areas are included.
[2] Includes Indian lands.

Source: U.S. DOC 1991

WETLANDS

Wetlands not only act as sources and sinks of greenhouse gases, but are also extremely vulnerable to changes in the climate. More than half of the nation's wetlands (excluding Alaska) have been lost since the eighteenth century, with seven states losing more than 80 percent of their original wetlands. From the mid-1950s to the mid-1970s, wetlands in the lower 48 states were converted at the rate of 185,000 hectares (457,000 acres) a year. Estimates by the U.S. government in 1991 indicate that the rate of loss from the mid-1780s to the mid-1980s for the continental United States has slowed

Table 2

TOTAL U.S. WETLAND LOSSES 1780–1989

State	Total Surface Area of State	Millions of Acres		Percent Wetlands Lost
		1780s	1980s	
Alabama	33.03	7.57	3.78	50
Alaska	375.30	170.20	170.00	<1
Arizona	72.90	0.93	0.60	36
Arkansas	33.99	9.85	2.76	72
California	101.56	5.00	0.45	91
Colorado	66.72	2.00	1.00	50
Connecticut	3.21	0.67	0.18	74
Delaware	1.32	0.48	0.22	54
Florida	37.48	20.33	11.04	46
Georgia	37.68	6.84	5.30	23
Hawaii	4.12	0.06	0.05	12
Idaho	53.47	0.88	0.39	56
Illinois	36.10	8.21	1.25	85
Indiana	23.23	5.60	0.75	87
Iowa	36.03	4.00	0.42	89
Kansas	52.65	0.84	0.44	48
Kentucky	25.85	1.57	0.30	81
Louisiana	31.05	16.19	8.78	46
Maine	21.26	6.46	5.20	20
Maryland	6.77	1.65	0.44	73
Massachusetts	5.28	0.82	0.59	28
Michigan	37.26	11.20	5.58	50
Minnesota	53.80	15.07	8.70	42
Mississippi	30.54	9.87	4.07	59
Missouri	44.60	4.84	0.64	87
Montana	94.17	1.15	0.84	27
Nebraska	49.43	2.91	1.91	35
Nevada	70.75	0.49	0.24	52
New Hampshire	5.95	0.22	0.20	9
New Jersey	5.02	1.50	0.92	39
New Mexico	77.87	0.72	0.48	33
New York	31.73	2.56	1.03	60
North Carolina	33.66	11.09	5.69	49
North Dakota	45.23	4.93	2.49	49
Ohio	26.38	5.00	0.48	90
Oklahoma	44.75	2.84	0.95	67
Oregon	62.07	2.26	1.39	38
Pennsylvania	29.01	1.13	0.50	56
Rhode Island	0.78	0.10	0.07	37
South Carolina	19.88	6.41	4.66	27
South Dakota	49.31	2.74	1.78	35
Tennessee	27.04	1.94	0.79	59
Texas	171.10	16.00	7.61	52
Utah	54.35	0.80	0.56	30
Vermont	6.15	0.34	0.22	35
Virginia	26.12	1.85	1.07	42
Washington	43.64	1.35	0.94	31
West Virginia	15.48	0.13	0.10	24
Wisconsin	35.94	9.80	5.33	46
Wyoming	62.66	2.00	1.25	38

Source: CEQ 1992

by 37 percent, to approximately 117,000 hectares (290,000 acres) a year (Table 2), although some recent studies suggest even slower rates of decline in the 1980s.

Roughly 69 million hectares (170 million acres) of wetlands exist in Alaska. Many of these areas are publicly owned, although precise figures are not available. Total wetland losses in Alaska have been less than 1 percent, although in coastal areas losses have been higher.

AGRICULTURAL LAND

Agricultural land–and its productive capacity–is among the most sensitive natural resources to the impacts of potential climate change. Currently, the United States enjoys a natural abundance of productive agricultural lands and a favorable climate for producing food, feed grains, and many other agricultural commodities. The area of U.S. crop land used has remained relatively stable (about 160 million hectares or 395 million acres) for the last sixty years. However, the area of crop land harvested actually declined in response to improved crop yields —from 144 million hectares (356 million acres) in 1930 to 124 million hectares (306 million acres) in 1990.

The productivity of U.S. crop land has been markedly improved through the use of yield-increasing technologies, including drainage, irrigation, fertilizers, improved seeds and plant varieties, herbicides, and pesticides. Mechanization has also been an important influence.

Table 3 shows the price and yield statistics and the management practices applied to land dedicated to major U.S. agricultural crops. The United States today harvests about the same area as it did in 1910, although the population has grown by two and one-half times, and food exports are considerably larger. Another indication of the high productivity of U.S. crop lands is the fact that the United States leads the world in donations of food to other nations. Between 1987 and 1989, the United States donated about 7 million metric tons of cereals, oils, and milk to other nations.

The number of farms in the United States has declined from 6.3 million in 1930 to 2.1 million in 1987. Meanwhile, the average number of hectares (acres) per farm has increased from 63 to 184 hectares (156 to 455 acres). The distribution of farms and the value of production by farm sales has changed even more drastically. In 1949, 6 percent of the farms (289,000) had farm sales exceeding $40,000 (based on 1980 prices) and were producing 40 percent of the total value of production or farm sales. In 1982, 29 percent of the farms (695,000) had sales exceeding $40,000 (1980 prices) and were producing 88 percent of the total value of production or farm sales.

Table 3

PRINCIPAL U.S. CROPS: 1985–1990

Crop and Year	Acreage (mil.) Set aside[1]	Planted	Harvested	Yield per Acre	Farm Price[2]
Corn for grain				*Bu.*	*$/bu.*
1986	14.3	76.7	68.9	119.4	$1.50
1987	23.1	65.2	59.5	119.8	1.94
1988	20.5	67.7	58.3	84.6	2.54
1989	10.8	72.3	64.8	116.2	2.25
1990	10.1	74.2	67.0	118.5	(NA)
Hay				*Sh. tons*	*$/ton*
1985	–	(NA)	60.4	2.46	67.60*†
1986	–	(NA)	62.4	2.49	59.70*†
1987	–	(NA)	60.1	2.45	65.00*†
1988	–	(NA)	65.1	1.94	85.20*†
1989	–	(NA)	63.4	2.29	87.50*†
Soybeans				*Bu.*	*$/bu.*
1986	–	60.4	58.3	33.3	4.78
1987	–	58.2	57.2	33.9	5.88
1988	–	58.8	57.4	27.0	7.42
1989	–	60.8	59.5	32.3	5.55
1990	–	57.8	56.5	34.0	5.75
Wheat				*Bu.*	*$/bu.*
1986	21.0	72.1	60.7	34.4	2.42
1987	23.9	65.8	56.0	37.7	2.57
1988	22.5	65.5	53.2	34.1	3.72
1989	9.6	76.6	62.1	32.7	3.82
1990	7.1	77.3	69.4	39.5	2.61
Cotton				*Lb.*	*Cents/lb.*
1986	4.2	10.0	8.5	552	52.4
1987	3.9	10.4	10.0	706	64.3
1988	2.2	12.5	12.0	619	56.6
1989	3.5	10.6	9.5	614	67.3
1990	1.9	12.4	11.7	640	67.8
Potatoes				*Cwt.*	*$/cwt.*
1985	(NA)	1.4	1.3	299	3.92
1986	(NA)	1.2	1.2	296	5.03
1987	(NA)	1.3	1.3	301	4.38
1988	(NA)	1.3	1.2	283	6.02
1989	(NA)	1.3	1.3	289	6.85
Tobacco				*Lb.*	*$/lb.*
1985	(NA)	(NA)	.7	2,197	1.65†
1986	(NA)	(NA)	.6	2,001	1.52†
1987	(NA)	(NA)	.6	2,028	1.57†
1988	(NA)	(NA)	.6	2,160	1.65†
1989	(NA)	(NA)	.7	2,016	1.71†
Sorghum for grain				*Bu.*	*$/bu.*
1986	3.0	15.3	13.9	67.7	1.37
1987	4.1	11.8	10.5	69.4	1.70
1988	3.9	10.3	9.0	63.8	2.27
1989	3.3	12.6	11.2	55.4	2.05
1990	3.0	10.7	9.1	62.9	(NA)
Rice, rough				*Lb.*	*$/cwt.*
1986	1.5	2.4	2.4	5,651	3.75
1987	1.6	2.4	2.3	5,555	7.27
1988	1.1	2.9	2.9	5,514	6.83
1989	1.2	2.7	2.7	5,749	7.10
1990	1.0	2.9	2.8	5,507	(NA)

Source: U.S. DOC 1991

Note: Marketing year beginning May 1 for hay, June 1 for wheat, August 1 for cotton and rice, September 1 for soybeans, corn, and sorghum. Acreage, production, and yield of all crops periodically revised on basis of census data. See also Historical Statistics, Colonial Times to 1970, series K 506-563.

[1] Acreage set aside under diversion, PIK (payment-in-kind), and acreage reduction programs.

[2] Except as noted, marketing year average price. U.S. prices are computed by weighting U.S. monthly prices by estimated monthly marketings and do not include an allowance for outstanding loads and government purchases and payments.

* Prices are for hay sold baled.

† Season average prices received by farmers. U.S. prices are computed by weighting state prices by estimated sales and include an allowance for outstanding loans and government purchases, if any, for crops under government programs. Bales of 480 pounds (218 kg) net weight.

U.S. rangeland is considered to be in its best overall ecological state since the turn of the century. About 80 percent of the area is rated as in stable or improving condition. However, significant work remains to be done to improve the rest. 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 number of cattle increased to 86 million in 1945 and to 132 million in 1975. Since then, cattle numbers have declined (to 98 million by 1990), reflecting a significant decline in average beef consumption per capita in recent years and greater weight per head of cattle.

Coastal Zones

Like many of the land resources described above, U.S. coastal zones are extremely vulnerable to climate change, particularly its related sea level rise. Coasts and oceans contribute significantly to the U.S. economy and to the quality of life of U.S. citizens. Excluding Alaska, U.S. coastal zones support nearly half of the nation's population while accounting for only 11 percent of the land mass. Between 1960 and 1988, coastal populations rose more than four times the national average. 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.

These rapid increases in population have subjected coastal zones to a disproportionate share of the disruptive impacts of human activities. A 1990 federal assessment 42,956 estuarine coastline kilometers (26,693 miles) and 6,952 ocean coastline kilometers (4,320 miles) revealed that only 56 percent of estuarine waters are swimable and fishable, while 89 percent of ocean coastline is deemed suitable for these activities.

Wildlife Resources

As is true for most other nations, the United States has not conducted a comprehensive, nationwide survey of its wildlife or biodiversity. However, during the past twenty years, evidence of the erosion of the diversity of life at all levels has grown within the United States and worldwide, and the consequences of climate change could lead to significant additional impacts.

In 1991, the U.S. government added 71 domestic species to the Threatened and Endangered Species List, bringing U.S. species on the list to 668. 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 a key to the growth and prosperity of the United States. Water resources have been developed for navigation, irrigation, hydroelectric power, urban and domestic use, municipal and industrial uses, and recreation. They have enabled urban and agricultural centers to flourish in semi-arid regions of the county. However, potential climate changes, including changes in precipitation and evaporation, may have significant impacts on water resources leading to limitations on the availability of fresh water, particularly for agriculture, and increases in levels of aridity in some areas. Currently, most of the nation's freshwater needs are met by withdrawals from streams, rivers, lakes, reservoirs, and ground-water aquifers. Even though total withdrawals of surface water more than doubled from 1950 to 1980, withdrawals still remained less than 21 percent of the renewable supply in 1980. However, some areas of the country 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 as drinking water for growing urban populations and American Indian water rights, but also for industry, agriculture, recreation, and support of natural ecosystems. The flows of many streams in this part of the country are fully allocated to current users, limiting opportunities for expanded water use by major new facilities, although recently enacted state legislation adopts a market-based approach to water pricing and allocation, thus offering the potential to alleviate projected shortfalls. Also pertinent are minimum-flow requirements to preserve threatened and endangered species.

Table 4

U.S. TRANSPORTATION SYSTEM

System Components	System Size		Vehicles in Use	
	Number	Unit	Number	Type
Highways				
(Using all highways)				
Interstates	44,700	miles	149,550,000	cars/taxis
Other principal arteries	132,000	miles	44,479,000	trucks
Minor arteries	222,000	miles	4,223,000	motorcycles
Collectors	808,000	miles	275,000	private buses
Local roads	2,674,000 (including school buses)	miles	351,000	public buses
Airports				
Commercial	29	major airports	3,698	carrier aircraft
	400	primary airports	533	cargo aircraft
			1,221	commuter aircraft
General aviation	16,700	GA airports	217,200	GA aircraft
Mass Transit				
Motor bus	231,000	route miles	57,000	buses
Rail	1,321	route miles	10,200	railcars
Commuter rail	4,587	route miles	4,700	railcars
Demand-response vehicles	—		16,100	vans
Railroads				
Class I	128,000	miles	19,647	locomotives
Regional	16,000	miles	748,000	freight cars
Local	15,000	miles	500	passenger cars
Switch/terminal	4,000	miles		
Waterborne				
Ports and	177	major ports	Merchant Marine:	
inland waterways	11,700	miles	709	U.S. flagships
			Commercial fleet:	
			5,200	self-propelled
			32,000	nonself-propelled
Pipelines				
Gas	1,151,000	miles		
Oil	201,000	miles		

Sources: U.S. DOT 1990, 1991a, 1991b

The U.S. Economy

The United States of America can be characterized most accurately as a mixed economy. That is, some economic activity is carried out by private decision makers (i.e., companies and consumers) and organized in free markets, and other economic activity is carried out by the federal, state, and local governments of the United States. Moreover, most of the private-sector "market" activity in the U.S. economy is subject to some sort of government action or oversight.

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, especially 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 exchange, as opposed to tradition or force, is the most efficient means of organizing economic activity. Put another way, 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 is expected to lead to an allocation of the resources of the U.S. economy that produces the greatest possible social welfare.

The production of some goods and services creates costs or benefits that are not captured by the price system. In these cases, the price system causes too much or too little of the good or service to be produced to maximize social welfare. Market failures can be said to occur in either of these cases. The U.S. government has frequently intervened to promote the allocation of resources that more closely resemble the welfare maximization allocation in markets characterized by market failure.

The U.S. government intervenes in the market to provide for public goods, such as national defense. 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, only part of the costs of emissions from motor vehicles accrue to the vehicle owner; the remainder accrue to other members of society and to the environment. As a practical matter, it is very difficult to establish accurately the cost of the externality in order to internalize it by a fee or tax. Government intervention may include regulations to limit the physical quantity of pollution that individuals may produce, or charging polluters a fee for each unit of pollution emitted. Such interventions need to take into account their effects on international competitiveness if other countries do not similarly intervene.

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, most government interventions are intended to facilitate or support well-functioning markets. By protecting property rights, 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, attention should also be given to the fact that "government imperfections" exist. It is not true, for example, that in formulating policy one can count on a dispassionate government to intervene flawlessly to correct market imperfections. The government itself is a source of imperfections—as evidenced, for example, by pork-barrel spending, continuation of federal enterprises, price controls, and restrictions on domestic and international trade. Nobel prizes in economics have been awarded in recent years to economists who caution that the public sector itself is a source of imperfections. The choice in practice, of course, is not between imperfect markets and perfect government but between imperfect markets corrected—or possibly made worse—by an imperfect government

Composition and Growth

From 1960 to 1991, the U.S. economy grew at an average annual rate of 2.9 percent, raising real gross domestic product (GDP) from $2 trillion to nearly $5 trillion by the end of the period (including capital consumption adjustment) (Figure 9). In 1991, U.S. per capita GDP amounted to $22,450, which represented a 76 percent increase in real terms above the 1960 amount. Growth generated a 75 percent increase in per capita income, which stood at $19,189 in 1991. During this period, the percentage of GDP devoted to pollution control and abatement expenditures also rose steadily, from 0.97 in 1972 to 2.09 in 1990.

The structural changes of the past thirty years in the U.S. economy are apparent in Figure 10. For three decades, income and employment generated by the service sector have grown substantially, while other sectors have shown only modest growth. In terms of national income, the service sector (which includes communications and public utilities, finance, insurance, and real estate) expanded from 27.1 percent of the economy in 1960 to 41 percent in 1991.

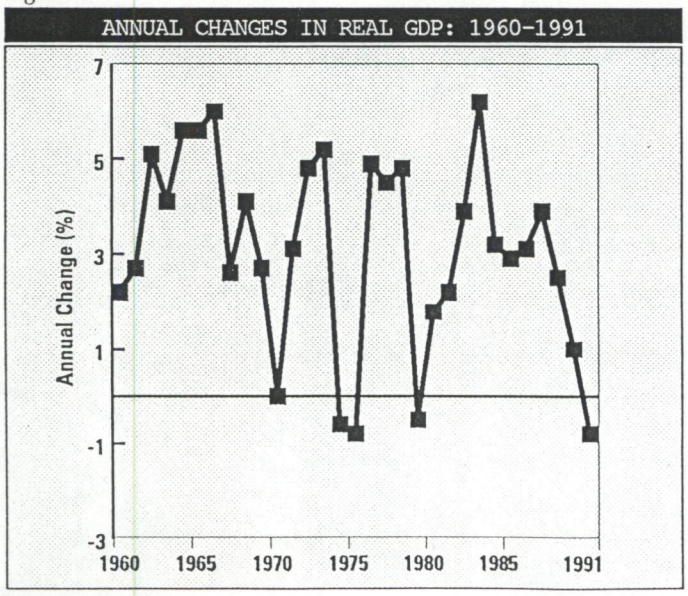
Employment in the service industries nearly tripled over the same period, while employment in the natural resource industries (agriculture, forestry, fisheries and mining) declined by some 212,000 full-time equivalents. ("FTE" is an equivalency measure that takes account of less-than-full-time positions.) Payrolls in the trade, transportation, and government sectors nearly doubled since 1960, while manufacturing and constructions jobs grew more slowly.

U.S. real wages have lagged below their long-term growth trend since the early 1970's. In 1991 average gross hourly earnings in 1982 dollars in private nonagricultural industries were 12.7 percent below the 1973 figure.

The United States earned a surplus in its international merchandise trade accounts throughout the post World War II period until the 1970's (Figures 11 and 12). Since 1976 it has incurred a yearly balance of trade deficit, which peaked in 1987 at $159.5 billion (3.5 percent of GDP). Since then the trade balance has improved steadily, with a deficit of $73.4 billion in 1991 (1.3 percent of GDP).

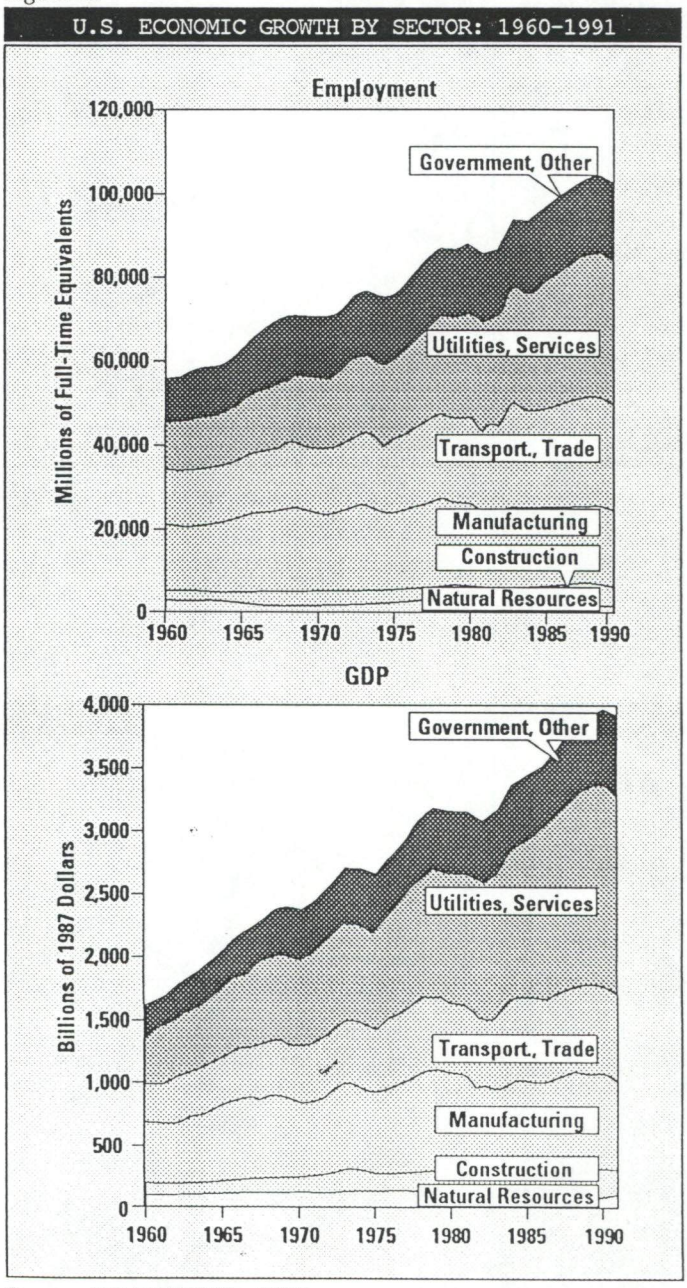
While earnings on services and investment income have partially offset the trade deficit, the U.S. balance on current account has also been negative for a number of years. After reaching a high of $160 billion in

Figure 9



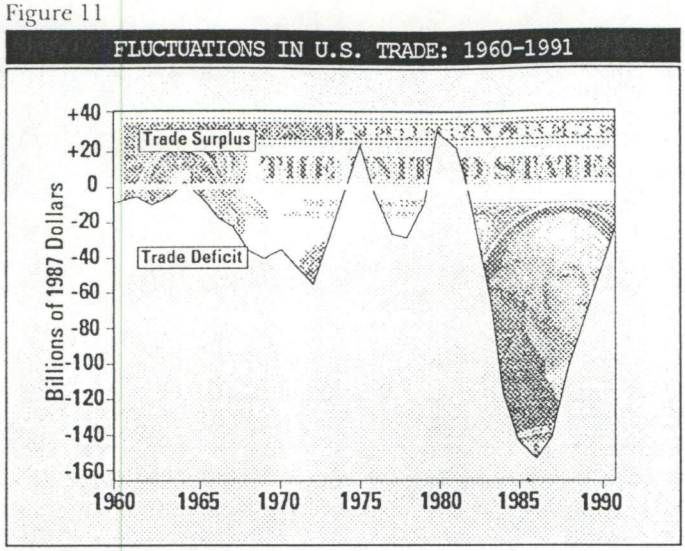
Source: CEA 1992

Figure 10



Sources: U.S. DOC 1992a, 1992b

Figure 11



Sources: CEA 1992a; U.S. DOC 1992a, 1992b

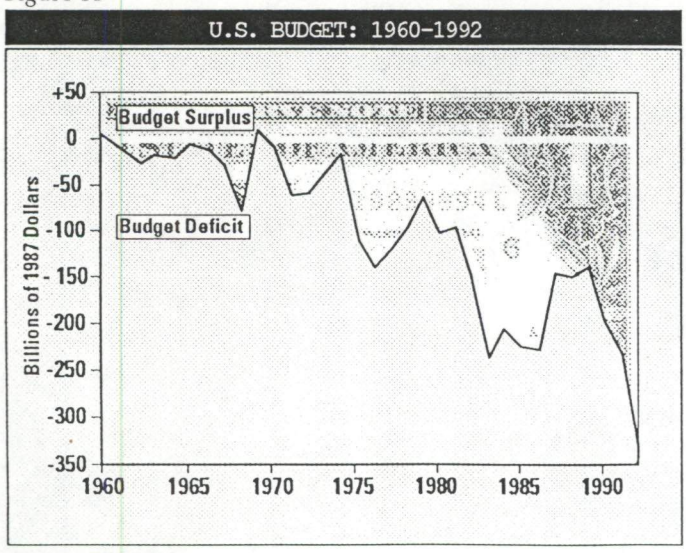
1987, the deficit on current account declined to $92 billion in 1990, and to less than $4 billion in 1991. (The 1991 figure was affected by large payments received from other countries in connection with the Gulf War.)

Since 1980 the foreign exchange value of the U.S. dollar reached a high in 1985 and then declined. In 1991 the Real Exchange Rate Index of the dollar was 29 percent below the 1985 level and 8 percent below the 1980 level.

As a result of the large deficits in its international accounts, the net international investment position of the United States fell from a positive figure of $258.5 billion in 1982 to a negative figure of $360.6 billion in 1990, a shift of $619 billion (based on direct investment at market value).

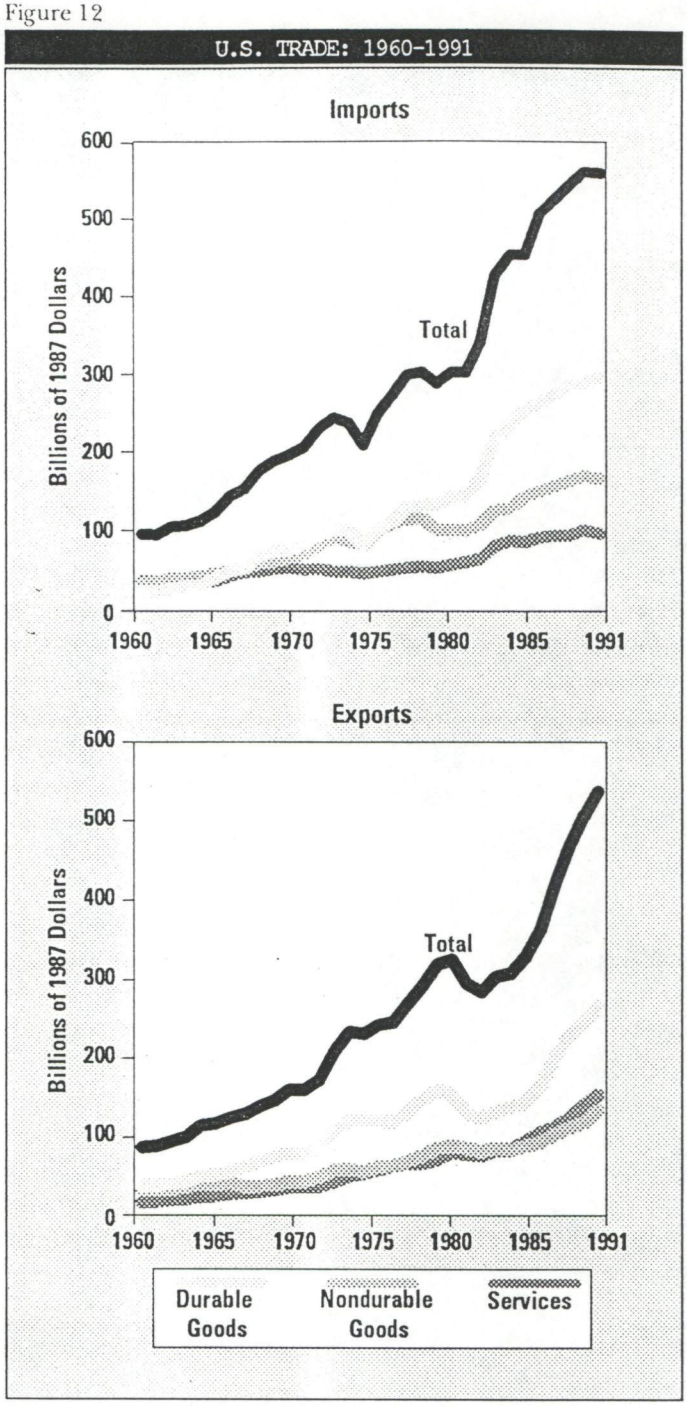
U.S. federal government outlays have exceeded its revenues for 31 of the past 33 years, resulting, in part, in a three-fold increase in the gross federal debt since 1960 (Figure 13). While the trend toward progressively

Figure 13



Source: CEA 1992

Figure 12



Sources: CEA 1992; U.S. DOC 1992a

larger federal budget deficits is expected to be reversed in the near future, even comparatively optimistic projections suggest that the U.S. government will continue to increase its debt through the end of the century.

An important implication of the federal budget deficit for environmental protection in general, and for measures to address climate change, in particular, is that any measures the government takes should be cost-effective. That is, of all the measures that might achieve a given reduction in greenhouse gas emissions, the preferred measure would be the one that maximizes net benefits to the nation.

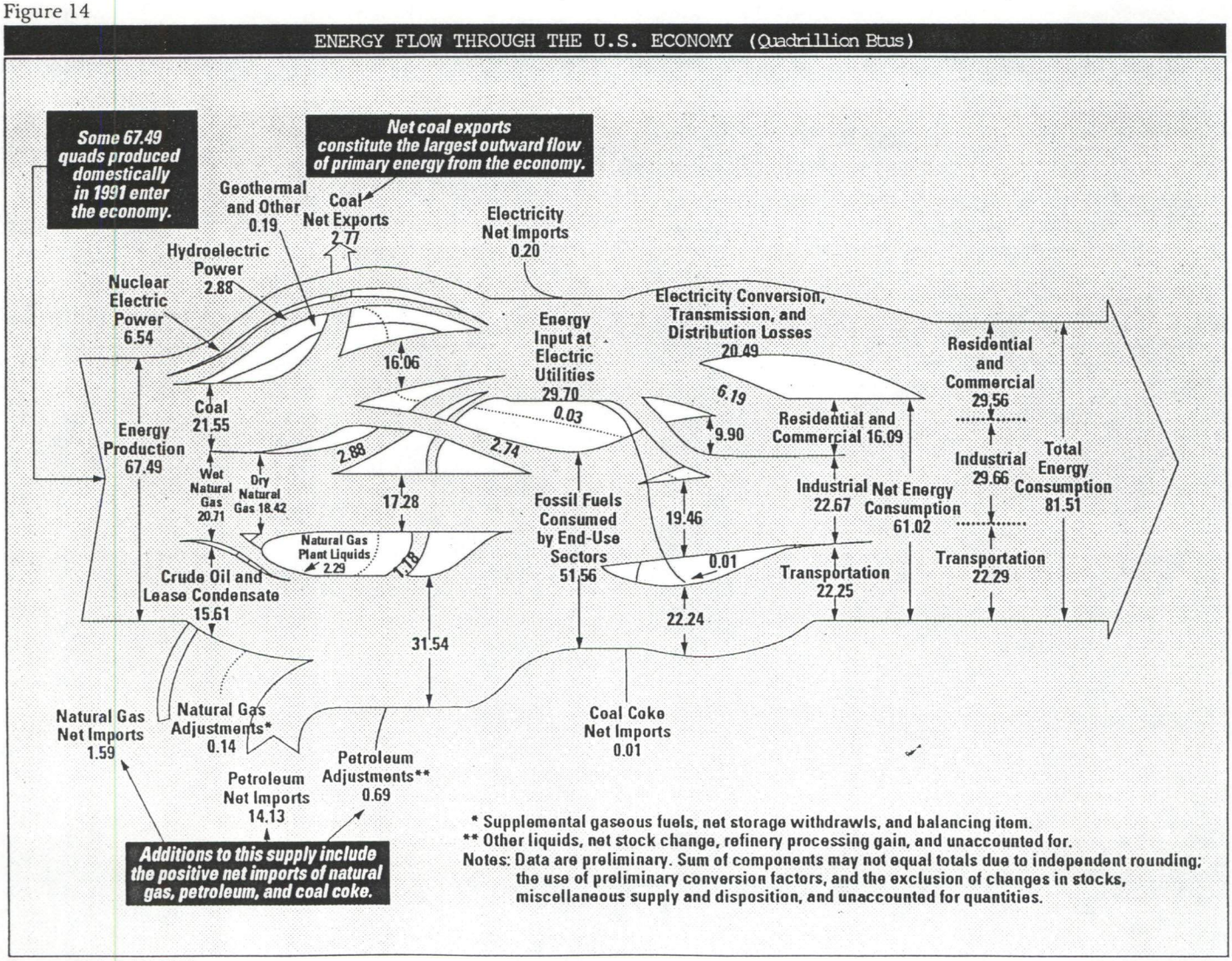
Energy Production and Consumption

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 that has a long economic life was developed in response to abundant and relatively inexpensive energy resources.

U.S. government estimates suggest that undiscovered recoverable energy resources in the United States included 49.4 billion barrels of crude oil and 399 trillion cubic feet of natural gas in 1987. Proved reserves in the same year were 28.7 billion barrels and 196.4 trillion cubic feet for oil and gas, respectively. Except for small additions in 1980 and 1987, 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 265 million pounds (120 million kg) of uranium oxide, recoverable at $30 per pound or less.

The most abundant U.S. energy resource, however, is coal (Figure 14). At the beginning of 1991, the demon-

Figure 14



Source: U.S. DOE 1992

strated reserve base of coal contained 470 billion short tons, about half of which is thought to be recoverable. The vast majority—88.9 percent—of this total is bituminous coal. Lignite and anthracite coal provide 9.5 and 1.5 percent of total coal reserves, respectively.

Coal, natural gas, and crude oil have comprised the bulk of U.S. energy production since 1960, accounting for 96.1 percent of production in 1960 and 85.7 percent in 1991. The commercial introduction of nuclear electric power and expanded hydroelectric generation displaced some of the production formerly contributed by fossil fuels (Figure 15). Other sources of renewable energy provide only a small part of domestic energy supplied. Geothermal energy, which is produced from hot-dry rock, steam, or hot water, has historically provided less than 1 percent of the domestic production of electricity. Production estimates for other renewable-energy sources, such as solar, wind, and waste products, are also small.

Growth in fossil fuel production has come mainly from coal and natural gas. These two fuels now contribute almost as much energy to the U.S. economy as was produced in 1960 by all fuels combined. Crude oil production, by contrast, first rose and then fell, with an overall increase of only 4.6 percent over 32 years. Figure 14 illustrates the flow of energy resources into and out of the U.S economy.

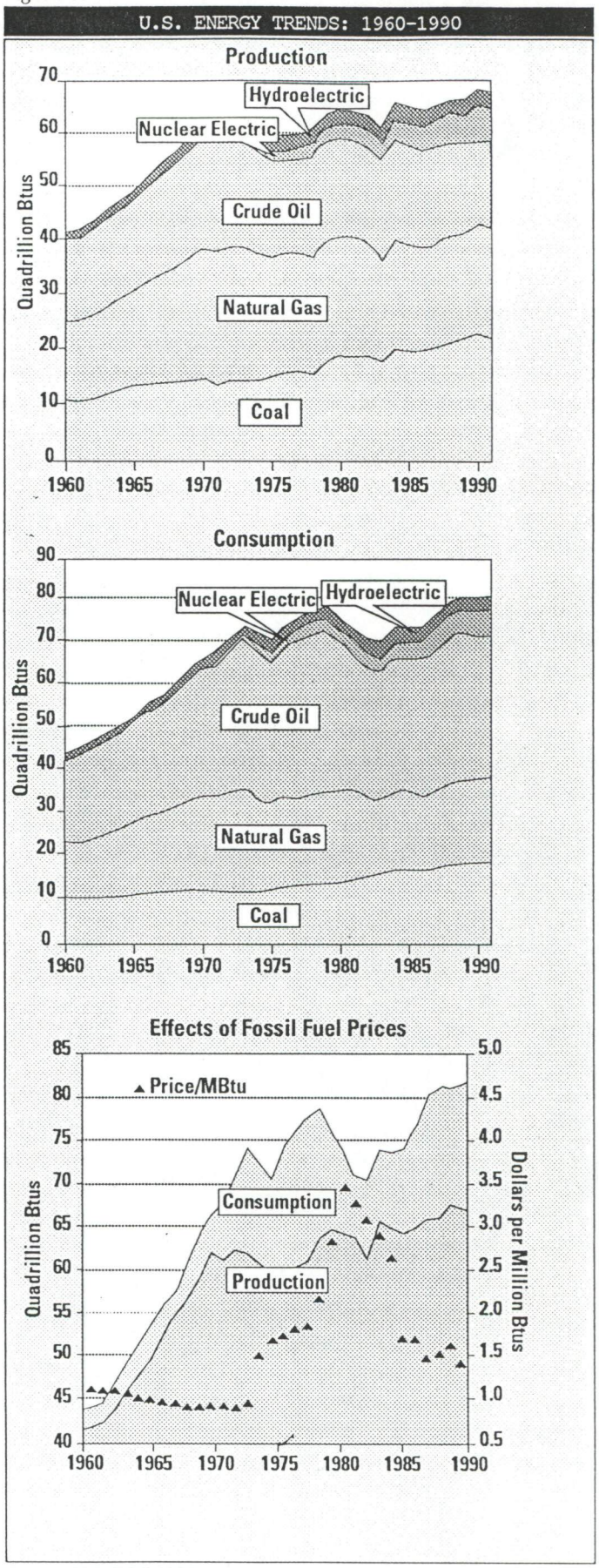
Before 1970, the United States imported a small amount of energy, primarily in the form of petroleum. Lower acquisition costs for imported crude oil in the early 1970s, however, put U.S. oil producers at a comparative disadvantage relative to their foreign counterparts. By 1971, the U.S. trends in energy consumption and production began to diverge (see Figure 5).

On the consumption side, rising petroleum imports have permitted a 64.3 percent increase in petroleum use since 1960. However, increases were dampened by international oil price shocks in 1973 and 1979-80. Since 1981, however, energy prices have fallen almost as rapidly as they had risen in the 1970s. After drop-offs following the oil price shocks, U.S. energy consumption again rose, until leveling off in the period from 1988 to the present. Petroleum's share of total energy consumption fell from 45.5 percent in 1960 to 40.1 percent in 1991.

Likewise, domestic energy production has varied with energy prices over the past 20 years. However, that variation has been less pronounced than the variation in consumption. Overall, U.S. energy production has risen by approximately 9 percent since 1973.

Since the early 1980s, when energy prices began to fall, U.S. energy consumption has increased faster than domestic production. If that trend continues, the United States will need to import more than half of its

Figure 15



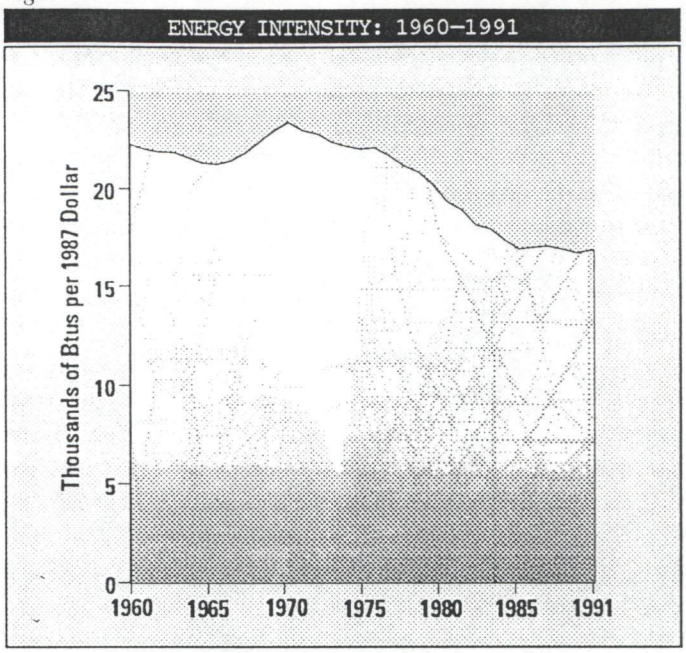
Source: U.S. DOE 1992

oil by 2010. Since oil is projected to comprise nearly half of U.S. energy needs by that date, the U.S. economy could, in such a scenario, remain vulnerable to variation in world energy prices.

Growth in the U.S. economy and population, rather than a worsening in the relative efficiency of energy use, is the major force behind recent and projected increases in energy use. Figure 16 shows a 27.2 percent decrease in the overall energy intensity of the U.S. economy since its peak in 1970. Similarly, the amount of energy consumed by U.S. households fell by 16.6 percent from 1970 to 1989; and by 1985, U.S. industrial energy intensity had declined 25 percent from its 1972 level. However, these improvements in per-unit energy use efficiency have not been large enough to counterbalance increases in the size of the population in the numbers of automobiles and households, and in the level of economic output.

In 1991, the generation, transmission, and distribution of electricity removed 20.49 quads from the stream of total usable energy, leaving 61.02 quads available for consumption by end users. Industry and transportation consumed nearly three-quarters of this energy, while the residential and commercial sector uses just 26 percent. However, because more than 60 percent of electricity is delivered to residential and commercial users, a larger portion of the conversion, transmission, and distribution losses is attributed to that sector. As a result, total energy consumption of 81.51 quads is distributed fairly evenly among residential/commercial, industrial, and transportation uses.

Figure 16



Sources: CEA 1992; U.S. DOE 1992a, 1992b

Industrial Energy Use

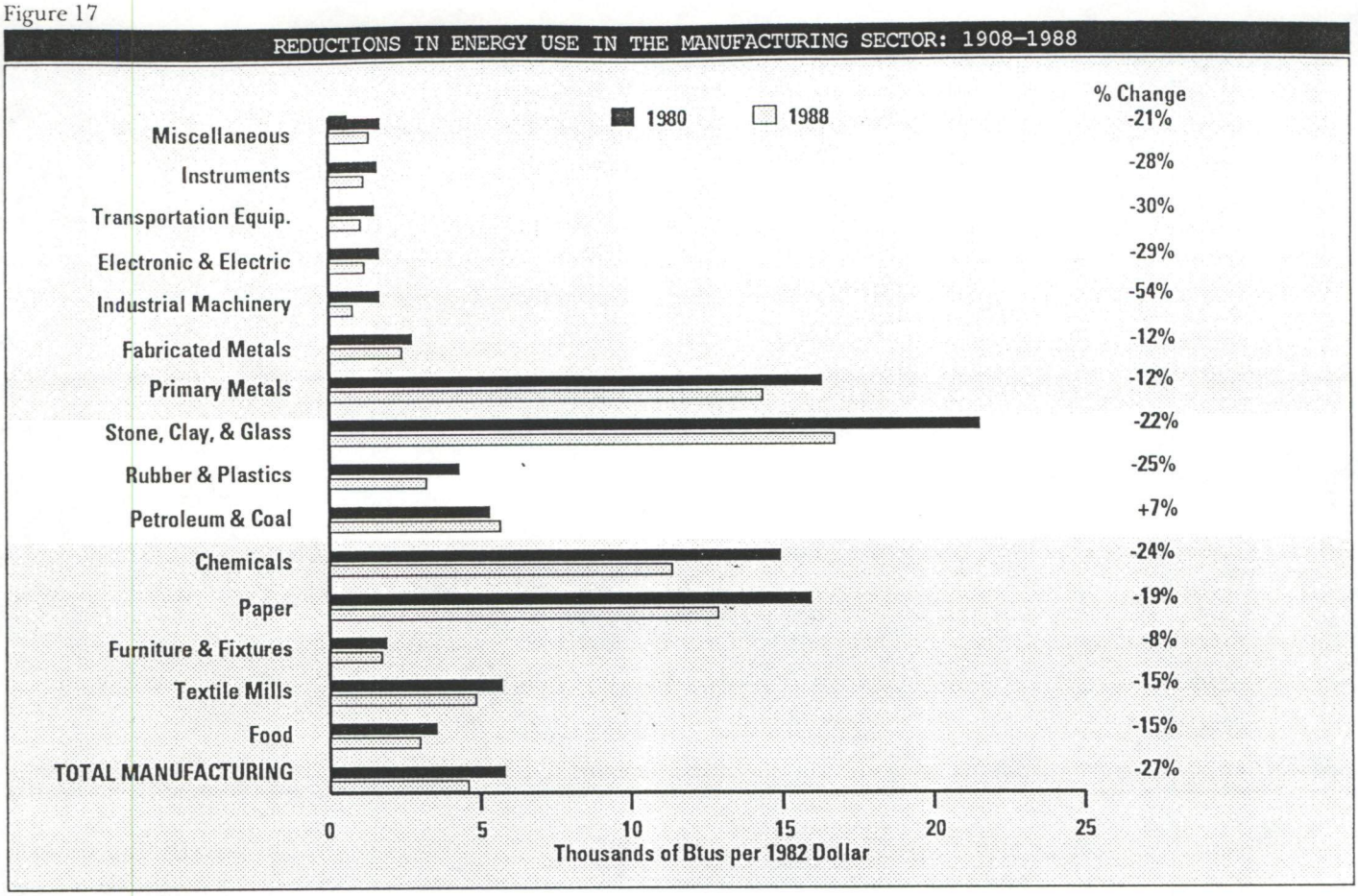
While definitive information on energy use for all industries is not yet available, the relative shift in the American economy away from manufacturing (Figure 10) may be partly responsible for the marked decline in the energy intensity of the U.S. economy. In 1960, more than 22,000 Btus of energy were used to produce one dollar of gross domestic product (GDP, measured in 1987 dollars). By 1991, U.S. industries were producing one dollar's worth of output with only 16,800 Btus. This 25 percent gain in efficiency was the direct result of (1) a changing mix of goods and services in the gross domestic product, as well as (2) technological improvements in the use of all forms of energy, and (3) increasing efficiency in the transformation of coal to electric energy, offset by the substitution of electricity for the less efficient uses of oil and gas. (The ratio of other forms of energy to GDP has been virtually unchanged since 1960.)

Energy intensity is also decreasing in the manufacturing sector. Of fifteen industry groups for which information is available, only one increased its energy intensity during 1980-88. Some groups decreased their intensity by as much as 54 percent, and the average improvement for all manufacturing industries was 27 percent (Figure 17). Most of these improvements (a portion of which may have resulted from structural shifts in the U.S. economy) were achieved in the first half of the 1980s, and reductions in overall energy intensity (Figure 16) seem to have slowed since the early part of the decade.

Residential Energy Use

The number, density, characteristics, and distribution of private dwellings can be good indicators of resource consumption and some types of environmental impacts. The purchase and turnover of major appliances, motor vehicles, and other consumer products typically occur at the level of the household. In this sense, dwellings might be a better indicator of energy consumption than population statistics.

Figure 17



Source: U.S. DOE 1992

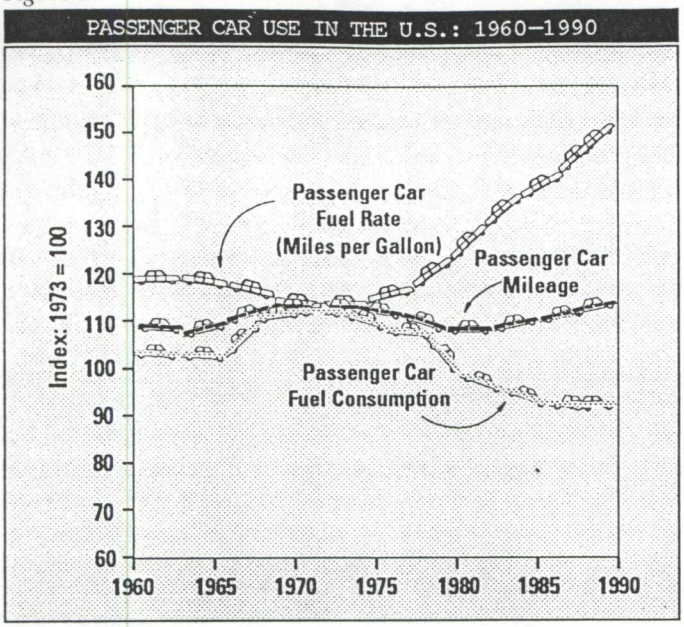
The United States has 102 million housing units, approximately half of which are detached and occupied by a single family. As of 1990, the average U.S. household consisted of 2.63 people, down from 3.33 in 1960. The median size of a U.S. dwelling is 1,604 square feet. The typical U.S. dwelling has five rooms and is situated on 0.12 hectares (0.39 acres); but average lot sizes range from almost 0.20 hectares (one-half acre) in the South to less than one-quarter acre in the West. Twenty seven percent of U.S. dwellings are multiple-unit, attached complexes, and 7 percent of these contain 20 or more units. Approximately 6 percent of U.S. dwellings are classified as trailers or mobile homes. Most occupied dwellings in the United States were constructed before 1979, with 13 percent constructed in 1980 or later. The median age of dwellings in the United States is thirty years. During 1978-87, average energy consumption per household dropped over 25 percent, from 138 million Btus to 101 million Btus.

Transportation Energy Use

The need for transportation is closely linked to the nation's population and demographics. However, the transport sector also accounts for approximately one-quarter of U.S. greenhouse gas emissions. Since the 1920s, U.S. transportation has evolved into a six-modal system of waterborne, highway, mass transit, air, rail, and pipeline transport (Table 4).

The current U.S. surface transportation system is dominated by automobiles. In 1990, the highway share of personal travel was 88 percent, in contrast to the mass transit share at 2.5 percent. At the same time, demand for freight transportation continued to increase. Over 3.6 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. Between 1920 and 1985, 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.

Figure 18



Source: U.S. DOE 1992

Motor vehicles provide another good indicator of a nation's energy consumption. As of 1991, there were 190 million cars and trucks registered in the United States, up from 74 million in 1960. The average age of U.S. automobiles is about 7.5 years, and 19 percent of the U.S. automobile fleet is over twelve years old.

In 1990, personal passenger vehicles in the United States traveled a total of 2.4 trillion km (1.5 trillion miles), using 273 billion liters (72 billion gallons) of fuel, with an average fuel efficiency of almost 21 miles traveled per gallon (8.9 km/liter) of fuel. In 1969, U.S. personal passenger vehicles traveled a total of 971 billion miles, using 64 billion gallons (242 billion liters) of fuel, with an average fuel efficiency of about 13.5 miles per gallon (5.7 km/liter) (Figure 18).

In 1990, there were 1.8 vehicles per U.S. household, compared with 1.2 in 1969. Daily vehicle miles traveled per household averaged 41.4 (66.7 km) in 1990, up 22 percent from 1969. The average vehicle trip length was about nine miles (14.5 km) in 1990, and the average annual travel per driver was about 13,000 miles (20,934 km), up by about 4,000 miles (6,441 km) from 1969.

Political and Institutional Systems

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

Federal Regulatory Agencies

Today's federal programs to curb pollution were built on longstanding resource conservation and public health programs. The U.S. government took its first regulatory steps to protect and manage environmental resources near the end of the last century. However, it was not until the 1970s when most of the existing federal environmental laws, agencies, and regulatory programs were created. These programs responded to public concern about environmental degradation and to inadequacies of controls that previously had been imposed solely at the state and local levels. U.S. environmental protection and resource management at the federal level thus evolved from state and local regulatory programs.

The U.S. Environmental Protection Agency (EPA) was established primarily to control pollution and thus to better protect human health and the environment, while leaving related activities, such as natural resource management (wildlife, minerals, parks, forests, agriculture, fisheries, etc.), with the Departments of the Interior, Agriculture, and Commerce, and most aspects of public health protection with the Department of Health and Human Services and the Department of Labor. The result is that the federal government's responsibility for environmental and natural resource

protection and management is shared among several departments and agencies.

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.

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

U.S. Congress

The U.S. government is divided into three separate branches: the executive branch, whose regulatory authority is discussed above; 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.

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 ratifies international treaties, such as the U.N. Framework Convention on Climate Change.

THE U.S. LEGISLATIVE PROCESS

The U.S. Congress consists of two elected chambers, the Senate and the House of Representatives, having generally equal functions in law making. 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 Government

Each of the fifty United States enjoys significant autonomy in its approach to environmental regulation and management activities. State governments implement federal laws by issuing permits and monitoring compliance with regulatory standards. States also generally have discretion to set standards more stringent than the national ones. 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 Government

Land-use decisions usually are made by local governments. Local power to regulate land use is derived from a state's power to enact legislation to promote the health, safety, and general welfare of its citizens. States vary in the degree to which they delegate these "powers" to local governments, but control over land use usually is exercised to a considerable extent at the local government (county or city) level. 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.

U.S. Court System

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

Cases usually enter the federal court system at the district court level. However, disputes between states may be brought directly before the Supreme Court. In the process of filing civil environmental cases, complaints are brought on behalf of the federal 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. Courts may direct, for example, 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 and scientific issue. Political action, at any level, requires sound advice and information from the scientific community. Therefore, it is important that governments have access to the best scientific information available.

The United States enjoys access to scientific information through several important agencies. The independent, congressionally chartered National Academy of Sciences (NAS) and the National Academy of Engineering are key sources of high-level scientific advice in the United States. The NAS is a key coordinator for the U.S. scientific community, convening special study groups to address important issues, such as controlling and mitigating the effects of climate change. NAS study panels are frequently requested by the President or Congress.

The President's Science Advisor, and the Office of Science and Technology Policy which he heads, oversee U.S. scientific research programs on issues, including climate change. The Science Advisor chairs the Federal Coordinating Council for Science, Engineering, and Technology, which is the parent organization for the interagency Committee on Earth and Environmental Sciences. One of the Committee's activities is the U.S. Global Change Research Program, a multidisciplinary research effort aimed at resolving uncertainties associated with the climate system. The Science Advisor also chairs the President's Council of Advisors on Science and Technology, a group of academic, governmental, and private-sector leaders who advise the President on science and technology issues.

The President's Council on Environmental Quality (CEQ) is another source of information on climate change issues. Under the National Environmental Policy Act, one of CEQ's principal functions is to monitor and inform the President of trends in environmental quality. In connection with this function, CEQ convened the Interagency Committee of Environmental Trends, whose purpose is to promote consistency and coordination among the various producers and users of statistical information on environmental protection, natural resources, and related issues. CEQ also produces the President's annual report to Congress on environmental quality, as well as statistical documents on environmental trends.

National Revenue Structure

Federal, state, and local governments in the United States collect most of their own-source general revenue from taxes on income, sales, or property.

Federal Revenue

As illustrated in Table 5, the major sources of federal government revenue are individual and corporate income taxes. Indeed, the federal government raises more money from income taxes than state and local governments raise from all taxes combined.

The federal government levies no property or general sales tax, but does collect sales taxes on selected excises, such as motor fuel and alcoholic beverages. The federal government also earns revenues from environmental and natural resource management. In 1991, the government collected over $8.4 billion in revenues from such activities as leasing and extraction of natural resources on federal lands, taxes on emissions of chlorofluorocarbons, and penalties for oil spills and hazardous waste cleanup.

Table 5

SOURCES OF FEDERAL REVENUE: 1987–1988

Sources of Revenue	Federal	State	Local	All
		Millions of Dollars		
General Revenue				
Intergovernmental Revenue	2,859	107,241	162,713	—
From federal	—	100,478	17,124	—
From state	2,859	—	145,590	—
From local	—	6,763	—	—
General Revenue, Own-Sources	689,696	338,280	271,263	1,299,239
Taxes	562,600	264,080	171,595	998,275
Property	—	5,049	127,191	132,240
Individual income	401,181	80,133	8,216	489,530
Corporation income	94,195	21,685	2,056	117,936
Customs duties	16,317	—	—	16,317
General sales gross receipts	—	87,010	18,159	105,168
Selective sales and gross receipts	36,287	43,126	7,963	87,376
Motor vehicle and operators licenses	—	9,644	646	10,291
Death and gift	7,594	3,241	34	10,868
All other	7,026	14,193	7,330	28,549
Current charges	80,081	34,436	60,122	174,639
Miscellaneous general revenue	47,015	39,763	39,546	126,324
Total	**$692,555**	**$445,521**	**$433,977**	**$1,299,239**
Special Revenue				
Utility Revenue	—	3,030	46,196	49,226
Liquor Store Revenue	—	2,767	524	3,291
Insurance Trust Revenue	319,788	90,491	14,348	424,628
Total	**$319,788**	**$96,288**	**$61,068**	**$477,143**

Source: U.S. Bureau of the Census 1992

State Revenue

Sales taxes are the largest single source of state revenue, and state governments are also the largest users of revenue generated through sales tax (Table 6). A number of 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.

Local Revenue

Property taxes are by far the major source of local revenue (Table 6). 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 usually administered locally, whereas local sales taxes are usually "piggybacked" on the administration of state sales taxes.

Table 6

SOURCES OF STATE AND LOCAL REVENUE[1]

Type of Tax	Number of States Using the Tax	Number of States with Localities Using the Tax
General Property	22 states and DC	50
General Sales	45 states and DC Exceptions are AK, DE, MT, NH, OR	31
Individual Income	40 states and DC Exceptions are AK, CT,[2] FL, NV, NH,[2] SD, TN,[2] TX, WA, WY	13
Corporation Income	45 states and DC Exceptions are NV, SD, TX, WA, WY	6
Selective Excises		
Motor fuel	All 50 states and DC	~8
Cigarette	All 50 states and DC	~6
Alcoholic beverage	All 50 states and DC	~9

[1] As of January 1989.

[2] CT, NH, and TN tax dividends and interest. CT also taxes capital gains, but not rents or labor income.

Source: Mikesell 1991

Policies Affecting Energy and Environmental Resources

Energy Policies

In recent years, U.S. lawmakers have exerted enormous effort toward balancing a range of energy policy concerns. On the one hand, abundant and affordable energy has long been a driving force behind the growth of the U.S. economy. On the other hand, energy dependence has resulted in economic instability when supplies are threatened. Additionally, concerns have arisen about the health and environmental effects associated with energy production, transport, and use. Finally, concerns have emerged about the ability of resource-inefficient products to compete in a global marketplace.

Several federal initiatives are intended to alleviate energy-related concerns through market incentives, restructured fiscal provisions, and conventional regulation. The National Energy Strategy is the United States' first comprehensive plan for managing its energy resources and has market reliance as its keystone. Since market pressures have already led to improvements in

energy efficiency in the United States, government action also focuses on removing remaining barriers to an efficient operation of markets.

In April 1991, the President issued an executive order on federal energy management, requiring a dramatic reduction in energy usage by the nation's largest energy consumer—the federal government. In addition to its cost-saving and energy-conservation attributes, the executive order is expected to yield other beneficial effects by demonstrating the opportunities for energy efficiency and conservation and by helping to establish markets for conservation and efficiency goods and services.

Federal R&D

The United States has an extensive program of energy technology research and development, many parts of which are focused on energy efficiency and a reduction of greenhouse gas emissions. Federal support for energy technology research and development has increased during the 1990s, after a period of substantial budget reductions in the 1980s. The budget for 1993 contained almost one billion dollars for energy-related research and development.

Various federal agencies are involved in energy research and development individually, and through cooperative programs with the private sector and academia. The U.S. government operates an extensive system of national research laboratories that address a broad research agenda, including energy technology research and development. Joint programs, such as the National Industrial Competitiveness through Environment, Economics, and Energy program, the Innovative Concepts Program, and the National Technology Initiative, encourage and support private efforts to develop energy-efficient, competitive, and environmentally clean technologies.

Transportation Policies

Traditionally, U.S. transportation policy has focused on the promotion of commerce and trade, national security concerns, and personal mobility. In the past two decades, environmental concerns have been emerging as a priority issue in U.S. transportation policy. Indeed, the greenhouse gas emissions associated with transportation are significant.

As mentioned earlier, the United States is a large and comparatively sparsely populated nation. Over the last forty years, U.S. metropolitan areas have expanded dramatically, with the bulk of this growth taking place in suburban regions. Because of low population densities in many suburban and rural regions, the ridership and tax base needed to sustain mass-transit systems is insufficient. Therefore, access to mass transit has not been a priority concern in establishing settlement patterns in growing metropolitan areas, and the personal automobile has emerged as the principal mode of travel there.

Significant federal efforts to limit the impact of transportation on environmental quality began in the 1960s, in response to urban air-quality concerns. 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 "corporate average fuel economy," or CAFE, standards, have risen from an initial level of 18 miles per gallon (7.7 km/liter) in 1978 to a current level of 27.5 mpg (11.7 km/liter) (Figure 18). Rising CAFE standards have not had a directly proportional impact on reducing total fuel consumption—and thus emissions of greenhouse gases—due to simultaneous increases in the number of automobiles and the average amount of automotive travel by the U.S. population. Annual vehicle-miles traveled have increased markedly, from 775.9 (1,249 km) in 1969 to over 1,400 (2,254 km) in 1990.

Apart from concerns about carbon dioxide emissions resulting from automobile fuel combustion, U.S. transportation policy has devoted considerable attention to emissions of such substances as carbon monoxide, nitrogen oxides, and volatile organic compounds, which are greenhouse gas precursors. The Clean Air Act and its amendments established National Ambient Air Quality Standards to protect public health and welfare. In turn, to meet tailpipe emission standards, automobile manufacturers began in the 1970s to use catalytic convertors and other technologies. Such policies contributed to considerable improvements in U.S. air quality. For example, nationwide transport-related emissions of carbon monoxide and reactive volatile organic compounds were reduced by almost 50 percent between 1970 and 1990.

Recent legislation reflects a new 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. The Act integrates environmental and economic considerations to an unprecedented degree.

Agricultural and Forestry Policies

For the past fifty years, agricultural and forestry progress policies and practices have reflected awareness of conservation goals and sustainable use for food and fiber production. Legislation and public-private partnerships have worked to protect a productive environment by creating incentives to reduce soil erosion on agricultural lands, enhance privately-owned wildlife habitat, maintain wetlands, and improve water quality.

Recent U.S. policies to improve forest conservation on both public and private lands now involve initiatives for reforestation and the sustained use of forest resources. Since fiscal year 1991, the President has annually requested sufficient funding through the U.S. government to support annual plantings of 970 million trees in rural areas and 30 million trees in urban areas to meet the President's goal of increasing reforestation by one billion trees per year in this decade. In 1991, over 25 million trees were planted or improved in urban areas alone. In 1992, nearly $20 million will be available to cost-share tree planting and improvements in rural areas. The federal government also cooperates with state foresters and private nonindustrial landowners to develop forest stewardship plans before harvesting their timber.

Recently, the U.S. government has adopted the principle of ecosystem management for publicly owned forest lands and have announced that clearcutting would be ended as a standard harvesting practice on those lands. The federal government also has launched related research at 122 national forests and grasslands and at ten research centers across the nation focusing on ecosystem management.

The conservation title of the 1985 Farm Bill changed the priorities of U.S. federal soil and water conservation agencies, of their state and local program participants, and of farmers themselves through such programs as the Conservation Reserve Program, the Swampbuster provision, and the Sodbuster provision. The Food, Agriculture, Conservation, and Trade Act of 1990 (1990 Farm Bill) strengthened the 1985 provisions and provided farmers with incentives to prevent pollution through a long-term adoption of alternative farming methods, such as low-input sustainable agriculture.

To remain eligible for farm program benefits, farmers must develop and carry out approved conservation plans on highly erodible crop land. To date, the Soil Conservation Service has helped 1.3 million farmers develop conservation plans to protect 55 million hectares (135 million acres) of land. In 1991 farmers implemented 52 percent of their conservation plans, mostly by enrolling highly erodible land in the Conservation Reserve Program, which temporarily removes such crop land from production. In addition to reducing soil erosion, the program stabilized the use of agricultural chemicals and nutrients, thus having a positive impact on water quality and associated aquatic systems.

The Swampbuster provision of the 1985 Farm Bill amended in 1990 protects the environmental values of wetlands—including wildlife habitat, flood control, filtering of nutrients and toxics, and ground-water recharge—by outlawing the conversion of wetlands to crop land a violation.

The Farm Bill's Sodbuster provision reduced the incentive for converting grasslands and forests to crop production by requiring the use of conservation measures on all such converted land. The Super Sodbuster amendment of the bill prohibits participants in the Conservation Reserve Program from bringing newly purchased, highly erodible land into crop production.

Greenhouse Gas Inventory

Signatories of the *Framework Convention on Climate Change* agreed to inventory and report their nations' human-related emissions of greenhouse gases by "sources" and removal of these emissions by "sinks." Before signing and ratifying the Convention, the United States had taken steps to fulfill this obligation. In 1991, at the request of the Intergovernmental Panel on Climate Change, the United States produced an inventory of U.S. greenhouse gas sources and sinks for 1988 (U.S. Government 1991). This inventory relies on published U.S. government emissions data where available and is supplemented by calculations using U.S. data and the analytical methods of calculation proposed by an international group of experts (OECD 1991). The results, reported in this chapter, are preliminary and will be revised with improved information in 1993.

Overview of the Greenhouse Gases

The main greenhouse gases (both natural and human-related) are water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs). Tropospheric ozone (O_3), also a greenhouse gas, is produced by reactions of nitrogen oxides (NO_X), carbon monoxide (CO), and nonmethane volatile organic compounds (VOCs) in the atmosphere.

Table 7

ESTIMATED GHG EMISSIONS FROM HUMAN ACTIVITIES

Emission Sources	CO_2*	CH_4	N_2O	CFCs†	NO_x	CO	Nonmethane VOCs
	millions of metric tons						
U.S. (1988)	5,000	15–51	0.3–1.2	0.7	20	53	16
Global (1990)	20,000–24,000**	360	10	1.8	58–81	740–2,600	120

* These figures only include emissions from burning of fossil fuels, cement production, and oil and gas production. They do not include net uptake or emissions due to land-use changes.

** IPCC has estimated CO_2 emissions from tropical deforestation at 4,800 million metric tons.

† These estimates do not come from measurements of emissions. They are the results of the U.S. Environmental Protection Agency's Integrated Assessment Model and Vintaging Model.

Sources: IPCC 1992a; IPCC 1992b; U.S. Government 1991

Scientists agree that human activities are emitting enough greenhouse gases to change the composition of the earth's atmosphere. Since preindustrial times (1750-1800), the concentration of CO_2 in the atmosphere has risen 25 percent. Over this same time period, CH_4 concentrations nearly doubled, while N_2O concentrations increased by 8 percent. Furthermore, during the past few decades, until the Montreal Protocol took effect, emissions of CFCs have increased at least 4 percent a year. With the exception of CH_4 and some of the halocarbons (carbon compounds which include chlorine, bromine, fluorine, and iodine)[1], the emission rates of most of these greenhouse gases have been steady or increasing over the past decade (IPCC 1992a).

As the largest economy in the world, the United States contributes a significant share to global greenhouse gas emissions, as shown in Table 7. The gases in the table are arranged from left to right in decreasing order of the importance of their contribution to radiative forcing.

Carbon Dioxide

Globally, the burning of carbon-containing fossil fuels emits 20,000–24,000 million metric tons (MMTs)

[1] Halocarbons comprise a broad category of gases, including chlorofluorocarbons (CFCs), that contribute to radiative forcing of climate. CFCs are the best-known halocarbons, and they are controlled under the Montreal Protocol.

of CO_2 (5.5–6.5 billion metric tons of carbon) each year (IPCC 1992a). Between 1950 and 1988, U.S. annual CO_2 emissions roughly doubled (Figure 19). Almost all of these emissions originated from the burning of fossil fuels: 44 percent from oil and oil products, 37 percent from coal, and 19 percent from natural gas. Small amounts of CO_2 are also emitted from various other activities, including cement production (about 0.6 percent), landfills, and domestic sewage. Figure 20 shows a breakdown of emissions from fossil fuel burning in the United States.

Some of the CO_2 emitted from human activities remains in the atmosphere, while some is absorbed by the ocean or is stored in soils, vegetation (including trees and other woody biomass), and other carbon "sinks." In U.S. forests, carbon uptake currently exceeds emissions. The removal of trees by timber harvesting, land-use conversion, and fuelwood use emits roughly 1,300 MMTs of CO_2. (All estimates in forestry and agriculture are assigned an error range of +/- 50 percent because they are so uncertain. Research to improve these estimates continues.)

Other sources of carbon emissions that are not yet quantified include any emissions due to flooding of land, conversion of grasslands to cultivated lands, and forest death and decline from air pollution. In 1991, the U.S. government estimated that U.S. forests absorbed 1,690 MMTs of CO_2 in 1988, bringing net CO_2 uptake removal from forests to 188-563 MMTs of CO_2 (4-11 percent of fossil energy emissions). In contrast, land conversion globally, primarily tropical deforestation, has led to a net average annual flux of 2,200–9,500 MMTs of CO_2 (0.6–2.6 billion metric tons of carbon) to the atmosphere over the past decade (IPCC 1992a). (This last estimate does not include all carbon uptake in terrestrial systems.)

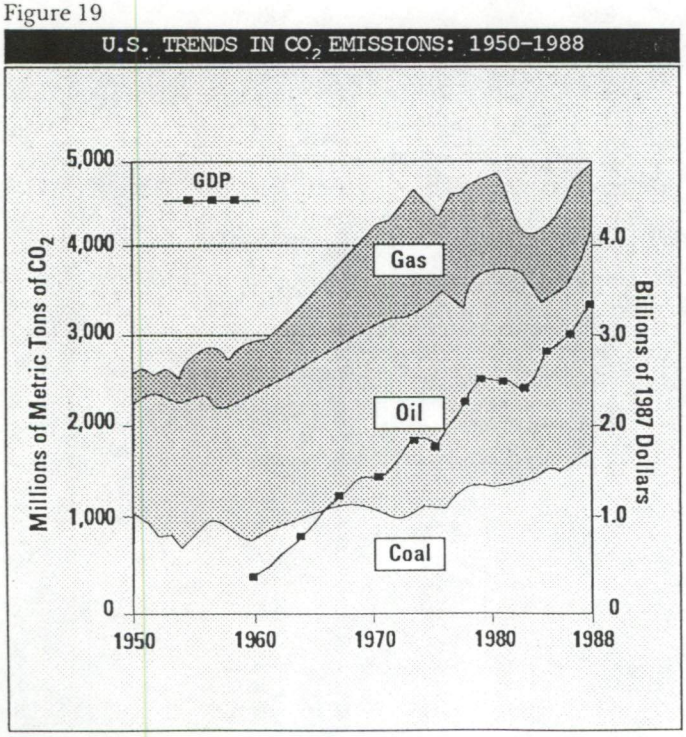
Methane

CH_4 is produced primarily through the anaerobic (without oxygen) decomposition of organic matter. Table 8 shows the contributions from each major source in the United States in 1988 and the large range of uncertainty in the estimates. This does not include net changes in CH_4 emissions due to net changes in the acreage of wetlands.

Nitrous Oxide

For 1988, U.S. N_2O emissions were estimated to be 0.34–1.21 MMTs, but this estimate is highly uncertain. Anthropogenic (produced by human activities) N_2O emissions come from the use of nitrate ammonium and organic fertilizers, fossil fuel burning, biomass burning, and emissions from soils due to agricultural manage-

Figure 19



Source: U.S. EPA

Figure 20

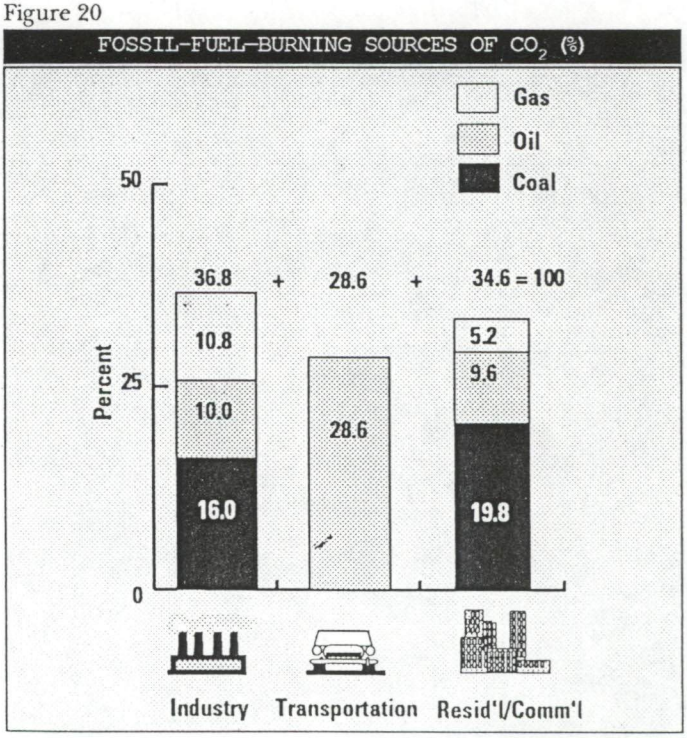


Table 8

U.S. METHANE EMISSIONS IN 1988

Methane Sources	Millions of Metric Tons
Agricultural activities (*enteric fermentation—digestion process in some livestock, animal waste, and rice cultivation*)	6.8–15.3
Landfills and domestic sewage (*waste decomposition*)	3–20
Coal mining (*e.g., release of methane from the coal seam*)	4.0–9.2
Oil and natural gas production and distribution	0.9–3.1
Incomplete combustion in burning of fossil fuels	0.3–3.8
Total	**15.0–51.4**

Source: U.S. Government 1991

ment (e.g., irrigation) and land conversion. Fertilizer nitrates can also leach into ground water, which releases N_2O to surface-water systems. Industrial processes are another large source of N_2O emissions. For example, the United States produces about one-third of the world's nylon, which resulted in 0.25 MMTs of N_2O emissions in 1988 (U.S. EPA 1992). It is estimated that fertilizer use contributed 0.05–0.85 MMTs, while energy burning for transportation accounted for 0.04–0.11 MMTs. Data on emissions from fossil fuel burning in stationary sources (such as electric utilities) and land conversion are not currently available, but are expected in 1993.

Nitrogen Oxides

Nitrogen oxides (NO_x) are important GHG precursors because they contribute to the formation of ozone, a greenhouse gas, in the lower atmosphere (troposphere). NO_x is formed primarily when fuel is burned at high temperatures. In 1988, the United States emitted 19.6 MMTs of NO_x, 38 percent of which came from electric utilities. Fuel use in automobiles and trucks accounted for 32 percent, and industrial energy use for 16 percent. Because NO_x emissions, along with CO and nonmethane VOC emissions, are important components of air pollution and precursors of photochemical smog, they have been controlled in the United States during the past several decades. As a result, the emissions of these gases per unit of industrial activities and per vehicle miles driven in the United States are among the lowest in the world. From 1970 to 1980, NO_x emissions from electric utilities and highway vehicles grew by 50 percent. Though emissions from electric utilities stayed constant over the next decade, those from highway vehicles fell by over 40 percent.

Chlorofluorocarbons

CFCs are solely a product of the chemical industry. They do not occur naturally in the environment. CFCs are used for a wide range of purposes, including refrigeration, solvent cleaning, sterilization, and insulation. CFC-11 and CFC-12, the most abundant halocarbons in the global atmosphere, are used in blowing plastic foams, in aerosol cans, and in refrigeration (Lashof and Tirpak 1990).

In 1988, the United States emitted roughly 0.7 MMTs of halocarbons, including CFCs (Table 9). Under the Clean Air Act Amendments of 1990, the United States will phase out CFC production by 1996.

Carbon Monoxide

Over 90 percent of the 53.4 MMTs of CO emitted in 1988 can be attributed to burning fuel. When fuel is not completely burned, a portion is emitted as CO, rather than CO_2. For industrial sources, with generally efficient equipment, the emission of CO relative to CO_2

Table 9

ESTIMATED CFC EMISSIONS IN 1988

CFC-11	CFC-12	HCFC-22	CFC-113	CFC-114	CFC-115	Carbon tetra-chloride	Methyl chloroform	Halon-1211	Halon-1301
.067	.127	.074	.078	.005	.003	.029	.302	.0008	.0014

Note: These estimates are not measurements of emissions. They are the results of the U.S. Environmental Protection Agency's Integrated Assessment Model and Vintaging Model.

Sources: U.S. Government 1991

is very small. The largest contributor of CO emissions is transportation (about three-fourths of all emissions). Half of transportation CO emissions come from gasoline use in passenger cars. More efficient and less polluting engines have reduced the ratio of CO emissions to vehicle miles driven by half over the past decade (U.S. EPA 1991). Residential fuel use accounts for about 12 percent of CO emissions, and industrial processes account for the remainder.

Nonmethane VOCs

Human-induced nonmethane volatile organic compounds are emitted by the evaporation of fuels and of solvents in products used by industry, commercial establishments, and consumers.[2] During 1988, industrial processes accounted for 51 percent of anthropogenic nonmethane VOC emissions. The largest contributors include surface coating, petroleum product storage and transfer, production of organic chemicals, and petroleum refining.

Energy use for transportation accounted for 43 percent of human-induced nonmethane VOC emissions—four-fifths of which came from gasoline use in passenger cars. Motor vehicle controls have reduced these emissions by two-thirds since 1970. Between 1981 and 1990, emissions from highway vehicles decreased by 34 percent, despite a 37 percent increase in vehicle miles traveled during this period (U.S. EPA 1991). The remaining nonmethane VOC emissions were due to other energy combustion processes.

Uncertainty and Limitations of Emission Estimates

The U.S. greenhouse gas inventory for 1988, produced in 1991, provides a starting point for developing a more detailed and comprehensive national inventory. The U.S. government expects to update and improve the estimates presented in this chapter over time. Knowledge of the sources, emission rates, and removal of greenhouse gases is evolving rapidly. Priorities for further analysis are:

- *Improved understanding about how emissions are produced.* More scientific research is needed to develop methods for estimating emissions from new source and sink categories and to refine existing methodologies. Sources and sinks of methane emissions may be the most important area needing research, particularly emissions from waste management, ruminant animals, and rice production. Also needed is additional study of how different types of land conversion and management affect net emission fluxes, including emissions from soils.
- *Refinement of estimates of the rate of emissions or removal from a given activity.* Current estimates of rates of emission or removal are often based on measurements under a narrow, nonrepresentative set of conditions. New measurement efforts are needed in the following areas: the rates of CH_4 released under different landfill conditions, N_2O formation from energy combustion and fertilizer applications, leakage from oil and gas systems, emission changes due to land conversion, the carbon content of different soils and vegetation, and the CH_4 content in the coal seam before mining.
- *Better information on activities producing emissions.* Important areas where data need improvement include the amount and types of land undergoing spe-

[2] This discussion does not include increases in natural emissions from planting trees (e.g., pines and hardwoods in northern states).

cific types of conversion; equipment type and emission control technology in oil and gas systems; and the fates of harvested carbon (for paper, housing, etc.) and its effects on emissions or storage over time.

- *Complete estimates in all source categories.* Not all sources and sinks of emissions have yet been quantified, either because data are incomplete or because methods for estimating emissions do not yet exist. Priorities include emissions from some types of land conversion, such as those due to flooding of land,

center vertically

Adaptation Actions

The United States is engaged in a variety of actions for facilitating adaptation to potential global climate change. The first step in designing appropriate measures is to understand vulnerability to the impacts of climate change. Only then is it possible to develop specific measures in each sector to address these impacts. However, because of the significant uncertainties associated with predicting local and regional impacts of climate change, few of the actions that might be developed can be definitively assumed to lead to successful adaptation to climate change.

In spite of these uncertainties, U.S. efforts to adapt to climate change have followed this sequence of steps. Thus, this chapter begins with an analysis of vulnerability to climate change, and continues with analyses of the specific programs and measures that are being taken to adapt to climate change as it affects water resources, agriculture, coastal zones, and terrestrial ecosystems.

It is important to note that the analyses presented here do not necessarily apply to other countries where other circumstances may lead to the adoption of different measures. While some of these measures may be applicable elsewhere (like the mitigation actions described in the following chapter), these measures–and their likely effects–are specific to the United States, with its continental-scale geography and diverse economic and demographic circumstances.

Facilitating Adaptation to Climate Change

Vulnerability Assessment

Assessing vulnerability requires consideration of the *degree of risk* that people, property, natural systems, and social and economic systems may face from the impacts of potential global climate change. An assessment of vulnerability should:

- Estimate physical, ecological, and socioeconomic vulnerability to the impacts of potential global climate change.
- Consider factors not related to global climate change that may increase or decrease vulnerability, such as population growth, economic expansion, land management and resource utilization, and technological innovation (IPCC 1990a, 1992a).
- Identify measures to reduce vulnerability.

Past analyses of the sensitivity of U.S. natural resources to climate change have not considered fully the factors that are not related to climate change that affect vulnerability. Thus, existing studies can more properly be considered to be sensitivity, rather than vulnerability, analyses.

In existing studies, impacts are initially determined at the regional, watershed, or smaller geographical scale, and then are aggregated upward. However, projections of climate change at regional (or smaller) scales are extremely uncertain. To be more acceptable, analyses should incorporate realistic ("automatic") responses from sectors likely to be affected and should account for institutional, legal, and economic frameworks in existence at the time the effects of climate

[1]Long-term GNP per capita increased by 1.8 percent per year between 1950 and 1991, and 1.5 percent between 1970 and 1991.

[2]These calculations use the standard formulas for assessing the impacts of population growth on various resources, with the exception that growth in demand is often assumed to increase one-for-one with economic growth. See, e.g., UNFPA/UN (1992), Ehrlich (1991).

Facilitating Adaptation to Climate Change

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Previous modelling efforts also have not generally considered factors affecting the vulnerability of human and natural systems to agents of global change (e.g., economic and population growth, and technological innovation) other than climate change. For example, while the impacts of human-induced climate change could be significant, in many instances they could be relatively small, especially compared with the larger effects resulting from increasing populations, improving productivity and other factors not related to climate change (IPCC 1990c; Goklany 1992).

The U.S. Census Bureau's current best estimate is that the U.S. population could increase from about 257 million in 1992 to about 471 million in 2080—an increase of 83 percent. This growth, which would be caused by high fertility and immigration, would, without technological change, increase the pressures and demands on all resources proportionately.

While the hoped-for advancements in economic progress could increase the per capita demand for some resources, they could also allow for greater support for resource conservation and environmental protection (World Bank 1992). Given the projected population growth, and assuming that per capita income will increase by 1.5 percent per year[1] and that the demand on any natural resource increases at half that rate, then total natural resource demand could increase by over 250 percent by 2080.[2] However, technological advances would reduce this demand by reducing the amount of resources necessary for unit of output. Over the last

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[2]These calculations use the standard formulas for assessing the impacts of population growth on various resources, with the exception that growth in demand is often assumed to increase one-for-one with economic growth. See, e.g., UNFPA/UN (1992), Ehrlich (1991).

ninety years, the output of goods and services grew faster than the increase in resource demand. Productivity should increase in the future as well.

Technological Innovation

Technological progress will increase the demand for some resources while reducing it for others. It can improve the productivity and efficiency of all activities that use natural resources, as well as stimulate the substitution of scarcer or costlier forms of natural resources by others. These agents of global change ensure that tomorrow's world will be quite different from today's, even in the absence of human-induced climate change. They must be incorporated into "baseline" projections. The degree of vulnerability to climate change then must be estimated based not on *current* technologies and conditions, but on the additional changes (both positive and negative) that would occur relative to the "baseline" situation. Moreover, vulnerability to impacts of climate change must consider the future ability to cope with negative, or to take advantage of positive, impacts automatically by private or other decentralized sectors—that is, given the existing institutional, legal, and economic framework (IPCC 1990a, 1992a).

Adaptive Measures

Because of the uncertainties regarding potential global climate change, the impacts of such change, and vulnerability to global and climate change, measures to facilitate adaptation should be based on the following criteria (IPCC 1990d).

- *Flexibility.* Would the potential measures be adjustable at relatively low cost to account for new knowledge as science improves and uncertainties are reduced?
- *Timeliness.* How long would it take to formulate and effectively implement the measures, and how much time will elapse before effects on natural resources become evident?
- *Feasibility.* What would be the various institutional, economic, legal, and cultural barriers to their successful implementation, and how difficult would it be to overcome them?
- *Compatibility.* How compatible would the measures be with other climate-related responses and socioeconomic objectives?
- *Economically justifiability.* Given other outstanding societal goals that need to be met, and considering both the probability and the nature of the impacts of action and inaction, would the action be successful, regardless of whether climate changes?

Particularly, given other inevitable agents of change as well as the potential magnitude of their effects, an action should:

- Address high-priority, *current* problems that seem likely to be intensified by climate change.
- Provide net benefits to society, regardless of whether human-induced climate change is significant—i.e., the options should be justifiable on their own merits. This includes ensuring cost-effectiveness and economic efficiency, and consideration of opportunity costs.
- Help society cope with—and reduce vulnerability to—future change, regardless of the agent of change.

Adaptation measures could be anticipatory in that, by reducing vulnerability to other agents of change, they would increase the future resilience of ecosystems and species and their ability to deal with the impacts of climate change, if and when the changes are manifested. They could also be "reactive" in that they would be taken in response to specific effects, once manifested.

The urgency for considering measures to facilitate adaptation to human-induced global climate change is not always self-evident. Some measures could be implemented rapidly and hence can be deferred, while others might require substantial lead times. It is impossible to know which of these two circumstances applies without considering the costs and benefits of alternative responses.

Critical to a real predictions of vulnerability to climate change and to the decisions about adaptation measures are *local* forecasts of temperature, precipitation, and related changes—yet global circulation models do not provide good regional or local detail of predicted values to which contingence can be given.

Another key to predicting socioeconomic impacts is understanding actual economic responses. For example, many studies assume no spontaneous adaptation by farmers, whereas experience shows that farmers modify their practices—by changing to hardier crops, or conserving scarce inputs—in the face of major weather changes. Moreover, many studies calculate crop yield changes separately in separate countries, whereas the world market in agricultural commodities would adjust to such changes through shifting trade flows.

Agriculture and Forestry Resources

The ability of American farmers to respond to future climate changes will depend on the quantity and quality of the land, water, agricultural chemicals, farm decision aids, and other resources they have available, and how skillfully they manage those resources. Currently, the nation's capacity to produce grains and soybeans far exceeds domestic demand. In fact, over the next four decades, U.S. agriculture should have no difficulty meeting a population-driven domestic demand increase of 20-25 percent (CAST 1992).

These estimates do not take into account a reserve capability of some 25 million hectares of crop land in the U.S. land retirement programs. The projections (1990) of land in crops in 2030 suggest that this reserve crop land will not be needed, even though crop land is expected to decline by 30 percent from 1990 to 2030. However, this assumes no yield losses caused by restrictions in the use of agricultural chemicals, cultivation procedures, etc.

The projections indicate that by 2030, irrigated areas will have declined by about 40 percent from the 1980s to approximately 12 million hectares. The driving variables include weaker crop prices, rising costs of pumping ground water caused by both higher energy prices and declining water tables, and increasing opportunity costs of urban and industrial water uses. Increased water use efficiency due to elevated CO_2 levels may reduce water requirements of some crops, but will not permit crops to grown without irrigation where irrigation is currently required. Some increased water use may be seen due to increased leaf area production.

However, these projections for higher yields do not reflect the potential effects of rising temperature, increasing atmospheric CO_2, changes in water supplies for irrigation, or other climate variations. A sampling of recent computations for the equilibrium warming due to a doubling of CO_2 concentrations suggests that large regions of the United States will be drier. The regional and seasonal predictions by some general circulation models (GCMs) for the United States are for precipitation decreases, which are generally larger in the summer growing season. Warmer temperatures also would accelerate evaporation, exacerbating any shortages of soil moisture and runoff from less precipitation.

Gradual surface warming would be likely to alter the distribution and possibly the overall level of food production, though it could place stress on some areas while benefiting others. Model simulations with GCMs suggest that, all other things equal, a 3°-4°C average warming over the next fifty years could bring yield declines in the United States for crops like corn, soybeans, and winter wheat, but could also bring smaller yield declines or even increases in some areas or for some crops (U.S. EPA 1990; Adams et al. 1990).

Yet these estimates are inherently uncertain. Good crop yield forecasts require predictions of specific local changes in climate variables like temperature, precipitation, solar radiation, winds, stream flow, soil moisture, seasonal timing, and local extremes. Because the GCMs are unable to provide such specific information about the rate and local pattern of changes, the reliability of the above crop yield forecasts is doubtful (CAST 1991; IPCC 1990b; Kane et al. 1992). They also do not fully account for the recent finding that essentially all of the observed 0.3°-0.6°C warming of the last fifty years has been an increase in minimum (nighttime and winter) temperature and not in maximum temperature (Karl et al. 1991), suggesting that gradual warming may smooth out temperature extremes, reduce crop freezes, and perhaps facilitate agricultural improvement. But pest (insect, disease, and weed) outbreaks could be exacerbated without chilling and killing freezes to control both distribution and overwintering adults. Pests can also go through more generations per year under higher temperatures (increasing their populations).

In addition, a proper analysis of agricultural vulnerability requires a simultaneous consideration of the direct fertilization effects of elevated CO_2 content in the atmosphere. Doubling the CO_2 concentration of the atmosphere from 300 parts per million (ppm) to 600 ppm is estimated in laboratory studies to boost average plant growth and crop yield by about 33 percent in "C_3" plants and about 14 percent in "C_4" plants (Rosenburg et al. 1990). Named for the type of photosynthetic process they perform, C_3 plants include wheat, rice, barley, and legumes, and together make up 80 percent of the world's food supply and virtually all of the world's trees. C_4 plants where photosynthetic

process already uses carbon efficiently and therefore derive less of a boost from increased CO2 concentrations, include maize, sorghum, millet, and sugarcane, (IPCC 1990b).

Some analysts have been concerned that laboratory studies would overstate the benefits of CO_2 fertilization. However, field experiments have shown significant fertilization effects of the same magnitude. The effects may not occur under conditions of limited nutrients, water, temperature, and light (Cure and Acock 1986). A doubling of CO_2 concentrations may partly ameliorate water limitation and in some cases pollution damage. Doubling CO_2 concentrations raise the optimum temperature for photosynthesis in C_3 plants by about 4°-6°C, so global warming itself is not likely to inhibit the carbon fertilization effect (IPCC 1990b). But larger increases in temperature may be detrimental to plant growth, and even the 4°-6°C increase can be detrimental in some areas in summer, such as Texas. Crops grown at higher temperatures proceed more rapidly through various stages of development and therefore may spend less time accumulating dry matter during the most critical growth stage (e.g., the grain filling period). This may have a negative impact on yield. As to weed competition, it is noteworthy that fourteen of the world's eighteen worst weed pests are C_4 plants amid C_3 crops, implying that CO_2 enrichment might in fact help some crops outperform weeds. But C_3 weeds may be more of a problem in C_4 crops, such as maize. And the indirect effects of increasing CO_2, such as increasing aridity, may benefit C_4 species more than C_3 species (Patterson and Flint 1990). The fertilization effect appears to be comparatively larger under adverse growing conditions (limited nutrients or water, salinity, cool temperatures, or pollution) than in already optimal conditions. In particular, increasing CO_2 concentrations spurs plants to increase their water-use efficiency by about 30 percent, promising better resistance to drought and less need for irrigation (Rosenburg 1990, 1991). And rising CO_2 concentrations raise the optimum temperature for photosynthesis in C3 plants by about 4°-6°C, so global warming itself is not likely to inhibit the carbon fertilization effect. As to weed competition, it is noteworthy that fourteen of the world's seventeen worst weeds are C4 plants amid C3 crops, implying that CO_2 enrichment might in fact help crops outperform weeds (IPCC Impacts 1990b).

The net effect of rising CO_2 concentrations on agriculture, taking into account both potential warming and CO_2 fertilization, appears likely to be modest. The effects of changes in precipitation patterns and cloud cover could be severe. An early study found mild to insignificant reductions in U.S. yields (Dudek 1987), while more recent efforts, using a variety of GCMs, have predicted potential crop yield increases in the United States (Adams et al. 1990). Much depends on the assumptions made in the models.

Autonomous Adaptation

The ability to transform new knowledge into new equipment, material, and practices that fit changing physical and cultural endowments is one of the most important factors accounting for differences in agricultural productivity among regions and areas. If market prices are allowed to signal the new regional differences in scarcities and abundance, they will induce the invention and adoption of more efficient ways to grow crops, to use water, and to transform newly favored regions into farmland. This process, by definition, is autonomous (or self-governing), adaptation (CAST 1992).

The ability to autonomously adapt to climate change will depend on many factors. These include the capacity to organize and sustain the institutions that generate and transfer scientific and technical knowledge, the ability to transform new knowledge into equipment and materials, the level of husbandry and education among farmers, the efficiency of markets for inputs and products, and the effectiveness of public policy in easing rather than hobbling adaptation (CAST 1992).

Farmer adaptation and productivity increases have been enormously important over the past 100 years and could moderate predicted decreases in crop yields (Kane et al. 1992). Model simulations incorporating farmer responses to changing relative prices show smaller declines in crop yields in the United States than do simple GCM forecasts (Dudek 1987; Adams et al. 1990). Moreover, a careful empirical study of regional climate change in the central U.S. grain belt during the 1930s indicates considerable farmer resilience to even substantial and unanticipated changes in local climate (Rosenburg et al. 1991).

Regional Adaptation

One possible result of climate change is a regional redistribution of agricultural growing patterns. One study, which ignored nighttime warming, CO_2 fertilization, and international offsets, found that an increase in temperatures and aridity in the midwestern United States would reduce corn and soybean yields in the Corn Belt states. One study has calculated that for this climate scenario, irrigation in Iowa could increase from less than 1 percent to as high as 4 percent of the har-

vested crop land (Patterson and Keller 1990). In time, farmers would shift from corn to a mix of drought-tolerant crops, like those grown today in Kansas or Oklahoma. More dryland sorghum would be cultivated, and the remaining corn would be planted less densely, which would reduce the potential yield. And although sorghum is more tolerant to drought than corn, it would be planted on the drier sites. Winter wheat would be widely grown to produce a crop of grain before the summer heat and drought.

Under this regional scenario, farming methods now used in Kansas and Oklahoma would be adapted in the present Corn Belt. Also, new methods and varieties would be steadily developed as the climate changes. For example, for the "new" Minnesota, breeders would attempt to develop new varieties adapted to old Kansas weather, but also to the longer days of southern Minnesota. These new varieties would produce higher yields than the old varieties adapted to both the shorter days and the old weather in Kansas. New varieties can be developed and tested in 10-15 years. Absent undue regulation, biotechnology offers the hope of reducing these time spans significantly.

On the other hand, if the Corn Belt became warmer but more humid, then the present mix of crops would most likely be used. However, new varieties of that mix would need to be developed to better resist the diseases and insect pests that flourish in warmer, wetter climates, such as in the southeastern United States. Faster respiration during warmer nights might use some of the sugar made by photosynthesis during the day. However, farmers would be partly compensated for the resources invested in solving these problems by the higher yields possible from the longer-season hybrids they could grow in the warmer climate.

If the present Corn Belt climate were to shift northeast to northern Wisconsin and Michigan, corn and soybean yields would generally decrease. This is because the soils of the "new" Corn Belt would typically consist of recent glacial deposits, including sand and gravel, and not the deep layers of fertile topsoil that characterize the present Corn Belt. The natural drainage systems of the northern states are not well developed, and the potential land uses alternating between dry hills and lakes or marshes create problems for water quality in the wetlands and for soil carbon and fertility on the uplands.

Varieties would be bred to tolerate drought or poor drainage, drains would be laid, and fertilizer would be carefully applied. Most likely, other crops would be grown in the "new" Corn Belt. For example, vineyards might be established on the drought-affected hilltops, and hybrid poplar saplings for wood products might be planted in the poorly drained low areas. Thus, the diversity of the new region would promote crop diversity as well (CAST 1992).

Another possible shift of the Corn Belt might be to the Dakotas. To the extent that moistening is less likely to accompany the warming than is drying, a shift to the Dakotas is less likely. Because soils there resemble those in the present Corn Belt, yields and the mixture of crops might stay much the same. In fact, yields might be higher in the "new" Corn Belt, if the long days in the north were combined with ideal temperature and precipitation.

A Corn Belt shift could entail large social and environmental costs. Some rural communities and their physical infrastructure could become obsolete or might need to be relocated. If climate change were gradual and anticipated, these transitional costs could be modest.

Genetic Diversity Banking

Genetic diversity is essential for successful breeding, whether for crops, animals, or trees. The base of genetic diversity is provided by a series of collections of present and previous varieties farmers have used. Maintained in special germ-plasm banks, these collections number in the tens of thousands for each major crop. When needed, they can be screened for sources of resistance to new diseases, insects, tolerance of new kinds of environmental stress, or employment of new technological opportunities.

Plants growing in gardens and in native sites complement the germ-plasm banks. As climate changes, natural selection will proceed among diverse populations in native sites and will help breeders looking for new combinations to fit new climates. Because the germ plasm for the dozen or so crops that feed most people is concentrated in a few centers, managed preservation strategies will concentrate on these centers (Duvick 1984).

Government Facilitation of Adaptation

The United States has recently taken several important steps that will help facilitate automatic adaptation and increased productivity.

- The 1990 Farm Bill enacted new rules for farm-support payments that reduce the rigidity of farming practices.
- The 1992 Water Bill will encourage flexible transfer of water in California to the highest-value uses.

- The biotechnology oversight policy initiated in February 1992 and the rules on agricultural biotechnology proposed in November 1992 will help facilitate the development of genetic techniques for dramatically improved crops.

Water Resources

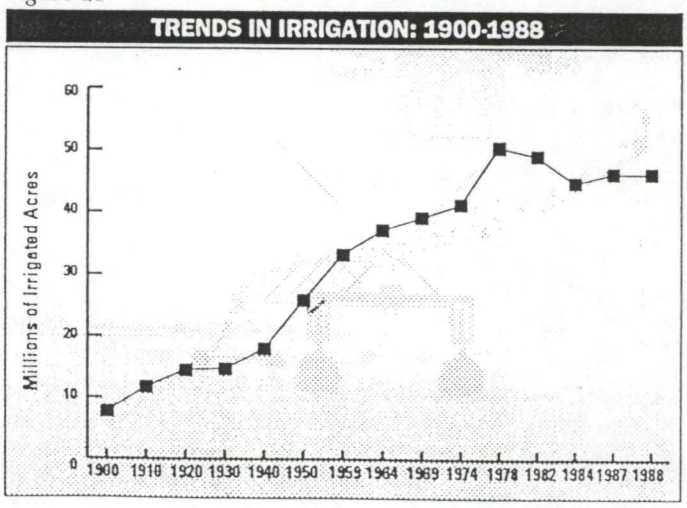
In the wake of each large flood, hurricane, or extended drought follow various socioeconomic and ecological impacts. Changes in global climate could significantly change pressures, both positively and negatively, on the quantity and quality of water supplies. Over the past two centuries, the nation's water resource management agencies have worked to reduce the nation's vulnerability to the hydrologic extremes associated with climate variability.

In most regions of the United States, agriculture is the main consumer of water resources. No new major federal irrigation projects have been authorized since 1968, while new flood control projects and coastal storm protection projects continue to be authorized on a regular basis. While the ongoing construction of major irrigation projects remains an important activity, it is declining, and spending continues to shift from construction to operations and maintenance (Figure 21). Once the three major federal irrigation projects currently under construction are complete,[3] construction activities will be on a considerably smaller scale, unless major new projects are authorized in the near future. One major flood control dam and reservoir is under construction, and another is in the planning stage.

Construction funding of major irrigation projects has declined principally because most of the best sites for major reservoirs have been used; the potential costs of construction at the remaining sites are high relative to expected benefits and to other alternative courses of action; federal and nonfederal budgets are strained; and water management projects are becoming increasingly controversial among environmental interests and a broader cross-section of the public interested in using streams in their free-flowing state for recreational uses and maintaining river valleys in their natural state.

In the past, when climate was assumed to be relatively constant (despite substantial year-to-year variations), managers could estimate new demands for water by evaluating measurable or observable factors—the rate of population growth, the rate of decline of groundwater supplies, or the degree of aridity in newly settled areas. For many years to come, the magnitude—and even the direction—of potential climate change is likely to be difficult to project at the regional level. Nevertheless, adaptive measures could be instituted to increase the flexibility of existing management regimes and, thus, increase the ability to respond quickly and inexpensively to changing conditions. Also, where technically, economically, and environmentally sound, new regimes could be constructed. These measures could include evaluating water supply systems, water transfers, water conservation measures, flood control, navigation, drought management, system optimization, global change research, and desalinization technologies.

Figure 21



[3]These projects are the Central Arizona Project, the Central Utah Project, and the Animas-La Plata Project.

Water Supply Systems

Given the uncertainty over the nature of hydrologic changes to be expected in any particular region and the cost of significantly changing existing water supply systems, a logical step is to evaluate the flexibility of current systems to the types of impacts that might result from climate change and to examine the feasibility of providing new water management systems. Toward this end, the United States has implemented the following measures:[4]

- Initiated the development of an advanced decision-support system that will apply the latest technology in artificial intelligence, expert systems, and computer graphics to increase our understanding of and improve the effectiveness of river basin and water system operations. This technology is being transferred to five agencies in the Santa Anna River Basin of California. The United States also is developing agreements for the public use of this software.
- Formed a drought coordination team to serve as a clearinghouse for drought-related information and participated on a federal/state drought management team.
- Established "AgriMet"—a cooperative information network that provides expanded data support for on-farm irrigation management and crop scheduling programs throughout the Pacific Northwest. Through regional analysis of the daily water use of crops, crop models translate real-time climate data from approximately 40 sites into data for publication in local newspapers.
- Initiated reallocation studies of numerous U.S. reservoir systems. These studies examine the feasibility of shifting storage in reservoirs designed for various purposes (hydropower, flood control, navigation, irrigation, in-stream flows, municipal and industrial water supply, and recreation) in direct response to changing needs in a given region.
- Initiated large-scale reallocation and systems management studies (e.g., the Missouri River, the Great Lakes, the Savannah River studies) that explicitly take potential climate change into account. These studies analyze the response of the hydrologic system to assumed climate changes and assess the vulnerability of the existing and potential water management systems to those changes.
- Conducted several studies, in conjunction with municipalities and urban areas, that focus on options for managing increasing demand for water. The federal government has also developed a sophisticated water-demand model to assist in these analyses.
- Initiated a three-year study (now in its final year) to develop a template for drought planning and management studies. These "drought-preparedness studies" may recommend instituting water demand management measures as a first response to drought conditions.

Water Transfers

A promising approach to coping with changes in climate, whether due to natural variability or human activity, is to foster flexibility in water management institutions. One means of doing this is to facilitate market transfers of water. A number of major public utilities supplying water have taken steps toward pricing systems that should ensure more efficient use. The 1992 Water Bill contains important provisions facilitating water transfers in California. Others are studying marginal cost pricing. Under this approach, water users trade contractual deliveries in water among themselves at whatever prices they establish.

The life of a water project is often fifty to one hundred years. No matter how well a project is planned, it would be impossible to accurately forecast the pattern of water demands over such a long period. Therefore, water transfers can provide a flexible means to accommodate new patterns of climate, agricultural production, population, and industrial growth without relatively major capital expenditures. Voluntary transfers may be particularly important in areas receiving relatively little rainfall, or where existing sources are fully used.

Facilitating water transfers in the arid western United States is particularly important because of the large quantities of water currently required for agriculture—typically 85-90 percent of water withdrawn. This implies that urban and industrial uses of water can double their current 10-15 percent level through either modest conservation of irrigation supplies or small reductions in the least productive agricultural uses. Market-based water transfers would give agricultural water users the incentive to do so willingly. For example, a 3 percent reduction in agricultural withdrawals in California would be equivalent to 918 million gallons of water per day—enough to supply the daily needs of 6.6 million urban users (roughly the size of Los Angeles).

[4]While the federal government has implemented or is implementing the measures discussed here, not all of them were undertaken specifically to address climate change issues. Regardless, they would be of use in adapting to climate change.

Market transfers of water are not new. Water rentals in the system of federal storage reservoirs on the Upper Snake River in Idaho stretch back to the 1930s. In 1972, the Utah Power and Light Company obtained 6,000 acre-feet of water from two irrigation companies in the Emery County Project for power-plant cooling. The city of Casper in Wyoming is paying the nearby Casper-Alcove Irrigation District to line the canal on portions of the district's distribution system. During the 1976-77 drought in California, the Bureau of Reclamation operated a water bank in which some 45,000 acre-feet of water changed hands. There is a highly organized market operating in the Northern Colorado Water Conservancy District in the Ft. Collins area, in which water from the Colorado Big-Thompson Project is exchanged at market value (Wahl and Osterhoudt 1986; NRLC 1991).

Two recent agreements between the Metropolitan Water District of Southern California (MWD) and the Imperial Irrigation District (IID) present a dramatic example of conservation possibilities. In late 1988, MWD struck an agreement with IID to fund conservation measures that would salvage 100,000 acre-feet of water annually for municipal and industrial uses in the MWD service area. Under the agreement, MWD will pay IID $92 million for the construction of conservation facilities, $3.1 million annually for operation and maintenance, and $23 million in five annual installments for indirect costs. Under a separate agreement, concrete lining of the All-American Canal (which carries water from the Colorado River to IID) will conserve another 70,000 acre-feet of water for use by MWD.

Studies by the federal government and the state of California estimate that there are up to another 250,000 acre-feet of water-conservation investments in the IID that could serve as the basis for future agreements. In addition, MWD has recently signed an agreement with the Palo Verde Irrigation District, whereby MWD would gain access to additional water supplies under certain conditions in exchange for payments to Palo Verde irrigators. A number of recent settlements of Indian reserved water rights claims have also included provisions allowing the tribes to market their water rights to nearby communities.

On the state level, some states have amended their water codes over the last ten years to facilitate transfers. For example, because of amendments adopted in 1982, California law now ensures that an appropriator has the rights to water that it conserves; this water may be sold or leased to other water users without fear of a reduction of the original water right or alteration of the priority date of any claim to use the water. In 1979, Idaho passed state water banking legislation ensuring that water users placing water in the bank would not be subject to forfeiture of their rights because of nonuse. The Oregon legislature also has passed legislation to give water users an incentive to conserve water. In New Mexico, salvaged water may be transferred if the applicant can demonstrate clearly that there is no impairment to other water-right holders, including junior appropriators (Wilkinson 1989).

In December 1988, the United States released a water transfer policy, outlining the principles the federal government would follow when facilitating voluntary water transactions. The policy statement was important for two reasons: (1) it acknowledged the importance of voluntary water transfers in meeting future water demands in the West, and (2) it stated that the federal government would be a facilitator of transactions among willing buyers and sellers.

However, very few of these transactions have taken place, partly because the rules are new and some aspects require clarification, and possibly because the rules have varied from one federal project to another. In addition, a number of institutional and legal barriers need to be surmounted.

For example, in the large federally constructed Central Valley Project in California, currently only short-term (one year or less) transfers are permitted, and transferees may not earn a profit on the transfer. This situation clearly reduces the incentives for entering into a transfer arrangement. On other projects, such as the Central Arizona project, rules for transfers are unclear. However, for some proposed transfers, the Bureau of Reclamation has attempted to avoid burdening them with unreasonable restrictions or financial penalties.

Water Conservation Measures

Water conservation measures can play an important role in bringing supply and demand into balance. Water conservation can be induced by regulatory measures, market-oriented incentives, or a combination of both.

Before granting building permits, a number of political jurisdictions require the installation of water-saving devices or the demonstration of a secure water right. Several municipalities also have attempted to induce water conservation through pricing mechanisms and other methods, such as installing water-saving devices, metering, and repairing leaks (Martin et al. 1984; MWRA 1990). The Reclamation Reform Act of 1982 requires districts that receive water from federal projects to establish water conservation plans. However,

this approach has several problems, including: (1) it has few teeth, unless an elaborate review process is set up; (2) it provides little basis for deciding which water conservation measures are appropriate; and (3) existing legislation provides no financial resources for implementing the water conservation measures.

The U.S. Bureau of Reclamation initiated several activities related to water conservation. These include:

- Establishing water conservation and advisory centers in the Bureau's regional and national offices. These centers coordinate water conservation programs, provide information on water supplies and conservation opportunities, provide technical assistance, training, and technology transfer, and promote public education programs.
- Initiating investigations to develop integrated and comprehensive water conservation plans that will emphasize a more efficient use of existing water supplies. The United States has worked with water users and other entities to pursue opportunities to conserve water on existing projects through rehabilitation, structural modification, or operational changes.
- Conducting a $3.2 million canal lining demonstration program on the federally constructed Deschutes Project (Oregon). About ten different firms are scheduled to demonstrate different canal-lining techniques. Annual seepage losses in the basin have been estimated at 250,000 acre-feet out. Although potential water savings with the lining cannot be determined until further work is completed, they could be in the range of 200,000 acre-feet.
- Completing a prototype project on the Coachella Canal in California to demonstrate techniques for lining canals while they remain full of water. This process allows water deliveries to continue while canals are lined to reduce seepage losses.
- Developing a comprehensive wastewater reuse initiative for Southern California, which will develop a long-range strategy for more effectively integrating fresh and reclaimed water management programs.

Flood Control

Changes in hydrology can increase or decrease flood threats on a regional basis. In addition to multiple-purpose water management projects and practices designed to provide maximum flexibility to meet a wide range of changing demands, projects designed for a single purpose, such as flood control, can be an important element in an adaptation and mitigation plan. Single-purpose flood control projects continue to be high-priority activities of the federal government and are normally undertaken in partnership with state and local governments.

Navigation

Climate change and natural vulnerability could affect the navigability of the nation's waterways. Inland waterways tend to be more susceptible than coastal areas in cases of both increased and decreased river flows. Severe drought in 1988 closed many sections of the Mississippi River navigation system with significant disruption of commerce. The need to maintain navigation must be closely examined in order to determine the advisability of major investments in infrastructure (such as new locks, storage reservoirs, or channel dredging) to increase the flexibility of the system to function under a wider range of precipitation patterns. Several studies conducted as a result of the 1988 drought indicate that major investments have, at best, marginal economic efficiency with respect to the need to keep the systems open 100 percent of the time. Effects on coastal ports are unlikely to be significant because of the dampening effect of the ocean on river and estuary water levels and of the long-term nature of potential sea level rise. Sufficient time appears to be available to alter coastal navigation infrastructure should significant sea level changes occur.

Drought Management

Many of the measures used to manage water under drought conditions will be useful if climate changes. The primary goal of most of these measures is to develop greater flexibility in existing management systems. One important innovation is the use of water banks, such as the banks in Idaho on the Boise and Payette River systems, and the California Emergency water bank. Users of the water banks may "deposit" their surplus water in the banks, thus making it available to others. The U.S. government has helped determine the quantities of water available for purchase, has reviewed the condition of ground-water wells, has approved transfers of base water-right supplies from federal service areas to other areas of need, and has helped coordinate joint federal and state project operations. In addition, on the Friant Unit of the Central Valley Project, water transfers occurred between districts as

part of a surface-water and ground-water conjunctive-use program.

The U.S. government also provides monthly reports on drought conditions for water users and project operators to help them make timely decisions and to enhance public awareness. It also works with state drought-response programs to disseminate information on water supply and on programs for drought response.

Desalinization Technologies

Desalinization technologies might prove useful in adapting to changes in climate, if they can be economically justified. The United States has undertaken much research in this area. Significant programs carried out at the Yuma Desalting Test Facility in the 1970s and early 1980s included developing suitable pretreatment for the desalting units, testing proposed equipment, developing a program to test larger-scale equipment, and proof-testing desalting equipment. During construction, research and development focused on solving problems specific to the facility, including biomass and grit removal, chemical feed and piping failures, dual-media filter performance, and membrane degradation. The U.S. federal government has shared information on desalting problems, experiences, and solutions with the desalting industry through cooperative studies, sponsored tests, technical papers and presentations, and other technology-transfer forums.

In response to a congressional request, in February 1990 the Bureau of Reclamation prepared a report entitled *A Plan for Improving Desalination and Water Treatment Technologies.* The report provided a general plan for establishing a cooperative program between the public and private sectors for developing desalination technologies (BOR 1992).

System Optimization

"System optimization" is the adoption of operational, management, institutional, or physical changes to gain more output from the same resources. "Joint use" is the coordinated use of federal facilities with nonfederal resources and management of a facility to optimize among multiple uses. Because of their cooperative natures, both approaches can meet new demands while maintaining services for existing users.

For example, in cooperation with the Western Area Power Administration, the Bureau of Reclamation developed a power optimization model to schedule water releases from its dams in the Lower Basin of the Colorado River on an hourly basis, in accordance with downstream water demands, physical and institutional constraints, and electrical loads. Additionally, at many projects for which it is responsible, the Army Corps of Engineers manages water releases from its reservoirs to enhance downstream water quality, fish habitat, and recreational opportunities.

The federal government also developed an optimization scheme that could improve the efficiency of hydropower generation by 2 percent, resulting in additional clean hydropower worth millions of dollars, without using additional water.

U.S. Coastal Zones Ocean Resources

Global climate change could alter life along the coast by changing the level of the sea, the frequency and intensity of storms, and water and air temperatures (IPCC 1990d). In the United States, only the first of these three potential impacts has been assessed in any detail.

Sea Level Rise

The IPCC estimates that under the "business as usual," high-emission scenario of a doubling of CO_2 emissions by the year 2100, sea level will rise on a global

average between 3 and 10 mm per year, or a total of 30 cm to 110 cm, with a best estimate of 65 cm by 2100 (IPCC 1990c).

The IPCC also emphasizes the need to address adaptive strategies to reduce vulnerability to sea level rise because of factors not related to climate change. In many parts of the United States and the world, natural systems that provide protection against the sea are being degraded by human development activities, such as mining for sand and coral, cutting mangroves, damming and confining the flows of rivers, and filling wetlands. In the United States, although many of these activities are being reduced through coastal zone management, many areas remain vulnerable to sea level rise because of high natural rates of erosion (e.g., New England) and subsidence due in part to human activities (e.g., Louisiana).

An acceleration in sea level rise could exacerbate current coastal problems, including shoreline erosion, loss of wetlands, flooding, and the salinization of water resources due to natural and human-induced causes. Given the scientific uncertainties of the rate of rise, there is no uniform perception of the risks at the federal or state government level. However, a number of scientific and technical studies have been carried out to identify areas at risk and to begin an assessment of the potential impacts.

The East and Gulf Coasts of the United States are particularly vulnerable to sea level rise. Most of the wetlands and lowlands of the United States are found along the Gulf Coast and the Atlantic Coast south of the central part of New Jersey, although there is also a large low wetland area around San Francisco Bay. Areas vulnerable to erosion and flooding are predominantly in the Southeast, while potential salinity problems are spread more evenly throughout the coast. In addition, sixty-one percent of the East Coast has low-lying shoreline geography consisting of unconsolidated sediments with dominant land forms, including estuaries (42 percent by length); barrier islands (18 percent); lagoons (15 percent); and rocky, embayed coasts (12 percent) concentrated in New England. High-risk erosion- and flood-prone areas along the East Coast have been identified along parts of Cape Cod, Long Island, and the New Jersey barrier beaches, the North Carolina Outer Banks, the southern Delmarva Peninsula, and the Georgia-South Carolina coastline. Major port cities with low areas include Boston, New York, Charleston, and eastern Miami (Gornitz et al. 1992). Other areas of the United States are also vulnerable, including the Gulf Coast states, California, the Virgin Islands and Puerto Rico, Hawaii, and the U.S. trust territories. Some areas are less vulnerable, such as Alaska.

A study by the U.S. Federal Emergency Management Agency (FEMA 1991) estimated that from the mid-Atlantic to the Gulf of Mexico, between approximately 23,000 and 27,000 square miles would be adversely affected by respective sea level rises of one and three feet by 2100, while the number of households in coastal floodplains is expected to increase from 5.1 to 6.6 million. About 110 million people—almost one-half of the total U.S. population—now live in coastal areas. By the year 2010, the coastal population will have grown to more than 127 million and will constitute almost 60 percent of the U.S. population. Some states, including Florida, will have increased more than 200 percent (NOAA 1990). In addition, the full-risk premium rate for flood insurance would increase by approximately 200 percent with a one-meter rise in sea level (FEMA 1991).The study also found that the full-risk premium rate for flood insurance would increase by approximately 200 percent with a one-meter rise in sea level.

If shorelines are allowed to retreat under a one-meter rise, coastal areas would become more vulnerable to flooding for four reasons: (1) a higher sea level provides a higher base for storm surges to build upon (a one-meter rise in sea level would thus enable a fifteen-year storm to flood many areas that today are only flooded by a one-hundred-year storm) (Kana et al. 1984); (2) beach erosion would leave particular properties more vulnerable to storm waves; (3) higher water levels would increase flooding due to rainstorms by reducing coastal drainage (Titus et al. 1987); and (4) a rise in sea level would raise water tables.

Some coastal areas are protected with levees and seawalls, and would thus not necessarily experience near-term inundation, erosion, or flooding. However, these structures were usually designed for current sea level and one-hundred-year storm events, and would not provide sufficient protection against future flooding and erosion from higher water levels (NRC 1987). In areas like New Orleans that are drained artificially, the increased need for pumping could exceed current capacities (Titus et al. 1987).

WETLANDS

The greatest estimated wetland losses would be in the Southeast, the location of 85 percent of all U.S. coastal wetlands. Without adaptive responses and assuming no formation of new wetlands, a one-meter rise could inundate 90-95 percent of wetlands in this region, with 40-50 percent of the losses occurring in Louisiana. By contrast, the Northeast and the West would each lose no more than 10 percent of their wetlands, if only currently developed areas are protected.

The dry land within two meters (seven feet) of high tide includes forests, farms, low parts of some port

cities, communities that sank after they were built and are now protected with levees, and the bay sides of barrier islands. The low forests and farms are generally in the mid-Atlantic and Southeast and would provide potential areas for new wetland formation if no barriers to their migration exist.

Barrier Islands

Some of the most important vulnerable areas are the recreational barrier islands and spits of the Atlantic and Gulf Coasts. A one-meter rise in sea level would inundate much of this valuable land. However, erosion threatens the high parts of these islands, and is generally viewed as a more immediate problem than inundation. Thus, a one-meter rise in sea level would generally cause beaches to erode 50-100 meters from the Northeast to Maryland; 200 meters along the Carolinas; 100-1,000 meters along the Florida coast; and 200-400 meters along the California coast (Everts 1985; Kyper and Sorensen 1985; Kana et al. 1984; Bruun 1962; Wilcoxen 1986). Because most U.S. recreational beaches are less than 30 meters (100 feet) wide at high tide, even a 30-centimeter (one-foot) rise in sea level, protecting the beach and dune systems would require some response.

Saltwater Intrusion

A rise in sea level would enable saltwater to penetrate farther inland and upstream in rivers, bays, wetlands, and aquifers. This intrusion would affect some aquatic plants and animals, and would complicate human uses of water. Increased salinity has already been cited as a contributing factor to reduced oyster harvests in Chesapeake and Delaware Bays (Gunter 1974), and to the conversion of cypress swamps in Louisiana to open lakes (LWPP 1987). Moreover, New York, Philadelphia, and much of California's Central Valley get their water from areas that are just upstream of water that is saline during droughts. Farmers in central New Jersey, as well as the city of Camden, rely on the Potomac-Raritan-Maggothy aquifer, which could become salty if sea level rises. For example, a 50-cm rise in sea level would enable the salt front in the Delaware River to migrate 10 km upstream during droughts, threatening Philadelphia's freshwater intake, as well as the Potomac-Raritan-Maggothy aquifer. The Delaware River Commission's long-term plan for reservoir construction and operation has incorporated assumptions about sea level rise since 1980 (Hull and Titus 1986). The South Florida Water Management District also spends millions of dollars every year to prevent Miami's Biscayne Aquifer from becoming saline (Miller and Brock 1989). All of these areas would be vulnerable to sea level rise and climate change.

Adaptive Measures

Measures for facilitating adaptation to a rise in sea level fall broadly into three categories:

- Protection (structural measures—seawalls, beach nourishment—to hold back the sea in vulnerable areas, and measures to protect or restore degraded or converted wetlands).
- Accommodation (allowing the sea to advance and adapting to it by raising the height of structures, etc.).
- Retreat (abandonment of the land and structures in vulnerable areas and resettlement of inhabitants) (Figure 22).

To date, most adaptive actions have been based on existing efforts to address impacts from activities not related to climate change, such as reducing damage to

Figure 22

SAMPLE MEASURES FOR ADAPTING TO SEA LEVEL RISE

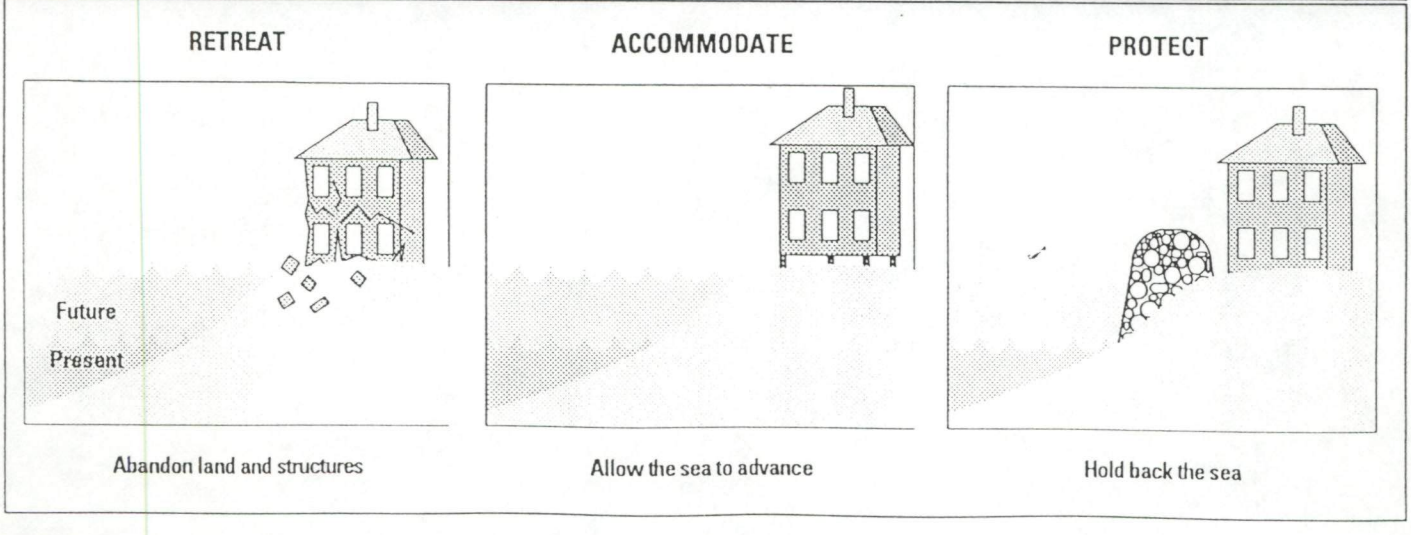


Table 10

STATE POLICIES FOR SEA LEVEL RISE

States Surveyed	Recognize Issue of Sea Level Rise	Have Existing Adaptive Policies	Have New Adaptive Policies
Alabama	No	Yes	No
Alaska	No	No	No
California	Yes	No	No
San Francisco Bay	Yes	Yes	Yes
Connecticut	No	No	No
Delaware	Yes	Yes	No
Florida	Yes	Yes	No
Georgia	No	No	No
Hawaii	Yes	No	No
Louisiana	Yes	Yes	Yes
Maine	Yes	Yes	Yes
Maryland	Yes	Yes	No
Massachusetts	Yes	Yes	No
Mississippi	No	No	No
New Hampshire	Yes	No	No
New Jersey	Yes	Yes	No
North Carolina	Yes	Yes	No
Oregon	Yes	No	No
Pennsylvania	No	Yes	No
Rhode Island	Yes	Yes	No
South Carolina	Yes	Yes	Yes
Texas	No	Yes	No
Virginia	No	No	No

Source:

shoreline structures, controlling erosion, and mitigating flood hazards. Because these impacts could be exacerbated by an acceleration in sea level rise, attention to factors that are not related to climate change but that are associated with vulnerability to sea level rise is the first-order priority for adaptation measures (IPCC 1992c).

The United States has started to assess the impacts of sea level rise. Most assessments in the United States have concluded that low-lying cities would be protected with bulkheads, levees, and pumping systems, while in sparsely developed areas, shorelines would retreat naturally (NRC 1987). This conclusion has generally been based on the commonly accepted assumption that the cost of these structures would be far less than the value of urban areas being protected, but greater than the value of undeveloped land. Federal and state expenditures indicate a willingness to protect developed shorelines with groins, revetments, or sand nourishment. Decision making regarding adaptive strategies is addressed at many levels (federal, state, and local) and through various institutions and agencies. The U.S. Congress has passed several pieces of legislation with elements that address the issues of vulnerability and adaptive response.

The Coastal Zone Management Act of 1972 created an integrated, comprehensive state and federal cooperative program for coastal resource management and development. Section 303 of the 1990 amendments to the Act calls for states to manage coastal development to minimize the loss of life and property "in areas likely to be affected by or vulnerable to sea level rise" and provides federal grants (Section 309) for "preventing or significantly reducing threats to life and destruction of property...by anticipating and managing the effects of potential sea level rise...."

A 1990 analysis of alternative policy responses to accelerated sea level rise indicates that state coastal management agencies prefer "strategic retreat policies" for relatively undeveloped areas (Klarin et al. 1990). These include laws and regulations that put conditions on the use of property located in areas susceptible to erosion and flooding, restrictions on hard structural protection, protection of critical environmental areas, and restrictions on post-storm redevelopment. However, in many moderately developed areas, states have restrictions on bulkheads and other structural measures to protect wetlands and habitats (e.g., Washington, Massachusetts). However, actions of state and federal governments as a whole continue to show the preferred response in densely developed areas is protection, rather than retreat.

Several state and local authorities have policies that are partly responsive to the impacts of sea level rise, such as setbacks for development (a response to coastal erosion). Table 10 shows the results of a survey of 23 states concerning whether they recognize sea level rise as an issue and whether they have existing or new adaptive policies that partly respond to the associated impacts. Table 11 outlines a range of seven policy responses that address conditions similar to the impacts associated with sea level rise and examples of federal and state actions.

Congress has directed the Federal Emergency Management Agency to assess the changes that might be necessary to modify the Federal Flood Insurance Program, based on a one-foot and a three-foot rise in sea level; passed the Coastal Barrier Resources Act to

Table 11

ALTERNATIVE POLICY RESPONSES TO SEA LEVEL RISE

Range of Policy Responses	Examples of Federal or State Policies
Zoning and Land Use	
Setbacks Based on Erosion Rate	South Carolina Beach Management Act (BMA) establishes setbacks of 40 times annual shoreline erosion rate and requires remapping the baseline every 5 to 10 years.
	North Carolina Coastal Areas Management Act (CAMA) establishes setbacks of 30 times annual erosion rate for single-residence and 60 times annual erosion rate for multiple-residence structures.
Building Codes/Size Restrictions	Maine Sand Dune Law restricts structures to 2,500 sq. ft. and 35 ft. in height with 1-ft. elevation above 100-year base flood level in low-hazard areas.
	North Carolina CAMA restricts structures size to 5,000 sq. ft. within shoreline setback areas.
Coastal Hazard Areas Restrictions	Maine Sand Dune Law restricts development to low-hazard areas. Density not to exceed 40 percent of undeveloped dune areas, with 20 percent being buildings.
	Florida Construction Control Lines establish area where a permit is required for new development. Creates a 30-year erosion zone that prohibits new construction.
Downzone to Restrict Development	Transferable Development Rights: a local, land-use planning method that keeps an area in a lesser or undeveloped state and shifts new development to preferred locations.
Economic Incentives/Disincentives	
Restrict New Infrastructure	Coastal Barriers Resource Act prohibits federally subsidized infrastructure within coastal barrier system.
Restrict Flood Insurance	Coastal Barriers Resource Act prohibits federally subsidized flood insurance for structures within coastal barrier system.
Incentives to Remove and Development Reimburses	National Flood Insurance Program/Upton-Jones Act program reimburses property owners 110 percent of structure's value to remove and 40 percent to relocate buildings that are in danger of collapse from erosion and flooding.
Proposed Tax Incentives	Delaware Beaches 2000 Plan proposed favorable tax assessments for land uses compatible with preservation of shoreline areas.
Ground-Water Resources Protection	
Manage Coastal Aquifers to Control Sea Water Intrusion	Maine: requires all permit applications for new wells to be reviewed by the local water district to determine the impact on ground-water recharge and sedimentation.
Project Design and Planning	
Engineering Standards	San Francisco Bay Conservation and Development Commission Bay Plan: mandatory project review requires proposed development engineering and design plans to incorporate consideration of sea level rise.
Remodel or Redesign Infrastructure	Charleston, South Carolina designed a new flood-control and drainage system to accommodate local sea level rise over the next 100 years.

Source: Klarin et al. 1990

e 11 continued

ALTERNATIVE POLICY RESPONSES TO SEA LEVEL RISE

tange of Policy Responses	Examples of Federal or State Policies
'nvironmental Engineering	
Resedimentation of River Deltas	Louisiana Coastal Environment Protection Trust Fund and federal/state task force sponsor local resedimentation projects.
Wetlands Mitigation Projects	State and federal laws require the mitigation of wetlands loss from development through enhancement and construction projects using reclamation, sedimentation, and vegetation methods.
Beach Nourishment, Dune Vegetation, and Stabilization	Florida: Beach Management Fund authorizes up to $35 million annually toward beach erosion, preservation, and restoration projects.
	Maryland: $60 million multi-year federal, state, and local program to renourish Ocean Beach shorelines.
	South Carolina: BMA requires property owners to replenish beach sand at a rate of 150 percent of the annual erosion volume to replace structures damaged by erosion.
tructural Engineering	
Large-Scale Hydrologic Projects	New Orleans, Louisiana has a system of dikes and levees for flood- and storm-protection control with pumps to reduce water levels.
Structural Protection for Coastal Development and Infrastructure	Continued use of seawalls, bulkheads, dikes, and other vertical structural devices to protect developed areas.
'rohibit Development and 'reserve Natural Shoreline	
Restrictions on Post-Storm Reconstruction	South Carolina BMA prohibits new or rebuilt structures seaward of setback lines and mandates replacement of all vertical erosion protection devices within 30 years.
	Texas Open Beaches Act prohibits reconstruction of damaged structures on property seaward of the vegetation lines which is open to public access.
Land Acquisition and Conservancies	California Coastal Conservancy allocates state bond monies to local governments and private organizations to acquire and manage ecologically sensitive coastal land.
	Florida buys shoreline property to preserve public access, beaches, and recreation areas.
	Local governments acquire easements, establish greenbelts, and buy development rights to create open space.
Preservation of Critical Wetland Habitats	Maryland Chesapeake Bay Critical Areas Act establishes buffers around wetlands and reduces the density of adjacent development.
	Snohomish County, Washington: county implements ordinances to reserve wetlands and aquatic lands for agricultural, recreational, or other nonstructural development uses.
Proposed Abandonment Policy	Long Island Regional Planning Board (NY) proposes ending long-term leases of selected state coastal lands and buying erosion-prone barrier island properties.

'ce: Klarin et al. 1990

eliminate federal subsidies to development on barrier islands; and has funded wetland restoration programs and acquisition programs (land and water conservation). In addition, Congress has directed the executive branch of the U.S. government to assess the impacts of global climate change, including sea level rise (e.g., Environmental Protection Agency, National Oceanic and Atmospheric Administration). Congress has also developed a "no net loss" policy for wetlands, which is directly related to the concern over resources and the protection of lives along the changing shoreline.

Anticipatory measures for reducing wetland losses fall into the following categories:

1. Prevent development through regulation or land purchase.
2. Allow development, but put property owners on notice that they will have to abandon the property if and when sea level rises.
3. Allow development without any conditions, and abandon the land as sea level rises through purchases or regulatory agencies.
4. Enhance mitigation and restoration efforts.

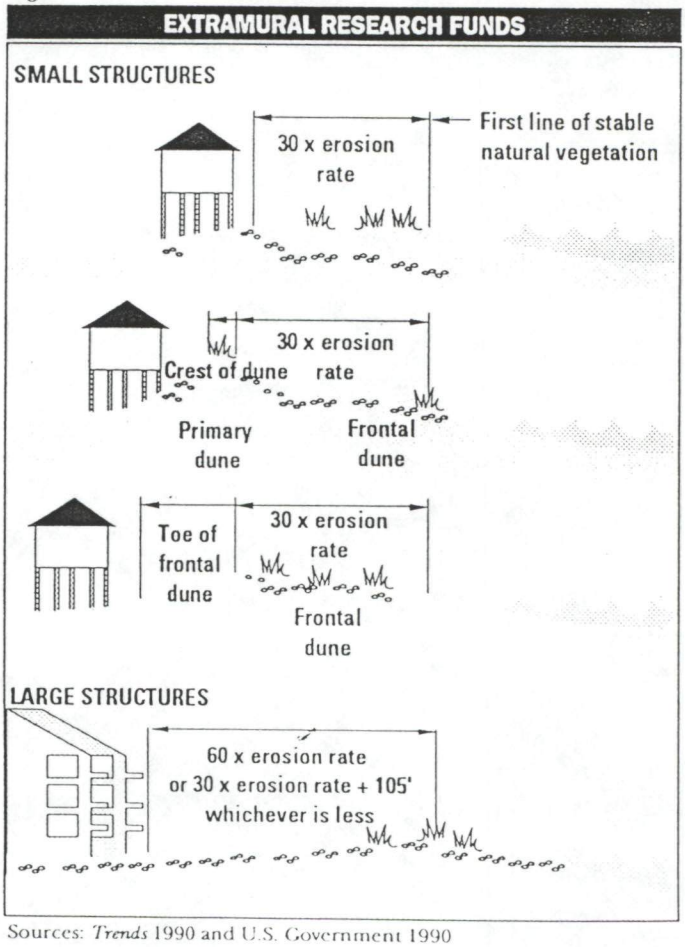
Several states have adopted the first approach to a limited extent through the use of setbacks (Klarin et al. 1990). These setbacks generally preclude building closer than the thirty- or forty-year historical erosion rate but do not include projected sea level rise in these calculations. Figure 23 illustrates setback requirements adopted by North Carolina. The constitutionality of such an action would certainly be subject to question based on the distance inland, etc. (Fishman 1992). No state has shown an interest in buying all the land vulnerable to a 50-100-cm rise in sea level.

Although the second option would have the lowest social cost, only Maine thus far has adopted that approach (Titus 1991). While the third approach may work in states with a very strong public trust doctrine, such as California (Fishman 1992), governments will probably not force people to abandon their homes to allow wetland migration, even if the courts would allow it, unless there is substantial advance notice, as in the Maine approach (Titus 1991). Regarding the fourth approach, several coastal management agencies are undertaking wetlands creation and reconstruction projects. In Louisiana, these projects are funded at $35 million a year.

Along the coast of Louisiana, adaptation to sea level rise is different from that of the rest of the United States. The Mississippi Delta is already losing fifty square miles of land a year because human activities have diminished the processes by which the delta once kept pace with sea level rise and natural subsidence. Many efforts are under way to correct the human modifications that are causing this rate of land loss, including a rediversion of freshwater flow and sediments; regulation of canal dredging; closing of unused canals; restrictions on new levels of construction; and regulation of freshwater flow to marshes. The currently planned measures are unlikely to delay the loss of the major parts of these wetlands if sea level rises even 60 cm (LWPP 1987).

Louisiana and other coastal states (including local governments) will continue to assess their vulnerability to accelerated sea level rise within the natural hazards component of their comprehensive coastal zone management programs. Using computer tools, such as Geographic Information System technology, they will be able to simulate sea level rise scenarios and their potential consequences and suggest appropriate and feasible response strategies. The federal government will continue to support such efforts as state coastal management planning and global monitoring (e.g., the Global Ocean Observing System) to help planners and decision makers address national interests in protecting life, property, and natural resources.

Figure 23



Sources: *Trends* 1990 and U.S. Government 1990

Ocean Resources

Global climate change could have profound impacts—both beneficial and destructive—n he distribution and productivity of valuable aquatic resources (Healy 1990). The principal effects would be caused by increases in water temperature and sea-level rise, but changes in precipitation and ocean currents would also be improtant. Habitats would shift poleward, and species abundances and distributions, thus affecting fisheries. It is likely that climate change will cause the extinction of some species and expansions of others.

Over two-thirds of fish caught for human consumption, as well as many birds and terrestrial animals, depend on coastal marshes and swamps for part of their life cycle. Coastal wetlands can keep pace with a slow rate of sea level rise. This ability has enable the area of intertidal wetlands to increase severalfold, with the slow rate of rise over the last few thousand years. However, if sea level rises too rapidly, the natural succession of the coastal ecology could be affected, leading to disruption in the life cycles of many species.

Adaptive Measures

The reactions to a changing environment may have as much impact on users of aquatic resources as the change itself. Several measures are currently being taken to address possible changes.

- *Determine the relationship of aquatic organisms to their environment and how the relationship changes with a changing climate.* This work includes movement towards adoption of large marine ecosystems as the focus of research on biota in the oceans. Work in this area is being integrated domestically among various federal agencies and internationally through several scientific organizations.
- *Strengthen fisheries management research, policies, and institutions.* In fisheries management, large marine ecosystems increasingly are being considered as the management unit for the conservation and management of living marine resources (Sherman and Gold 1990). In addition, the Magnuson Fisheries Conservation and Management Act allows U.S. fisheries managers considerable flexibility in dealing with shifting fisheries production. To further improve its fisheries management, the United States is educating its fisheries managers and its fishing industry about the possible consequences of a changing climate. Finally, with respect to the impacts of international policies on fisheries and fishing management, the U.S. has advocated the view that international treaties and agreements on fisheries and marine mammal conservation should consider the implications of the different population structures and distributions that would result from a changing climate.
- *Encourage cooperation among fishery, forestry, water, and other resource managers to ensure that the needs of aquatic resources are met.* In many parts of the United States, fisheries and water managers routinely negotiate water flows in rivers to provide the most public benefit from scarce water resources for farmers, electric power users, and anadromous (or riverine) fish.
- *Improve methods to assess socioeconomic impacts of climate changes.* Resource managers are conducting workshops on this subject to bring experts together to share information.
- *Consider habitat needs for aquatic resources in planning coastal protection measures and water resources actions.* For example, the need for wetlands to be able to migrate inland and the implications of salinity impacts due to sea level rise is explicitly addressed in the Delaware River Basin Commission dam operation/construction plan.
- *As habitats change, restocking them with ecologically sound species.* Research is underway in various U.S. institutions to learn more about the physiological needs and the predator/prey relationships of both aquaculture and wild fish species. If and when stocking becomes advisable, there is thus a strong scientific basis for making proper selections and avoiding harmful effects on native populations. Opportunities also exist for aquaculture to mitigate some impacts on species that are already severly threatened, such as the Headstart programs in which turtles are raised for a suitable period in facilities before being released into the wild.
- *Consider using aquatic species as indicators of climate change to validate climate models and to show whether climate change is already occurring.* Various researchers are working to determine if apparent changes in populations are early indicators of a changing environment.

Terrestrial Ecosystems

As described in earlier parts of this chapter, climate change and the attendant fluctuations in temperature and moisture could have a significant impact on terrestial ecosystems.

With regard to climate-related variables, past state-of-the-art modeling studies of the effects of climate change on U.S ecosystems have examined the sensitivities of certain species to particular variables. They haven't examined how a full, internally consistent set of changes in climate variables would affect ecosystems as a whole (Smith and Tirpak 1990). This is partly due to the lack of reliable climate change scenarios, as well as an insufficient understanding of the biophysical and ecological processes under new atmospheric and climate regimes (IPCC 1990b; Goklany 1992).

Due to temperature change alone, productivity in the higher latitudes would increase (because of a longer growing season). However, in the interior mid-latitudes, potentially drier conditions coupled with higher temperatures could reduce productivity. The direct effects of CO_2 on vegetation, including enhanced fertilization and more efficient water use could partly, if not wholly, offset any negative (or enhance positive) effects due to changes in climate variables.

Effects of CO_2 Fertilization in Managed Ecosystems

A number of field experiments on the fertilization effects of enhanced CO_2 levels in the atmosphere (i.e., without consideration of other changes in climate conditions) on U.S. ecosystems show mixed results. An experiment on an Alaskan tussock tundra system suggests this phenomenon may only have short-term benefits for trees and natural vegetation, possibly because of acclimation of carbon metabolism (Tissue and Oechel 1987). However, two other longer-term experiments, both on different wetland ecosystems in Chesapeake Bay, showed significant increases in carbon accumulation for the first four years, both above and below ground. These investigations note that there is no evidence in those data that carbon accumulation would reach saturation or decline due to elevated CO_2 (Arp and Drake 1991; Drake and Leadley 1991; Idso and Kimball 1991; Ziska et al. 1991).

In the absence of reasonably accurate *regional* climate change scenarios, experimental studies—like modeling studies—cannot replicate future conditions. Because of these shortcomings, the change in the net primary productivity of either portions of or the entire United States cannot be estimated with confidence. However, some investigators have also noted that CO_2 fertilization could explain the "missing" CO_2 terrestrial sink suggested by some studies (Tans et al. 1990). CO_2 fertilization would also explain the increasing amplitude of the seasonal swings in atmospheric CO_2 concentrations (Idso 1991).

The combined effect of changes in CO_2 concentrations and climate variables would be that ecosystems, which are constantly evolving, would evolve along a different path. Each species would react differently, forming new assemblies and relationships (Patterson and Flint 1990). There is also general agreement that the magnitude of impact will depend upon the *rate* of change in critical climate factors; that species at the edges of their range would be most affected, some negatively and others positively; and that the smaller the population or range, the greater the effect (IPCC 1990b). Some fear too rapid a change could cause the dieback or extinction of some species. On the other hand, other species may thrive. In particular, grassland and forest ecosystems and migratory species may be affected as follows:

- *Grassland Ecosystems.* As climate changes, grasses, forbs, and shrubs best suited to the changed climate will flourish, and those no longer suited will die back. Range managers will focus on how to sustain the ecosystem to meet the continually shifting set of economic, social, and cultural demands placed on it. In addition, managers would need to guard against pathogens and diseases that also could migrate as climate changes. Animal communities would also move in response to any changes in the abundance and distribution of their food sources and habitat. Plants will also colonize territory that has recently become suitable.

- Unmanaged *Forest Ecosystems.* Most unmanaged forest ecosystems (old-growth forests and abandoned areas) are highly diverse genetically and are thus capable of selecting variants to accommodate some climate change. As with range ecosystems, it is fully expected that the organization, structure, and composition of any particular habitat will change as the external climate variables change. Because most trees live for decades, if not centuries, once they are established, global climate change may be reflected by the vigor/health of existing forest communities, as well as patterns of reproduction (or lack of reproduction).
- *Migratory Species.* Migratory species depend on the quantity and quality of food sources habitat in more than one area. They may be adversely affected if the food and habitat in some of these areas is no longer suitable because of changes in climate (e.g., sea level rise). These effects would be mitigated if migratory species are able to locate suitable new habitat, or if their current habitat expands or becomes more productive.

Adaptive Measures

Because of the uncertainties regarding the vulnerability of ecosystems to climate change, and given other inevitable agents of global change as well as the potential magnitude of their effects, it is prudent to approach adaptation along the lines recommended by the IPCC (1990d) specified earlier in this chapter.

The majority of the measures that fit the IPCC definition are anticipatory in that, by reducing the vulnerability to other agents of change, they would increase the future resiliency of ecosystems and species and their ability to deal with the impacts of climate change, if and when they are manifested. Other actions would maintain institutional, legal, and economic flexibility so that site-specific "reactive" measures could be taken in response to specific effects, once their need becomes apparent. Specific adaptation measures that the United States is undertaking (or has undertaken) to adapt to any future climate change follow.

Improving the Knowledge Base

The U.S. government spends over one billion dollars a year on research on environmental biology so that reasoned judgments can be made on the sustainable use and management of ecosystems. More than $430 million of that total is from federal land management agencies and is devoted to research efforts undertaken to assist the rational use and management of the biological resources for which they are responsible (CEES 1992). These funds also are used to develop inventories, data bases, and systems to monitor the current state of natural resources, improve methodological tools for assessing impacts, and estimate the sensitivity and adaptability of natural resources to different global change scenarios.

Increasing the Productivity of Land Uses

Increasing the productivity of agriculture, forestry, and other land uses is critical because the less habitat that is available, the less likely species are to adapt. It also would reduce the conversion of land from its natural condition to other uses, such as the production of food, clothing, and shelter, and would reduce the loss of carbon sinks and reservoirs.

Over the past century, U.S. productivity in agriculture and forestry has improved substantially. Technological improvements in production, distribution, and storage, coupled with improved dissemination of information, have led to large efficiency gains throughout the agricultural sector. The American agricultural sector uses less land today than it did in 1910, even though it feeds over two-and-a-half times more people in the United States and millions more abroad (Goklany and Sprague 1992). If technology had been frozen at 1910 levels, then the United States would need to harvest more area than is contained in all its crop land and forest-land to produce the same quantities of food as it produces today. In fact, technological improvements have allowed farmland and timberland to revert to unmanaged forests in many areas. As a consequence, many species have become more abundant and widespread (USDA/DOI 1992). Increases in productivity also have contributed to the success of voluntary federal programs, such as the Agricultural Resources Conservation Program, which has permanent easements on environmentally sensitive crop land withdrawn from cropping.

Similarly, new technologies have allowed per capita timber usage to decline since 1900 by about 50 percent—from 157 cubic feet to 78 cubic feet in 1988—despite major increases in demand for pulp and paper products (U.S. DOI 1992). Absent these new technologies, much larger timber harvests would have been necessary to fulfill current demands, resulting in a greater loss of unmanaged forests, and their value as carbon sinks and reservoirs. Currently, annual forest growth exceeds timber harvest by 37 percent, and the national volume of wood in forests has increased by 25 percent since 1952.

The best insurance for continued U.S. technological progress is to ensure that action plans contain the key

elements that contributed to these past successes. These include:

- Focused basic and applied research programs. (The U.S. spends about $3 billion each year on agricultural research. About 30 percent of that is from the federal government).
- A cadre of highly educated farmers and managers.
- Effective information and technology transfer based upon the U.S. government's agricultural and marine extension services.
- A legal, economic, and institutional framework that makes possible the rapid development and adoption of efficient technologies—e.g., a free-market system. (As the historical experience of nations with economies in transition shows, this may be the single most important element. Government emphasis on research, education, and information is not enough to stimulate agricultural productivity.) However, increases in productivity are sometimes accompanied by undesirable side effects that themselves may need additional mitigation.

Reducing Habitat Loss

By taking the following actions, the U.S. government has significantly slowed the rate of habitat loss:

- It put the Conservation Reserve, Wetlands Reserve, Swampbuster, and similar programs to work to cut the annual rate of wetland conversion from about 450,000 acres in the 1950s to the mid-1970s, to about 120,000 acres in the 1980s (USDA/DOI 1992).
- It used money from the Land and Water Conservation Fund (LWCF), duck stamps, and various excise taxes to acquire sensitive—but threatened—areas. Since the 1930s, about 10 million acres have been purchased. Since 1965, over $17 billion from the LWCF have been used to purchase roughly 5 million acres.
- It obtained easements and entered into special arrangements with the private landowners of over forty million acres to give greater consideration to wildlife in their land management practices.

To reduce the vulnerability of ecosystems to climate change, several efforts have been undertaken to restore degraded habitat, to control introduced weedy species on public and private lands, and to create man-made habitats. Many efforts require active cooperation among federal, state, and local governments and private parties. Examples of specific actions include: special allocation of water for refuges, even during the current California drought, now in its sixth year; restoration activities on about 830,000 acres of wetlands in fiscal years 1989-92; reforestation and afforestation programs; and conversion of offshore oil platforms into man-made reefs. In part because of these programs, forests and rangelands on the whole are in much better ecological health now than they were fifty or more years ago.

Other examples include cooperative programs with Canada, Mexico, and Central American nations to conserve habitats for migratory species (waterfowl and neotropical birds) that spend part of their life cycle in the United States. For instance, the United States will spend about $140 million on the North American Waterfowl Management Plan in 1991 and 1992—with about half of this coming from the federal government.

Establishing Specially Protected Areas

The U.S. government has established specifically protected areas or habitats on about 10 percent of the U.S. land mass (about 225 million acres) (USDA/DOI 1992). Of this area, 90 percent, or over 200 million acres, is federally protected as national parks, wildlife refuges, wilderness areas, and wild and scenic rivers. Little or no development is allowed in these areas, which cover a wide variety of ecosystems. Since 1970, the area of national park and wildlife refuge systems has almost tripled to 169 million acres, while national wilderness areas have increased eight-fold to 95 million acres. The total length of the national wild and scenic river system has increased nine-fold to 9,500 miles over the same period. Many of these additions are in Alaska.

A substantial portion of the 70 million acres of state and local government land in the United States is classified as specially protected land (Daugherty 1991). All 50 states have endangered species acts, state forest and park systems, natural heritage programs, and regulations protecting forests. Approximately 40 states have established resource management systems whose explicit purpose is to protect "natural areas" or similarly designated areas. Additionally, several states have entered into partnerships with the federal government to ensure the continued protection of specific land areas (USDA/DOI 1992).

Using Land Management Plans

The federal government has established systems to update periodically the management plans for lands owned and managed by the federal government (about 650 million acres) (USDA/DOI 1992). In addition to specially protected (reserved) land, the U.S. government owns and manages another 450 million acres, including national forests, grasslands, and rangelands. These lands are managed in accordance with resource management plans which attempt to address any rea-

sonable, foreseeable impact on the land and its biological resources. Because these plans consider local factors and are updated periodically, if and when it becomes possible to project the impacts of climate change with reasonable accuracy, these plans will be useful for anticipating site-specific impacts and for developing, analyzing, and implementing adaptive measures specially tailored for those locations.

While conservation is the primary goal in the reserved areas, nonreserved lands are managed to promote both the wise use and the conservation of natural resources. The requirements for impact assessments under the National Environmental Policy Act help support conservation efforts. In addition, in 1992 both the U.S. Forest Service and the Bureau of Land Management announced policies that would place greater emphasis on total ecosystem management and thus enhance the resilience of species and habitats to climate change.

Adopting Conservation Laws, Policies, and Programs

Because no species exists in isolation, laws that conserve one species, such as the Endangered Species Act, also have helped to conserve broad communities and ecosystems. The United States has about twenty such laws, which have helped build up the populations of several species, including some that are listed as threatened or endangered (e.g., the trumpeter swan and the whooping crane) (USDA/DOI 1992). In addition, all fifty states have endangered species acts.

Captive breeding and greenhouse propagation programs are critical to the success of many efforts to save threatened and endangered species. Experience gained with these measures today will help similar measures if they are needed in the future. Similarly, the information contained in germ plasm can help researchers develop strains better adapted to a changed atmosphere and climate. For example, every year the U.S. government's National Plant Germ Plasm System distributes over 230,000 samples of germ plasm to more than 100 nations. In addition, the American Type Culture Collection maintains over 42,000 strains of microorganisms for use in education and research (USDA/DOI 1992).

Restricting Pollution

The U.S. spends 130 billion dollars a year to comply with statutes, regulations, and policies that reduce the pollution in the soil, water, and air (USDA/DOI 1992). While the primary focus of these laws is to reduce adverse impacts on human health, they also have contributed to healthier, more resilient ecosystems. These laws have helped reduce concentrations of DDT, PCB, and other organochlorine contaminants several-fold in the tissues of birds and fish, have reduced their vulnerability to other stresses, and have contributed to the recovery of some species, such as the bald eagle.

Involving the Private Sector

To allow for a rapid, effective implementation of adaptive measures, if and when necessary, institutional, legal, and economic frameworks must be flexible. In attempting to develop flexible frameworks, the IPCC recommends considering (1) giving local populations and resource users a stake in conservation and sustainable resource use—e.g., by investing them with clear property rights; and (2) decentralizing, as practicable, decision making on resource use and management, while incorporating mechanisms to ensure consideration of broad, societal interests (IPCCd). About 70 percent of the conterminous United States is privately owned (Daugherty 1987). These owners make decentralized decisions individually, within the constraints of applicable laws and regulations. Clearly they have an economic stake in the continued viability of their natural resources.

A corollary to this is that in the United States, active voluntary participation of private owners is critical to the success of any effort dealing with land resources. Voluntary actions include planting trees, providing feed for birds and animals, and participating in land conservation programs, as well as the millions of individual decisions made over the years by farmers and other landowners who have increased the productivity of land use markedly.

Promoting International Programs

The United States supports several international programs to conserve biodiversity and improve the productivity of agriculture and forestry in developing nations (USDA/DOI 1992). Without U.S. participation in such programs—e.g., through the "Green Revolution" and subsequent support—the pressure for land conversion in many developing nations would have been even more acute. In 1991, the United States spent about $700 million on international conservation, agriculture, and forestry activities.

Reducing Commodity Price Support Programs

The very success of technological progress in increasing productivity simultaneously increases pressures for the overproduction of crops and other natural resources. While each society has its own reasons for such subsidies, they prevent the realization of the full economic and environmental benefits that could result

from technological progress. They also encourage the exploitation of marginal lands and other resources, as well as the overexploitation of nonmarginal areas.

As part of the GATT negotiations, the United States is attempting to reduce habitat loss by working toward reducing price-support programs in international trade worldwide. Worldwide reduction in such subsidies would help strengthen the free-market economies of both developed nations as well as developing nations, because the latter are heavily dependent upon agriculture. In turn, stronger free economies would make both adaptation and sustainable development more affordable and would further reduce environmental degradation. Finally, this would also decrease greenhouse gas emissions in the developed nations by sustaining land-use decisions that would effectively produce multiple benefits for livestock, agriculture, and wooded systems.

Mitigation Actions

The National Action Plan is based on a variety of programs and laws that together act to reduce greenhouse gas emissions. The Plan deals with three greenhouse gases: carbon dioxide, methane, and nitrous oxide. It also addresses gases which are precursors to formation of ozone, another important greenhouse gas.

Most (80 percent) of the carbon emissions in the United States are caused by burning fossil fuels to produce energy. Reducing these emissions necessitates reducing the demand for energy services, substituting low-carbon fuels for fuels now being used, improving the efficiency of fossil fuel combustion, or increasing carbon "sinks." All of the actions described in this chapter for reducing net carbon emissions rely on these methods. Methods to reduce methane discussed in this chapter include capture from landfills and coal mines, while the principal improvements leading to reduction of nitrous oxide result from changes in nylon manufacturing processes.

One of the key building blocks of the National Action Plan is the National Energy Strategy (DOE 1991a), which includes energy-related aspects of the Clean Air Act Amendments of 1990, the Budget Reconciliation Act of 1990, the Intermodal Surface Transportation Efficiency Act of 1991, the Energy Policy Act of 1992, as well as a host of administrative actions at the federal, state, and local levels. To supplement National Energy Strategy programs, the President has initiated a number of additional actions through the Depart-ment of Energy, the Environmental Protection Agency, and other executive branch agencies to reduce greenhouse gas emissions from both the energy sector and other activities. Finally, an increasing number of states are incorporating global climate change policy concerns into legislation, administrative actions, sectoral analyses, and state action plans.

U.S. Views on Global Climate Change (DOS 1992) outlined existing U.S. policies and estimated their potential to reduce greenhouse gas emissions. Although the information presented focuses on the year 2000, many of the actions, particularly those affecting energy supply and demand, will have effects well into the twenty-first century. Most of the research, development, and demonstration programs initiated today will have their greatest impact after 2010.

Approaches for Reducing Greenhouse Gases

Standards, R&D, and Market Improvements

The National Action Plan for reducing greenhouse gases is based on a number of approaches that combine the efforts of the public sector (federal, state, and local governments) and the private sector. From the public-sector view point, these approaches can be grouped into four main categories:

- Undertaking regulatory actions, including the setting of standards.
- Conducting research and development to enhance efficiency, improve supplies, and promote fuel switching.
- Creating market enhancements, including developing incentives and providing information.
- Encouraging the voluntary adoption of processes and technologies that not only make economic sense but also make environmental sense.

The National Energy Strategy relies primarily on advanced technologies and improved energy management practices to help maintain adequate supplies of environmentally benign fuels while reducing energy demand. The strategy also relies on the removal of market barriers and the correction of market failures to meet environmental, energy, and economic objectives. The National Energy Strategy achieves reductions in energy consumption and carbon emissions through improved end-use energy efficiency and increased use of renewable energy and nuclear power. The legislative

content of the National Energy Strategy is embodied in the Energy Policy Act of 1992 (EP Act), which contains 30 titles. Included among the many actions in the EP Act are energy-efficiency standards and increased funding for research and development, as well as for studies directed at improving the U.S. planning process for dealing with global change.

Under both the National Energy Strategy and other programs, the United States has taken a lead in adopting prudent strategies to reduce greenhouse gases—strategies that are also justified on grounds other than climate change, such as reforestation and improved energy efficiency.

Voluntary Green Programs

In 1991, the U.S. government through the Environmental Protection Agency created several "green" programs. Each program targets an individual energy end use, assesses barriers that are preventing the penetration of advanced, energy-conserving technologies in its market, and employs a strategy tailored precisely to overcome those barriers through voluntary, public/private partnerships. Each program was designed comprehensively with strong attention to implementation and relies on one or more of several key elements:

- *Encourage corporate-wide purchasing frameworks* so that energy efficiency and full-life-cycle cost are considered up front. This helps to overcome internal organizational barriers (for example, so that departments responsible for purchasing equipment consider energy costs in their decisions—even when their department does not pay the electricity bills).
- *Identify energy-efficient products* so that corporate purchasers and consumers can make educated purchasing decisions. This helps overcome the lack of good information that makes it difficult to choose the most cost-effective products.
- *Promote mass purchases of energy-efficient technologies* to improve economies of scale and to reduce prices. Once the efficient technologies have moved into mass markets, their prices may fall to levels equal to or even below those of less efficient alternatives.
- *Encourage industry to commercialize more resource-efficient technologies* by demonstrating that these products will sell. Clear "market-pull" signals organized through mass-purchase initiatives and utility program coordination aimed at new technologies can help get products off the drawing board and onto store shelves.
- *Promote sensible utility regulation and legal frameworks* to encourage cost-effective investments in energy conservation and methane-recovery programs. Too often, regulatory barriers prevent cost-effective efficiency investments and increase capital requirements. Ensuring that companies and consumers can indeed profit from the wise use of resources—by improving energy efficiency or capturing and using methane for energy—leads to a more productive and less polluting economy.
- *Create "environmental best practices" agreements* to integrate environmental considerations into the design and planning of products and services. Placing environmental concerns in a primary role can lead to well-designed products, cost-effective manufacturing processes, and a wiser use of scarce natural resources.

State and Local Actions

To respond to concerns about global climate change, many states have begun developing inventories of greenhouse gas emissions, identifying impacts, and examining a wide range of policy options to reduce emissions.

The production and use of electric power and natural gas account for a significant amount of greenhouse gas emissions nationally. States can reduce greenhouse gas emissions and promote energy efficiency through utility-related regulations, energy-efficiency standards for buildings and appliances, tax incentives for switching to alternative fuels and cleaner technologies, and state procurement practices. These efforts are likely to have the greatest impact on greenhouse gas emissions in the near term and should have a variety of other short-term economic and environmental benefits.

Table 12

PROJECTED REDUCTION OF POTENTIAL RADIATIVE FORCING IN CARBON EQUIVALENT FOR 2000

Greenhouse Gas	Emission Reductions MMT	MMTC
Net Carbon Dioxide	337–477	92–130
Nitrous Oxide	.03–.04	8–12
Methane	2.27–2.64	25–58
Total		125–200

Note: Global warming potential for methane used is both 11 and 22.
MMTC = Millions of metric tons of carbon equivalent.
MMT = Millions of metric tons of gas.

Source: *U.S. Views* (DOS 1992)

Expected Emission Reductions

Table 12 summarizes the emission reductions that are expected to result from the National Action Plan. In carbon-equivalent terms, a reduction in the radiative-forcing potential of between 125 and 200 million metric tons of carbon equivalent is expected. The vast majority of the decrease is due to actions that decrease carbon emissions. Significant reductions are also expected from actions that reduce methane and nitrous oxide emissions (Table 13).

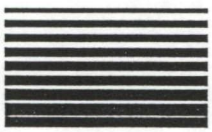
Table 13

PROJECTED CH_4 AND NO_x REDUCTIONS IN 2000

Pollutant	GWP = 11†		GWP = 22†	
	MMTC	MMT	MMTC	MMT
Methane				
Landfills	19	1.73	39	1.77
Livestock Waste Lagoons	3	0.27	7	0.32
Coal Mines	0–3	0–0.27	0–60	0–0.27
Total	25–28	2.27–2.54	52–58	2.36–2.63
Nitrous Oxide	**GWP = 270**			
Green Nylon Program	8–12	0.03–0.04		

† Global warming potential—using direct (GWP=11) or direct and indirect effects (GWP=22) over a 100-year time horizon.
MMTC = million metric tons of carbon equivalent.

Source: *U.S. Views* (DOS 1992



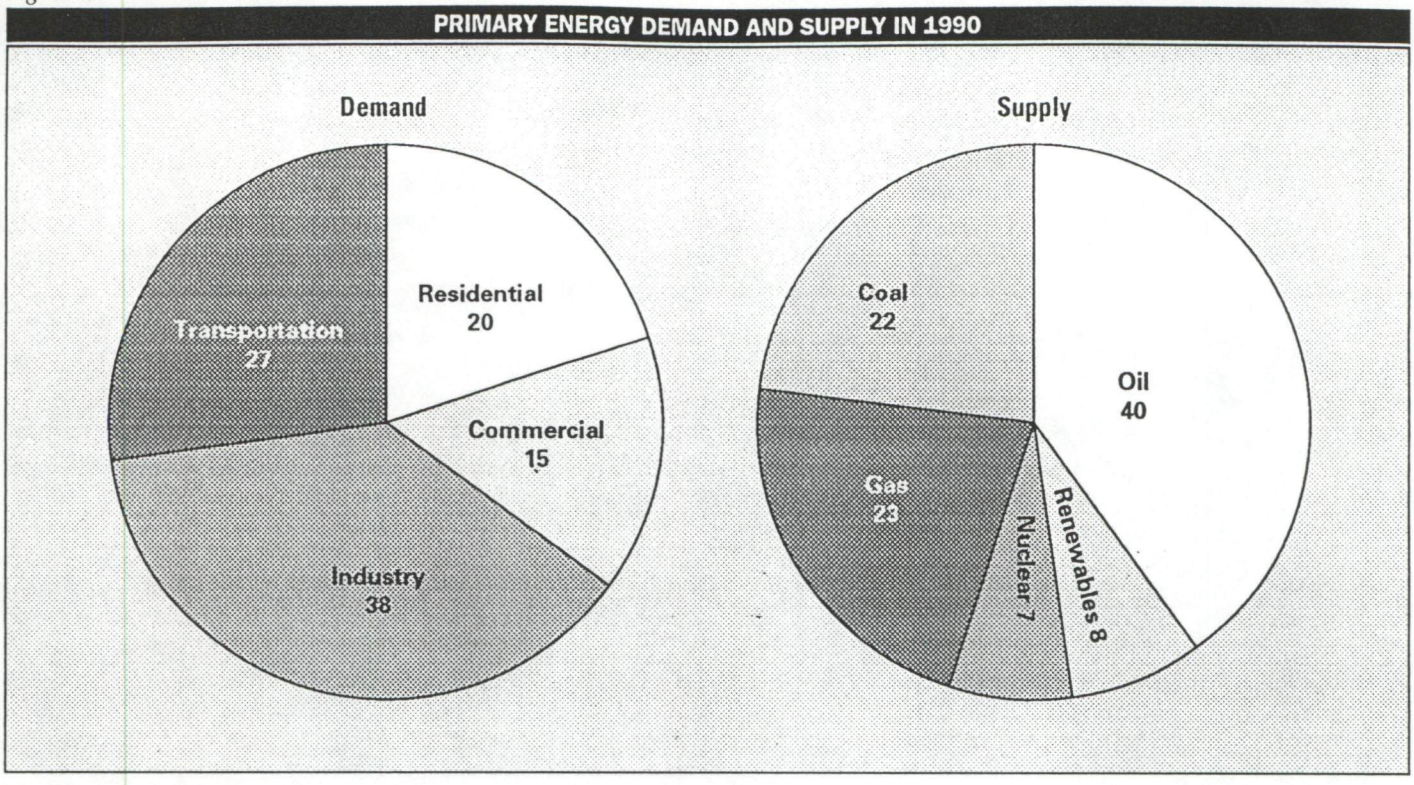
Energy Demand and Supply

In 1990, the United States consumed 84.6 million Btus of energy and produced 1,279 million metric tons (MMTs) of carbon. Energy production and consumption in the United States are the single largest sources responsible for greenhouse gases that are released into the atmosphere. Therefore, any efforts to moderate greenhouse gas emissions should include efforts that seek to improve the efficiency of energy production and distribution, reduce energy consumption, and encourage consumers to switch to lower-carbon fuels when it is economically efficient to do so.

In 1990, the largest end-use energy consumer was the industrial sector, which used about 32.1 quadrillion Btus (38 percent) of the primary energy supplied. The transportation sector followed next with 22.5 quadrillion Btus (27 percent). Residential and commercial energy consumption comprised about one-third of primary energy supplied to end users, with the residential sector consuming about 20 percent more than the commercial sector.

Petroleum products dominated primary energy supply in the United States in 1990, providing about 40 percent of the energy supplied. Natural gas and coal

Figure 24



followed, with each providing more than one-fifth of the primary energy supplied. Nuclear power and renewable energy supplied the remainder of energy user needs, each supplying more than 7 percent (Figure 24).

Energy Demand

Since the mid 1970s, the federal, state, and local governments, and government-regulated utilities of the United States have undertaken a number of actions to improve energy efficiency and reduce projected energy demand. These actions have included:

- Mandatory energy-efficiency standards for new buildings, major home appliances and equipment, and new light-duty motor vehicles.
- Financial support for improving the efficiency of low-income housing, schools, and other public buildings.
- Financial incentives for investing in energy efficiency in buildings and industry in general.
- Substantial funding for public transit and other more energy-efficient modes of transport.
- Public information and education programs.
- Collaborative government-private industry research, development, and demonstration of more energy-efficient technologies.
- Collaborative government-private industry research, development, and demonstration of renewable-energy technologies.
- Research, development, and demonstration of high-efficiency fossil fuel electricity-generating technologies, such as clean coal and natural gas fuel cells.

Electric Utilities: The IRP Approach

Future demand for electricity services in all sectors is most likely to be met through a wide variety of investments in new generation capacity and in programs and technologies that reduce consumption. Government-regulated utilities now spend about $2 billion annually on efforts to manage the demand for energy. These include consumer education programs and financial incentives to conserve energy. Regulators and utilities will need to be able to determine which of several available investments is most likely to provide the greatest net social benefits to consumers.

In the last decade, electricity suppliers and public utility commissions in a number of states have experimented with a variety of planning instruments designed to compare the costs and benefits of electricity supply and demand options. These instruments, variously known as least-cost utility planning, or integrated resource planning (IRP), continue to be refined in light of new knowledge about the full costs of fuel cycles, consumer response to utility investments in conservation, and technological innovation.

IRP is based on the premise that investments in electricity conservation and efficiency should be allowed to compete fairly with electricity supply options. That goal is best achieved by giving consumers and producers appropriate incentives to make efficient consumption and production decisions, and by facilitating competition among providers of both electricity generation and demand-reduction services. IRP is intended to provide a framework for creating such incentives and fostering such competition.

The Department of Energy's *Integrated Resource Planning Program* encourages utilities and state regulatory commissions to find the most cost-efficient means to meet electricity demand. The program provides accurate and timely information and analytical tools to consumers, utilities, and state commissions. The IRP process has been valuable in pointing out discrepancies in federal and state taxation and regulatory treatment of energy demand and supply investments. It is also designed to provide financial assistance, technical data, and evaluation criteria that will help states and utilities to build such programs. Since 1989, the states have made considerable advances in adopting IRP. In 1991, thirty-two states had some sort of IRP framework in place, compared with only twenty-one in 1989. The Department of Energy's enacted budget for fiscal year 1993 funded a 100 percent increase over the fiscal year 1990 IRP budget.

The EP Act promotes investments by utilities and consumers to invest in energy conservation and efficiency measures. Specifically, it encourages electric and natural gas utilities as well as federally owned and other public-sector utilities to implement IRP programs. The act also encourages state commissions to set rates so that (1) utility investments in energy conservation measures are at least as profitable as investments in supply-side measures, and (2) utilities are encouraged to make all cost-effective investments in energy efficiency for electric generation, transmission, and distribution.

Demand-side management (DSM) is widely practiced throughout the United States. DSM (a process in which utilities incorporate energy efficiency and conservation measures in their planning and acquisition programs) allows for more efficient use of existing gen-

TITLES OF ENERGY POLICY ACT RELATED TO CLIMATE CHANGE

Several titles of the Energy Policy Act of 1992 are extremely important to the overall strategy of reducing greenhouse gases. They include:

- *Title I—The energy-efficiency title of the Act establishes energy-efficiency standards, promotes research and deployment of energy-efficient technologies, promotes dissemination of energy-saving information, and provides incentives for state and local authorities to promote energy efficiency.*
- *Title III, IV, V, and VI—The alternative fuels and vehicle titles of the Act provide monetary incentives, establish federal requirements, and provide for research, design, and development of fuels and vehicles that can reduce carbon emissions.*
- *Title XII—The renewable energy title of the Act promotes increased research, development, production, and use of renewable energy sources.*
- *Title XVI—The global climate change title of the Act provides for the collection, analysis, and reporting of information pertaining to global climate change that enables the government to make more informed decisions and policies regarding greenhouse gas emissions. It requires the Department of Energy: to provide a report that analyzes the feasibility and economic, energy, social, environmental, and competitive implications, including the implications for jobs, of attaining various levels of carbon dioxide and other greenhouse gases by the year 2005; to provide a least-cost energy strategy; to appoint a Director of Climate Change; to provide a list to Congress of alternative schemes for reducing the generation of carbon emissions; to form an inventory of national aggregate greenhouse gas emissions; to collect data for voluntary reporting of reductions in greenhouse gas emissions; to publish an annual report detailing actions taken and their reported effect on greenhouse gas emission levels; and to promote trade in U.S.-made environmental technologies. The Act authorizes a fund to assist global efforts to mitigate and adapt to global climate change.*
- *Title XIX—This title includes revenue provisions that encourage the production of and investment in renewable electricity generation.*
- *Title XXI—This title establishes programs in the Department of Energy to evaluate cost-effective technologies to improve energy efficiency and increase the use of renewable energy.*
- *Title XXII—This title establishes national R&D initiatives in materials and manufacturing processes that will lead to more efficient and renewable energy technologies.*
- *Title XXVII—This title enables increased use of nuclear plant licensing and nuclear power and displacement of carbon-emitting sources.*

erative capacity. It is estimated that by the year 2000, peak-period electricity demand could be reduced by 56,000 megawatts if utilities successfully apply existing and planned technically feasible and economically efficient demand-side management practices and if consumers make sufficient capital available to pay for their share of these investments. Without these practices, an additional 6.6 percent of generating capability would be needed. The actual peak load reduction for 1990 due to demand-side management investments was almost 17,000 megawatts, or 3.1 percent of the total electricity-generating capability without demand-side management. Additional opportunities for economically efficient DSM programs may exist beyond currently planned DSM activities, but DSM's ultimate market penetration depends on the true cost-effectiveness of these programs in practice and determinations of DSM expenditures on different classes of rate payers. For this reason, the U.S. government supports efforts such as IRP to remove barriers to the implementation of cost-effective demand-side management.

Most states and federal Power Marketing Administrations (PMAs) improve the efficiency of the production and conversion of fossil fuels by regulating utility rate setting and planning processes. Least-cost planning is being used by PMAs and by other public utilities to forestall the need to invest in new generating capacity and to promote fuel switching. For example, the Bonneville Power Administration is currently using fuel switching (i.e., the direct use of natural gas) as a demand-side management resource. California has tied a utility's rate of return with progress in acquiring cleaner generating capacity. Iowa has passed legislation requiring electric companies to spend 2 percent of their revenues on energy-efficiency programs. Some states are providing incentives for research and development of clean technologies and renewable-energy sources. Given the global warming potential and concentrations of methane in the atmosphere, some states are encouraging natural gas utilities to reduce methane emissions through better inspection and maintenance of natural gas pipelines.

IRP is applied to various of activities in the residential, commercial, industrial, and transportation sectors.

Residential and Commercial Sector

Households and nonmanufacturing businesses comprise the residential and commercial sector. Together these components account for slightly more than one-third of the consumption of primary energy supplied to all end users. Among the major end-use fuels consumed in the residential and commercial sectors, natural gas use is the largest, followed by electricity, petroleum, and renewable energy. Most of the energy consumed in the residential and commercial sector is used for space conditioning (heating and cooling). Other major end uses include water heating and lighting.

Buildings

Residential and commercial buildings account for two-thirds of the nation's demand for electric power. During the 1970s, virtually all state and local governments established energy-efficiency standards for new residential and commercial buildings. Some of these standards have been strengthened since then, although most have not been substantially changed in over ten years. In January 1989, the Department of Energy issued model voluntary standards for new commercial and multifamily buildings. Just recently, it proposed parallel standards for low-rise residential buildings.

Buildings are complex, dynamic systems made up of numerous components and subsystems. The energy-related subsystems include the building envelope; 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. The Department of Energy's *Advanced Commercial Buildings Program* uses a whole-building approach to lower energy use in commercial buildings. It performs research and development on the interaction effects of the systems on each other, and develops building designs for minimizing total energy consumption. The Department is also developing computer-aided tools to help builders and architects use optimal design methods. By 2000, annual savings are estimated to be as high as 40 billion kWh.

Support has increased for this program as a result of the National Energy Strategy. Specific efforts include:

- *Building Efficiency Standards*—Expanded support for the adoption of more stringent energy-efficiency standards for new residential and commercial buildings, and financial assistance to states to support the training of building designers and contractors. The EP Act requires states to adopt more stringent energy-efficiency standards for commercial buildings and to consider adopting more stringent standards for new residences.
- *Mortgage Financing for Home Efficiency*—Support for more widespread use of residential energy-efficiency ratings and mortgage-financing incentives for energy-efficient housing or for efficiency improvements to existing homes.
- *Federal Agency Efficiency Programs*—Reinforcing the President's Executive Order 12759 to reduce energy use in federal facilities by 20 percent (from 1985 lev-

els) by 2000 by: encouraging innovative financing methods for investments in efficiency, requiring purchases of efficient products, and authorizing rewards to successful federal energy managers.

For example, the *Federal Energy Management Program* will establish federal leadership in using high-efficiency building components and establishing a data base on their operation. This data base will be essential in widespread private-sector acceptance of these technologies. Federal agency budgets for efficiency investments have more than doubled over the past several years and are expected to double again by the mid-1990s. By 2000, energy savings for the Federal Energy Management Program will be up to 500 trillion Btus per year.

The *21st Century Housing Program* is a new Department of Energy initiative that will bring government and industry together in consortia to develop designs and processes that will support the production of high-quality, energy-efficient, and affordable housing. The program emphasizes the integration of efficient building subsystems and the continued research and development of low-cost and low-energy components. The industrialization of the housing industry is expected to yield efficiency improvements of well over 25 percent over today's housing. Industry's lead role in the program will provide effective technology transfer to a historically fragmented housing industry.

The EP Act directs each state, within two years, to formally review its building codes and to certify to the Secretary of Energy whether it is feasible to adopt the Council of American Building Official Model Energy Code of 1992. This provision should improve the energy efficiency of new commercial buildings. In addition, many utilities offer attractive rebates for installing efficient commercial building technologies. The federal government, through the Department of Energy, is providing technical and financial assistance to states to encourage their efforts to improve energy efficiency by developing codes and standards and by conducting demonstration programs.

The Department of Energy's *Advanced Window Technologies Program* aims (1) to develop new energy-efficient window technologies that provide greater energy benefits than the best insulated walls or roofs (such as gas-filled, low-e windows), and (2) to develop the design data and tools to allow builders, architects, and engineers to evaluate and select the best window options. In addition, the Department is establishing testing and rating procedures for windows to be used for labeling.

Lighting

Lighting consumes almost 20 percent of all electricity used in the United States, and is projected to remain close to that level through the year 2000. New lighting technologies can double the light output per watt of current lights. In addition, light can be delivered from the source to the point of use by using new materials and new design concepts for fixtures, saving energy. The EP Act amends the Energy Policy Conservation Act to include new standards and labeling on the efficiency of some commercial lamp products.

The Department of Energy's standards and research and development are and will continue to be complemented by widespread utility programs and EPA's already established voluntary green programs that promote high-efficiency commercial, industrial, and residential lighting. Meanwhile, the development of advanced technologies will be a continuing goal at the Department of Energy in its work with industry groups.

The *Green Lights Program* is the Environmental Protection Agency's flagship voluntary green program that incorporates the corporate purchasing strategy. Green Lights promotes increased energy efficiency of commercial and industrial lighting by persuading corporations to voluntarily upgrade lighting systems with currently available efficient lighting products. Retrofits generally use electronic ballasts, T-8 lamps, reflectors, and control devices, such as occupancy and daylight sensors. Together with expanded utility and DOE programs, Green Lights provides broader, more stable markets for super-efficient products, allowing manufacturers to invest in the development and marketing of these products. Increased demand may bring the prices of some energy-efficient lamps and ballasts near to or even below the prices of current, less efficient lighting technologies.

As of September 30, 1992, just over a year and a half after the program's launch, Green Lights has 651 participants, including 296 corporate partners, 24 state and local government partners, 42 utilities, 195 lighting manufacturers, 55 lighting management companies, and 40 endorsers. These organizations include more than 100 of the Fortune 500's listings of the nation's largest manufacturing and service organizations. They have committed over 2.9 billion square feet of facility space to the program—equal to over 3 percent of the national total and far exceeding the leasable office space in seven metropolitan areas the size of Los Angeles.

The U.S. government estimates that by 2000, potential technical improvements could reach 65 percent for commercial and industrial lighting applications, with market penetrations ranging from 25 to 62 percent. Total electricity savings of 81-203 billion kWh in the commercial and industrial sectors will reduce otherwise projected carbon emissions by 17.0-50.1 MMTs in the year 2000.

Similarly, potential technical improvements could average 75 percent for residential applications, with assumed market penetrations in the year 2000 of 27 percent. Total electricity savings of 23.4 billion kWh in the residential sector could avoid 4.9 MMTs of carbon emissions in the year 2000.

Other voluntary corporate purchasing programs whose design will follow the example set by Green Lights include Industrial Motors, Commercial Cooking, Better Refrigerants, Industrial Electrolytics, and some green building technologies.

Space Conditioning

Over 40 percent of all electricity used on commercial buildings is used for heating, ventilation, and air conditioning (HVAC), and this share is expected to increase. In total, commercial HVAC equipment currently accounts for 13 percent of all electricity consumption in the commercial sector.

The United States is engaged in a variety of activities to reduce electricity consumed by this sector. In the near future, several energy-efficient technologies will be entering the marketplace. These will include: CFC-free and more efficient commercial refrigeration; heating, venting, and air-conditioning equipment that uses desiccants to control humidity; thermally activated refrigeration and air-conditioning equipment; and solar-thermal heating and cooling.

It is estimated that by 2000, HVAC systems in commercial buildings could realize average technical improvements of 53 percent, with a market penetration of 17 percent. All of these efforts are estimated to achieve electricity savings of 41.9 billion kWh and avoided carbon emissions of 8.8 MMTs by 2000.

Commercial

These efforts will be complemented by a voluntary "green program" aimed at retrofits, called *Green Commercial Buildings*. This will be a mass-purchase venture promoting increased energy efficiency in commercial building equipment. There is a rich portfolio of opportunities for improving energy efficiency in the commercial sector. Under the *Green Building* umbrella, the United States will develop specific programs to address each of the largest end uses of energy in buildings, including space heating, space cooling, ventilation systems, refrigeration, and water heating. The energy savings estimated for each of these areas range from 20 to 60 percent per application.

The voluntary initiative will first target variable speed motor drives (VSDs) for ventilation systems. The VSD effort is an early Environmental Protection Agency program to use the mass-purchasing strategy to reduce capital costs and allow manufacturers to invest more heavily in long-range VSD production. A group buy will signal that VSDs are no longer a "niche product"—that it is time to gear up to larger product lines to meet a large and growing demand. This market expansion should drive down prices. In fact, it is reasonable to believe that large markets enhanced by the green building efforts will use both this strategy and the corporate purchasing model, and will work in conjunction with utility demand-side management.

The Department of Energy is conducting research in several areas to improve the performance of commercial air-conditioning systems, including alternative cooling technologies, and systems integration methods that optimize thermal energy distribution and control within buildings. Several types of thermally activated heat-pump systems are being developed, including engine-driven and absorption-cycle systems that can cool and dehumidify buildings and use half the energy required by conventional electricity-driven air conditioners.

Residential

The EP Act sets minimum standards for various central air conditioners and heat pumps that will take effect on January 1, 1994. The Department of Energy's *Advanced Heat Pump Program* focuses on improving the efficiency of residential heating and cooling systems beyond these standards. It encourages the use of high-efficiency ground-source heat pumps and emerging gas-fired, air-source heat pumps that provide both space conditioning and water heating. The goals of the program are to advance the technology by demonstrating its performance potential and by quantifying its technical risks, thus providing industry with enough information to facilitate large-scale adoption. Under this scenario, it is assumed that 60 percent of the sales of ground heat pumps replace air-source heat pumps, 20 percent replace electric baseboard, and 20 percent replace oil. Gas-fired heat pumps are assumed only to replace gas furnaces, although they could replace some electric systems in high-cost regions. These upgrades, assuming a total market penetration of 2-3 percent, are estimated to save 1.8 billion kWh per year by 2000 and to reduce carbon emissions by 2.5 MMTs.

DOE's *Best Practices* program is designed to identify and document the best construction, design, and retrofit practices that yield the largest potential energy sav-

ings. The program supplies this information and technical assistance to builders and consumers to improve the design and operation of buildings.

Other programs for space heating include research and development of efficient thermal distribution systems to minimize losses in the transport of air to the point of use. In addition, research is being conducted to develop highly efficient, insulation materials that do not use chlorofluorocarbons, and to create advanced designs and materials for roofs and walls.

In concert with utility rebate and education efforts, the federal government will be encouraging energy-efficient mortgages and an *Energy Star* product identification effort targeting space conditioning and shell improvements. Technologies targeted for implementation include building envelope improvements such as extra wall, ceiling, floor, sill, and door insulation.

By the year 2000, with average assumed energy savings of 20 percent in new homes and 10 percent in existing residences and respective market penetrations of 8 percent and 10 percent, the United States estimates that the program could achieve electricity savings of 2.4 billion kWh by the year 2000 and could reduce carbon emissions by 0.5 MMTs.

Residential central air conditioners use more than 9 percent of residential electricity and 3 percent of total U.S. electricity and are projected to maintain these shares through the year 2000. As a result of the Department of Energy's advanced building systems program, annual savings for air conditioning should be 10.8 billion kWh in 2000. The EP Act requires revised standards for central air conditioners to take effect in 1995 that will result in a 25 percent increase in efficiency. In addition, a voluntary central air-conditioning program with utilities will use EPA's *Golden Carrot*™ model to improve the efficiency of central air conditioners for residential applications beyond 1994 standards. The Golden Carrot™ model encourages industry to commercialize more resource-efficient technologies by aggregating a large pool of appliance rebate money as an incentive. This rebate money, provided by utilities, sends a clear "market pull" signal that is designed to help get products off the drawing board and onto store shelves. This effort is expected to operate in concert with other efforts by electric and gas utilities and by the Department of Energy. While current stock models typically achieve a Seasonal Energy Efficiency Rating (SEER) below 10, new models are available with SEERs of 15-16.

By the year 2000, with average assumed energy savings of 29 percent per unit and market penetration of 40 percent, it is estimated that these programs could achieve electricity savings of 9.6 billion kWh and carbon emission reductions of 2.0 MMTs.

Approximately 27 million American households (30 percent) use room air conditioners. These units use nearly 2 percent of all residential electricity and are projected to continue using over 1 percent through the year 2000. The Energy Policy Conservation Act, as amended by the National Appliance Energy Conservation Act, set standards for various room air conditioners that became effective on January 1, 1990. The Department of Energy is currently working on amending those standards, to take effect sometime in 1996.

In addition, a voluntary program for residential room air conditioners will use EPA's *Energy Star* logo to identify efficient units. The program is expected to operate in concert with other efforts by the Electric Power Research Institute, utilities, and the Department of Energy. Following the precedent set by Energy Star computers (see below), this program will be based on a signed agreement with manufacturers who commit to introduce products that meet a target level of energy efficiency.

While nationally the current average room–air-conditioner stock achieves a SEER of between 6.5 and 8.5, current models are available at SEERs of 10, and development efforts with manufacturers are expected to produce cost-effective units with SEERs above 12. By the year 2000, with average assumed energy savings of 19 percent per unit and market penetration of 40 percent of eligible households, it is estimated that electricity savings of 1.2 billion kWh and carbon reductions of 0.3 MMT may be achieved.

Refrigerants

Using authority granted by the Clean Air Act Amendments of 1990, President Bush ordered an acceleration of the U.S. phase-out of the use of ozone-depleting refrigerants known as chlorofluorocarbons (CFCs) to December 31, 1995. The U.S. government has made significant progress in working cooperatively with U.S. businesses to develop safe, cost-effective alternatives to CFCs. The Department of Energy is facilitating and expediting this transition by assessing the energy impacts of various new alternatives. The Department of Energy is also developing new refrigerant mixtures having high thermodynamic performance and negligible impacts on the environment, as replacements for the CFCs used in existing air-conditioning systems.

The *Better Refrigerants Program* will build on these efforts by promoting CFC alternatives that increase the capacity and efficiency of equipment, while presenting little or no threat to stratospheric ozone. Through voluntary corporate purchasing initiatives, this program will increase the efficiency of residential and light commercial equipment by replacing HCFC-22 in air-conditioning systems, unitary heat pumps, and water-source

heat pumps, with HFC-32 and its blends. With average assumed technical improvements of 5 percent per unit and market penetration of 80 percent by the year 2000, this program will achieve savings of 8.2 billion kWh and carbon reductions of 1.8 MMTs.

Computers

Computers and their peripherals (printers, scanners, and integrated modem/fax machines) in the United States currently use 40 billion kWh/year of energy, or about 5 percent of electricity consumption in the commercial sector. By 2000, energy consumption by computer systems is estimated to reach 70 billion kWh/year, equal to nearly 7 percent of commercial-sector electricity and over 2 percent of total U.S. consumption. Most of this electricity is used by computers not in active use; in fact, it is estimated that 30-40 percent of these systems are left running at night and over the weekend.

The Environmental Protection Agency is currently working with the Department of Energy, manufacturers, utilities, and environmental groups on the *Energy Star Computers Program.* Formerly called Green Computers, this initiative promotes increased energy efficiency of computer systems. Under the program, the U.S. government is signing agreements with leading computer manufacturers who have committed to introduce computers capable of "powering-down" when not in use. The Energy Star logo will appear on these products, for easy consumer identification.

Within four months of its initiation, this successful program has signed partnership agreements with twelve leading computer manufacturers accounting for more than 40 percent of the personal computers sold in the United States. According to these manufacturers, energy-efficient personal computers will be coming to the market beginning in early 1993—at no extra cost to consumers. By the year 2000, with average assumed technical improvements of 57 percent per unit and market penetration of 65 percent, the program is expected to achieve savings of 26.3 billion kWh and carbon reductions of 5.5 MMTs.

Appliances

The Energy Policy and Conservation Act, as amended, established an energy-conservation program for consumer appliances. The federal government is updating—and strengthening where appropriate—national efficiency standards for major appliances and equipment. In support of these standards, the Department of Energy maintains uniform testing procedures, reassesses the standards periodically, and amends them as necessary. Energy labels are required on certain major appliances to allow consumers to consider energy costs in making their purchasing decisions.

Several states have developed low-interest loan and rebate programs for energy-efficient appliances. These include New York, Illinois, Maine, Washington, Idaho, and Iowa. The thirteen appliance types that require standards are: refrigerators, refrigerator-freezers, and freezers; room air conditioners; central air conditioners and heat pumps; water heaters; furnaces; dishwashers; clothes washers; clothes dryers; direct heating equipment; kitchen ranges and ovens; pool heaters; fluorescent lamp ballasts; and television sets. The U.S. Department of Energy has already updated the statutory standards for clothes washers and dryers, dishwashers, and refrigerators, and proposed standards for eight other product categories are nearing publication for public comment. This activity is expected to save 22.2 billion kWh per year by 2000.

Refrigerators

Refrigerators and freezers represent 20 percent of residential electricity consumption and about 7 percent of total U.S. electricity consumption. Their portion of residential electricity use is projected to decrease to about 15 percent in 2000.

The National Appliance Energy Conservation Act established minimum energy standards for U.S. refrigerators beginning in 1990, and directed the Department of Energy to update those standards for 1993. As a result of the U.S. Department of Energy's efforts, the average energy consumption of U.S. refrigerators will improve by roughly one-quarter between 1990 and 1993. By January 1, 1995, the Department of Energy is scheduled to set new standards that will take effect in 1998.

The U.S. Department of Energy is conducting refrigerator-related research and development on a number of fronts. New forms of insulation and advanced compressor designs will greatly reduce the energy requirements of conventional electrically driven refrigerators, and the use of alternative refrigerants will eliminate requirements for CFCs and HCFCs in these systems. In addition, the Department of Energy is working to develop thermally activated (natural gas) refrigerators that will be even more energy-efficient than the best possible electrically driven ones.

The EP Act directs the Department of Energy, in consultation with the U.S. Environmental Protection Agency, to explore opportunities for promoting advanced appliance technologies. The *Super-Efficient Refrigerator Program,* EPA's flagship Golden Carrot™ appliance effort, will affect efficiency improvements that go beyond the 1993 standard, while moving beyond CFC technologies. Developed by a coalition of diverse groups, including electric utilities and environmental organizations, the program coordinates the efforts of 25 major utilities that serve almost one-quar-

ter of U.S. households. Together, they will provide a strong, sustained "market pull" strategically designed to overcome the risks that prevent the mass commercialization of new technologies.

The utilities have formed a $30 million bid pool, which will reward the manufacturer who can most quickly and cost-effectively develop and market the most efficient CFC-free refrigerator-freezer. The $30 million will be dispersed on a unit-by-unit basis as refrigerators are shipped into the market. Utilities will reduce the price of the super-efficient refrigerators to the level of less efficient models. Utilities usually create individual, uncoordinated incentive programs with unpredictable life spans. The Golden Carrot™ venture coordinates and aggregates utility incentives in a long-term investment strategy that allows manufacturers to plan ahead.

The U.S. estimates that, by the year 2000, with average assumed technical improvements of 57 percent per unit and market penetration of 3 percent, electricity savings of 3.0 billion kWh and carbon emission reductions of 0.6 MMTs will be achieved.

Residential Clothes Washers

Clothes washers currently use less than 4 percent of residential energy and 0.7 percent of total U.S. energy. By the year 2000, they are projected to account for approximately 3 percent of residential energy consumption and 0.6 percent of total U.S. energy use.

The federal government has set standards for residential clothes washers to take effect in 1994. In addition, a "Golden Carrot™" residential clothes washer effort with utilities is aimed at promoting the replacement of the vertical-axis clothes washers, which are used in most U.S. applications, with high-efficiency horizontal-axis models, which are the predominant type in use throughout much of the world. Approximately 90 percent of washing energy is devoted to water heating. Horizontal-axis washers use about one-third of the hot water of vertical-axis machines. In addition, with added high-spin speeds for better drying and internal water-heating capacity, units may achieve total energy savings of 96 percent compared to the consumption of conventional units. (This estimate includes the savings in clothes drying and water heaters.)

By the year 2000, with an average assumed energy savings of 96 percent per unit and market penetration of 3 percent, this Golden Carrot™ program could achieve electricity savings of 1.3 billion kWh and carbon emission reductions of 0.3 MMTs.

Residential Clothes Dryers

Clothes dryers currently comprise about 6 percent of residential electricity consumption and 2 percent of total U.S electricity and are projected to hold these shares through the year 2000.

The federal government has set energy-efficiency standards for clothes dryers that go into effect in 1994. In addition, a "Golden Carrot™" effort with utilities will promote high-efficiency residential clothes dryers beyond the 1994 standard. Such dryers are expected to use increased insulation and air-to-air heat pumps as heat sources. The program will follow the Super-Efficient Refrigerator Program's model to spur investment in the development and commercialization of highly efficient electric dryers.

By the year 2000, with average assumed energy savings of 65 percent per unit and market penetration of 3 percent, this program is estimated to achieve savings of 1.2 billion kWh and carbon reductions of 0.3 MMTs.

Cooking Appliances

The commercial cooking sector provides extensive opportunities for improved energy efficiency. According to baseline projections by the Electric Power Research Institute, commercial cooking consumes just over 2 percent of commercial-sector electricity, and is projected to use 2.5 percent by the year 2000. Voluntary efforts undertaken cooperatively with the federal government, utilities, and manufacturers are expected to increase the efficiency of large commercial cooking operations. Technologies targeted for improvement include increased insulation, better heating elements, reflective pans, reduced thermal mass, and less contact resistance. Energy savings range up to 40 percent for some technologies, including bi-radiant ovens. Also, in concert with the efforts of utilities, the federal government's residential cooking program is an Energy Star labeling effort designed to improve the efficiency of residential cooking operations.

With average assumed respective technical improvements of 8 and 20 percent for each residential and commercial cooking unit, and market penetration of 40 percent (residential) and 30 percent (commercial), the program could achieve respective electricity savings of 1.2 and 1.8 billion kWh and carbon reductions of 0.3 and 0.4 MMTs by the year 2000.

Residential Water Heating

Residential water heating accounts for over 18 percent of all U.S. household energy consumption and

over 3 percent of national energy consumption. By the year 2000, it is projected to decrease to slightly under 3 percent of all U.S consumption. This consumption share is almost as large as that for all household appliances combined, excluding space conditioning.

Low-Flow Showerheads

Showering currently consumes about 40 percent of the energy used for all residential water heating, about 7 percent of total residential energy consumption, and over 1 percent of total U.S. energy consumption. The EP Act mandates a maximum flow rate for showerheads of 2.5 gallons per minute at 80 pounds per square inch, to take effect on January 1, 1994. In addition, the voluntary *Low-Flow Showerhead Program* (which is an Energy Star product identification effort) is targeted at further reducing energy consumption for showers. These efforts will be coordinated with utility demand-side management and corporate mass-purchasing programs.

By the year 2000, with average assumed energy savings of 58 percent per unit and market penetration of 11 percent, in conjunction with the national performance standard, this program could achieve annual electricity savings of up to 10.2 billion kWh and carbon emission reductions of up to 3.4 MMTs.

Solar Thermal Water Heaters

In the Department of Energy's Solar Heating Program, researchers in national laboratories and participating universities work collaboratively with private industry to identify promising new materials, develop and evaluate options for high-performance systems, and resolve existing technical and market barriers. One major effort involves replacing electric water heaters with solar domestic hot-water systems as part of utility demand-side management programs. In many parts of the country, these solar systems currently compete economically with electric hot-water systems. The Department of Energy had funded significant research in this area, and utility interest in these systems as a demand-side management measure is increasing. In addition, the United States is planning a mass purchase to initially move this technology out of a niche market and into the mass market. Assuming a market penetration of just 2-3 percent, annual savings could be 4.8 billion kWh in 2000.

The *Solar Thermal Water Heater Program* promotes aggregated or coordinated large-scale investment in passive-solar water-heating systems for residential applications. Accompanying these efforts, a new generation of low-cost, solar hot-water heaters has appeared. They include batch systems, thermo-syphon systems, and advanced passive designs that rely on simplicity, low maintenance, and minimal energy consumption from pumps. Such systems can deliver approximately 70 percent of annual hot-water demand, and their cost-effectiveness will increase as they move from niche markets into the mass market. By the year 2000, it is assumed this technology could realize average energy savings of 70 percent per unit and market penetration of 2 percent in homes heated by gas and 3.5 percent in those heated electrically. It is estimated that this program will achieve annual savings of 4.8 billion kWh and carbon emission reductions of 1.0 MMTs in the electrically heated market, and an additional 0.4 MMTs from gas-heated homes.

Other End Uses

Several miscellaneous residential and commercial end-use programs are *Energy Star* identification efforts. These are designed to improve the efficiency of a number of projects, including electronics other than computer systems, vertical transportation (such as elevators), pool and well pumps, and fans. As with other Energy Star efforts, manufacturers of a given technology will commit to introduce products that meet target energy-efficiency levels set cooperatively with the Environmental Protection Agency, the Department of Energy, and other groups. These products will then be identified for consumers by the Energy Star logo. By the year 2000, with average assumed technical improvements of 13 percent per unit and market penetration of 40 percent, the Energy Star program is expected to achieve savings of 15 billion kWh and carbon reductions of 3.1 MMTs.

Industrial Sector

The industrial sector consumes more than a third of the nation's energy, in roughly equal shares of electricity use, direct fuel use, and the use of energy resources, such as oil and gas as process feedstocks, and biomass. A small number of major manufacturing groups account for more than 60 percent of the sector's energy use—primary metals, petroleum refining, chemicals, and pulp and paper. And about two-thirds of the sector's electricity use is attributable to motor drives.

Since the 1970s, the federal government has funded a large research and development program directed at energy-efficiency and waste-reduction technologies for use in the industrial sector. The government also supports:

- Twenty-two university-based *Energy Analysis and Diagnostic Centers*, which offer energy-efficiency audits by professional engineers and engineering students to small and medium-sized manufacturing plants. To date, over 4,000 audits have been conducted. At the start of fiscal year 1992, cumulative annual program savings were 66 trillion Btus. The National

Energy Strategy calls for an increase to as many as 40 of these centers over the coming years.

- *The National Technology Initiative*, an initiative to accelerate the commercialization of federally funded technologies through the development of partnerships with the national laboratories and industry, university, federal, state, and local government representatives.
- *National Industrial Competitiveness Through Energy, Economy, and Environment*, a federal-state-industry partnership aimed at addressing problems of waste reduction and disposal.
- *Industrial energy management workshops and guidelines* for chief executive officers, senior industrial managers, and industrial plant managers.

Many states and utilities also have programs directed specifically at encouraging efficiency improvements in industry, such as cash rebates or low-interest loans for investments in energy-efficient motors or lighting systems. Some states and utilities also provide financial or technical assistance for energy audits. In addition, the EP Act contains tax exemptions for utility rebates to businesses that make energy-efficiency investments.

Equipment

Lighting

The EP Act requires efficiency standards and labels for fluorescent lamps, electric motors, packaged heating and cooling systems, and other categories of equipment often used in industrial facilities. These requirements are complemented by the Environmental Protection Agency's Green Lights program.

Industrial Motors

Electric motor systems accounted for 20 percent of all U.S. energy consumption in 1990, and were responsible for one-sixth of the nation's man-made CO_2 emissions. The Electric Power Research Institute estimates that industrial motors consume close to 67 percent of the electricity used by the industrial sector and over 23 percent of all U.S. electricity, and that they will maintain these shares through the year 2000.

Under the EP Act, most electrical motors manufactured in the United States must meet minimum energy-efficiency requirements by the end of 1997. The Department of Energy's *Electric Drives* program develops and facilitates the implementation of electric motor systems. These systems include: energy-efficient motors, which raise electric motor efficiency from 85 to 95 percent; adjustable-speed drives, which save energy by allowing motors to match their speed with varying process requirements, thereby reducing and avoiding wasted mechanical energy; and advanced motor-driven mechanical systems or processes.

These efforts will be complemented by a voluntary corporate purchasing program, sponsored by EPA, called *Green Motors*. In addition, many utilities are expected to continue demand-side management programs offering rebates for motor efficiency upgrades. Energy-saving technologies and measures include adjustable-speed drives, downsizing, and power-factor controllers. For example, a typical 50 horsepower industrial motor can be equipped with an adjustable-speed drive at an installed cost of about $7,000, achieving 30 percent savings.

By 2000, adjustable-speed drives and other improvements could achieve efficiency gains of 30 percent per motor system with an assumed market penetration of 16 percent. Under these assumptions, the Green Motors program could save 39.5 billion kWh of electricity and reduce carbon emissions by 8.3 MMTs.

Industrial Heat Pumps

Industrial heat pumps can reduce energy use by 1.5 quads per year and CO_2 emissions by 20-30 MMTs by 2010. The Department of Energy's *Industrial Heat Pumps* program is developing and installing fuel-saving equipment, increasing industry's awareness of these potential benefits, broadening the information base available to industry to help further development of these pumps, estimating the market potential of various pumps, illustrating the opportunities for their use, and estimating the potential global benefits of using them.

Processes

Electrolytics

Aluminum and other nonferrous metals are produced in electrolytic reduction cells. These cells consume large amounts of electricity, with energy efficiencies of typically less than 50 percent. The Department of Energy's *Process Electrolysis Program* focuses on researching and developing improved technologies that increase the energy efficiency of aluminum production and new electrolytic technologies for other metals. New concepts are evaluated in collaboration with U.S. industrial partners, and then are developed and demonstrated in the specific industrial application under the Department's Metals Initiative program. Process electrolysis research focuses on projects for the aluminum, magnesium, and neodymium industries. In the mid-term, anode projects could save up to 5 percent of the electricity needs of these industries annually. Within five years, it is anticipated that the copper and inert anode projects will be completed.

The U.S. Environmental Protection Agency's *Industrial Electrolytics Program*, a corporate purchasing

effort, targets efficiency investments in electrolytic processes in the industrial sector. The Electric Power Research Institute estimates that electrolytic end uses consume 11 percent of industrial electricity and will use close to 12 percent in the year 2000. By that time, the U.S. government forecasts an average technical improvement of 20 percent per application and market penetration of 13 percent through the Industrial Electrolytics Program.

Technology examples include aluminum production, where respective energy savings from the use of bipolar cells, inert anodes, and wettable cathodes are 30, 10, and 20 percent; and chloralkali production, where improvements of 10 percent can be achieved by replacing mercury cells with diaphragm and membrane cells. This initiative will target industrial practices and structure agreements between specific industries and the federal government to achieve efficiency improvements.

The electrolysis programs could achieve savings of 1.8 billion kWh and carbon emission reductions of 0.4 MMTs.

Metals

As part of the *Metals Initiative,* the Department of Energy is developing new technologies that will significantly improve the energy efficiency of the metals industry. One key project is direct steel-making, which eliminates the use of coke ovens. This project could reduce CO_2 by 12 million tons/year by the year 2020. Other metals initiatives include super-plastic steel, near-net-shape casting of low-carbon steel sheet, and stable cathodes to increase the energy efficiency of aluminum production cells.

Waste Minimization/Utilization

Each year U.S. industry generates an estimated 12 billion tons of waste that embody as much as 10 quads of energy. The National Energy Strategy's increased funding for the research, development, and demonstration of more energy-efficient industrial technologies and new research and regulatory initiatives to encourage industries to minimize process wastes, has both environmental and energy benefits.

The Department of Energy's *Industrial Waste Program* focuses on minimizing the production of waste and converting and using the waste that is produced, such as recycling materials for industrial processes and using waste as feedstocks into industrial processes. These activities could save an estimated 1 quad/year in the short term, and 5 quads/year in the long term. In addition, activities conducted by the Environmental Protection Agency's *Municipal Solid Waste Program* are estimated to potentially save 3 quads per year—1 quad by recycling the waste, and 2 quads by using it to generate energy.

TRANSPORTATION SECTOR

The U.S. transportation sector is 97 percent dependent on petroleum and accounts for nearly two-thirds of all U.S. petroleum consumption. Cars and trucks consume more than three-quarters of all the energy used by the transportation sector.

In the mid 1970s, the United States established both requirements for labeling the fuel economy of automobiles and energy-efficiency standards for new light-duty motor vehicles. Since then there has been a large, federally funded program to research, develop, and demonstrate motor vehicle technologies that are more energy-efficient and capable of using alternative fuels, such as electricity and natural gas. Federal, state, and local governments also provide more than $5 billion annually for constructing, upgrading, and maintaining public transit systems.

Federal and state governments also provide support to public transit and other energy-efficient modes of transportation.

Enhanced Energy Efficiency

Research and Development

Under the National Energy Strategy, the Department of Energy has greatly expanded its support for the research, development, and demonstration of more energy-efficient and fuel-flexible vehicle technologies, including major funding for the *Advanced Battery Consortium,* a $400 million collaborative research effort among the Department of Energy, the three major U.S. automakers, and battery manufacturers. The budget in this area has almost doubled between fiscal 1991 ($86 million) and fiscal 1993 ($162 million).

Federal support for research and development in the transportation sector is designed to improve the efficiency of oil use and to increase the availability and use of alternative fuels. Program efforts center on developing advanced, high-efficiency alternatives to the internal combustion engine, evaluating the combustion and emission characteristics of alternative fuels, demonstrating alternative-fuel vehicles in realistic settings, and developing biofuels from renewable resources. In addition, research is being conducted on fuel cells and alternative hybrid propulsion systems. Fuel cells, which use chemical processes to extract energy from hydrogen, offer the long-term prospect of efficiency that is twice that of internal combustion engines, with little or no emissions. The gas turbine and low-heat-rejection diesel are also being researched for their fuel efficiency and for their potential to use alternative fuels.

DOE also conducts research and development on advanced materials, such as ceramics that can withstand much higher temperatures, thus leading to higher ther-

mal efficiency. In addition, such materials provide lower friction, longer wear, and greater corrosion resistance. The Department has also expanded its research and development of technologies to improve transportation system efficiency, such as magnetic levitation for high-speed trains and intelligent-vehicle and highway systems.

During 1992, the U.S. National Academy of Sciences concluded that some further gains (an increase of roughly 25 percent over the next ten years) in auto fuel economy were possible, without significant effects on auto safety or performance, but could entail significant costs.

Actions to Reduce Congestion

The *Intermodal Surface Transportation Efficiency Act* 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. The Act requires the development of a prototype of a completely automated highway and vehicle system, with 1997 as a goal for completion.

It also requires urban areas with a population of more than 200,000 to develop a congestion management system that includes strategies for reducing travel demand and improving operational management. Under a pilot program, cities will experiment with such strategies as high-occupancy vehicle lanes, incentives for using mass transit, accommodations for pedestrians and bicyclists, and congestion pricing (e.g., imposing fees for using highways during peak periods).

This Act provides funding for a wide variety of research, development, and planning efforts. For example:

- It funds metropolitan traffic planning efforts and a National Planning Research Program, which includes the development of transit technologies.
- It makes available $750 million for the development of a magnetic-levitation prototype.
- It also has authorized $66 million for the development of an Intelligent-Vehicle Highway System and requires the promotion of compatible standards to promote the widespread use of intelligent-vehicle technologies.
- It also funds a variety of joint public- and private-sector projects on researching and developing electric vehicles and advanced transportation systems.
- It provides $5 billion for modernizing rail systems.
- It directs $6 billion of funds toward transportation projects in areas that are exceeding the Clean Air Act's limitations for ozone and carbon monoxide concentrations.

The *Clean Air Act Amendments* allow states to include in their compliance plans measures designed to reduce congestion and the demand for driving. These measures include applying road and parking pricing schemes, creating incentives for using carpools and mass transit, and accelerating the scrappage of old cars.

The *EP Act* increases federal tax exemptions allowed for employer-provided support, up to $60 per month, for employee use of public transit or high-occupancy commuting vehicles, and it limits to $155 per month the tax exemptions permitted for employer-provided parking benefits.

California already has set tailpipe emission standards that are tighter than those of the Clean Air Act, while other states have increased the monitoring and enforcement of automobile emission standards. Connecticut uses an aggressive carpooling program to decrease traffic congestion, reduce air pollution, cut CO_2 emissions, and save gasoline. Connecticut also set higher fuel-efficiency standards for state-owned passenger cars and light-duty trucks. Texas law requires fleets of more than fifty school buses and state agencies with fifteen or more vehicles to switch to alternative fuels. Also, Washington, Vermont, Oregon, and other states are promoting alternatives to riding alone, such as carpools and van pools, and/or are providing high-occupancy vehicle lanes and park-and-ride facilities.

Alternative Fuels

Natural gas will be one of the primary fuels used in the federal fleet demonstrations of alternative fuels, either as compressed natural gas or in the form of methanol derived from natural gas. The increased use of these fuels may result in some net reductions in greenhouse gas emissions. However, it is the longer-term development and introduction of biofuels (derived from nonfood crop sources—e.g., trees, grasses, waste paper) that could result in substantial reductions in greenhouse gas emissions.

During combustion, biomass-derived fuels emit CO_2, which is reabsorbed by the trees or grasses that are planted and harvested to produce more fuel. This creates a rotating fuel cycle in which there is little increase in net CO_2 emissions.

Federal agencies conduct research to reduce the costs of producing biofuels. Scientists have been developing fast-growing and productive crops for fuel use. Sources of biofuels that are currently subjects of research and development include:

- Short-rotation woody crops.
- Herbaceous nonfood crops (which may be used for chemicals and industrial feedstocks as well).

- Oil seed crops (soy beans, sunflower seeds, rape seeds) for conversion to a substitute diesel fuel.
- Ethanol from biomass, including corn wood and cellulosic plants through fermentation of sugars (hydrolysis of starch).
- Methanol from wood or other biomass.

Overall, by 2010 alternative fuels are projected to displace as many as 3.8 million barrels of oil (0.61 million cubic meters) per day.

The EP Act of 1992 contains 51 sections that pertain to transportation. Most of them place greater emphasis on existing Department of Energy programs, mainly in the near-term implementation of vehicles that use alternative fuels. In addition, the Act calls for:

- The mandated phase-in of alternative fuels to the federal fleet: 10 percent in 1995, up to 75 percent in 1999, plus many other state government and commercial fleet provisions.
- The expanded use of alternative fuels for heavy-duty commercial trucks.

Energy Supply

In 1990, the United States produced more energy than it ever had before. Some of this increased production was due to efforts to remove market barriers to the efficient production of energy resources. Efforts to increase domestic energy production have been supplemented by research and development efforts to create new technologies that have allowed marginal resources to be produced profitably.

Between 1980 and 1990, the U.S. production of coal and nuclear power increased, while domestic production of crude oil decreased. To offset this decrease, net oil imports increased steadily between 1982 and 1990. Although natural gas production in 1980 exceeded production in 1990, natural gas production appears to be making a comeback. In 1990, petroleum supplied 40 percent, natural gas supplied 23 percent, coal supplied 22 percent, renewables supplied 8 percent, and nuclear power supplied 7 percent of U.S. energy needs (see Figure 24).

Renewable Technologies

For fiscal year 1993, the federal budget is about $250 million for research, development, and demonstration of renewable-energy technologies. State governments now spend $500-$1,000 million annually in support of renewable-energy programs, including about $250 million in grants from the federal government.

In the National Energy Strategy, the U.S. government proposed expanding federal support for renewable and other alternative fuels. The increased funding for research and development will accelerate development and will reduce the cost and improve the performance of emerging renewable technologies.

The EP Act contains several provisions that encourage the use of renewable energy. They include:

- An amendment of the joint ventures program in the Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989 to convert it into a five-year program to further the commercialization of certain renewable-energy and energy-efficiency technologies through demonstrations and commercial application projects with for-profit businesses and other entities on a cost-sharing basis (Section 1202).
- A tax credit for electricity produced from qualified wind or closed-loop biomass (plants grown to produce electricity, as opposed to plant or wood waste) facilities for the first ten years after the facility is placed in service (Section 1914).
- A permanent extension of the general business tax credit for qualified investments in solar and geothermal properties (Section 1916).
- An authorization for the Department of the Army and the Department of the Interior, without further appropriation, to improve federal hydroelectric projects in the Pacific Northwest Region (Section 2406).

Nuclear Power

Nuclear power is a proven electricity-generating technology that emits no greenhouse gases. However, no new commercial nuclear power reactor has been ordered in the United States since 1978. A primary reason for this is that all U.S. nuclear power plants have been licensed in a process in which several important decisions were made only after construction was complete. Under this process, a plant's operating license could be denied after billions of dollars have been invested in constructing the plant. This has created great financial risk and uncertainty for utilities wishing to build nuclear power plants.

The U.S. government has taken action in several areas to promote the use of nuclear power. The Department of Energy has entered into a partnership with industry to develop standardized, advanced light-water reactor designs for commercial application. Also, the Department is supporting a strong program (the enacted budget for fiscal year 1993 is $68 million) of research and development on more advanced nuclear power systems that show promise of potentially signifi-

cant breakthroughs in economics, safety, licensing, and waste management. New designs with passively safe features, along with continued proper management and disposal of high-level nuclear waste, will increase the safety of the nuclear option and will make it more economically attractive.

The EP Act modifies the licensing process for nuclear power plants. It provides for the issuance of a combined construction and operating license and allows emergency planning procedures to be addressed before plant construction begins. All design work essential to safety evaluation, siting, and emergency planning decisions will have to be completed before construction. These changes will reduce the costs of nuclear power plants and the risk and uncertainty of investing in them.

The successful application of practical fusion energy technologies at some point in the 21st century could provide an environmentally acceptable alternative to fossil-fuel combustion. Research and development programs that pursue both magnetic-confinement and inertial-confinement fusion energy systems will continue under the National Energy Strategy. The enacted fiscal year 1993 budget is $340 million for these programs—an increase of 15 percent over fiscal year 1991 appropriations.

Natural Gas and Coal

U.S. government support for increased use of natural gas should help reduce the emissions of greenhouse gases from coal-fired plants. The Department of Energy's natural gas research and development program addresses all aspects of the natural gas sector: production, use, delivery, storage, and environmental and regulatory impacts. The enacted budget for fiscal year 1993 has more than $108 million for all natural gas research and development activities—an increase of 25 percent over fiscal year 1991 appropriations.

An initial effort for coal mines is directed toward demonstrating that flooding coal beds with nitrogen and applying innovative techniques for interpreting reservoir dynamics will increase methane recovery from 30-50 percent under current practices to 70-80 percent. An economic and engineering analysis will be performed to determine the optimum process configuration for application to pre-mine degasification. Parallel laboratory studies will examine the effect of other gases on recovery and the potential for carbon sequestration. If a mixture of gases is found to be superior, additional demonstration testing will be conducted.

About 55 percent of the nation's electricity is produced from coal. Since 1987, the federal government has supported a multibillion-dollar, multiyear *Clean Coal Technology* demonstration program. Whereby it pays up to 50 percent of the costs of selected projects that test emerging technologies on a commercial scale. Participating private-sector firms pay the remainder of the project costs. In the aggregate, these advanced technologies will greatly reduce greenhouse gas emissions by improving energy efficiency.

The EP Act directs the federal government to consider extending this demonstration program specifically for projects that can achieve greater efficiency than commercially available technologies in converting coal to electricity and in controlling emissions. The new projects should produce technologies that will be available for commercial use by 2010.

Electricity: Competition and Distribution

The EP Act also amends the Public Utility Holding Company Act and the Federal Power Act:

- To encourage competition in wholesale electric power markets through the expanded use of independent power producers.
- To reduce restrictions on access to electricity transmission facilities and services.

By allowing all resource options to compete fairly in meeting the economy's need for energy, these provisions may enhance the development of renewable, natural gas, nuclear, and energy-conservation technologies for transportation and electricity production. As a result, CO_2 emissions should be reduced.

The U.S. system for transmission and distribution of electricity operates at an efficiency-loss rate of 8 percent. The EP Act directs the Secretary of Energy to evaluate the potential for cost-effectively saving energy by upgrading existing utility distribution transformers. Core losses from transformers currently amount to approximately 2 percent of all electricity distributed by U.S. utilities. This action will complement existing R&D programs in power electronics, materials and electricity storage, and efficiency.

In addition, the United States will complement this study with a voluntary EPA Amorphous-Core Transformer Program, which will organize mass purchases of amorphous-core transformers. The amorphous technology provides an average savings of 60-70 percent over new silicon transformers and 80-85 percent over old "high-loss" transformers. The program is expected to achieve a total market penetration of 25 percent by the year 2000, saving 9.0 billion bkWh annually and reducing 1.9 MMTs of carbon emissions.

Changes in Agriculture, Forests, and Land Use

Responsible resource management is a longstanding tradition in the United States. U.S. policies over the last century have steadily added value to lands that produce both commodities and environmental benefits. After declining over three centuries, forest cover has been effectively stabilized since the beginning of the 20th century. Annual forest growth now exceeds harvest by 37 percent, and total wood volume is 25 percent larger than it was in 1952. U.S. agricultural policy, especially since the 1980s, has been reoriented to reduce commodity-support programs for crop production and to integrate environmental goals with commodity production. Recent U.S. actions will improve the state of the U.S. land base and will also reduce greenhouse gas emissions. While some uncertainty exists, the continuation of these programs at anticipated levels is conservatively estimated to have an aggregate effect of expanding the carbon sink by 5-9 million tons in 2000.

Analyses of greenhouse gas and economic benefits associated with current U.S. forest, agriculture, and other land-use actions rely on information from the most recent national assessments of forest and agricultural land use in the United States (conducted every five to seven years). The land-use assessments have identified multiple benefits for resource conservation programs under way for reasons not related to greenhouse gas emissions, but that will contribute to expanding U.S. carbon sinks.

Several land-use management programs jointly affect both the forest and the agriculture sectors. To fully account for shifts in timber and agricultural production, the land use needs to be assessed as a comprehensive set of resource management programs. The 1995 assessment will evaluate future federal and private land-management resources that will both enhance the renewable resource base and expand carbon sinks.

Recycling Forest Products

Increasing recycling of forest products, such as paper, shifts the demand to other products and contributes to standing timber inventories. This expands carbon sinks on forest land. Changes in recycling are not the result of major federal action. Rather, changes have been stimulated by voluntary recycling programs, changes in consumer preferences, minimum recycled fiber contents, and industry commitments. These actions are expected to increase substantially over the next decade. The American Paper Institute has set a goal of 45 percent paper recycling by 1995.

America the Beautiful

The President initiated the *America the Beautiful* program in 1990, with the goal of planting one billion trees a year. The rural component of this program, funded at roughly $32 million a year, shares the cost to private land owners for developing improved wildlife habitat, enhanced recreational opportunities, and woodland management on nonindustrial private forest lands.

The urban tree component of the America the Beautiful program, currently funded at $20 million a year, promotes urban forest research and tree planting, and has a goal of planting 30 million trees a year. Urban tree planting successfully integrates volunteer programs and local community programs with federal and nonfederal organizations. A voluntary program called *Cool Communities* plans to demonstrate the potential for energy conservation through strategic landscaping and urban tree planting. The program's long-term goal is to increase the amount of tree cover by 10 percent in 50 "cool communities," thereby increasing carbon sequestration and reducing emissions through reduced air-conditioning demand (Figure 26).

Conservation Reserve Program

The Conservation Reserve Program was established as a ten year effort in 1985, to convert 40-45 million acres of highly erodible and economically marginal crop land to conservation uses. The program allows landowners to remove acres from agricultural production for ten to fifteen years, in return for an annual conservation lease payment and cost-sharing of land-conversion costs.

Over the past seven years, 35.4 million acres of crop land have been converted to conservation uses in the program, including 2.3 million acres planted with trees.

Conservation Tillage Provisions

Provisions of the 1990 Food Security Act promote conservation tillage practices. Conservation tillage reduces soil erosion and water runoff and increases carbon storage in the soil. The Act makes eligibility for farm income stabilization programs contingent on the development and implementation of conservation plans on tracts of land deemed highly erodible.

Conservation tillage practices were applied on over 79 million acres during 1991. The recent upward trend of high-residue conservation tillage systems is expected to continue, as farmers adapt their practices to meet the conservation compliance provisions.

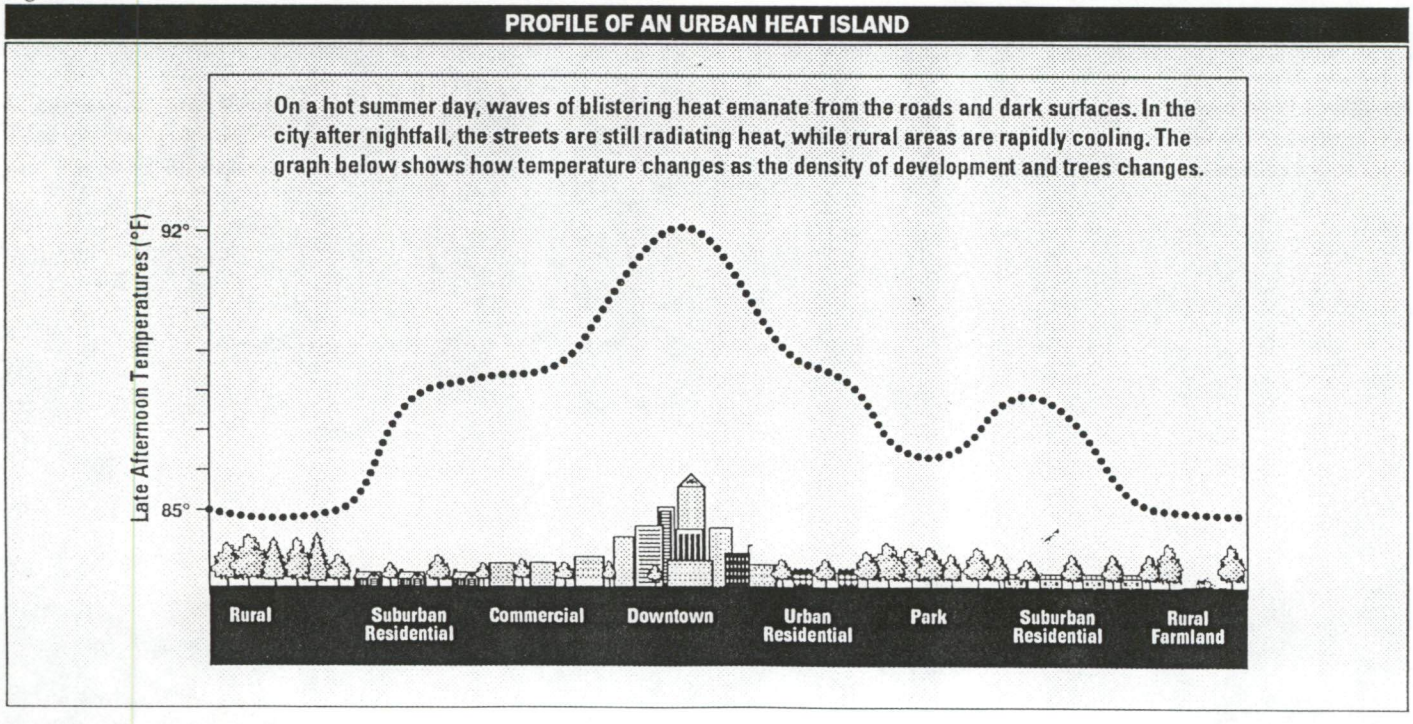
Livestock Waste Management Program

The Livestock Waste Management Program is conceived as a program to encourage the recovery of methane from dairy and swine farms for energy use on those farms. This program will be used to enforce air- and water-quality regulations. In many areas of the United States, livestock manure is handled in liquid manure management systems that are conducive to anaerobic fermentation, thus producing methane. Covered manure holding ponds can be used as part of these systems and have proven to be economical for large dairy and swine operations. The methane collected can be used on the farm for power generation or other purposes.

This National Action Plan assumes that methane recovery will be applied to the livestock manure of about 10 percent of U.S. dairy cows (representing 1 percent of U.S. dairy farms) and 8 percent of U.S. swine (3 percent of swine farms) by 2000.

In the base case estimate for 2000, U.S. livestock waste emissions will reach 2.5 to 5.5 Tg. The Livestock Waste Program will reduce emissions by about 1.2 Tg of methane, equivalent to 7 MMTs of carbon.[1]

Figure 26



[1]Assumes a methane global warming potential of 22, where CO_2 is 1.

Other National Mitigation Actions

In addition to carbon dioxide, other important greenhouse gases are included in the National Action Plan. In the United States, particular attention has focused on developing options for reducing emissions of methane and nitrous oxide.

Methane Reduction and Recovery

As noted earlier in the section on the U.S. inventory of greenhouse gases, methane is a large contributor to potential global warming, second to carbon dioxide. In 1990, methane is estimated to have contributed about 18 percent to global radiative forcing. Methane's overall contribution is large because it is a potent greenhouse gas. Furthermore, methane concentrations in the atmosphere are rising at rates greater than those for CO_2.

Municipal solid waste landfills are the single largest source of methane, accounting for about 40 percent of the total, with estimated emissions of 13.5 MMTs of methane. Other important sources are domesticated livestock (6.7 MMTs), coal mining (4.5 MMTs), and production, industrial processes, and land-use changes (3 MMTs). In 1990, U.S. activities produced about 36 MMTs (205 MMT carbon equivalent) of methane in the United States, or about 70 percent of total methane emissions.

Methane released by human activities is generally a wasted resource. This opens the door for low-cost, if not profitable, emission-reduction opportunities. Because methane is the primary constituent of natural gas, it can be collected as it is emitted from several sources and can be used for fuel for power generation or direct industrial and residential use.

Landfills

In the United States, methane emissions from landfills will be reduced by regulations developed to control the emission of nonmethane organic compounds and air toxics. Landfills affected by the regulation will be required either to flare their landfill gas or to burn it as fuel for power generation or other purposes. The regulation will apply to all landfills that produce at least 150 Mg of nonmethane organic compounds per year. Comments were also requested on two more stringent versions of the rule—levels of 100 Mg and 25 Mg.

The National Action Plan assumes the adoption of the 150 Mg version, under which about 6 percent of existing landfills and 9 percent of new landfills will be affected by 2000. This will reduce methane emissions by about 6.5 million MMTs—equivalent to 39 MMTs of carbon. These reductions represent about 50 percent of projected total emissions from U.S. landfills (assuming a 13-MMT baseline for methane emissions).

Coal Mining

This program will facilitate the expanded recovery and use of methane from coal mining activities by removing legal and technological barriers. Strategies include promoting the expanded use of degasification technologies and developing incentive programs from the use of recovered methane.

The U.S. government is calculating emission reductions resulting from the reduced coal use forecast under the National Action Plan and from actions taken by coal mines to sell or use the methane recovered by degasification systems instead of venting it to the atmosphere. The base case assumes that in 2000, U.S. coal mines will emit 5.1 to 7.6 Tg (6.4 Tg mid-point) of methane.

The National Action Plan also assumes that 4 percent of underground mines will use methane-recovery techniques by the year 2000. Estimated reductions of up to 6 MMTs of carbon-equivalent emissions in the high case.[2]

Reducing N_2O from Nylon Manufacturing

Nitrous oxide was estimated to account for about 5 percent of global radiative forcing in 1990. It is a potent greenhouse gas, with a global warming potential of 270

[2]Assumes a methane global warming potential of 22, where CO_2 is 1.

over a 100-year period. In comparison, the global warming potential for carbon dioxide is 1.

At present, specific sources and emission rates of nitrous oxide are poorly documented and subject to great uncertainty. The most important sources are considered to be biogeochemical processes in fertilized sources; combustion processes, such as savanna and forest burning, fuel-wood burning, and fossil fuel combustion; and industrial processes related to such industries as nylon production. U.S. nitrous oxide emissions, although uncertain, were estimated to be about 0.3 to 1.2 MMTs in 1988 (8 to 12 MMTs carbon equivalent).

The Nylon Manufacturing Program is a voluntary U.S. industry program aimed at eliminating U.S. nitrous oxide emissions from the production of adipic acid during nylon manufacturing. Besides eliminating emissions of nitrous oxide and using reductive furnaces and recycling technologies in adipic acid plants, this technology can save energy and enable the recycling of by-products. Several U.S. companies have already installed or have committed to installing such furnaces.

The National Action Plan assumes that several major adipic acid producers in the United States will implement this technology by the year 2000, and thus reduces U.S. nitrous oxide emissions from adipic acid production by 50–75 percent. This effort will reduce total U.S. nitrous oxide emissions by about 0.11 to 0.16 MMTs each year by the year 2000, or about 8 to 12 MMTs carbon equivalent.[3]

State Mitigation Programs

Reforestation and Tree Planting

States can promote carbon sequestration through reforestation programs. For example, Arkansas, North Dakota, California, and other states promote urban and/or residential tree planting programs that reduce CO_2 emissions and energy consumption while emitting high levels of nonmethane hydrocarbons. Missouri has a strategic landscaping program for public and nonprofit organizations to cut energy consumption. Connecticut requires applicants for air-discharge permits to offset CO_2 emissions by planting trees or turf grass. And in Iowa, state utilities are required to include tree planting as part of the comprehensive energy-efficiency plans they submit to the state board.

Strategies for Reducing CFCs

Under the Clean Air Act, CFCs are to be phased out by the year 2000. But states still can take some interim steps to reduce CFC use. For example, Florida, Hawaii, and Maine restrict the sale of products manufactured using CFCs. A California regulation tightened emission standards for aerospace companies and required recycling of ozone-depleting CFCs and phasing out of CFCs and halons by January 1, 1997. Another approach used by New York, Minnesota, Vermont, and Oregon promotes CFC recovery and recycling, especially from refrigerators and automobile air conditioners, through regulations and economic incentives.

Other State Activities

States can reduce greenhouse gases through recycling, product bans and restrictions, and waste disposal regulations. For example, many states are developing both mandatory and voluntary programs to increase recycling. Others are implementing programs to encourage methane collection and recovery from landfills. States also can reduce greenhouse gas emissions by encouraging green labeling and other public education programs (Table 18).

[3]Assumes a nitrous oxide global warming potential of 270, where CO_2 is 1.

Table 18

STATE MITIGATION POLICIES

Goals	Implementation Mechanism
Agriculture	
Improve livestock management	Encourage collection and conversion of methane from livestock waste.
	Provide incentives to encourage methane recovery from existing anaerobic lagoons that store manure.
	Research the potential to reduce methane emissions from enteric fermentation.
Improve energy efficiency	Provide technical assistance for evaluating irrigation and other agricultural systems.
Improve agriculture management	Limit the use of nitrogenous fertilizers and promote soil conservation practices.
Forestry	
Promote reforestation programs	Provide tax incentives for individuals to plant trees.
	Create municipal grants to encourage citywide tree planting.
	Fund tree planting by state and local agencies and volunteer organizations.
	Require CO_2 offsets.
Improve forest management	Promote sound forest management practices by private landowners.
Waste Minimization	
Promote recycling	Provide tax incentives for recycled material use and require state and local governments to purchase recycled products.
	Evaluate, design, and implement advanced disposal fees.
	Design and implement variable collection rates (e.g., inverted block rates–the more you dispose, the higher the fee).
	Encourage green labeling.
Reduce methane emissions from landfills	Create more stringent landfill gas monitoring requirements.
	Encourage upgrading landfill gas for use as a substitute for fossil fuels.
	Encourage diverting non-toxic, compostable materials from landfills.
	Require local air quality districts to comply with suggested measures put forth by the California Air Resources Board to collect and process landfill gas.
Reduce CFC emissions	Accelerate CFC phase-out beyond the schedule established by the Montreal Protocol and the federal Clean Air Act.
	Place restrictions on the use of substitute CFC chemicals with high infrared absorbing materials.
	Establish rules to regulate the safe recovery of CFCs "banked" in appliances, machinery, and other products prior to disposal.
	Require state and local agencies to restrict the purchase of CFC-containing products.

Estimating Reductions in Emissions

A key feature of the National Action Plan is its careful attention to credible methods for estimating the effects of policies. The method used to quantify the effects of the actions described above consisted of the following principal steps:

- Develop baseline projections of future energy markets to provide an analytical starting point of carbon emissions.
- Analyze each option described above independently.
- Integrate these options within a modeling framework.

Development of Baseline Energy Projections

A set of baseline projections of future energy markets was established using many independent model results and analyses. Because the function of this baseline is to provide a starting point for analyzing the potential of the options for reducing CO_2 emissions, the projections assume no changes in current 1990 U.S. energy policies. As such, the baseline is characterized as the "No Further Policy Action Case," or simply the "No Action Case."

These projections are based upon a set of specific assumptions about markets, technologies, and resources, such as GNP growth rates and oil and gas prices. There are basically four types of assumptions underlying the projections:

- Economic factors, which include GNP growth rates, world oil prices, and other assumptions.
- Energy resources, which include proved reserves and undiscovered resources.
- Behavioral factors, which assume energy consumers minimize energy costs to meet energy demand or supply.
- Technology factors, which include information on the costs of energy-consuming and -producing technologies, their performance, and when they will be commercially available.

In this analysis, the GNP growth rates are assumed to be 1.8 percent between 1990 and 1995, and 2.8 percent per year between 1995 and 2000. This is called the "Central GNP Case." The Central GNP Base Case, expressed in 1990 dollars, assumes the following future prices for oil and gas:

Energy Source	1995	2000
oil ($/barrel)	$21.07	$26.07
gas ($/MCF)	$2.13	$2.51

However, the key assumption in these projections is no change in federal policies. This clearly will not happen, especially over an eight- or ten-year time horizon. Thus, these projections, which provide a point of departure for analysis of energy policy options, paint only one portrait of the future.

The No Action Case was developed with the aid of diverse analytical tools and the judgments of numerous experts both within and outside the Department of Energy. The starting point for this case was the *1990 Annual Energy Outlook* "base case forecast" (U.S. DOE 1990a). Detailed sector- and fuel-specific models maintained by the national laboratories of the Energy Information Administration and Department of Energy were used to generate independent projections for demand and supply. These independent projections were then integrated through the Department of Energy's FOSSIL2 U.S. energy model to provide price and to quantity the feedbacks among sectors to clear energy market results (U.S. DOE 1991). However, the economic growth rates and natural gas protections used for this exercise were lower than those used to formulate the National Energy Strategy as the basis for the *1990 Annual Energy Outlook*.

To maintain internal consistency, information developed with the detailed models, including underlying assumptions and projected changes in market structure, was transferred to the integrating model, FOSSIL2, by calibrating the structure of the integrating model. Through this type of information sharing, consistency was maintained among the models, despite some inconsistencies among them. The sector- and fuel-

specific results of this integration process were then applied in the detailed models to check the results.

Stand-Alone Analysis of Options

The options selected for analysis cover a broad range and will affect virtually every fuel- and energy-consuming sector of our economy. Options were analyzed by groups of experts from the national laboratories, the Environmental Protection Agency, the Department of Energy, and other federal agencies. Because of the differences in energy type, sector structure, and the nature of problems facing each sector, these groups selected models or other methodological approaches best suited for the examination of each individual option. Therefore, many different models and other tools were used to evaluate the impacts of National Energy Strategy options on specific energy markets. These models and tools were not necessarily the same as those used to develop the No Action Case, because many of those initial tools lacked sufficient policy detail to be useful for these analyses. Consistency among the tools was maintained by using the detailed assumptions and results of the No Action Case. Table 12 presents the independent estimates of the effects of the actions selected as part of the National Action Plan.

These projections are sensitive to assumptions regarding energy prices, economic growth, and technology penetration, and will change as these factors change and as the effects of current actions are seen. The actual carbon-equivalent reductions could be substantially higher or lower than these figures. Market penetration assumptions, in particular, are very sensitive to the availability of capital for these new technologies, investment tax policies, etc. Also, they do not include the results of U.S. joint implementation actions discussed at the end of this chapter, since their effects have yet to be reliably quantified.

U.S. Views (DOS 1992) is based on the National Energy Strategy and the FOSSIL2 modeling system that was used as part of the strategy to project and quantify the impacts of programs and legislation. However, in compiling *U.S. Views,* many program estimates were made exogenously from the modeling environment. As a result, many of the energy marketplace adjustments that are captured endogenously by the model were omitted. Recognizing this, a number of exogenous adjustments were made in *U.S. Views* to compensate for marketplace actions that would occur when these programs are implemented. These adjustments are shown in Table 14.

Some of the savings from the actions additional to the National Energy Strategy are already accounted for in Table 15 under the National Energy Strategy. For example, the EP Act contains requirements for building shell efficiency standards, while the additional actions call for improvements in heating, ventilation, and air conditioning equipment. Full credit for the building standards and equipment improvements could not be taken for both the additional actions and the strategy. Thus, the table identifies the overlap with the italicized numbers and subtracts them. The overlap for all measures was estimated to be 116 billion bkWh and 24 MMTs. This figure was determined based on an assessment of each additional action in comparison to the National Energy Strategy.

Another adjustment is needed to account for changes in consumer behavior that might occur as a result of the additional actions. More specifically, consumers might decide to increase their desired level of energy services as a result of the additional actions. This adjustment, or "rebound," can occur for two reasons. First, the reduced demand for electricity might cause prices to drop and, therefore, might provide an incentive for increased consumption. Second, lower electric bills will leave consumers with more money to spend on additional energy services. For example, with greater market penetration and use of advanced heat

Table 14

PROJECTED CO_2 EMISSION REDUCTIONS FOR 2000

CO_2 Mitigation Actions	Emission Reductions (MMTC)	Electric Energy Savings (BkWh)
Actions in NES Proposals		
Efficiency improvements and integrated resource planning		
Natural gas regulatory reform		
Expanded use of biofuels		
R&D for renewables, transportation, and energy efficiency		
Provides framework for additional actions (Table 3)	45	128
Additional Carbon Actions (from Table 3)	75–108	306–429
NES Overlap	*24*	*116*
Consumer Response to Lower Prices[1]	*8*	*38*
Carbon Sinks "America the Beautiful" and other forestry programs	*5–9*	
Total Net CO_2 Reduction	**92–130**	

Note: Italicized numbers are subtracted to avoid double counting.

[1] This value (12–20 percent of the electricity savings) is included as an adjustment for increases in demand for energy services that will result as the introduction of these efficient technologies lower consumer costs. The actual "rebound" effect may vary significantly from this value.

Source: *U.S. Views* (DOS 1992)

Table 15

REDUCTIONS IN CARBON EMISSIONS FROM ADDITIONAL ACTIONS IN 2000

Mitigation Actions	Potential Technical Improvement %	Market Penetration %	Electricity Savings (BkWh)	Carbon Reductions (MMT)
Residential/Commercial Sector				
Green Lights/DSM/Standards				
Residential	75	27	23.4	4.9
Commercial (includes industrial)	65	25–62	81–203	17.0–50.1
Green Buildings/Standards	53	17	41.9	8.8
Residential Heating and Cooling				
Advanced heat pumps	20	2–3	1.8	2.5
Residential space heating				
– New	20	8		
– Old	10	10	2.4	0.5
Central air conditioning	29	40	9.6	2.0
Room air conditioning	19	40	1.2	0.3
Improved refrigerants	5	80	8.2	1.8
Residential Appliances				
Standards	NA	NA	22.2	4.7
Golden Carrot™ refrigerators	57	3	3.0	0.6
Clothes washers	96	3	1.3	0.3
Clothes dryers	65	3	1.2	0.3
Residential Water Heating				
Low-flow showerheads/standards	58	11	10.2	3.4
Solar thermal water heaters	70	2–3.5*	4.8	1.4
Energy Star Computers	57	65	26.3	5.5
Cooking				
Residential	8	40	1.2	0.3
Commercial	20	30	1.8	0.4
Miscellaneous End Uses	13	40	15.0	3.1
Industrial Sector				
Green Motors/Standards	30	16	39.5	8.3
Electrolytics	20	13	1.8	0.4
Transportation Sector				
Tire Inflation, Auto Inspection, and Maintenance, etc.	NA		NA	3.0
1991 Transportation Act (ISTEA)	NA	NA	NA	4.0
Electricity Utility Sector				
Amorphous-Core Transformers	70	25	9.0	1.9
Subtotals: Gross Additional Carbon Actions			**306–429**	**75–108**

Note: These impacts reflect the effect of the additional actions together with utility demand-side management programs and the efficiency standards of the Energy Policy Act of 1992. NA means not applicable.

* Homes with gas heaters (2%) and homes with electric heaters (3.5%).

Source: *U.S. Views* (DOS 1992)

SAMPLE METHOD FOR DETERMINING EMISSION REDUCTIONS

Analysis of the impact of the Intermodal Surface Transportation Efficiency Act (ISTEA) on greenhouse gas emissions requires investigation of at least three issues.

- *First, a judgment must be made about the likely response of states and cities to funding options and air-quality restrictions contained in ISTEA and in the Clean Air Act Amendments. What will the money be used for? Leading transportation planners and practitioners were asked to forecast the types of projects likely to emerge from ISTEA. They attributed to ISTEA the construction of nineteen new rail transit systems, mostly light rail. They also projected, given the requirements of the Clean Air Act Amendments, a proliferation of mild transportation control measures, such as high-occupancy vehicle lanes, ramp metering, and signal computerization. Twelve larger cities with high records of vehicle miles traveled and severe air-quality problems are projected to implement firm measures, such as parking fees and reductions in employers' parking subsidies. Road pricing, a very stringent measure, was not considered in the analysis.*
- *Second, these actions must be translated into reduced vehicle miles traveled (VMTs). Although it was assumed that the rail systems would reduce traffic on the nation's most congested roadways, they were not found overall to lead to very large reductions. In an effort to be conservative, this analysis excluded possible VMT and emission reductions from the construction of mass transit. Other measures described above are expected to have a significant impact on VMTs. The expected series of transportation control measures is projected to reduce national VMTs by 1.4 percent. (In scenarios where states and cities adopted more stringent measures, VMTs declined by as much as 5.7 percent.)*

  Of course, ISTEA funds will also be used to expand highway capacity. In accordance with the conformity requirements, however, it was assumed that any increased highway capacity will have a neutral effect on emissions. In the short term, new road capacity relieves congestion and increases travel speed, thus reducing fuel use and CO2 emissions of carbon dioxide. However, in the long term these conditions attract more drivers. Thus, for the purpose of this study, these effects were assumed to cancel.
- *Third, VMT reductions must be translated into greenhouse gas emission reductions. Emissions from transportation have essentially a linear relationship with the quantity of fossil fuel used. After accounting for the effects of changes in average fuel economy (miles per gallon), a relationship can be shown between CO_2 emissions and VMTs. This relationship was used to determine the overall emission reductions from ISTEA. Given the strength of the Clean Air Act's requirements, the likelihood that firm Transportation Control Measures will be more widely adopted than assumed here, and the setting aside of any reductions resulting from the expansion of mass transit, the projected CO2 emission reductions may be considered conservative.*

pumps, heating bills will be lower, and consumers may raise their thermostats a few degrees. Rebounds can occur for almost any of the additional actions listed. To compensate for this effect, potential energy savings/reductions were reduced by 12-20 percent. The actual rebound effect may vary significantly from this estimated value.

Ideally, all of the additional actions contained in *U.S. Views* would be incorporated in an integrated energy model where they compete against other options in a changing marketplace. However, time did not allow for this type of analysis.

Integration of Options

Most energy policy options affect more than one sector or fuel; changes in one sector often affect fuel prices, which in turn affect energy demand and supply in other sectors. In addition, policy options usually do not work in isolation from other options; some options work in tandem, while others have overlapping impacts. Therefore, capturing interactions among energy prices, supply, demand, and policies is essential. As noted above, the Department of Energy's FOSSIL2 model is used to perform the integration analysis.

The effects of supply-side actions on demand and prices are straightforward. Supply actions that increase the production of oil, gas, renewables, and nuclear power are projected to lower energy prices and raise energy demand. In general, supply actions that generate electricity (e.g., renewable and nuclear) are projected to displace the use of coal, oil, and natural gas in electricity generation. Supply actions, such as advanced oil and gas production, are projected to lower prices and raise demand for oil and gas. The overall effects of the supply actions are higher supply, lower prices, and higher demand.

On the demand side, reductions are achieved by imposing efficiency standards (building standards, lighting standards, and motor standards), using market

incentives (integrated resource planning), and improving energy efficiency through research and development. All of the demand-side actions interact with supply-side actions in a manner that could either offset or reinforce reductions. The aggregate effect of actions is not the simple summation of their estimated individual effects. It was found that:

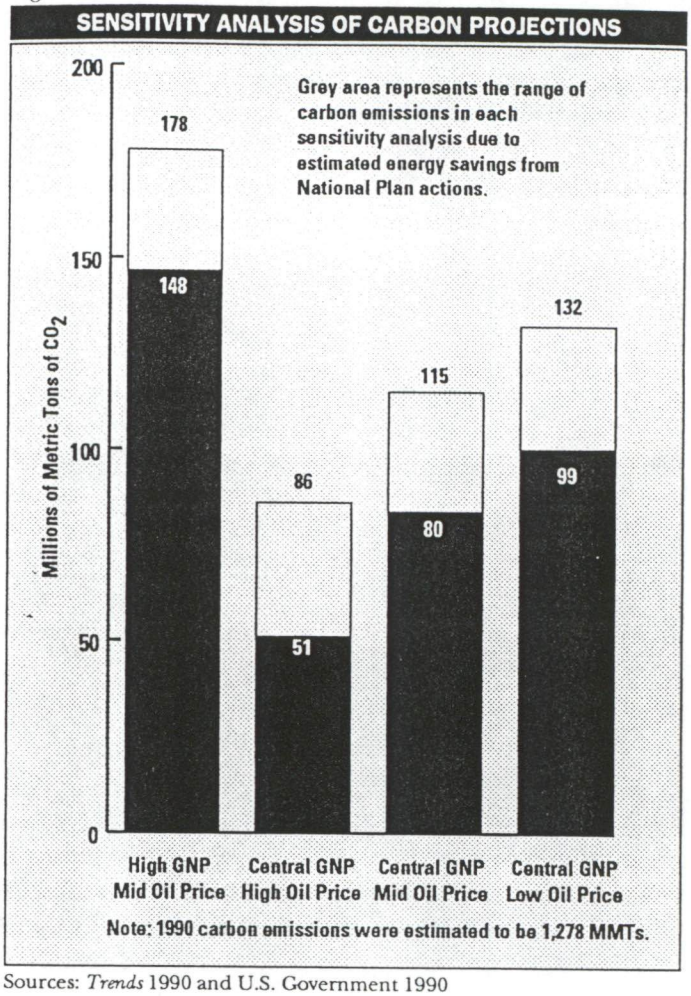
- Standards will force consumers to use more energy-efficient equipment. As a result, demand for energy will decrease.
- Integrated resource planning (IRP) encourages conservation, regardless of whether there are standards. IRP programs are projected to increase in effectiveness over time due to projected higher energy prices. If an IRP program encourages consumers to adopt a technology that is equal to or more efficient than the standards, the benefits prescribed by the standards will be reduced. This reduction increases over time as technology improves and energy prices rise. Consequently, the independently derived effects of standards and IRP cannot be added.
- Research and development measures, however, reinforce the benefits of IRP and have positive effects on energy conservation. They will improve energy efficiency, lower the costs of conservation, and make IRP a more attractive choice because it increases the return on conservation.

As noted, assumptions about economic growth and energy prices are incorporated in the model runs. The results of the model presented in Tables 14 and 15 are compared with those generated by the model under somewhat different assumptions in Figure 25. The figure shows the effect on carbon emissions of increasing the economic growth rate assumption and of increasing and decreasing the world price of oil.

The No Action Case is one of many possible projections of future U.S. energy markets. It is based on an extensive set of assumptions regarding economic growth rates, world oil prices, U.S. energy resources, and costs and performance characteristics of energy-consuming and -producing technologies.

Economic growth rates and the level of world oil prices are two key factors that strongly affect both domestic demand and supply of primary energy and, consequently, carbon emissions. Assumed economic growth rates determine the future gross national product (GNP), which reflects the level of various economic activities (e.g., commercial growth, industrial production, and travel). All of these economic activities demand energy. In general, higher GNP is associated with higher energy demand. Assumptions about the world oil price over time are based on implicit assumptions about the availability of world petroleum reserves. Larger-than-expected petroleum reserves could be translated into lower world oil prices in the future. Consumption, related closely to oil prices, could increase significantly.

Figure 25



Sources: *Trends* 1990 and U.S. Government 1990

Figure 25 shows the effects of the following three assumptions on carbon emissions in 2000 compared with the 1990 level:

- High Economic Growth—assumes GNP growth rates are 2.5 percent between 1990 and 1995, and 3.6 percent between 1995 and 2000.
- Low World Oil Price—assumes oil prices are $19.87 and $18.97 per barrel in 1995 and 2000, respectively (1990 dollars).
- High World Oil Price—assumes oil prices are $26.44 and $32.56 per barrel in 1995 and 2000, respectively (1990 dollars).

Table 16

PROJECTED GREENHOUSE GAS LEVELS FOR 2000

Greenhouse Gas	MMTC Equivalents	MMTC Equivalents for $ GNP
Carbon	1,355–1,395	0.196–0.202
Nitrous Oxide	59–63	0.009
Methane	95–98, 182–188	0.014, 0.026–0.027
Total	1,500–1,545, 1,590–1,638	0.217–0.223, 0.230–0.237

Note: Methane double range due to GWP = 11 and GWP = 22; U.S. GNP in 2000 = $6,919 billion (1990$).
MMTC = millions of metric tons of carbon equivalent.

Source: *U.S. Views* (DOS 1992)

The Central GNP case, reflecting the values in Tables 14 and 15, shows a range of carbon emission increases between 80 and 115 MMTs. For the High GNP growth rate case, carbon emissions are projected to increase to 148–178 MMTs in 2000. This reflects the result of increased economic activities associated with higher economic growth. For the High Oil Price case, carbon emissions are projected to increase to 51–88 MMTs. Increases in carbon emissions for this last case are the smallest among all four cases because the high prices choke off demand. On the other hand, in the Low Oil Price case, carbon emissions are projected to increase to 99–132 MMTs.

The results from this sensitivity analysis show that increases in carbon emissions in the year 2000 from the 1990 level can range between 51–178 MMTs. This range reflects some of the uncertainty regarding future economic growth rates and crude oil prices. Clearly, other factors could also affect the projected carbon emissions.

There are a variety of ways to represent the contribution of U.S. greenhouse gas emissions. In contemplating projected greenhouse gas emissions, one needs to consider the overall economic activity, the composition of that activity, and a measure of efficiency. Table 16 presents the absolute level of the emissions of these gases, as well as the relative size of their emissions to gross national product. Table 17 presents their level and relative position in the transportation sector. Table 17 also presents emissions resulting from electricity generation. Furthermore, this table presents the ratios of total electricity sales to GNP and of the total vehicle kilometers traveled to GNP and population.

Table 17

STATISTICS FOR VIEWING U.S. ENERGY USE IN 2000

Variables	Units of Energy
Transportation	
VKMT for Light-Duty Vehicles	3,360 billion km
Transportation-Related Carbon Emissions	382 MMTC
Emissions/VKMT	0.11 MMTC
VKMT per Billion Dollars of GNP	0.49 billion km
VKMT per Capita	12.49 billion km
Electricity	
Electricity Sales	3,461 BkWh
Residential + Commercial Carbon Emissions	141–150 MMTC
Emissions/Electricity Sales	0.04 MMTC
Industrial Carbon Emissions	80–83 MMTC
Emissions/Electricity Sales	0.02 MMTC
BkWh/GNP	0.50 BkWh

Note: VKMT = vehicle kilometers traveled.
MMTC = millions of metric tons of carbon equivalent.
U.S. Population in 2000 = 269 million.

Source: *U.S. Views* (DOS 1992)

Joint Implementation

Since greenhouse gases mix globally, emission limitations achieved anywhere are of global significance. For this reason, the Framework Convention for Climate Change allows parties to the Convention the flexibility to pursue limitations wherever they are most cost-effective. This provides the opportunity for countries to achieve greater total emission reductions than they would if they were confined to higher-cost actions available within their own national borders. It also offers an important avenue for other parties, particularly countries with developing economies and economies in transition, to attract significant investment income.

As with any actions to limit emissions—whether implemented within one country or jointly among parties—it is important that any quantitative reductions claimed be verifiable. Claimed reductions need to be accompanied by transparent supporting analysis and by follow-up to evaluate the success of long-term projects in achieving real emission reductions.

In addition to undertaking many actions at home to meet its commitments under the Convention, the United States is keenly interested in pursuing opportunities for joint implementation. The United States would like to develop cost-effective cooperative arrangements with other countries to limit net greenhouse gas emissions. Title 16 of the Energy Policy Act of 1992 also encourages U.S. private-sector enterprises to support actions abroad as well as at home that limit net greenhouse gas emissions.

Because joint implementation was authorized in the Convention signed in June 1992 (and ratified by the United States in October), and because joint implementation implies an agreement at some level between interested parties (governments) on a joint action, like many countries the United States is only now exploring formal agreements styled as "joint implementation" under the Convention. As joint implementation actions become more concrete, they will be quantified in the National Action Plan, just as domestic actions are currently quantified in this chapter. Allocation of the greenhouse gas reductions achieved will necessarily be worked out among the cooperating parties.

Ongoing efforts are expected to result in several joint implementation actions. Success is especially likely where the actions are cooperatively organized, not just by government agencies, but also with the active participation by nongovernmental organizations (NGOs), including both nonprofit and for-profit enterprises. These NGOs can contribute relevant expertise and international contacts, independent and transparent estimates of the costs and effectiveness of projects, and financial support. They can also assist governments in selecting projects that pose valuable opportunities.

Current activities that appear promising for joint implementation include:

- *The U.S.-Canada Joint Project on Cost-Effective Greenhouse Gas Reduction Strategies* is a cooperative activity by the U.S. Environmental Protection Agency and Environment Canada. Partly under the auspices of the U.S.-Canada Air Quality Agreement and with a view to joint implementation under the Climate Convention, this project seeks to identify the most cost-effective greenhouse gas reduction actions available in both countries.

- With the explicit purpose of advancing joint implementation under the Climate Convention, in June 1992 the *Environmental Defense Fund* (EDF) (a U.S. NGO) and the *Institute of Market Economics* (IME) (a Russian NGO affiliated with the Russian Ministry of Ecology) signed a memorandum of agreement to develop forest conservation projects in Russia that help conserve forest values and sequester carbon. EDF and IME are now developing specific projects. The first project proposal (draft November 1992) is for conservation and carbon sequestration in the threatened forests of the northern Vologda Region. EDF and IME are seeking both public- and private-sector financing for this joint implementation action, and have approached U.S. electric utilities as well as the U.S. government about the Forests for the Future Initiative.

- U.S. companies are also pursuing activities overseas to conserve forest values and reduce net CO_2 emissions. Examples include *Applied Energy Systems*, the *New England Electric System*, and the *Los Angeles Department of Water & Power*.

Additional joint implementation actions may grow out of certain ongoing international assistance efforts. These include the following—many of which are discussed in more detail in the chapter on International Activities:

- U.S. and Russian agencies have formed the *U.S.-GAZPROM Working Group* to identify opportunities for reducing methane leaks from natural gas systems in Russia using U.S. technology.
- In June 1992, the U.S. *Department of Energy* in cooperation with *Siemens Solar Industries-U.S.* signed agreements to promote solar photovoltaic electricity in rural Brazil.
- EPA has begun projects in China to recover coalbed methane from coal mines.
- EPA and private-sector companies are currently exploring an opportunity with India *to improve the feed of Indian dairy cattle* by adding molasses urea block, thus reducing methane emissions.
- AID and EPA have formed a *U.S.-Polish Working Group to reduce methane emissions from coal mining.* The project has completed an inventory that identified the 17 gassiest mines in Poland.

Research Programs

Living in harmony with the earth requires a better understanding of the global system and the deleterious impacts human beings have on it. It also requires learning how society can better accommodate unavoidable global changes. Two U.S. research programs focus on these needs. The Global Change Research Program is a nationally integrated earth-system program that seeks to expand our knowledge of the processes that affect global change and to develop integrated models to predict its effects. The less formally structured Environmental Technologies Research Program aims to develop technologies for reducing greenhouse gas emissions and to formulate adaptive response strategies for reducing vulnerability to global changes. Both programs are summarized here, along with their near-term research activities and their payoffs.

U.S. Global Change Research Program

The U.S. Global Change Research Program supports the needs of the United States and other nations to reduce the uncertainties concerning natural and human-induced changes in the earth's environment. The program is designed to lead to an improved predictive understanding of the earth system for supporting national and international policymakers' needs across a broad spectrum of environmental issues. To fulfill this goal, the program has developed four parallel, but interconnected, research activities:

1. Long-term observations and data and information management.
2. Process research.
3. Integrative modeling and prediction.
4. Policy-relevant scientific assessments.

The U.S. Global Change Research Program is currently funded at $1.4 billion annually and involves 18 departments of the government and executive offices of the President. The scope of the research supported by the agencies in the program reflects a broad interest in and commitment to understanding the potential causes and consequences of climate and global change. The range of earth-system phenomena and environmental issues includes: (1) natural and human-induced changes in greenhouse gases and aerosols and the resultant predicted changes in global and regional climate; (2) depletion of the stratospheric ozone layer by human activities and the resultant increases in surface-level ultraviolet radiation; (3) behavior of the El Niño - Southern Oscillation phenomenon and global climate-weather perturbations; (4) biotic responses to such influences, the possible large-scale changes in vegetative cover that they may induce, and the feedbacks that these may have on further climate change; (5) the impact of human activities on climate and global change, sea level changes, and changing abundance of wildlife species or biodiversity; and (6) economic and social responses to naturally occurring or human-induced changes in the climate system, as well as appropriate mitigative or adaptive strategies.

The planning, coordination, and execution of these research activities are in close association with and in support of the science priorities of the World Climate Research Program and the core projects of the International Geosphere-Biosphere Program and the International Social Science Council. Furthermore, this level of effort will underpin U.S. participation in and contribution to the international assessments related to some or all aspects of global change—e.g., (1) the scientific, impact, and technology-economic assessments of stratospheric ozone depletion that are conducted under the auspices of the Montreal Protocol and (2) the scientific, impact, and policy-response assessments of the Intergovernmental Panel on Climate Change, both carried out by the World Meteorological Organization and the United Nations Environment Programme. U.S. research will also support national

assessments on (1) science issues, such as the local and regional impacts associated with ozone depletion, natural climate variability (e.g., arising from the El Niño - Southern Oscillation phenomenon), and greenhouse warming, and (2) the economic and social costs of these impacts and of potential response strategies. The improved understanding of the earth system is the foundation upon which environmental technologies will be developed to reduce the emissions of greenhouse gases, or to enhance their sinks, or to provide the capability to cope with the effects of global change.

The following sections discuss the four major components of the U.S. Global Change Research Program.

Observations and Data Management

The goal of this component of the U.S. Global Change Research Program is to establish an integrated, comprehensive, long-term program of documenting changes in the earth system and managing the research data efficiently so as to facilitate the rapid advance of its understanding. The research program requires massive quantities of highly diverse data and information to improve our understanding of global change processes. Long-term observations of important physical, chemical, biological, economic, and social parameters provide the critical basis for determining when climate and/or global changes have actually occurred. They also provide the "reality tests" for evaluating models and predictions, as well as identifying new types of processes that must be characterized and incorporated into more representative global models. While space-based technology enables some parameters of the earth system to be measured on the needed global scales, the integrated program strategy also critically depends on long-term ground- and ocean-based observation, as well as on the concomitant data management programs to gather, manage, and share global change data and information.

Near-Term Activities

The major research activities in the near term of this element of the program are as follows:

- Expand the acquisition, and accelerate the delivery to the scientific community, of important global data sets from ongoing satellite missions and ground-based (remote-sensing and in-situ) time series—e.g., atmospheric composition (particularly stratospheric ozone and other chemically and radiatively important trace gases and aerosols, ocean circulation, forest extent and vegetation index, global ocean geoid shape, polar and sea ice extent, and tropospheric temperature distributions and trends.
- Provide new satellite and ground-based data on the distribution and trends of ocean color and circulation, solar irradiance, stratospheric ozone, and sulfur dioxide—all of which will aid the characterization of radiative forcing and responses.
- Accelerate the development of a strategy and a coordinated international plan for the Global Climate Observing System and the Global Ocean Observing System, both of which are first steps to filling an important observational gap.
- Continue to improve the ground-based time-series characterization of ground-level UV-B radiation, chlorofluorocarbon and halon substitutes, and tropospheric ozone and its precursors, which are needed for assessing the degree to which the radiation budget is being perturbed.
- Complete the planning for and begin the implementation of the Environmental Task Force findings for the use of classified data for global change research, which could substantially expand the environmental data available to researchers.
- Implement the Earth Observing System Data and Information System, and initiate the first steps toward a complete Global Change Data and Information System, thereby establishing the pathways by which these large data sets can be obtained and digested by researchers.
- Expand the data holdings in the Global Change Master Directory, which would alert researchers to the wide variety of data available.
- Continue developing the Earth Observing System, now designed to be a set of three medium-sized satellite platforms and two smaller spacecraft. Three Earth Observing System satellites, each designed to fly for five years, will provide a comprehensive land, atmosphere, and ocean data set continuously for fifteen years.
- Complete the development of the quasi-operational, basinwide, atmospheric observing system in the equatorial Pacific, which is designed to support research and prediction of the El Niño - Southern Oscillation phenomenon and its consequences for climate change.

Process Studies

Understanding the processes that govern global change is the second of the major components of the U.S. Global Change Research Program. Along with long-term observations, the characterization of fundamental earth-system processes provides the basic scientific underpinnings of the analysis, modeling, prediction, and assessments that aid policy-relevant decisions related to both natural and human-induced changes of the earth system. Process research involves laboratory studies, small-scale in-situ studies, major field campaigns, and diagnostic modeling of the fundamental science required to understand physical, biological, economic, and social relationships, including important feedbacks. As summed up by the International Geosphere-Biosphere Program: "An important facet of process studies is the synthesis of findings into quantitative models of the process under consideration, which can be tested and also can serve as building blocks in the development of global models."

The U.S. program's process-related research activities consist of the following types of studies:

- *Greenhouse gases, aerosols, and ozone.* Characterization of the processes that influence the atmospheric concentrations of the chemical species and aerosols that directly or indirectly influence the local radiative balance and the global energy balance. These processes include terrestrial and oceanic sources and sinks—both human-influenced and natural—of these compounds.
- *Water, energy, and sea level change.* Investigation of the processes that regulate the global energy and water cycle—namely, those that influence the atmospheric radiation and energy balance, clouds and precipitation, solar forcing, sea ice, sea level, the role of the ocean in climate, and land-surface properties (including hydrology), as well as those that have shaped the paleoclimatic record of these parameters.
- *Ecological systems.* Studies of processes and properties that determine the responses and feedbacks to regional and global climate patterns of terrestrial, freshwater, and marine organisms and ecosystems, at all spatial scales, to changes in climate and ultraviolet radiation.
- *Economics and human interactions.* Economics forms the bridge between the natural sciences and policy in global change. The federal economics research program addresses five major areas: economic forces and climate change, economic impacts and adaptation, the value of information and decision making under uncertainty, the impact of technological change, and policy instrument evaluation. The federal government has now formed an interagency committee for Research on the Economics of Natural Resources and the Environment to coordinate federal research on issues, including climate change. Other aspects of human interactions research include population growth and other social factors influencing greenhouse emissions, and the impacts of global change on human health and well-being.

Near-Term Activities

The major near-term activities of this component of the program are as follows:

- Initiate the Global Energy and Water Experiment's Continental-Scale International Project, which examines the energy budget and hydrological cycle of the Mississippi River watershed.
- Complete the final phases of the Tropical Ocean Global Atmosphere Project's Coupled Ocean Atmosphere Response Experiment activity, and initiate the Central Equatorial Pacific Experiment. Both will improve understanding of this major component of the climate system and will enhance the testing of the validity of the tropical "thermostat" hypothesis.
- Implement the World Ocean Circulation Experiment field program. The start of this activity is critical to meeting the overall objective of a "snapshot" of oceanic circulation, including heat and mass transport of global oceanic circulation, which is a major factor in predicting the timing of a greenhouse gas warming.
- Initiate the international Global Ecosystem Dynamics project in the North Atlantic, which examines the relationship between oceanic physical and biological processes that govern how the recruitment of marine fish and zooplankton are linked to climate change.
- Focus global carbon cycle studies on identifying the sinks of the "missing carbon." An improved understanding is essential to better predictions of the future atmospheric carbon dioxide abundances that result from specific emission scenarios.
- Further integrate the stratospheric ozone research conducted in laboratory studies, field observations (such as the 1994/95 Southern Hemisphere campaign), and model results to obtain a more reliable assessment of global ozone trends, including the

effects of polar-ozone and in-situ processes on global ozone, the potential ozone-depleting effects of high-speed passenger aircraft, and the relationship of lower-stratospheric ozone loss to climate change.

- Expand the research on the processes and global trends in atmospheric aerosols to improve the understanding of the net role of greenhouse gases and aerosols in global warming.
- Increase the emphasis on understanding the formation of global tropospheric ozone, focusing on quantifying human-influenced ozone production in the Northern Hemisphere (e.g., the international North Atlantic Regional Experiment), the role of biomass burning, and the quantification of the indirect radiative role of some greenhouse gases.
- Expand the understanding of cloud radiation, snow/ice albedo, aerosols, and water vapor and other feedback processes, and conduct model comparison studies to help further develop and assess the representativeness of state-of-the-art general circulation models.
- Develop new Land Margin Ecosystem Research sites; initiate experiments on vegetative species and ecosystem responses to increased temperatures and/or atmospheric carbon dioxide levels; continue to develop vegetative-response models on landscape, regional, and continental scales; and establish ties between the U.S. program and similarly focused international programs on terrestrial and coastal ecosystems.
- Address paleoclimate studies on processes that cause decade-to-century-scale changes. Use the studies to compare general circulation model outputs with recorded historical data.
- Focus economics and other human-dimension research activities on analyses of how human activities affect natural processes and how individuals and economic, social, and other institutions perceive and respond to changes in natural conditions.
- Focus economic research on technical innovation and the likely paths and consequences of technical change in the economy. Determine economy-wide costs of a shift to more energy-efficient processes and devices.
- Focus economic research on decision making under uncertainty and the value of information. Assess critical scientific uncertainties on which future policy decisions will rest. Determine the costs and benefits of waiting to make large, irreversible investment decisions, and evaluate trade-offs among health, safety, environmental protection, and market goods.

Integrative Modeling and Prediction

The third (and major unifying) component of the U.S. Global Change Research Program is building a predictive understanding of the behavior of the earth system on the time scales of primary interest to humans—namely, those ranging from seasons, to decades, to centuries. Indeed, the development and use of integrative models as the central tool for relating individual research projects meaningfully to one another and for achieving constantly improving predictive insight into earth-system behavior is one of the primary objectives of the program in the near term. As noted above, the success of this endeavor will depend critically on (1) how well the key earth-system processes are being characterized so that they can be incorporated into models and (2) the comprehensiveness of global observations (including paleoclimatic records), against which the model predictions can be compared and, hence, evaluated. Furthermore, because of the integrative nature of diagnostic and predictive modeling, a substantial degree of organization is required at the national level to pull together the results of the far-flung research activities that must be embodied and to provide unified and improved predictions at regular intervals.

While the overall focus of the program's integrated earth-system modeling and prediction effort is to develop comprehensive global models and exploit them for regular predictions, this broad-scale endeavor has distinct components and will most likely occur in stages. Virtually every major process study in the program has or will have an important modeling component. These process-oriented, diagnostic and predictive models are the building blocks of larger, integrated earth-system models. Furthermore, special attention is required not only for an increase in traditional disciplinary modeling activities in the natural sciences (i.e., increased depth), but also for a deliberate expansion of the program's modeling of the relevant social-science and economics systems (i.e., increased breadth).

Near-Term Activities

The major near-term activities of this component of the program are as follows:

- Compare the results of current general circulation models for common input conditions and standard observational records, which will identify potential differences in predictive capabilities and will help assess the abilities and uncertainties associated with the present state of the art.
- Examine the features of natural variability based on paleoclimatic data and model predictions for decade-to-century time scales, and assess the significance of the results to the early detection of a greenhouse warming signal.
- Improve the characterization of land-surface processes (both physical and biological) in general circulation models, with an emphasis on a better representation of mid-continental summer drying, and increase the resolution of such models, in both the spatial and the vertical scales, which should improve the 1 percent per year calculations for increases in carbon dioxide concentrations.
- Build a more fully coordinated and comprehensive modeling program among the agencies within the program and with researchers in the United States and abroad by establishing a program of model experimentation that more extensively draws upon work conducted within the observations and process research components of the program. This will provide better and more timely predictive information to the assessment component of the program.
- Stimulate the development and use of new computational tools for future applications in earth-system modeling, such as Massively Arrayed Parallel Processor computers.
- Initiate a terrestrial ecosystem regional-scale modeling program to examine scale-specific responses to climate change in conjunction with the Terrestrial Ecosystem Regional Research Activities Laboratory.

Policy-Relevant Assessments

The fourth major component of the U.S. Global Change Research Program is assessing the evolving state of scientific knowledge and describing it in policy-relevant terms that will provide the scientific basis for national and international policymaking activities over a broad spectrum of global and regional environmental issues. This component uses, synthesizes, and distills the results from the preceding three components. Its primary goal is to ensure that the United States is able to fully and actively participate in and contribute to the Intergovernmental Panel on Climate Change and other international assessment activities.

Near-Term Activities

The near-term emphasis of the assessment component of the program will be to enhance the U.S. research contributions to and help with the preparation of (1) the 1994 scientific assessment required by Section 106 of the Global Change Research Act of 1990; (2) the major climate-system assessment of the Intergovernmental Panel on Climate change in 1995, which will serve as the input to the initial meeting of the Conference of the Parties to the Climate Convention; and (3) the major 1995 ozone-layer depletion assessment, which is regularly required by the Conference of Parties to the Montreal Protocol as part of the basis for consideration of amendments. The activities of the assessment component of the program will address in the near term four key aspects of global change that will contribute substantially to aiding the complex policy decisions associated with these two major environmental issues.

Determining if Human-Induced Changes Have Been Observed

This requires not only observing global change, but also establishing cause-and-effect relationships and differentiating between natural variability and human-induced change. For example, this differentiation has been achieved in the case of springtime ozone depletion over Antarctica, which is caused by the anthropogenic emissions of chlorine- and bromine-containing chemicals (e.g., chlorofluorocarbons and halons). This early-detection assessment thrust incorporates long-term ground-based and satellite global observations, process studies, and model simulations of the paleo and recent historical record, all of which are used to test whether a picture of global change is emerging that, across many varied parameters, is consistent with the expectation based on human-influenced forcing of the global system. The near-term U.S. research program contains the following topics that will contribute to this test: (1) observations of forcing functions, (2) sources and sinks of atmospheric gases, (3) observations of earth-system responses, (4) paleoclimatic data,

(5) climate process studies, (6) model simulations, (7) signal processing and other detection strategies, and (8) data management. In addition, the Earth Observing System, which is currently under development for launch starting in 1998, will provide many global data sets for such detection activities.

Synthesizing Predictions and Assessing Confidence Levels

Predictions of future regional and global changes with improved levels of confidence require the development of reliable high-spatial-resolution earth-system models (long-term objectives) and realistic scenarios of human activities that might influence the earth system. Thus, this assessment component will focus on building a realistic set of emission scenarios whose differences reflect a useful spectrum of possible policy choices, synthesizing the results of the most comprehensive of current models for these scenarios, examining their similarities and differences, investigating the results of previous sensitivity studies, and, based on all these, estimating current confidence levels for the predictions. An important factor in these uncertainty analyses will be how closely the model simulations represent the observed record of current and past global changes. The near-term research program contains the following topics that will aid this assessment component: (1) physical-climate processes, (2) ecosystem processes and interactions with the physical climate system, (3) social and economic studies, (4) process-level models, (5) integrated earth-system models, (6) advanced computational capabilities, and (7) long-term observations and paleoclimatic studies.

Describing the Overall Impacts of Predicted Changes

Characterizing the possible physical, biological, economic, and social responses that could be associated with predicted global changes uses the understanding of the biological and physical processes that are directly or indirectly affected by environmental changes. A large majority of these characterizations are at the "case-study" level. This assessment activity will synthesize the results of these individual studies, supplement them with new investigations, and prepare a common summary of the impacts in key societal areas—e.g., agriculture, coastal habitation, national economy by major sectors, and demographics. The near-term research activities that will help provide the basis of these assessments contain the following topics: (1) regional global change possibilities, (2) human adaptation, (3) hydrological and ecological impact studies, (4) coastal zone and sea level rise patterns, (5) agricultural response models, (6) social dynamics models, and (7) reconstruction of responses to past climate changes.

Quantifying the Importance of Human Influences

The relative importance of human influences on the climate system is at the heart of formulating mitigative or adaptive strategies. Such quantification requires an improved understanding of the carbon cycle, primarily the role of the oceans and terrestrial biosphere in sequestering anthropogenic carbon dioxide; atmospheric transformation processes that remove greenhouse gases; the development of chemistry-climate models; and an examination of how realistic scenarios of human activities might influence the emission of greenhouse gases, aerosols and their precursors, and substances that deplete stratospheric ozone.

This assessment component will focus on synthesizing a common view of the implications of the results of these studies for the formulation of relative indices that can reflect the relative importance of human impacts on the earth system. For example, the concept of global warming potentials for greenhouse gases will be examined in its simplest terms, as well as how it could evolve through a hierarchy of more realistic models. The near-term research activities contain the following topics that are relevant to this task: (1) sources and sinks of carbon dioxide; (2) sources, sinks, and atmospheric transformations of non-carbon-dioxide greenhouse gases and their precursors, aerosols and their precursors, and ozone-depleting gases; (3) scenarios of anthropogenic trace gas emissions; and (4) carbon-cycle, atmospheric-chemistry, and climate models.

Environmental Technologies Research Program

Another series of research programs under way in the United States focuses on environmental technologies that will reduce the emissions of greenhouse gases, remediate the effects of increasing greenhouse gases, and reduce vulnerability to earth-system changes. The following research and development programs form some of the basis for new or modified environmental technologies.

Reducing Vulnerability

Research programs to reduce the vulnerability to global change are focusing on characterizing and predicting the effect of water and energy fluxes on social and economic situations. Predictive capabilities for large river basins will be improved both by better representation of fundamental hydrologic processes to account for scale, spatial, and temporal variability, and by including remote-sensing, geographical information systems, and real-time data. Other studies focus on assessing both the impact of climate changes on water quality in upstream impoundments and the responses of hydrological systems using resource management and global change scenarios. Additional research will evaluate the technological capability to measure crop water use and climate change using remote sensing. Developing the capability to adapt to changes in the hydrologic characteristics of regional storms under scenarios of climate change will include the gathering of data, as well as developing the models and technology necessary for understanding the nature, extent, and scope of potential global climate change impacts on regional water resources.

Impacts on Power Generation

Studies will also attempt to determine the sensitivity of reservoir and power supply systems to extreme weather conditions. This will include developing comprehensive historical regional climate data bases. Improved tools are also being developed for the coordinated planning and scheduling of hydro- and thermal-power generation and multipurpose reservoir operations on regional and river-basin scales.

GHG/Ecosystem Interactions

Research focusing on reducing the growth of atmospheric concentrations of greenhouse gases by increasing sinks and maintaining reservoirs for carbon dioxide includes studies on soil management techniques and tree planting. Other research addresses the effects of increasing atmospheric carbon dioxide and climate change on the yield and water-use efficiency of crop and rangeland ecosystems.

Long-term field studies are being conducted to evaluate soil-cover management in the Great Plains and how it influences the flux of carbon and nitrogen trace gases. The way that plants distribute carbon above and below ground, while adapting to changing carbon concentrations in the atmosphere, will be studied to understand how these properties affect the carbon balance of terrestrial ecosystems. This knowledge will be

translated into new technologies for managing plant biomass systems.

Other studies are addressing how the movement of nutrients within the soil and uptake by plants affect environmental quality and fertilizer efficiency. This information will help researchers identify the types of new technologies that need to be developed and used in mitigating the effects of global change.

Monitoring Forest Health

Regular monitoring of the health of forests enables researchers to assess the effects of annual environmental threats on a regional scale. Knowledge from these assessments is incorporated into programs designed to improve land- and resource-management technologies. These programs place more emphasis on socioecological values, such as biological diversity, forest health, and sustained production, while reducing vulnerability to climate change.

Coastal Zone Impacts

Several studies are addressing the effects of climate change on coastal zones and their watersheds (e.g., habitation, fisheries, and protected marine mammals) to enhance the capabilities to predict, assess, and mitigate the effects of possible climate changes on such systems.

Emission Abatement Technologies

Technologies for efficiently capturing and economically using methane emissions include: coal, oil, and gas production; systems for handling livestock waste; the anaerobic digestion of solid waste at waste water treatment plants; and landfills. Potential options for producing electricity in such applications are of high priority. Other studies include addressing the technical feasibi-lity of producing methanol from domestic resources by the hydrocarb process. Additional projects being proposed will focus on the use of marine biomass in sequestering carbon and as an alternate form of biomass energy.

Ultraviolet Radiation

Stratospheric ozone depletion will continue to increase, despite current regulations, for at least another decade. This thinning of the ozone shield allows potentially harmful increases in levels of UV-B radiation at the earth's surface. Programs are being created to develop biochemical and biophysical technologies for reducing the vulnerability of plants and animals, human health, and the infrastructure within human communities to the stresses of radiation.

International Activities

Support of international activities—both between and among developed and developing countries—is critical for effective global efforts to address potential climate change. Realizing the importance of creating and sustaining an international cooperative network, the Framework Convention on Climate Change urges developed countries that are Parties to the Convention to take all practicable steps to promote and facilitate the transfer of, or access to, environmentally sound technologies and know-how. Furthermore, the Convention specifically provides Parties with the opportunity to implement their commitments jointly.

In addition to its efforts to begin joint implementation of specific commitments under the Convention, the United States has responded vigorously to the need for international cooperative work through extensive programs and initiatives in several areas:

- Bilateral and multilateral financial and technical assistance (technology cooperation).
- Participation in international organizations working to address climate change, including research and assessment programs.
- Active support of and participation in negotiations of international agreements, including the Framework Convention on Climate Change.

There is a clear link between these programs and initiatives. Bilateral and multilateral assistance are outgrowths of a strong international process, developed through international agreements. Technological assistance depends on adequate training and public awareness on all sides—on the parts of both recipients and donors. A successful international program must be integrated, with appropriate coordination among the technical, financial, and governmental agencies involved.

Formal links among government agencies alone are not adequate for the task. The United States also has a history of strongly encouraging the participation of representatives from both environmental organizations and industry in international environmental activities. Many such nongovernmental organizations are already actively engaged in developing and transferring practices and technologies to address U.S. and global emissions of greenhouse gases, and have announced intentions to continue with these efforts. By ensuring their continued participation, the United States and the international community will benefit not only from governmental support, but also from the dynamism that these private organizations bring to the process.

While the United States has already published an extensive list of technology cooperation activities (U.S. DOS 1991), new programs and initiatives related to climate change are being developed and funded regularly. At the end of each section in this chapter are lists of some of the most important new initiatives and programs that have been created, and that may not have been included in previous reports. The activities listed are focused on addressing global climate change issues, rather than more local or regional problems. While the United States does have considerable locally and regionally focused investments, they are not included in this selected inventory.

Technology Cooperation

The United States is undertaking various bilateral and multilateral financial and technical assistance activities and initiatives that fall under the rubric of "technology cooperation." Technology cooperation (which includes technology transfer) consists of processes by which two or more parties identify individual and common interests to share information, knowledge, know-how, managerial skills, and/or hardware regarding environmentally sound and energy-efficient technologies. Elements of technology cooperation in the context of climate change include information exchange, technology development and transfer, technical assistance and training (including institutional capacity building), country studies, and technical systems.

In calling for such a cooperative process, the United States recognizes that success will depend on a two-way relationship based on mutual interests and benefits; technology cannot be transferred on demand. Furthermore, the United States recognizes that the diffusion of technology depends heavily on the creativity and dynamism of the private sector. The export and licensing of goods and services, supported by direct foreign investment and joint ventures among companies, results in the adaptation and subsequent diffusion of technologies relevant to the country in which this activity is occurring.

Governments in free-market democracies are not usually in the business of developing or owning technology. Consequently, they are not in a position to give technologies away. However, governments can—and the United States does—facilitate technology transfer through programs and activities designed to stimulate and support transfers. Governments can promote partnerships and more sustainable patterns of economic growth. Clear and reliable policies governing investment and joint ventures, as well as sound policies related to the protection of intellectual property rights, encourage cooperation across national borders. The most effective and extensive transfer of technology occurs in countries where the business and investment environment encourages these activities.

Technical Assistance and Training

An important element of technology cooperation is capacity building through technical assistance and training. In many countries, insufficient capacity to fully use existing technologies is a major barrier to adoption of these technologies. Therefore, the United States is promoting the following comprehensive training programs to transfer these technologies to both the public and the private sectors.

- The Technology Cooperation Corps is being developed with the collaboration and participation of representatives of the U.S. and international business communities. This initiative will help determine how U.S. corporations may share their expertise in environmental management and technology, will identify the needs and potential for the transfer of "green" technologies, and will help make them available.
- The U.S. Agency for International Development (AID) will provide a grant to the *Central American Research Institute for Industry* for training and technical assistance to programs that involve the private sector in developing energy-efficient strategies for generating power. The Institute will develop an energy strategy for Central America as a whole.
- AID is conducting a project to develop the core of a national energy demand-management program in Morocco, where the Ministry of Energy and Mines will head implementation of the project's information and awareness, technical support, training, and policy analysis components. The technical support component will conduct forty energy audits and forty-five technico-economic feasibility studies of energy demand-management projects.
- AID is assisting *Guatemala's National Electrification Institute* in expanding rural electrical services.

Other U.S. programs that emphasize capacity building and training include the following:

- The Committee on Earth and Environmental Sciences and the National Science Foundation (NSF) are developing coordinating mechanisms for training scientists internationally across traditional disciplinary boundaries in global change research.
- The United States is a party to over 600 bilateral Science and Technology Agreements that support cooperative research activities. Details of these programs are published annually in the *Report to Congress on Science, Technology, and American Diplomacy* (Title V Report).
- AID has initiated a project to promote efforts in Latin American and Caribbean countries to improve natural resource management and conservation capabilities and programs. The project will provide three global warming advisors, who will be located in Latin America. These advisors will provide guidance on the implementation of the congressionally mandated Global Warming Initiative.
- The U.S. Forest Service is working with Brazilian and Russian scientists to develop research capacities to measure the release of greenhouse gases from biomass burning in tropical and boreal forests and savanna ecosystems. The program has already concluded two years of measurements in cooperation with Brazilian scientists and has initiated program planning with the Russian scientific community.
- The U.S. Environmental Protection Agency (EPA) is conducting a series of studies to develop more precise carbon storage accounting methods for use in evaluating the greenhouse benefits of the protection and enhancement of forest sinks. Studies to date have concentrated on Russian and Siberian forests.

- NSF initiated a program to understand stratospheric ozone chemistry, with emphasis on ozone depletion over Antarctica. For fiscal year 1993, NSF allocated $5.6 million for this program.
- The *Forestry Development Project* is part of a multi-donor effort supported by AID to strengthen the institutional capacity of Nepal's Ministry of Forests and Soil Conservation, to implement Nepal's Master Plan for the forestry sector, and to increase nationwide use of improved stove models.
- The *Science and Technology for Development* program, sponsored by AID, redirects Egyptian science and technology programs to help solve priority development problems identified as having the greatest impact on end users, and to build capacities in selected technologies.
- AID's *Coastal Resources Management Project* helps developing countries create an integrated approach to coastal resource management by transferring U.S. experience through pilot projects in Ecuador and in several Asian countries.
- Through its *Environmental and Natural Resources Management* program, AID is promoting the sustainable management of the Philippines' tropical forests and increased economic efficiency in the forest products industries. The program's main component will consist of performance-based disbursements aimed at assisting policy reform in six areas, including removing constraints to imports and exports of forestry raw materials, products, and technologies.

Country Studies

Country studies provide an analytical basis from which countries may develop national measures and actions to address climate change. The studies are thus a necessary first step for developing countries and countries with economies in transition in seeking to meet their obligations under the U.N. Framework Convention on Climate Change.

In February 1992, the United States pledged $25 million over two years to help these countries prepare climate country studies. Furthermore, as needed and agreed to, the United States will also provide related technical assistance in implementing programs identified in the country study process.

The primary objectives this initiative are:

- To enhance the abilities of countries and regions to assess their vulnerability to climate change, their net emissions of greenhouse gases, and their options for to mitigating and adapting to 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 over time.
- To develop data and information that can be used at the national, regional, and global levels to assess current and future trends in net anthropogenic emissions of greenhouse gases, to provide information for discussion of options that can address climate change, and to further national and international discussions of climate change issues.

The United States expects that the results of the country studies it assists will be made widely available internationally. These studies will seek to improve knowledge and understanding within the host country of the various options and methods available to it for developing specific national policies and measures to mitigate and adapt to climate change. Toward this end, the United States is prepared to facilitate substantial technical support and exchanges of experts or special missions with each host country involved.

Information Exchange

As part of its effort in technology cooperation, the United States has promoted the creation and development of programs for information exchange. These range from clearinghouse efforts designed to provide information on specific technologies—including information on their vendors and on regulations inhibiting their use—to information on emissions of greenhouse gases. The following programs are examples of the diversity of U.S. activities in this area:

- The *Environmental and Energy-Efficient Technology Transfer Clearinghouse* has been developed jointly by AID, EPA, and the U.S. Department of Energy (DOE). This on-line, computer-based information service provides a "one-stop shopping" data base on energy-efficient and environmental technologies, vendors, regulations, other data bases, and related information. It is currently operating in Mexico City; in Vienna at the United Nations Industrial Development Organization; in Washing-ton, D.C., at EPA and at the Inter-American Development Bank; and will soon be operating in Puerto Rico.
- *INFOTERRA/US* serves as the U.S. focal point for the United Nations Environment Programme's environ-

mental information exchange and referral service, which handles over 6,000 requests a year.

- The United States supports the *Green Ties (Technology Information Exchange System)* being developed by the International Energy Agency to disseminate information on technologies related to reducing greenhouse gas emissions. The United States will be a major contributor to the system and will include in it an extensive data base being developed by DOE that will characterize energy technologies.
- The *Green Pages,* published by EPA, identifies and describes U.S. vendors of pollution control, renewable energy, and energy-efficient technologies, services, and equipment. This book is also available through the *Environmental and Energy-Efficient Technology Transfer Clearinghouse.*
- EPA has developed a series of *Technical Information Packets* on fourteen environmental issues (including climate change) for international dissemination. The packets include technical documents, articles on specific technologies, a directory of EPA experts, a list of relevant electronic data bases, and information on training opportunities.
- The *Caribbean Environment and Development Institute,* initiated by EPA, assists in developing an environmental network in the region for sharing expertise, technology, and information, for developing partnerships, and for coordinating existing programs that emphasize capacity building, technical cooperation, and training.
- AID is supporting the creation of the *World Council for Energy Efficiency* to provide a focal point for collection and dissemination of information on energy-efficient end uses.
- The Department of Commerce has begun a series of *National Environmental Technologies Trade Initiatives* that will work in concert with the Export-Import Bank and other federal agencies and with U.S. industries to ensure that U.S. environmental technologies and services are made available to address global environmental problems. In conjunction with other trade initiatives, the United States will organize bilateral conferences on environnmental technologies and developing countries in Latin America, Asia, and Eastern Europe. Each conference will focus on the need for environmental technologies, will highlight relevant U.S. expertise in this field, and will disseminate information about financing to acquire U.S. technologies.
- The U.S. Department of Agriculture's Information Centers collect and disseminate information in the areas of alternative forming systems, biotechnology, technology transfer, water quality, rural development, and plant genome. The U.S. government has also developed and disseminated an information packet on global climate change.
- The U.S. government is working to establish a *Global Change Research Information Office* that will disseminate U.S. government information on global change to foreign governments, businesses, and citizens, as required by Congress *(Public Law 101-606).*

Emission Inventories and GHG Monitoring

Several of the information-exchange programs are specifically designed to monitor, inventory, and disseminate data and information regarding emissions of greenhouse gases. Furthermore, many technical assistance and training programs are designed to develop in-country capacity to carry out these data collection and management tasks. DOE and EPA are supporting various efforts in this area.

- EPA is participating in the working groups of the *International Global Atmospheric Chemistry Project,* which is concerned with the preparation of a global emissions inventory.
- DOE is initiating longer-term measurements at the first of its global *Climate Information Systems Atmospheric Radiation Measurement* sites to address the roles of clouds and aerosols on climate. These measurements will help scientists quantify the atmospheric radiative budget of clear and cloudy skies.
- EPA is providing training and assistance to Poland to create a monitoring network for episodic climate conditions and to install and operate a continuous-emissions-monitoring system at the Skawina Power Plant in Krakow.
- DOE is working with the People's Republic of China, to measure methane emissions from rice paddies so as to increase the scientific community's understanding of past and future changes in the atmospheric concentrations of methane. EPA is assisting the *Chinese Institute of Environmental Health Monitoring* in the use of air-quality indices to evaluate air-quality data and is providing the People's Republic of China with methods for testing specific pollutant emissions.

- EPA is assisting Mexican scientists in evaluating ozone data and in developing emission inventory capabilities.

Technology Development and Transfer

The United States has an array of programs for developing and transferring energy-efficient technologies.

- The *Assisting Deployment of Energy Practices and Technologies* (*ADEPT*) program will assist developing countries and countries with economies in transition in their choice and application of new energy technologies. The program will promote cooperative efforts in the area of energy technology adaptation, commercial demonstrations, and training. The program's missions will include research and demonstration ventures that are jointly supported by DOE and host country government agencies. These joint ventures will involve U.S. national laboratories and private-sector groups working on integrated project teams with their host country counterparts to ensure that a viable and sustained transfer of technology and operating practices is achieved. Use of indigenous fuel sources will be stressed, including use of biomass, geothermal, solar, wind, and improved efficiency in fossil fuel conversion.
- The *Energy Policy Act* of 1992 establishes a program for facilitating the transfer of U.S. renewable-energy technologies to developing countries.
- Through various technical assistance, training, and research activities, AID is promoting private ownership, financing, and operation of energy facilities (primarily in the electric power sector) in developing countries. Under this project, AID is developing collaborative ties with other U.S. agencies, multilateral development banks, and other bilateral donors to encourage energy development within the private sector.
- The *U.S. Biomass Energy Systems and Technology* (*BEST*) project promotes investment in commercial biomass energy (bioenergy) projects that use crop wastes, wood wastes, and municipal solid wastes to create energy by-products. To help reduce investment risk and monitor new technologies, AID will sponsor applied research, both field studies and bioenergy system research and development, through a competitive research grants program.
- Collaborative research and development projects have been initiated between the U.S. government and the Institute of Biochemistry and Physiology of Microorganisms (IBFM) at Pushchino, Russia—the heart of biotechnology research in the former Soviet Union. The two projects in biofuels work will supplement technology development and will enhance technology transfer to U.S. and Russian industry. They will be characterized by two major efforts:

  1. Development of a bioreactor system to convert carbon dioxide to value-added products. During yeast fermentation to ethanol, carbon dioxide is generally a waste product. Finding new uses for this gas will improve the economics of ethanol production. Fermentation is highly advanced and supplements U.S. technology.

  2. Development of a high-density lignocellulose fermentation technology. To augment the yield of ethanol from corn, it is necessary to perform fermentations on corn fiber and residues. At the high density of biomass required to diminish reactor costs, special technology is crucial; some of this already is being developed in Russia. By combining Russian and U.S. technology, industry ultimately can lower costs of producing fermentation chemicals and alternative fuels.
- The U.S. Department of Agriculture is studying the transfer of technology between developed and developing countries and is examining the economic and political benefits and costs of various policy instruments (including subsidies and tax policies). It will examine the effects of different international trade regimes on technological development.
- Sponsored by AID, the *Committee on Renewable Energy, Commerce, and Trade* (*CORECT*) program facilitates introduction of renewable-energy and energy-efficient technologies in foreign markets.
- AID's *Private-Sector Energy Development* program is designed to stimulate and accelerate the development of private energy and power projects in developing countries by encouraging private investment in capital projects and identifying policy barriers to technology cooperation.
- A new Partnership Program within AID will strengthen forest-based private enterprise in developing countries. It will conduct case studies, expand technical and managerial capacity, seek to establish forest-based enterprise co-ventures, secure funds to catalyze such ventures, and build research and development expertise.
- Through its *America's 21st Century* program, DOE is entering into a new partnership with countries in Latin America and the Caribbean to promote the

use of commercial, renewable-energy technologies. Under this program, the United States will assist the U.S. renewable-energy industry in forming joint ventures in these countries.

- In late 1991, the U.S. Department of Commerce and the Mexican Ministry of Commerce launched the *U.S.-Mexico Business Committee on Environmental Technology Transfer.*
- DOE's *Clean Coal Program,* funded at $410 million in fiscal year 1992, promotes the development of energy-efficient technologies for using coal. Specific examples of projects using technologies transferred from the program for use abroad include: the Krakow Clean Fossil Fuel and Energy-Efficiency Project and the Eastern and Central Europe Energy-Efficiency Project. Other benefits from the programs include technical cooperation agreements to deploy clean coal technologies, guides and directories, and trade missions.
- The Filipino system of Rural Electric Cooperatives is receiving financing from AID for commodity packages needed to reduce system energy losses. The project will provide essential equipment to these cooperatives that have experienced line losses of up to 50 percent due to lack of spare parts and hardware.
- AID is supporting a project to expand the Indian government's capacity to exploit alternate energy resources and develop selected technologies to the application stage. Subprojects include biomass production/conversion, energy efficiency, and information exchange.
- AID's Forest Conservation and Management project provides a grant to Costa Rica's Neotropical Foundation to promote sustainable development of forest and agricultural resources in the buffer zone surrounding Corcovado National Park on the Osa Peninsula. Specific activities will include involving campesinos in long-range forestry planning and improving their forestry technologies.
- AID's *Utility Management and Energy Policy* project is designed to make the use of renewable-energy resources economically competitive in Egypt. The project will field test renewable-energy technologies, establish an information system, and provide training and support for renewable-energy initiatives.
- Through the Global Environment Facility, a joint effort of the World Bank, the United Nations Environment Programme, and the United Nations Development Programme, EPA has begun projects in China to recover methane from coal mines. EPA is funding an inventory of methane-emitting Chinese mines and a demonstration program to identify best-recovery techniques and to train Chinese engineers in their use. Separately, EPA is funding a bilateral project to promote U.S. recovery technologies in China through a *Methane Technology Clearinghouse.* Emissions from Chinese coalbeds are estimated at 9-17 Tg per year, of which 4.0-7.5 Tg may be recoverable through this project. EPA spent $200,000 on this program in fiscal year 1990.
- AID's *Haitian Agroforestry Project* is designed to help hillside farmers in Haiti grow economically viable tree, shrub, and grass crops using appropriate land-use and soil conservation measures. Applied research will emphasize three areas: (1) nursery technology, especially containerized production of indigenous species and nonnursery methods for introducing indigenous and exotic species; (2) hedgerow technology, determining what combinations of shrubs and grass/forage species are best for soil conservation and erosion control; and (3) alley-cropping systems for hillside farming.
- The United States has supported the establishment of *Energy Efficiency Centers* in Eastern Europe and Russia to encourage economic development and environmental protection through energy efficiency. Activities include technical training and demonstration, technology and information transfer, identification of domestic and foreign partners for joint ventures, public information services, and policy analysis and development. Centers currently exist in Warsaw, Krakow, Prague, and Moscow. Funds are provided by AID, by the World Wildlife Federation, and by the Conservation Foundation.
- AID provides well over $100 million a year to support activities that emphasize eliminating or minimizing the major obstacles to successful technology transfer. These obstacles include the lack of technologies adapted to the needs and conditions of developing countries, the need for financial and institutional resources, conflicting development goals, and the need for a sound economic and legal climate to facilitate a reasonable return on investment.
- The United States has promoted an international legal framework for protecting intellectual property rights to provide the necessary incentives for the development and transfer of new technology.
- The United States has led efforts to develop appropriate mechanisms to protect intellectual property rights through multilateral trade agreements and unilateral action. These mechanisms condition preferential-treatment benefits and access to the U.S. market on nondiscriminatory practices that protect

the intellectual property rights of U.S. companies. The United States curbed inappropriate compulsory licensing regimes through bilateral negotiations with individual countries and through conditions in the General Agreement on Tariffs and Trade/Trade-Related Intellectual Property Rights (GATT/TRIPs) measures to preserve effective incentives for innovation and transfer of new technology.

Public and Private Partnerships

International actions are more likely to be successful where they involve the organized, active participation of governmental and nongovernmental organizations, including nonprofit groups and private-sector companies. These organizations can contribute relevant expertise and international contacts, independent and transparent estimates of the costs and effectiveness of projects, and financial support, and can help governments select projects that pose valuable opportunities.

The following activities, while by no means exhaustive, represent the kind of projects that may lead to effectively addressing global greenhouse gas emissions.

- The *U.S. Environmental Training Institute* has been established by the U.S. Agency for International Development (AID) as a nonprofit public-private initiative to build environmental management capacity in developing countries. U.S. companies teach topical courses, developed by the U.S. Environmental Protection Agency (EPA) and by firms in the recipient country, that are designed for policy leaders and potential clients from developing countries. The Institute provides scholarships for most attendees and offers firms the opportunity to showcase technologies. It received $300,000 in federal start-up funds and gets additional in-kind federal support; total federal support exceeds $1 million. U.S. industry covers program costs.
- The *U.S.-Asian Environmental Partnership* is a comprehensive program designed to bring together Asian and U.S. businesses, nongovernmental organizations, and governments to enhance Asia's environment and to promote economic progress through technology cooperation, fellowships and training, and joint environmental protection and conservation activities.
- U.S. and Russian agencies have formed the U.S.-GAZPROM working group to identify opportunities for reducing methane leakage from natural gas systems in Russia using U.S. technology. The working group includes EPA, eight U.S. engineering and natural gas firms, GAZPROM (the Russian natural gas distributor), and the Russian government. The working group met in Russia in the summer of 1992. Out of an estimated annual emissions of 18-38 Tg of methane, this project would recover about 5-25 Tg.
- In June 1992, DOE, in cooperation with Siemens Solar Industries-U.S., signed an agreement to promote solar photovoltaic electricity in rural Brazil. It is estimated that photovoltaic electricity costs about $1,000 per home, compared to $8,500 per home for CO_2-emitting fossil fuel combustion, previously favored by Brazilian utilities. The project will install 2,000 home lighting photovoltaic systems, 1,000 in each of the states of Ceara and Pernambuco, and in rural areas without access to central power plants. DOE, which will provide $800,000 of the $2.65 million for the project, would like to expand these agreements to cover 50,000 homes.
- The *Environmental Business Council* is exploring activities with an association of "envirotech" firms. The Council has sponsored trade missions to Mexico and Asia, and "reverse-trade" missions, in which foreign industry representatives are brought to the United Nations to be introduced to U.S. technology. The Council also plans future missions to Eastern and Western Europe. It has established a "Plan of Cooperation" with Mexico to coordinate education and technology transfer and joint business ventures.
- The *Program for the Acceleration of Commercial Energy Research (PACER)* is a U.S./Indian collaboration in science and technology to foster innovation in the Indian electric power sector. This is accomplished through R&D consortia that link industrial and government R&D sectors and focus on advanced coal combustion technologies, renewable-energy systems, advanced electric power technologies, and improved transmission and distribution technologies.
- DOE's Office of Technology Development and the Coalition for International Environmental Research Assistance at Ohio University in Athens are jointly providing financial assistance to develop international programs for environmental technology, including *ENVIROTRADE*.

- EPA and private-sector companies are currently exploring an opportunity with India to improve the feed of Indian dairy cattle by adding molasses urea block, thus reducing methane emissions. A recent project-scoping report indicated that out of 6-10 Tg of annual methane emissions from India cattle (including draft and dairy animals), 1 Tg might be prevented through the feed program.
- AID, the Peace Corps, Applied Energy Systems (AES, a U.S. electric utility), and CARE (a nongovernment, nonprofit organization) are supporting a project in Guatemala to limit net CO_2 emissions through forest conservation and reforestation. The project aims to involve 40,000 Guatemalan families in sustainable forestry, planting 52 million seedlings by the year 2000. U.S. agencies are contributing $9.3 million of the project's total $14.5 million funding, AES has contributed a $2 million endowment, and CARE contributed the remaining $3.2 million.
- Many other U.S. companies are also pursuing forest conservation activities overseas. Examples include Applied Energy Systems (operating a project with the Nature Conservancy in Paraguay), New England Electric System (commencing a sustainable harvest project in Malaysia), the Los Angeles Department of Water and Power (exploring forest conservation opportunities in Central and South America), Pacificorp (exploring opportunities), and the Rockefeller Foundation (exploring opportunities in South America).
- AID and EPA have formed a U.S. Working Group to Reduce Methane Emissions from Coal Mining. The group met in Poland in March 1992 and again in Washington, D.C., in October 1992. The project is now soliciting U.S. companies to find investors in coal-bed methane recovery. Of the 1.3-2.6 Tg of methane emitted by these mines annually, the project could recover 0.6-1.1 Tg.

International Research and Assessment Programs

A key component of the U.S. international efforts in climate change involves active participation in international research programs. While the details of the U.S. Global Change Research Program are outlined in the research section of this report, many of the U.S. domestic programs are coordinated with research efforts of other countries. U.S. scientists work closely with their foreign counterparts—for example, scientists within the World Climate Research Program and core projects of the International Geosphere-Biosphere Program—in planning specific global change research programs. The United States has also been heavily involved in creating international global change research institutes and in the assessment work of the Intergovernmental Panel on Climate Change (IPCC). Furthermore, researchers actively participate in developing the emerging international programs in the human dimensions of climate change research, particularly in economics research.

As these programs move from planning to implementation, intergovernmental organizations will have an increasingly important role in oversight and coordination. These organizations, in concert with the International Council of Scientific Unions, will assist in broadening participation in and governmental support for global change research, particularly in developing countries. These organizations include the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), and the United Nations Environment Programme (UNEP).

The United States shares in funding activities through related U.S. national programs, augmented in some cases by direct funding of specific international coordinating activities. It is estimated that the United

States provided nearly one-half of the total costs of these international programs (and their coordination) in fiscal year 1992. Total global funding for these programs is increasing as more countries become directly involved in research.

IPCC

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 as an intergovernmental forum to assess changes in the earth's atmospheric composition as a result of natural and anthropogenic fluxes of greenhouse gases. The IPCC also assesses the likely impacts of potential climate change and considers the technical and economic aspects of response options. The IPCC prepared an assessment of current scientific and technical information on climate change for use by the Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change and is expected to continue to provide information to the INC's successor, the Conference of Parties to the Climate Convention.

Recognizing the scientific concerns about increased atmospheric concentrations of greenhouse gases, the United States took the lead in promoting the establishment of the IPCC under the joint auspices of the United Nations Environment Programme and the World Meteorological Organization. Since the IPCC's inception, the United States has chaired the IPCC's Working Group III on response options. The United States expects to continue in its leadership role in this organization and will continue to provide both technical and financial support for maintaining the high standards that have been set.

The United States has long maintained that measures for responding to climate change should take into account the state of the world's scientific understanding of the issue, including the significant uncertainties involved, and that international efforts to fill the gaps in our understanding should be a fundamental component of any response. The United States has also advocated thorough analysis of the costs and benefits of possible responses and basing global responses to climate change on the results of this analysis. In this regard, the United States has focused international attention on the need for the IPCC to expand its economic analysis of climate change questions, including those related to emission scenarios, valuation of the impacts of change, and benefits of response strategies. The IPCC's continuing scientific and technical work furthers these objectives and helps to ensure the solid underpinnings of alternatives considered by the parties to the Climate Convention.

The United States has extended substantial support to the IPCC Working Group on Response Strategies—providing expert professional staff, funding the preparation and printing of its publications, and covering meeting costs for regular sessions of its subgroups. In addition, the United States contributed nearly $430,000 to the IPCC in 1992, and expects to increase this funding in fiscal year 1993 to nearly $600,000.

WMO

The basic objective of the World Meteorological Organization (WMO) is to coordinate, standardize, and improve world meteorological activities and to encourage an efficient exchange of meteorological information among countries. 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 (WCIP). WMO has long been one of the principal organizations upon which the United States relies for providing needed international coordination for these programs. The WCIP specifically focuses on the need for improving global responses to climate change, and particularly emphasizes adaptation, mitigation, and education. In fiscal year 1990, the United States contributed nearly $7 million to WMO, or approximately 25 percent of its budget.

UNEP

The United Nations Environment Programme (UNEP) has also played an active role in global climate issues, and the United States has long been an active participant in this organization. UNEP's main responsibilities include promoting and coordinating international cooperation in the field of human environment and providing general policy guidance for the direction and coordination of environmental programs within the United Nations. One of UNEP's major climate change activities is to design and implement a Global Environmental Monitoring System, including its Global Resources Information Data Base component. This program links more than twenty-five major global monitoring networks, including networks established and supported by U.S. agencies.

Because of the overlap between UNEP and WMO programs in the area of global climate research, there are joint management responsibilities between the Executive Director of UNEP and the Secretary-General of WMO. For example, UNEP's Executive Director

assumed full responsibility for managing the WCIP, which is now operated under the Global Environmental Monitoring System.

U.S. involvement in these programs has been significant. For example, funding for the WCIP has been growing for the past decade; from 1980 to today (including the 1992-93 allocations), the total expenditure has been $12,413,211. In addition, U.S. support for UNEP organizations has totaled approximately 25 percent of its total budget: in fiscal year 1990, the United States contributed $12 million to UNEP.

IOC

The Intergovernmental Oceanographic Commission (IOC) is the United Nations agency—and the only intergovernmental organization—that deals with oceanography, the study of which is fundamental to understanding the global climate system. The IOC works closely with WMO and UNEP in its climate-related activities. It is a co-sponsor of the World Climate Research Program, and also coordinates the Global Ocean Observing System (GOOS), a key component of the Global Climate Observing System.

The United States plays an active role in the IOC, with U.S. scientists helping to design and implement the GOOS, and also providing staff support to such IOC programs as the *Global Sea Level Monitoring System* and the *World Data Centers for Oceanography*. In fiscal year 1992, the United States provided $500,000 for the IOC and its activities.

Research Institutes

The United States has also been instrumental in creating global change research institutes, designed particularly to address the regional implications of global change in developing countries. The United States helped coordinate the intergovernmental process that developed the regional global change research institute initiative. In 1992, this process led to the signing by eleven countries of a formal agreement to establish the Inter-American Global Change Research Institute.

The Institute has been conceived as a network that includes an Institute directorate and a number of research centers that will conduct and sponsor basic research on global change processes that are of special importance to—and in some cases unique to—the Americas. The Institute is also designed to serve as an effective link between science and the policy process.

The United States currently hosts and supports the interim secretariat of the Institute, and is actively involved in promoting the rapid implementation of the Institute Agreement. Additionally, the United States has committed $5 million to support the Institute during its start-up phase.

Other Research Programs

The United States is also engaged in a host of other climate-related research initiatives with other countries and international organizations.

- NSF is participating in international efforts to study the seasonal and interannual variability of the coupled ocean-atmosphere system, including support for major observational and computational facilities and instrumentation. The budget request for fiscal year 1993 was $14.4 million.
- NSF has contributed to international programs to identify and quantify the biological, chemical, and physical processes controlling biogeochemical cycling and fluxes in the oceans and effects of atmosphere. The budget request for fiscal year 1993 was $18 million.
- On August 19, 1987, the United States signed a bilateral agreement with the People's Republic of China, called ANNEX II to the Protocol on Fossil Energy Research and Development on Cooperation in the Field of Atmospheric Trace Gases. The research being conducted is divided into four tasks: (1) analysis of general circulation models of climate; (2) preparation analysis of paleo-historical and instrumental climate information and data; (3) model-to-data comparisons to study the relationship between large- and regional-scale climates; and (4) methane emissions from rice paddies as sources of atmospheric methane. Each task includes opportunities for Chinese scientists to train in the United States.
- DOE has instituted a project to establish the Energy Research Laboratory at the government of Indonesia's National Center for Research, Science, and Technology as a national energy research and development laboratory. The primary activity under this project will be to develop new energy technologies needed for Indonesian industrial development.

Multilateral Fora

The United States is also a participant in numerous multilateral fora critical to the development of an international consensus on global climate change policy matters. These include such financial and policymaking bodies as the Intergovernmental Negotiating Committee, the Global Environment Facility, the International Energy Agency, and the Organization for Economic Cooperation and Development.

INC

The Intergovernmental Negotiating Committee (INC) for a Framework Convention on Climate Change (FCCC) successfully served to both negotiate and conclude the present Convention. It is expected to continue its work on the Convention and to serve as the international mechanism to coordinate preparation for entry into force of the FCCC.

The United States has provided substantial financial support to the INC. Convention negotiations, which began in February 1991 pursuant to UN Resolution 45/212, were hosted by the United States at a cost of about $1.6 million. In addition, the United States contributed $200,000 to the special voluntary fund, which supported the travel of delegated from developing countries to the negotiations. The United States has budgeted continuing—and increasing—levels of support for the INC for the coming fiscal year.

Finally, the United States showed its determination to move forward with the rapid implementation of the Climate Convention by promptly ratifying Convention on October 15, 1992 (the fourth country to do so), by its efforts to prepare its National Plan, and by its support of related IPCC activities, such as the September 1992 Workshop on Country Studies.

Global Environment Facility

In response to environmental and development concerns, multilateral and bilateral donors and lenders have taken several steps to assist developing countries to incorporate environmental costs and benefits more systematically into their development policies and programs. However, there has also been a general recognition that some environmental programs are global in nature and thus merit international cooperation in order to promote global solutions.

The Global Environment Facility (GEF) was established in 1991 as a three-year pilot program to assist developing countries. In its pilot phase, the GEF provides for the funding of agreed incremental costs of achieving agreed global benefits in four areas—one of which is global warming. The United States has played an active role in shaping this new organization, and has pledged to contribute $150 million in parallel funding of GEF-approved projects.

Participants in the GEF (including the United States) have agreed that, with some restructuring, the GEF should receive continued international support beyond the three-year pilot phase. The United States expects that the GEF in time will assume a central role in providing financial support to developing countries as they take actions to meet their commitments under the Climate Convention. In anticipation of continued GEF activity, the United States has committed itself to a contribution of $50 million to be directed to the permanent GEF mechanism. Of this sum, the U.S. Congress has already appropriated $30 million for the GEF, provided it meets certain conditions regarding public participation and transparency.

Participation in Other Fora

The United States is an active participant in the work conducted by numerous other international organizations and under numerous agreements related to climate change. Relevant organizations include the International Energy Agency, the International Atomic Energy Agency, the Organization for Economic Cooperation and Development, the United Nations Food and Agriculture Organization, and numerous financial institutions (such as the World Bank) in which the United States seeks greater recognition and

integration of environmental considerations in their lending practices.

The United States is also a party to—and an active member of—numerous international agreements other than the Framework Convention on Climate Change that are relevant to the issue of climate change. For example, it is a party to the *1985 Vienna Convention for the Protection of the Ozone Layer* and its *1987 Montreal Protocol on Substances that Deplete the Ozone Layer,* as amended. The Montreal Protocol contains measures for controlling emissions from ozone-depleting substances (such as chloroflourocarbons). U.S. scientific and policy experts have been major contributors to the research and analytical work that has taken place under both the Vienna Convention and the Montreal Protocol, enabling sound decision making as to necessary adjustments and amendments to the controls on ozone-depleting substances.

Further, the United States is a party to numerous multilateral and bilateral agreements related to various other aspects of climate change—for example, to cooperate in controlling other pollutants and to conduct research on climate change and energy-efficiency measures. Among these agreements are the regional *ECE Convention on Long-Range Transboundary Air Pollution and Its NO_x Protocol,* and the bilateral *U.S.-Canada Air Quality Agreement,* which contains extensive control measures on greenhouse gases, including NO_x and sulfur dioxide.

The United States supports several other multilateral financial mechanisms that have programs specifically tailored to address global climate issues. It has focused the World Bank's attention on several important policy issues relevant to climate change, including the following:

- The United States has been engaging the multilateral development banks for some time on the issue of reforming energy-sector policies, calling for lending to be based on least-cost integrated resource planning, which includes a cost-based ranking of both supply- and demand-side investments. Recent legislation has supported this approach *(Public Law 102-391).*

- The United States has encouraged multilateral development banks to increase lending to and increase their staff positions in the areas of renewable energy and improvements in the efficiency of energy end uses.

- The United States also encourages multilateral development banks to take an integrated least-cost approach to the transportation sector. The environmental costs of this sector, including pollution, figure greatly into these calculations. In addition, the United States advocates devoting a substantial portion of loans and grants in the transportation sector to improvements in the efficiency of energy end uses.

- AID supports innovative financing for technology cooperation in energy through such programs as the Energy Technology Innovation Fund, the International Fund for Renewable Energy and Efficiency, and the Environmental Enterprise Fund.

- EPA has collaborated with the Export-Import Bank in producing a brochure on the opportunities for receiving Bank assistance for exporting U.S. environmental goods and services.

- The Forests of the Future initiative announced in June 1992 that it proposes to double international assistance funding for forest conservation, starting with a U.S. down payment of $150 million in additional forest conservation assistance. This initiative will help contribute to "protection and enhancement of sinks" of greenhouse gases, as urged in the Framework Convention on Climate Change.

In addition to these formal international organizations, U.S. federal agencies that support global change research coordinate their support for programs in this area with counterpart agencies in other countries through a number of informal arrangements. Of these, the most important are the *Committee on Earth Observing Satellites (CEOS)* and the *International Group of Funding Agencies for Global Change Research (IGFA).*

CEOS serves as the focal point for international coordination of global change activities associated with space-based earth observations and related data management. It is composed of government agencies with funding and program responsibilities for satellite observations and data management. CEOS addresses policy and technical issues of common interest related to the spectrum of earth-observation satellite missions and data received from such missions.

IGFA is composed of national agencies that fund global change research in the natural, social, and economic sciences. A major aim of IGFA is to optimize the allocation of national contributions to global change research. The group 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 the resources available.

Executive Office of the President

CONFERENCE ROOM RESERVATION REQUEST

NAME OF INDIVIDUAL HOSTING/ATTENDING EVENT: D. Allan Bromley

EXTENSION: X-6202

OFFICE/AGENCY: OSTP

DATE OF MEETING: 12/2/92

STAFF PERSON RESPONSIBLE FOR CLEARANCE: Ruth A. Fisher

HOURS: From: 4:00p To: 5:30p

TYPE OF EVENT: ☒ Meeting ☐ Reception Other _____ | Official: XX | Private:

PURPOSE OF MEETING: Meeting of the Global Change Strategy Task Force

NUMBER OF ATTENDEES: 35

IN ATTENDANCE: ☐ President ☐ First Lady ☐ Vice President

ROOM(s) REQUESTED: ☐ 22 OEOB ☐ 274 OEOB ☐ 450 OEOB ☐ 474 OEOB ☐ 476 OEOB ☐ Roosevelt Room West Wing

Other 472 OEOB

GSA REQUIREMENTS: ☒ NO ☐ YES (fill out TYPE OF SERVICE below)

TYPE OF SERVICE:

☐ Elevator Service ☐ #4 ☐ #5 ☐ #7

Time Reserved _____

Floors Reserved _____

☐ Podium

☒ Coat Rack

☐ Flags

SPECIAL ROOM ARRANGEMENTS (Rooms 22 and 474 OEOB Only)

☐ Theatre: Number of Chairs _____

☐ Reception: Number of Table(s) _____ 6ft _____ 8ft _____ 10ft

☐ Other _____

WHITE HOUSE STAFF MESS REQUIRED: ☒ NO ☐ YES Estimated Cost $ _____

Funding to be Provided by: _____

Counsel's Approval: _____

REMARKS: Please add 8 extra chairs around the wall.

OFFICIAL USE ONLY

DATE OF REQUEST: | APPROVED BY:

RETURN TO: White House Administrative Office
Room 1, OEOB

TRANSMISSION REPORT

THIS DOCUMENT WAS CONFIRMED
(REDUCED SAMPLE ABOVE - SEE DETAILS BELOW)

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TOTAL PAGES SCANNED : 1
TOTAL PAGES CONFIRMED : 1

*** SEND ***

No.	REMOTE STATION	START TIME	DURATION	#PAGES	MODE	RESULTS
1	2024561414	12- 1-92 9:47AM	0'43"	1/ 1		COMPLETED 9600

TOTAL 0:00'43" 1

NOTE:
No. : OPERATION NUMBER 48 : 4800BPS SELECTED EC : ERROR CORRECT G2 : G2 COMMUNICATION
PD : POLLED BY REMOTE SF : STORE & FORWARD RI : RELAY INITIATE RS : RELAY STATION
MB : SEND TO MAILBOX PG : POLLING A REMOTE MP : MULTI-POLLING RM : RECEIVE TO MEMORY

Executive Office of the President

CONFERENCE ROOM RESERVATION REQUEST

NAME OF INDIVIDUAL HOSTING/ATTENDING EVENT: D. Allan Bromley (Ruth)	EXTENSION: X-6202
OFFICE/AGENCY: OSTP	DATE OF MEETING: 12/2/92
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Other 472 OEOB

GSA REQUIREMENTS: ☒ NO ☐ YES *(fill out TYPE OF SERVICE below)*

TYPE OF SERVICE:)

☐ Elevator Service ☐ #4 ☐ #6 ☐ #7

Time Reserved _____

Floors Reserved _____

☐ Podium

☒ Coat Rack

☐ Flags

SPECIAL ROOM ARRANGEMENTS (Rooms 22 and 474 OEOB Only)

☐ Theatre: *Number of Chairs* _____

☐ Reception: *Number of Table(s)* _____ 6ft _____ 8ft _____ 10ft

☐ Other _____

WHITE HOUSE STAFF MESS REQUIRED:

☒ NO ☐ YES Estimated Cost $ _____

Funding to be Provided by: _____

Counsel's Approval: _____

REMARKS:

Please add 8 extra chairs around the wall.

OFFICIAL USE ONLY

DATE OF REQUEST:	APPROVED BY:

RETURN TO: White House Administrative Office
Room 1, OEOB

FAX TO JOHN

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 03 1992

OFFICE OF
POLICY, PLANNING AND EVALUATION

Dr. Allan Bromley
President's Science Advisor
The White House
Washington, D.C. 20500

Dear Dr. Bromley:

I am writing to clarify and expand upon the concerns I expressed in yesterday's meeting regarding the U.S. Climate Change National Action Plan. As I stated in the meeting, we believe it is inappropriate for the U.S. to transmit the Plan to the International Negotiating Committee (INC) at this time.

Our fundamental concern is that the draft Plan does not satisfy the requirements of the Convention. Article 4.2(b) of the Convention states that "each of the Parties shall communicate ... detailed information on its policies and measures ... with the aim of returning individually or jointly to their 1990 levels of ... greenhouse gases not controlled by the Montreal Protocol." While the current document catalogs many ongoing U.S. legislative and regulatory activities in the energy and other sectors, it does not convey any sense that the aim of such activities is to return U.S. emissions to their 1990 levels. In fact, the message of the document is that the U.S. is pursuing a number of policies for reasons quite apart from climate change whose incidental effect is to limit emissions close to but above the aim of the Framework Convention. Nowhere does the Plan describe why U.S. commitments fall short of the aim of Article 4 and what the U.S. intends to do about it. Specifically, the plan fails to list additional policies that would return emissions to 1990 levels or even to launch a dialogue on what additional policies might be considered. We would be happy to develop such a list of options.

In light of the U.S.'s leadership in ratifying the Framework Convention and the importance the U.S. has placed on national plans, the failure to fulfill Article 4 renders the document inadequate. President Bush has made national action plans a cornerstone of the global climate change strategy embodied in the Framework Convention. The Bush Administration has argued compellingly that progress on climate change will only be made when countries move beyond rhetoric and identify specific policies to fulfill the Convention's aims. The draft Plan undermines this argument.

Furthermore, the Plan sets a poor precedent. Rather than serving as the basis for a prompt start to the action-oriented process envisioned in the Convention, the document will signal to other countries that they should simply catalog current climate change-relevant actions without taking a hard look at what actions may be needed to meet the aims of the Convention. The Plan has other shortcomings as a model. For example, methods are not transparent and estimates are based on 1988 emissions data.

A final consideration is that the plan has not benefited from any public comment. Public involvement would likely reveal additional options, would help build the consensus needed to implement a U.S. climate change agenda, and would set an example for other countries.

We are sensitive to the President's proposal that "countries meet by January 1, 1993, to present and review their national action plans." However, the State Department has indicated that no other country is intending to submit a plan at the December INC meeting. Therefore, we believe that the Administration can best meet the spirit of the President's proposal by preparing a detailed outline for release at the end of the year. We would propose opening a process of public dialogue by publishing a document in the Federal Register and eliciting public comment.

Putting out an action plan that is on its face insufficient to meet the terms of the U.S. commitment under the Convention would not advance President Bush's efforts to promote a thoughtful and coherent international response to climate change. Finally, given the inherently controversial nature of the document, moving the Plan into the international arena at this time would also work against the President's commitment to minimize confusion about U.S. policy during this period of transition.

Sincerely,

Dick Morgenstern

Richard D. Morgenstern
Acting Assistant Administrator

cc: Michael Deland, CEQ
Linda Stuntz, DOE
John Schrote, DOI
Paul Gilman, OMB
David Bradford, CEA
Robert Reinstein, DOS
J.R. Spradley, DOC

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

December 8, 1992

Dr. Allan Bromley
Assistant to the President
for Science and Technology
Room 358 Old Executive Office Building
Washington, D.C. 20500

Dear Dr. Bromley:

This letter responds to the December 3 letter to you from Richard D. Mogenstern, Acting Assistant Administrator, Office of Policy, Planning and Evaluation, of the Environmental Protection Agency, which urges you to reverse the decision of "the Bromley Group" to distribute the U.S. Climate Change National Action Plan (USNAP) at next week's meeting of the International Negotiating Committee (INC) for a Framework Convention on Climate Change.

Please be informed that the Department of the Interior most strongly opposes EPA's suggestion. The decision of the interagency group, chaired by you, to go forward with distribution of the USNAP at the INC meeting was made after full and careful consideration of all relevant factors and vigorous debate. EPA was the only agency opposed to the final decision. We are concerned that their communication may discredit the interagency process.

In our opinion, the EPA letter contains a variety of misstatements and misleading inferences, to which our response is as follows:

First: It is not true, as EPA contends, that the USNAP does not satisfy the requirements of Article 4 of the United Nations Framework Convention on Climate Change (Convention). The EPA letter implies that the Convention somehow obligates the United States to return its year-2000 net greenhouse gas emissions levels to their 1990 levels, as distinguished from aiming at such result in light of national circumstances. As you know, and as the Senate explicitly recognized when it ratified the Convention, there is a critical distinction between "aiming" at 1990 levels and being obligated to achieve that result. As the Senate Committee on Foreign Relations stated in its formal report on the Convention:" "This aim [of returning emissions to their 1990 levels] is in the reporting section of article 4.2 and is not legally binding."

EPA is wrong when it asserts that the USNAP "does not convey any sense that the aim of such policies [i.e., those described in the USNAP] is to return U.S. emissions to their 1990 levels." A fair reading of the USNAP does not support EPA's view. The Introduction, under the sub-caption "Mitigation" on

page 4, contains the unequivocal statement: "The United States is pursuing numerous actions to mitigate the risk of potential climate change by limiting net greenhouse gas emissions." It then summarizes the estimated effects of those actions in limiting greenhouse gas emissions and shows that we are doing an excellent job in "aiming" at a return to 1990 levels in the year 2000, namely, net emissions "of only 1.4 to 6 percent above 1990 levels." The 32-page section on Mitigation Actions cannot be read as anything other than a serious attempt to reduce net U.S. greenhouse gas emissions by the year 2000, with the comparison to 1990 being very much in mind.

One of the problems with the EPA approach is that, when it recites the provisions of Convention Article 4.2(b), concerning the reporting requirement of nations such as the United States, it conveniently omitted key words of the Convention. The EPA letter describes the requirement as being to communicate "detailed information on its policies and measures . . . with the aim of returning" emissions to their 1990 levels. The eclipses obscured the fact that the missing words described the policies and measures that are to be the subject of the report, namely, "policies and measures referred to in subparagraph (a) above." That is a curious omission, since subparagraph (a) is the part of the commitments provisions that specifically provides for "taking into account the differences in these Parties' starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, ..."

EPA's failure to quote accurately the reporting requirement may account for the emphasis in its letter on the "aim" of returning year-2000 emissions levels to 1990 levels without acknowledging that the "aim" is in light of the national circumstances expressly provided for in the Convention text.

With the full provisions of the reporting requirement in mind, it is clear that EPA also is wrong when it states that "nowhere does the Plan describe why U.S. commitments fall short of the aim of Article 4 and what the U.S. intends to do about it." The EPA statement ignores the fact that the "aim of Article 4" includes taking into account a variety of national circumstances that affect the nation's greenhouse gas limitations policies. Insofar as our nation is concerned, those circumstances are set forth in the lengthy chapter on "National Circumstances" and in the analysis at pages 25 et seq of the chapter on "Mitigation Actions," which show, among other things, projected economic growth.

Second: We specifically object to the EPA's criticism that "the plan fails to list additional policies that would return emissions to 1990 levels or even to launch a dialogue on what additional policies might be considered." There are two bases for our objection:

(1) The Convention in no way calls for discussion of potential policies that have not been adopted by a nation.

(2) From the very beginning of interagency consideration of the scope and content of the USNAP, it has been agreed by all participating departments and agencies, including EPA, that the USNAP to be prepared would be based solely on existing legislation, policies, and programs. Throughout the process of developing the detailed outline of the USNAP and preparing the multiple drafts of the various chapters, all participants understood that there would not be an attempt to develop material on potential policies that have not yet been adopted. For EPA to raise at this late date an objection to the USNAP based on a departure from the agreed approach to the USNAP is untimely and unproductive.

Third: It was agreed by the involved agencies that notice of the USNAP would be published in the Federal Register and comments thereon would be invited. Such comments as may be received may be of benefit to those who have the responsibility for preparing future iterations of the USNAP. But, that in no way implies that the U.S. Government should not distribute at the INC meeting, in keeping the President's public commitment, made at the UNCED in Rio, the highly credible document that now exits.

We trust that you will honor the unanimous views of the departments and agencies (other than EPA) regarding the importance of distributing the USNAP at the INC meeting. If there is any doubt about the decision made on Wednesday, we suggest that there be a full Cabinet meeting with the President to discuss the situation.

Sincerely,

JOHN E. SCHROTE
Assistant Secretary
Policy, Management and Budget

cc: Michael Deland, CEQ
Linda Stuntz, DOE
Paul Gilman, OMB
David Bradford, CEA
Robert Reinstein, DOS
J. R. Spradley, DOC
Richard D. Morgenstern, EPA

THE WHITE HOUSE

WASHINGTON

December 9, 1992

Dear Dr. Morgenstern:

Upon my return from a meeting of the Science Advisors of the G-7 countries in Paris this week, I received your letter of December 4, 1992 regarding the US Climate Change National Action Plan, and would like to make a few brief comments for the record. To begin with, I must conclude that your comments constitute a personal view of the Plan, because this Plan has been produced in response to specific commitments made by both President Bush and EPA Administrator Reilly at UNCED in June. Indeed, it was EPA Administrator Reilly who announced, on behalf of the US, the series of activities to facilitate a "Prompt Start" of the climate change convention as a vital first step in addressing greenhouse gas emissions reduction, and completion of the US National Action Plan by January 1, 1993 was one of the steps in that six-step plan.

To help move the implementation phase of the Convention forward, the United States is providing this plan to the INC meetings this week to aid in discussions in the Convention process, while it is, at the same time, under review in our own country through the Federal Register process. As we have stated, the Plan represents only the first iteration in a series of regular reports. However, the Plan, imperfect as it may be at this stage, is the result of a great deal of very hard work by many, dedicated individuals in the different government agencies who have been laboring very hard to meet the President's and Administrator Reilly's stated commitments and to provide the negotiations with useful material to help move the convention process forward at an accelerated rate.

I continue to hold a great respect for the interagency processes which have produced this report and which have provided a vehicle for full and open review by all interested government agencies. In fact, you were part of the full and open discussion of the issues on December 2, 1992 by the US policy review group set up by President Bush in 1989 here in the White House for climate change issues, the Global Change Strategy Task Force. In that meeting, ten federal agencies voted to provide the US National Action Plan to the Intergovernmental Negotiating Committee (INC) for discussion at this week's INC meetings, while, at the same, distributing the Plan for review here in the US through the Federal Register process. You, on behalf of the Environmental Protection Agency, were the one vote against this action - against fulfilling an international commitment made by the President as well as by your own Administrator (and, as I have subsequently discovered, against the stated position of your Administrator on this issue).

In addition, I also feel that widely circulating a letter which is inaccurate and deliberately misleading such as yours of December 4, just prior to a major international meeting where the US is attempting to provide practical and useful information to a discussion of a crucial environmental issue like greenhouse gas emissions reduction, is by no means a service to the country or to the environment.

As we move from one Administration to another over the next month, President Bush and the other members of this Administration remain committed to continuing to take whatever concrete steps are possible to accelerate the most expeditious implementation of the climate change convention in order to reduce worldwide greenhouse gas emissions. In the short time left in this Administration, I sincerely hope you will join us in this very important effort.

Sincerely yours,

D. Allan Bromley
The Assistant to the President
for
Science and Technology

Dr. Richard Morgenstern
Acting Assistant Administrator
Office of Policy Planning and Evaluation
Environmental Protection Agency
Washington, D.C. 20460

TYPE: ACTION DOCUMENT NUMBER: 9203580
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

****

FROM: SCHROTE, John: U.S. DEPARTMENT OF THE INTERIOR

TO: DR. D.A. BROMLEY

DATE OF CORRESPONDENCE: 12/08/92

SUBJECT: HE IS WRITING REGARDING RICHARD MORGENSTERN'S LETTER CONCERNING THE VIEWS EXPRESSED IN THE U.S. CLIMATE CHANGE NATIONAL ACTION PLAN MEETING.

****

DIRECTORATE ASSIGNED: ENVIRONMENT

STAFF ASSIGNED:

ACTION REQUIRED: AS NECESSARY

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: 12/28/92

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
INTERNATIONAL/POLICY

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 12/14/92 DEPT RECEIVED:

FILE: P-ENVIRONMENT

CENTRAL FILES:

3580

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

TAKE PRIDE IN AMERICA

December 8, 1992

Dr. Allan Bromley
Assistant to the President
for Science and Technology
Room 358 Old Executive Office Building
Washington, D.C. 20500

Dear Dr. Bromley:

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JOHN E. SCHROTE
Assistant Secretary
Policy, Management and Budget

cc: Michael Deland, CEQ
Linda Stuntz, DOE
Paul Gilman, OMB
David Bradford, CEA
Robert Reinstein, DOS
J. R. Spradley, DOC
Richard D. Morgenstern, EPA

THE WHITE HOUSE

WASHINGTON

December 9, 1992

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Sincerely yours,

D. Allan Bromley
The Assistant to the President
for
Science and Technology

Dr. Richard Morgenstern
Acting Assistant Administrator
Office of Policy Planning and Evaluation
Environmental Protection Agency
Washington, D.C. 20460

TYPE: ACTION DOCUMENT NUMBER: 9203579
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

****

FROM: MORGENSTERN, Richard D.: U.S. ENVIRONMENTAL PROTECTION AGENCY

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 12/03/92

SUBJECT: HE IS WRITING REGARDING THE CONCERNS HE EXPRESSED IN THE MEETING ON THE U.S. CLIMATE CHANGE NATIONAL ACTION PLAN.

****

DIRECTORATE ASSIGNED: ENVIRONMENT

STAFF ASSIGNED:

ACTION REQUIRED: AS NECESSARY

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: 12/28/92 STAFF DUE DATE

DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
INTERNATIONAL/POLICY

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 12/14/92 DEPT RECEIVED:

FILE: P-ENVIRONMENT-GLOBAL CHANGE

CENTRAL FILES:

3579

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DEC 03 1992

OFFICE OF
POLICY, PLANNING AND EVALUATION

Dr. Allan Bromley
President's Science Advisor
The White House
Washington, D.C. 20500

Dear Dr. Bromley:

I am writing to clarify and expand upon the concerns I expressed in yesterday's meeting regarding the U.S. Climate Change National Action Plan. As I stated in the meeting, we believe it is inappropriate for the U.S. to transmit the Plan to the International Negotiating Committee (INC) at this time.

Our fundamental concern is that the draft Plan does not satisfy the requirements of the Convention. Article 4.2(b) of the Convention states that "each of the Parties shall communicate ... detailed information on its policies and measures ... with the aim of returning individually or jointly to their 1990 levels of ... greenhouse gases not controlled by the Montreal Protocol." While the current document catalogs many ongoing U.S. legislative and regulatory activities in the energy and other sectors, it does not convey any sense that the aim of such activities is to return U.S. emissions to their 1990 levels. In fact, the message of the document is that the U.S. is pursuing a number of policies for reasons quite apart from climate change whose incidental effect is to limit emissions close to but above the aim of the Framework Convention. Nowhere does the Plan describe why U.S. commitments fall short of the aim of Article 4 and what the U.S. intends to do about it. Specifically, the plan fails to list additional policies that would return emissions to 1990 levels or even to launch a dialogue on what additional policies might be considered. We would be happy to develop such a list of options.

In light of the U.S.'s leadership in ratifying the Framework Convention and the importance the U.S. has placed on national plans, the failure to fulfill Article 4 renders the document inadequate. President Bush has made national action plans a cornerstone of the global climate change strategy embodied in the Framework Convention. The Bush Administration has argued compellingly that progress on climate change will only be made when countries move beyond rhetoric and identify specific policies to fulfill the Convention's aims. The draft Plan undermines this argument.

Furthermore, the Plan sets a poor precedent. Rather than serving as the basis for a prompt start to the action-oriented process envisioned in the Convention, the document will signal to other countries that they should simply catalog current climate change-relevant actions without taking a hard look at what actions may be needed to meet the aims of the Convention. The Plan has other shortcomings as a model. For example, methods are not transparent and estimates are based on 1988 emissions data.

A final consideration is that the plan has not benefited from any public comment. Public involvement would likely reveal additional options, would help build the consensus needed to implement a U.S. climate change agenda, and would set an example for other countries.

We are sensitive to the President's proposal that "countries meet by January 1, 1993, to present and review their national action plans." However, the State Department has indicated that no other country is intending to submit a plan at the December INC meeting. Therefore, we believe that the Administration can best meet the spirit of the President's proposal by preparing a detailed outline for release at the end of the year. We would propose opening a process of public dialogue by publishing a document in the Federal Register and eliciting public comment.

Putting out an action plan that is on its face insufficient to meet the terms of the U.S. commitment under the Convention would not advance President Bush's efforts to promote a thoughtful and coherent international response to climate change. Finally, given the inherently controversial nature of the document, moving the Plan into the international arena at this time would also work against the President's commitment to minimize confusion about U.S. policy during this period of transition.

Sincerely,

Dick Morgenstern

Richard D. Morgenstern
Acting Assistant Administrator

cc: Michael Deland, CEQ
Linda Stuntz, DOE
John Schrote, DOI
Paul Gilman, OMB
David Bradford, CEA
Robert Reinstein, DOS
J.R. Spradley, DOC

THE WHITE HOUSE

WASHINGTON

December 9, 1992

Dear Dr. Morgenstern:

Upon my return from a meeting of the Science Advisors of the G-7 countries in Paris this week, I received your letter of December 4, 1992 regarding the US Climate Change National Action Plan, and would like to make a few brief comments for the record. To begin with, I must conclude that your comments constitute a personal view of the Plan, because this Plan has been produced in response to specific commitments made by both President Bush and EPA Administrator Reilly at UNCED in June. Indeed, it was EPA Administrator Reilly who announced, on behalf of the US, the series of activities to facilitate a "Prompt Start" of the climate change convention as a vital first step in addressing greenhouse gas emissions reduction, and completion of the US National Action Plan by January 1, 1993 was one of the steps in that six-step plan.

To help move the implementation phase of the Convention forward, the United States is providing this plan to the INC meetings this week to aid in discussions in the Convention process, while it is, at the same time, under review in our own country through the Federal Register process. As we have stated, the Plan represents only the first iteration in a series of regular reports. However, the Plan, imperfect as it may be at this stage, is the result of a great deal of very hard work by many, dedicated individuals in the different government agencies who have been laboring very hard to meet the President's and Administrator Reilly's stated commitments and to provide the negotiations with useful material to help move the convention process forward at an accelerated rate.

I continue to hold a great respect for the interagency processes which have produced this report and which have provided a vehicle for full and open review by all interested government agencies. In fact, you were part of the full and open discussion of the issues on December 2, 1992 by the US policy review group set up by President Bush in 1989 here in the White House for climate change issues, the Global Change Strategy Task Force. In that meeting, ten federal agencies voted to provide the US National Action Plan to the Intergovernmental Negotiating Committee (INC) for discussion at this week's INC meetings, while, at the same, distributing the Plan for review here in the US through the Federal Register process. You, on behalf of the Environmental Protection Agency, were the one vote against this action - against fulfilling an international commitment made by the President as well as by your own Administrator (and, as I have subsequently discovered, against the stated position of your Administrator on this issue).

In addition, I also feel that widely circulating a letter which is inaccurate and deliberately misleading such as yours of December 4, just prior to a major international meeting where the US is attempting to provide practical and useful information to a discussion of a crucial environmental issue like greenhouse gas emissions reduction, is by no means a service to the country or to the environment.

As we move from one Administration to another over the next month, President Bush and the other members of this Administration remain committed to continuing to take whatever concrete steps are possible to accelerate the most expeditious implementation of the climate change convention in order to reduce worldwide greenhouse gas emissions. In the short time left in this Administration, I sincerely hope you will join us in this very important effort.

Sincerely yours,

D. Allan Bromley
The Assistant to the President
for
Science and Technology

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