



UNITED STATES DEPARTMENT OF COMMERCE  
Office of the Under Secretary for  
Oceans and Atmosphere  
Washington, D.C. 20230

July 18, 1994

MEMORANDUM FOR: Committee on Environment and Natural Resources  
(CENR) Full Committee

FROM: Donna Wieting *Donna Wieting*  
CENR Executive Secretary

SUBJECT: CENR Subcommittee Reports for Clearance

I am pleased to forward with this memorandum two reports drafted by subcommittees of the CENR. The first report is entitled "A Directory of Federal Activities Related to Mitigation of or Adaptation to Global Change - FY 1993 - FY 1994" prepared by the CENR Technology and Engineering Subcommittee. The second report is entitled "The U.S. Global Change Data and Information System (GCDIS) Implementation Plan" prepared by the Global Change Research Subcommittee. Each report has the concurrence of your agency representatives on the respective subcommittees.

The reports are forwarded to you for your review and clearance. With your approval, the reports will be published as a product of the CENR. Please indicate your approval, or need for further discussion, by returning the attached form to me by July 29, 1994. Please call me at (202) 482-5916 if you have any questions.

Attachments

cc: CENR Co-Chairs  
CENR Vice Chairs  
CENR Points of Contact



PLEASE RETURN BY TUESDAY, JULY 26.

Please check applicable box and sign in space provided for each report.

1) A Directory of Federal Activities Related to Mitigation of or Adaptation to Global Change - FY 1993 - FY 1994.

\_\_\_\_\_ I approve publication of the report.

\_\_\_\_\_ I approve publication of the report with minor editing (attach comments).

\_\_\_\_\_ I would like to have further discussion with CENR Principals before publication of the report.

2) The U.S. Global Change Data and Information System (GCDIS) Implementation Plan.

\_\_\_\_\_ I approve publication of the report.

\_\_\_\_\_ I approve publication of the report with minor editing (attach comments).

\_\_\_\_\_ I would like to have further discussion with CENR Principals before publication of the report.

\_\_\_\_\_  
CENR Principal Member Signature

\_\_\_\_\_  
Agency

\_\_\_\_\_  
Date

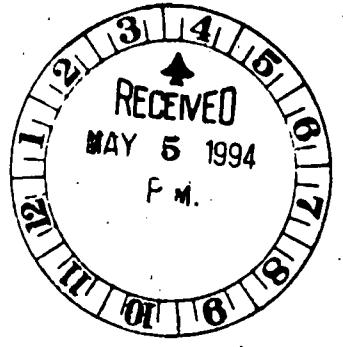
Return by FAX and mail to:

Donna Wieting/Executive Secretary  
Committee on Environment and Natural Resources  
National Oceanic and Atmospheric Administration  
Room 5805  
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*Dr. Baker?*

National Science and Technology Council  
Committee on the Environment and Natural Resources  
Subcommittee for Technology and Engineering Research



May 2, 1994

Dr. D. James Baker, Co-chair  
Committee on the Environment and Natural Resources  
14th Street and Constitution Avenue, NW, Room 5128  
Washington, DC 20230

Dear Dr. Baker:

I transmit herewith a copy of the volume, "A Directory of Federal Activities Related to Mitigation of or Adaptation to Global Change - FY 1993-FY 1994." The intended audience is private sector groups interested in Federal mitigation and adaptation activities as well as all Federal agencies. A companion volume listing mitigation and adaptation activities of the private sector is in preparation. The Electric Power Research Institute has offered to provide the costs of printing and distribution of both volumes.

The Directory was prepared under the direction of the Subcommittee on Technology and Engineering Research. In addition to our approval, we would like to have the approval of the Committee on the Environment and Natural Resources (CENR). Then the Directory could be published as a product of the CENR.

It is for this reason I am transmitting the Directory to you with the approval and recommendation of the Subcommittee on Technology and Engineering Research.

Sincerely,

A handwritten signature in black ink, appearing to read "Joe Bordogna". The signature is fluid and cursive, with a long horizontal stroke at the end.

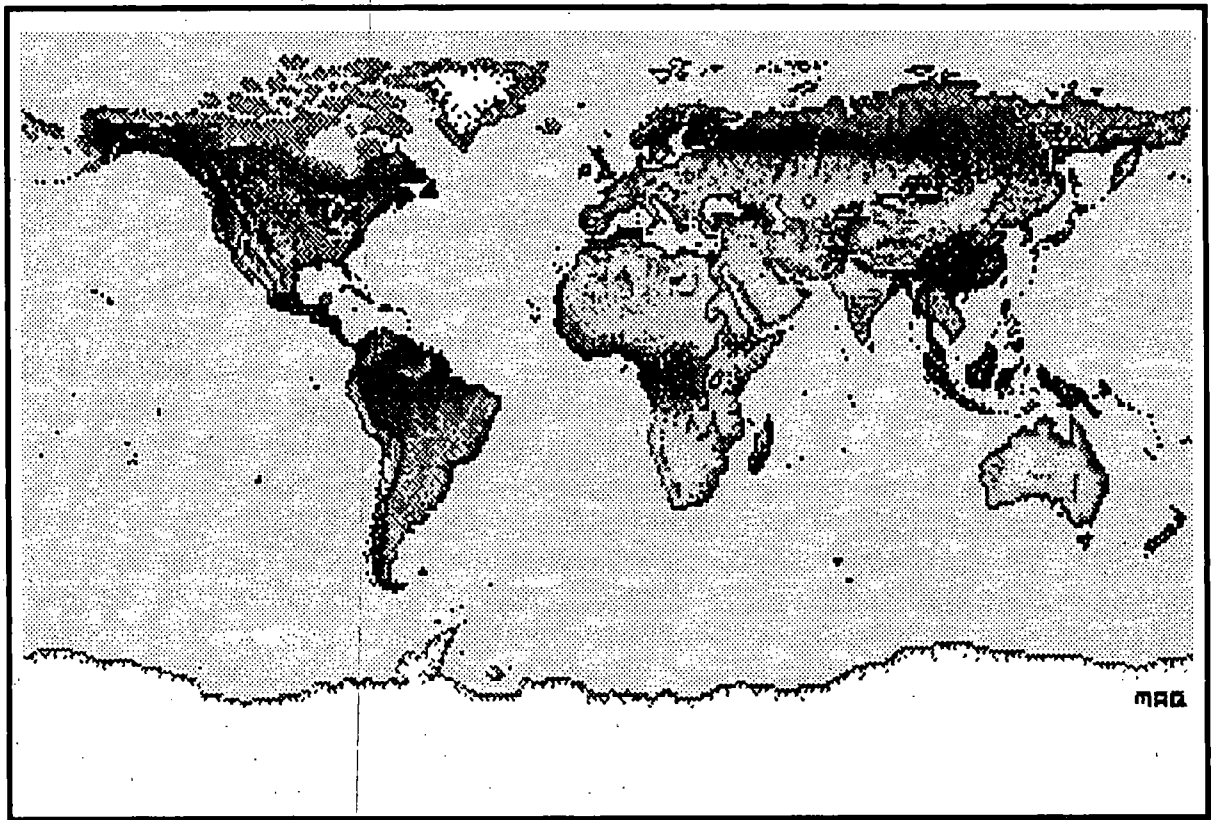
Joseph Bordogna  
Chair  
Subcommittee on Technology and Engineering Research

Enclosure

# DIRECTORY

## OF FEDERAL RESEARCH ACTIVITIES RELATED TO MITIGATION OF OR ADAPTATION TO GLOBAL CHANGE

FY 1993 - FY 1994



COMPILED BY:

SUBCOMMITTEE ON TECHNOLOGY AND ENGINEERING RESEARCH

COMMITTEE ON THE ENVIRONMENT AND NATURAL SCIENCES

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

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# **I. EXECUTIVE SUMMARY**

1. The Mitigation and Adaptation Directory for fiscal years 1993 and 1994 is the second edition of this book. The first edition covered fiscal years 1991 and 1992. There have been several changes between the two editions, notably in organizational relationships. This second edition is prepared under the direction of the Subcommittee on Technology and Engineering Research of the Committee on Environmental and Natural Resources, National Science and Technology Council.

2. The social and economic research program shown in the FY 91-92 edition has been expanded to a separate section of the overall U. S. Global Change Research Program and, thus, is not reflected in this edition.

3. The most growth has occurred in research programs addressing mitigation of environmental changes. The U. S. Department of Energy (DOE) alone has 44 mitigation programs, totaling \$1.4 billion principally in energy efficiency and alternative energy sources. One example is DOE's \$42.8 thousand program in combustion systems. The technologies that comprise Combustion Systems research focus on total system improvements that will yield both lower emissions and significantly higher efficiencies.

4. Research programs of other agencies cover a full range including protection of food, fiber, and forestry research; biological diversity, ecosystem protection, and regional climate change effects. The Department of Agriculture, for example, has a research program that addresses environmental change impacts on crop production by focusing on the belowground (root area) plant responses to elevated levels of CO<sub>2</sub>. The National Science Foundation is funding research on the effects of climate change on coastal ecosystems. The Tennessee Valley Authority is assessing the effects of climate change on the ecosystem represented by the Tennessee river basin. A review of the Directory will reveal a wealth of research addressing this common theme of environmental change.

5. In numbers and dollars (in thousands) of programs, the following growth has occurred:

	FY 91-92		FY93-94	
	#	\$	#	\$
Mitigation, Focused	18	\$13,885	26	\$80,728
Mitigation, Contributory	8	992	42	2,368,461
Adaptation, Focused	14	4,402	11	22,688
Adaptation, Contributory	28	16,590	19	42,418
Combined, Focused		11,084	2	643
Combined, Contributory		87,314	5	101,863
Totals	68	134,267	105	2,616,801

This represents a 50% increase in programs, and a 160% funding increase, from fiscal year 1991 to fiscal year 1994.

6. Additional copies of the Directory may be obtained from:

USDA Global Change Program Office  
 1621 N. Kent Street, Room 60LL  
 Arlington, Virginia 22209  
 Phone: 703-235-9018  
 Fax: 703-235-9046

## II. SUMMARY DEFINITIONS

**Mitigation:** technologies and practices, which, if implemented, could offset or limit the magnitude of global environmental changes that have a negative effect on the quality of life.

**Adaptation:** technologies and practices, which, if implemented, could facilitate natural and societal adjustment to the environmental, social, and economic consequences of global change.

### **III. PROGRAMS**

**A. MITIGATION - FOCUSED**

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Belowground Responses to Global Environmental Change and the Biogeochemical Dynamics of Carbon.  
**Budget (In Thousands):** FY93 \$372 FY94 \$372

**Program Description:** Plant responses to elevated CO<sub>2</sub> are being researched. The work is being conducted as an integrated, multi-species project with two main research thrusts: one study (5- year duration) uses sorghum and soybean as model plant species and the other involves longleaf pine. Plants are being exposed to air with an ambient concentration of CO<sub>2</sub> (~360 ppm) or to air with twice that amount of CO<sub>2</sub> within open top chambers. The first major focus of this study is to investigate the effects of higher CO<sub>2</sub> on root growth and other belowground processes, such as changes in the composition and activity of populations of fungi, bacteria, and nematodes in the rhizosphere. The second major focus is to determine what plants do with extra atmospheric CO<sub>2</sub>. For example, how much is used for production of plant material, how much is released into the soil by plant roots and perhaps remains in the soil, and how much is given back to the atmosphere by plant processes such as respiration. Cooperative research efforts include: the effects of elevated CO<sub>2</sub> on nitrogen uptake by plants and its effect on water quality, soil processes including biomineralization (bedrock weathering), and CO<sub>2</sub> effects on seed quality. The longleaf pine study is examining the interacting effects of elevated CO<sub>2</sub> and resource availability (namely differences in nitrogen and water) on carbon allocation patterns, respiration, and root function. The long-range goal of this research is to examine, in addition to longleaf pine, the response of other species (i.e., wiregrass, wax myrtle, etc.) which comprise a natural and endangered ecosystem. Ultimately, this research will examine competition among species as influenced by CO<sub>2</sub>. Other related studies being carried out in conjunction with this work are effects of CO<sub>2</sub> on root colonization by mycorrhizal fungi and the role of elevated CO<sub>2</sub> in production of pyrogenic plant metabolites and its relationship to water quality.

**Linkages with other Federal Agencies:** DOE, EPA.

**Linkages with private sector NGO's and academia:** Alabama Agricultural Experiment Station, Auburn University, University of Minnesota, Duke University, Woods Hole Research Center, Smithsonian Institution, and Lawrence Livermore, Oak Ridge, and Brookhaven National Laboratories.

**Contact Person:** H. H. Rogers  
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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Effects of Nutrient Transport in Cropping Systems in Environmental Quality and Fertilizer Efficiency.  
**Budget (In Thousands):** FY93 \$486 FY94 \$486

**Program Description:** Objectives of this program include the assessment of nitrogen and other nutrient pathways within the crop and soil and from the crop and soil to the atmosphere and ground-water; the development and use of non-invasive techniques to measure radiatively active trace gas fluxes that affect global climate change and carbon balance and the effect of agricultural ecosystems on and by these gases; and the evaluation of methane emissions from cattle under grazing, feedlot, and dairy conditions including the methane emission from waste lagoons and waste-disposal systems. Additional objectives include cooperative studies with animal scientists for the reduction of methanogenesis and emissions in ruminant animals.

**Linkages with other Federal Agencies:** DOE.

**Linkages with private sector, NGO's, and academia:** University of Georgia (cooperative research), Texas A & M University (cooperative research on methane emission and reduction from ruminants), Masstock Southern Dairies (cooperative research on nutrient dynamics and trace gas emissions), Georgia Institute of Technology (cooperative research on trace gases), Campbell Scientific (development of trace gas measurement technology).

**Linkages with international organizations:** CSIRO [Australia] (cooperative studies on global climate gases and trace gas measurements technologies), CABO, University of Utrecht, Wageningen Agricultural University, NMI/PR, and Soils Institute [Netherlands] (cooperative research on agriculture trace gases), University of Guelph [Canada] (cooperative development of trace gas measurement instrumental and cooperative research).

**Contact Persons:** L.A. Harper and R.R. Sharpe  
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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: CO<sub>2</sub>  
**Focused or Contributory:** Focused  
**Program Title:** Prediction of Long Term Changes in Carbon Storage and Productivity of U.S. Soils as Affected by Changes In Climate and Management: Regional Analysis of Controls on Soil Carbon Levels  
**Budget (In Thousands):** FY93 \$40 FY94 \$40

**Program Description:** A systems analysis of benchmark data from a network of thirty-nine long term field experiments in North America is being conducted to evaluate climate, soil and land use, and management controls on soil C levels in agricultural and grassland ecosystems. The historic databases from these sites, dating back as long as 100 years and including management history, annual productivity and changes in all properties, are being analyzed with the CENTURY model, version 4.0, which enables simulation of complex rotation and tillage regimes. The analysis will provide a basis for evaluating whether current agricultural systems in North America are acting as net sinks or sources of CO<sub>2</sub> and to what extent temperate agricultural soils can sequester C with projected future changes in management and climate. We anticipate utilizing these analyses as part of the forthcoming Intergovernmental Panel on Climate Change assessment on mitigation of global change by agriculture, chaired by C. V. Gale.

**Linkages with other Federal Agencies:** EPA (Global Change Research Program), DOE (NIGEC-Great Plains Region).

**Linkages with private sector, NGO's and academia:** Colorado State University, Michigan State University.

**Linkages with international organizations:** International Geosphere Biosphere Program/Global Change in Terrestrial Ecosystem, Committee for Soil Organic Matter Task 3.3.3.

**Contact Person:** K. Paustain/C.V. Cole  
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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Prediction of Long-term Changes In Carbon Storage and Productivity of U.S. Soils as Affected by Changes in Climate and Management  
**Budget (In Thousands):** FY93 \$285 FY94 \$273

**Program Description:** The spatial and temporal variability in carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrogen (N<sub>2</sub>O) trace gas fluxes in a natural (shortgrass prairie) and managed (cultivated wheat) ecosystem, and as affected by management practices, daily and seasonal changes in climate, are being assessed using a comprehensive soil-gas exchange model. The one-dimensional soil gas exchange model uses a finite difference numerical method and simulates gas transport in the soil through advective-dispersive flow in the liquid phase and diffusive flow in the vapor phase. The dynamics of gas movement in the soil consider the spatial and temporal variabilities in soil properties with depth, such as layering, soil moisture and temperature, plant root distribution, microbial activities, and the kinetics of soil chemical reactions as determined by changes in soil redox potential.

The soil gas exchange submodels were written as independent units (modular) so it can easily be linked to accept dynamic variables from existing biological (plant and microbial), water, solute and heat flow models. Presently, refinement and validations of the soil gas exchange model are being made using field data from field experiments conducted in 1991 and from other (within ARS and U.S. Geological Survey) collaborative sources.

**Linkages with other Federal Agencies:** USDO/USGS.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Impacts of Climate and Environmental Change on Agricultural Resources and Watershed Processes  
**Budget (In Thousands):** FY93 \$345 FY94 \$306

**Program Description:** A process-based modular modeling system and a simpler decision support system are being developed for cropland and rangeland enterprises. The system models will include atmosphere-land, surface, gas, and energy exchange processes. The process-based system models will be used to analyze effects of global change on biological, chemical, and physical processes and agricultural production. This analysis will identify methods of mitigation and adaptation. The decision support system will be used by farmers and ranchers for quick analysis and results of mitigation and adaptation activities.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: CO<sub>2</sub>  
**Focused or Contributory:** Focused  
**Program Title:** Global Change and the Structure and Function of Ecosystems  
**Budget (In Thousands):** FY93 \$500 FY94 \$500

**Program Description:** Experiments are conducted in large controlled-environment chambers to document the responses of natural ecosystems to increasing atmospheric carbon dioxide (CO<sub>2</sub>), from the low CO<sub>2</sub> levels of the last Ice Age through the increases of the last 200 years to the higher levels anticipated in the future. The specific objective is to determine how changing atmospheric CO<sub>2</sub> has altered ecological processes which influence the vegetation composition and productivity of rangelands and other natural ecosystems. Different species of native plants are grown alone in monocultures and together in mixtures across a range of CO<sub>2</sub> concentrations, and physiological, whole-plant, and "community" responses are monitored over time. Availability of water, nitrogen, and other resources is controlled and resource use efficiency is measured to test the hypothesis that CO<sub>2</sub> levels alter specific composition of native vegetation primarily as differentially influencing resource capture by and use efficiency of individual species. CO<sub>2</sub> effects on ecosystem processes such as nitrogen fixation also are studied.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** Texas A&M University.

**Linkages with international organizations:** None.

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808 East Blackland Rd.  
Temple, TX 76502

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Carbon Dioxide Sinks  
**Focused or Contributory:** Focused  
**Program Title:** Carbon Dioxide Fluxes Above Agricultural Lands  
**Budget (In Thousands):** FY93 \$52 FY94 \$52

**Program Description:** The rate of increase in atmospheric carbon dioxide (CO<sub>2</sub>) concentration may be reduced by enhancing carbon (C) storage in plant biomass and soils. Increases in soil C content have been associated with changing agricultural land uses and shifts in management practices which allow organic matter to accumulate, but such studies document relatively slow changes which must proceed for years or decades before significant responses can be measured. In this study, the Bowen ratio/energy balance approach is utilized to measure short-term C fluxes through the soil/plant/atmosphere continuum, using infrared gas analyzers sampling at two heights above the vegetation. Diurnal as well as seasonal C flux above the vegetated surfaces of a sorghum field, a field converted to perennial grass, and an adjacent native prairie are measured continuously for 3 years. The contribution of soil respiration is monitored by measurement of CO<sub>2</sub> flux in small chambers. These flux rates will provide direct measurements of C sequestration by contrasting kinds of agricultural vegetation. In conjunction with meteorological measurements, estimates of plant biomass and soil organic C and water content, and monitoring of the timing and nature of farming activities, they will provide insight into the timing of mechanisms of C gain and loss.

**Linkages with Other Federal Agencies:** DOE.

**Linkages with private sector, NGO's and academia:** Texas A&M University, Texas Agricultural Experiment Station.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Carbon Dioxide Sinks  
**Focused or Contributory:** Focused  
**Program Title:** Global Change and Agriculture: Effects of Land Use and Management Practices on Atmospheric CO<sub>2</sub> Levels  
**Budget (In Thousands):** FY93 \$90 FY94 \$90

**Program Description:** Organic carbon (C) content of soils is analyzed at sites subjected to contrasting land uses or management practices for extended periods of time to assess whether management options vary in their ability to sequester atmospheric carbon dioxide (CO<sub>2</sub>). In a representative study, soil C content was analyzed on pairs of adjacent fields, one maintained in continuous cultivation for decades and the other planted to grasses under the Conservation Reserve Program (CRP) 5 years earlier. Nearby native pastures also were sampled. These three land uses were compare mapped at five locations in the Great Plains, where 72% of all CRP enrollments occur, to determine whether conversion from cropland to grassland sequesters atmospheric CO<sub>2</sub>. Averaged across all locations, soil organic C contents of continuously cultivated croplands, CRP lands, and native pastures were 59.2, 65.2, and 90.8 metric tons C ha<sup>-1</sup> respectively, to a depth of 300 cm. Cultivation for decades reduced soil organic C by 25.6 metric tons ha<sup>-1</sup>, or 28%, relative to uncultivated native pastures, but fields enrolled in the CRP for only 5 years regained 6 metric tons C ha<sup>-1</sup> or 1.1 metric tons C ha<sup>-1</sup>/yr<sup>-1</sup>. If these rates of soil C recovery are representative of all CRP land, the 17 million ha of cropland enrolled nationally are sequestering about 45% of the 38.1 million metric tons C released annually into the atmosphere by U.S. agriculture, including that generated by the manufacture of nitrogen fertilizer.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** Texas A&M University.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Assess, Predict, and Mitigate Agricultural C and N Trace Gas Fluxes That Contribute to Global Change.  
**Budget (In Thousands):** FY93 \$228 FY94 \$228

**Program Description:** Long term field (3 to 5 year) measurement of the soil-atmosphere exchange of NO, CH<sub>4</sub> and CO<sub>2</sub> in native and managed grasslands in the Great Plains, in montane and in tropical systems, and factors which influence these fluxes are being conducted. These studies are being used to develop a predictive understanding of the contribution of C and N transformations in native and agricultural soils through construction of general process-based models of the soil-atmosphere exchange of N<sub>2</sub>O and CH<sub>4</sub>. These trace gas submodels are being developed and interfaced with a daily-time-step version of a general ecosystem model (CENTURY). This model structure should permit simulation of the impact of probable climate and land use change on trace gas fluxes. Methods of mitigating N<sub>2</sub>O emissions while improving N-use efficiency in N-fertilized soils also are being investigated.

**Linkages with other Federal Agencies:** DOE (Post Doctoral Program).

**Linkages with private sector, NGO's and academia:** Colorado St. University Network Coordinator for a national effort to develop a coherent terrestrial tract gas network: Building a U.S. Trace Gas Network (TRAGNET).

**Linkages with international organizations:** International Geosphere Biosphere Program/International Global Atmospheric Chemistry Project. Coordinating committees for Activity 2.5 of Focus 2 and Activity 5.2 of Focus 5. DECO-N<sub>2</sub>O national inventories.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Assess Predict, and Mitigate Agricultural C and N  
Trace Gas Fluxes That Contribute to Global Change  
**Budget (In Thousands):** FY93 \$228 FY94 \$228

**Program Description:** Long term field studies in progress are designed to evaluate the effect of management practices in the Great Plains on soil-atmosphere exchange of C and N trace gases. Preliminary results indicate NO and N<sub>2</sub>O exchange are best simulated by the product of a constant that reflects soil N availability, an exponential function of soil temperature, and a dual- slope linear function of soil water-filled pore space that captures the dependence of microbial activity on both solution phase and gas phase diffusion rates in soil. Understanding dependence of the model constant on the sizes and/or transformation rates of identifiable soil N pools and developing an effective method of adjusting the effect of precipitation for soil water content prior to wetting require additional work before this approach can be extended over the much larger areal and temporal domains to which it may apply. An analogous model of CH<sub>4</sub> oxidation in soil has been more difficult to parameterize. Concurrent laboratory soil incubation studies investigate the influence of soil C, N, and CO<sub>2</sub> availabilities as well as soil pH and water content, on the production/consumption of intermediate and final products of microbial C and N transformation processes.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's, and academia:** Prairie View A&M University.

**Linkages with international organizations:** None.

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Fort Collins, CO 80522

**Agency:** U. S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Sequestration and Release of Carbon in the Terrestrial Carbon Cycle and its Interaction with the Atmosphere  
**Budget (In Thousands):** FY93 \$60 FY94 \$70

**Program Description:** To evaluate effects of long-term grazing intensity including non-grazed Conservation Reserve Program areas and conservation tillage systems on soil carbon and nitrogen changes.

A. Two native pastures with 75-year history of different grazing intensity will be evaluated. Grazing intensity has resulted in major species changes. The moderately grazed pasture has remained a typical Northern Great Plains mixed prairie site, whereas the heavily grazed pasture has changed to a predominately blue grams (C-4 species) pasture. Both pastures and adjacent enclosures of virgin grasslands have been sampled to 1.1 m depth. Soil carbon and nitrogen and carbon isotope signature will be determined at depth increments. Results will be related to grazing intensity and species composition. Also, plots within the moderately grazed pastures have been enriched with C-13 to evaluate root turnover and fate of root carbon. Conservation Reserve Program-type pastures established in 1986 and either grazed, nongrazed, or hayed also have been sampled to evaluate soil carbon changes.

B. Soil samples by increment depth of 1.5 m were taken in the 65-acre cropping systems-conservation tillage study during the fall of 1991 to determine the effects of cropping sequence, tillage, and nitrogen applications over a six-year period on soil carbon, nitrogen, and soil property changes. The treatments in this study provide a wide range in crop and residue production systems where changes in chemical/physical soil properties and cycling of carbon, nitrogen, and phosphorus can be investigated.

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Mandan, ND 58554

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research service  
**Function:** Mitigation: CO<sub>2</sub>  
**Focused or Contributory:** Focused  
**Program Title:** Responses of the Shortgrass Prairie to CO<sub>2</sub> and Global Climate Change  
**Budget (In Thousands):** FY93 \$47 FY94 \$28

**Program Description:** We are examining how indigenous plants of the shortgrass prairie respond to elevated atmospheric CO<sub>2</sub> concentrations and global climate change. In particular, we are investigating how photosynthesis, growth, nutrient and water uptake, and survival of native plants are influenced by CO<sub>2</sub> temperature and soil water availability. Responses of belowground organisms, plant roots and soil chemistry to plant and environmental perturbations also are being studied so realistic models can be developed to predict how the prairie will be expected to respond in future CO<sub>2</sub>-enriched environments. The combined experimental/modeling exercises will allow us to anticipate how vegetation will respond to the rapidly changing environment, and allow agricultural scientists to propose management strategies to optimize use of the native rangelands for agriculture and recreation.

**Linkages with other Federal Agencies:** USDA-CSRS

**Linkages with private sector, NGO's and academia:** Colorado State University; University of Toronto; Utah State University; Front Range Community College

**Linkages with international organizations:** International Geosphere Biosphere Program

**Contact Person:** Jack A. Morgan  
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**Fax Number:** 303-482-2909  
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1701 Center Avenue  
Ft. Collins, CO 80526

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Dynamics of Greenhouse Gases and Climate Change in Subarctic Land Management and Cropping Systems  
**Budget ( In Thousands):** FY93 \$726 FY94 \$723

**Program Description:** Long term field (3 years) measurements of the flux of N<sub>2</sub>O, CH<sub>4</sub> and CO<sub>2</sub> are being conducted on cropped land with various tillage, cropping history and residue management and on managed grasslands in subarctic agriculture systems. These studies are being used to evaluate the contribution of northern agriculture to the exchange of these gasses between the atmosphere and the soil. Information collected at this location is being used by the trace gas network (TRAGNET) headed by Dr. Arvin Mosier (ARS, Ft. Collins, CO). Studies will be conducted during FY94 to ascertain the effects of long days (>22 hours of sunlight), cool summers, and low sun angle on plant responses to elevated atmospheric CO<sub>2</sub>. These studies will be conducted in growth chambers and open topped chambers in the field.

**Linkages with academia:** University of Alaska Fairbanks, Center for Global Change and Arctic System Research.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Global Change Research, Modeling, and Data Base Management with Emphasis on Terrestrial Systems  
**Budget (In Thousands):** FY93 \$295 FY94 \$295

**Program Description:** The program of TERRA is the development, documentation and dissemination of systems analysis methodologies (SAM) for terrestrial ecosystem problem solutions. Tools being developed to meet this goal will enable the Lab to improve the terrestrial component of integrated earth system models. The TERRA SAM provides a capability to study the cumulative regional effects of local decisions. It is based on a broad library of available ecosystem component models, data bases, modeling systems, GIS, visualization tools, and collaboration technologies based on computer aided decision programs. The SAM and the collection of tools is being developed and evaluated by focusing on testbed problems that cover a wide range of scales. The testbed problems address such questions as: what are the regional scale effects of local and policy level decisions, what is the relative significance of climatic, biologic, hydrologic, and socio/economic factors in these decisions. Stakeholders in the testbed areas are an integral part of the development of the issues and the analyses of those issues. Water allocation, vegetation utilization, and land use restrictions are the kinds of issues addressed.

**Linkages with other Federal Agencies:** DOI; TERRA is an Interagency Laboratory made up of representatives from the Forest Service, Agricultural Research Service in USDA and the Geological Survey in the USDI. The Soil Conservation Service also contributes to the effort.

**Linkages with the private sector, NGO's and academia:** IBM (International Business Machines) and CIESIN (Consortium for International Earth Science Information Networks) have personnel assigned to work on site. Personnel from Colorado State University and the University of Colorado are also on site and we have contracts with other Universities. A staff member is also the Director of the NSF sponsored Sustainable Biosphere Program .

**Linkages with international organizations:** Staff maintains contact with the International Geosphere Biosphere Program and organizations similar to TERRA in other countries.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** Crop Responses to Global Climate Change  
**Budget (In Thousands):** FY93 \$272 FY94 \$312

**Program Description:** To help farmers adapt to future climate change and mitigate any damaging effects, process-based models are being developed for the major farm crops. This will (1) improve our understanding of how crops respond to environment and to farm management practices, and (2) give us tools for developing and delivering strategies to adapt to climate change. Carbon dioxide (CO<sub>2</sub>) concentration, temperature, and rainfall are all expected to change, but our knowledge of how these affect crops is incomplete; they cannot be studied in simple field-plot experiments. Simulating crop responses to these variables allows us to predict how crop growth and yield will change and how farmers are likely to adapt their management practices. The crop models can then be used as on-farm decision aids to deliver this knowledge. Present research on developing a better model of how plants control CO<sub>2</sub> uptake and water loss, especially when they are grown in high CO<sub>2</sub>. Methods also are being developed for aggregating results up from the field scale to make predictions for countries or states. Models of soybean, cotton and wheat are in various stages of development.

**Linkages with other Federal Agencies:** DOE.

**Linkages with private sector, NGO's and academia:** University of Maryland, University of Idaho, Duke University Phytotron, Mississippi State University, Scientific Committee on Problems of the Environment, International Geosphere-Biosphere Program.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation  
**Focused or Contributory:** Focused  
**Program Title:** Carbon Dioxide and Climate Change Effects on Crops and Trace Gas Exchange with the Atmosphere.  
**Budget (In Thousands):** FY93 \$319 FY94 \$324

**Program Description:** Long term measurements (3-5 years) of the factors that govern methane emissions of rice are being conducted in two types of environments: in outdoor, sunlit, controlled-environment plant growth chambers, and in temperature gradient greenhouses. The objectives are to understand the effects of rising atmospheric CO<sub>2</sub> concentration and projected increase in temperatures on methane emissions of a range of rice cultivars, and to measure the reductions in methane emissions that can be obtained through water table management, soil organic matter management, and cultivar selection under both present and predicted future CO<sub>2</sub> and climatic conditions. Measurements are oriented toward understanding processes of methane generation, oxidation and emission, and in investigating management practices for mitigating these emissions while sustaining, or even increasing, rice production. Because the goal is to develop basic information for both sustaining rice production as well as mitigation of methane emissions, this activity also involves adaptation to global change.

**Linkages with other Federal Agencies:** DOE (Global Change Research, Environmental Sciences Division, OHER, OER); (Corvallis Environmental Laboratory).

**Linkages with private sector, NGO's and academia:** University of Florida; Florida State University.

**Linkages with international organizations:** International Rice Research Institute; FAO Expert Consultation, for the Interdepartmental Subcommittee on Global Change Research.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Forest Service  
**Function:** Mitigation  
**Focused or Contributory:** Focused  
**Program Title:** Recycling and Wood Uses Research  
**Budget (In Thousands):** FY93 \$2,500 FY94 \$2,500

**Program Description:** This program addresses one of the greatest environmental challenges now facing the United States: finding acceptable low-cost disposal and recycling methods for an enormous and ever increasing accumulation of waste products. In the next 15 years, 75 percent of all current landfills will be closed. Of the 180 million tons of solid waste produced annually in this country, 44 percent (by weight) is paper and wood waste. Reducing the volume of paper and wood wastes can substantially extend landfill life. Exploratory studies already have shown that a cooperative research and demonstration program with our partners can provide the technical capability to increase the recovery of wastepaper and wood to 40 percent from today's rate of 31 percent. Much of the research will be done in cooperation with our industry partners. The Forest Service will conduct studies on new methods of making paper; continue work on developing new concepts and processes for making composites from recycled paper and plastics; increase research on non-polluting bleaching processes for recycled fibers and include work on "green technologies". The Forest Service emphasis on green technologies reflects that priority and will focus on green technologies in the following areas: forest operations technologies for management of all resources; biological control of forest pests; biologically-based processes (biopulping, bioremediation); new preservatives/adhesives (without heavy metals and chlorinated compounds); and nonchlorine bleaching (e.g., using enzymes and recyclable catalysts). We are establishing research on "Housing—A Home for Recycled Materials," an initiative to provide building materials from recycled fiber. The objective is to create opportunities for recycled materials to be used. Housing is a large market. Research is needed to overcome standards and codes barriers for materials to be acceptable in structures.

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**Agency:** National Science Foundation  
**Bureau:** Division of Chemical and Thermal Systems  
**Function:** Mitigation; Carbon Dioxide; Methane; Ozone & Precursors; Nitrous Oxides; Other Emissions  
**Focused or Contributory:** Focused  
**Program Title:** Combustion and Thermal Plasmas  
**Budget (In Thousands):** FY93 \$850 FY94 \$800

**Program Description:** A large fraction of the resources of the Combustion and Thermal Plasmas Program Element is dedicated to programs of importance in the mitigation of products deleterious to our surroundings. In some cases, the connection is very direct: for example, we have approximately ten ongoing programs investigating the production of toxic materials such as dioxins in the incineration of various waste product streams, with the goal of developing processes and strategies for minimization/elimination of such products. The work focuses on the combustion aspects of incineration and the emission of possible noxious gaseous effluents. It is closely related to corresponding flame studies involving halogen and metal containing flames. In addition, we have programs aimed at reducing production of unburned or partially burned hydrocarbons, carbon monoxide, and oxides of nitrogen from internal combustion and other combustion devices. These programs range from practical end-use device studies to fundamental studies of various unit processes (e.g. chemical kinetic steps) involved in combustion processes which can result in the production of undesirable products. We also are actively funding projects for the development of diagnostic tools which can be used in monitoring production of such products in commercial devices and serve as integral parts of dynamic control loops for minimization of such production via dynamic modulation of various press parameters. Sample titles of some of our ongoing research programs in this area are: Study of Transient Phenomena in a Small-Scale Hazardous Waste Incinerator; Wide-Temperature Range Chemical Kinetic Studies for Understanding the Role of Chromium in Waste Incineration; Optical Monitoring of Hazardous Waste Combustion; Combustion of Chlorinated Hydrocarbons in Hazardous Waste Incineration; Modeling Aspects of Hazardous Waste Incineration; Chemical Kinetics of Combustion of Chlorinated Hydrocarbons; Hazardous Waste Thermal Remediation; Particulates and Soot in Flames; Formation and Oxidation of Carbon in Diffusion Flames; Diesel Engine Combustion and Emissions; Enhanced Adsorption of Heavy Metals in Waste Water Incinerator Effluent; Oxidation of Chlorinated Ethenes; A More Efficient Incinerator for Hazardous Wastes; Catalytically Stabilized Thermal Incineration; Investigation of the Chemical Mechanisms for NO Removal. Some of the programs listed above, as well as other programs currently being funded, include among their ultimate goals more efficient conversion of combustion energy to work and/or electrical energy and more efficient utilization of fuel energy in chemical pressing activities. The ultimate payoff of these activities, in terms of global change, will be reductions in the amount of hydrocarbon fuels being burned and thus a lowering in the production rate of carbon dioxide, an inevitable product of hydrocarbon combustion which is so important as regards global warming. Obviously, until such time as we can arrive at suitable substitutes for hydrocarbon combustion as an energy source, our only possible strategy for minimizing this carbon dioxide production (at a given "comfort level") is to maximize the efficiency of utilization of the thermal energy locked in our hydrocarbon fuels.

**Linkages with other Federal Agencies:** DOE, DOD, EPA.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):**  
Industry through their participation in the Engineering Research Centers.

**Linkages with International organizations:** None.

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**Agency:** National Science Foundation  
**Bureau:** Division of Electrical and Communication Systems  
**Function:** Mitigation: Carbon Dioxide, Nitrous Oxide, Sulfur Dioxide  
**Focused or Contributory:** Focused  
**Program Title:** Power Systems Engineering  
**Budget (In Thousands):** FY93 \$1800 FY94 \$

**Program Description:** The electric power industry has been a key component of the concerns regarding air pollution, acid rain, and global warming. The current daily and minute-by-minute allocation of generating units is based primarily on the unit size, cost of fuel, and time required to change output levels. Environmental restrictions add a new dimension to this problem of allocation, and will provide critical information for the operation of electric power systems. The cost associated with meeting restrictions and reducing emissions will vary with time as alternative units are dispatched to meet changing load. Research in this area is essential to provide a mechanism to minimize the cost of operation while maintaining system reliability and environmental quality. This will involve new concepts such as the "cost of environmental quality" which must be factored into power system planning and operation strategies. The 1990 Clean Air Act Amendment provides for the "trading" of emission limits to achieve minimum cost production while reducing overall emissions. New technologies for cleaner production add new options for the industry. This flexibility creates a totally new framework for the operation of power systems. Research in this area would focus on new approaches to the incorporation of emission constraints (CO<sub>2</sub>, NO<sub>X</sub>, SO<sub>2</sub>) into the overall planning and operation process to ensure that environmental affects are limited at reasonable costs. In addition there would be need to develop dynamic physical models of significant global warming feedback to develop a measure of electrical energy production impact. This would lead to an effective comparison of energy production alternatives and strategies based on their impacts on global climate change.

**Linkages with other Federal Agencies:** DOE.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Electric Power Research Institute.

**Linkages with international organizations:** UNESCO.

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**Agency:** Department of Commerce  
**Bureau:** National Institute of Standards and Technology  
**Function:** Mitigation: Chlorofluorocarbons and Halons  
**Focused or Contributory:** Focused  
**Program Title:** Chlorofluorocarbon Alternatives  
**Budget (In Thousands):** FY93 \$0 FY94 \$0  
\*Funding received from other Federal Agencies

**Program Description:** NIST goals are to provide the generic measurement methods, data, and models needed to phase-out chlorofluorocarbons (CFCs) by the year 2000 (as required by the revised Montreal Protocol) and to replace hydrochlorofluorocarbons (HCFCs) early in the 21st century (also required by the revised Montreal Protocol and by the 1990 amendments to the Clean Air Act). NIST is in a unique position to address all aspects of both problems - from identifying and implementing alternatives in end uses to obtaining a better understanding of their environmental properties and effects. NIST is performing research in three critical areas. First, NIST is providing generic thermophysical properties data and state-of-the-art microcomputer-based predictive models for promising CFC alternatives and their mixtures. These data and models are helping in the choice of alternatives for specific applications and in the design and optimization of equipment to use them. Second, NIST is developing generic engineering measurement methods and data to assist in the design of refrigeration systems. These methods and data will ensure that current and future refrigeration systems perform efficiently with alternative refrigerants and refrigerant mixtures. Finally, NIST is providing benchmark experimental data and models for the kinetic and thermodynamic properties of CFC alternatives and related compounds and byproducts. These data and models are needed to understand the chemical stability of alternatives in end uses and to calculate atmospheric lifetimes to assess the potential impacts of alternatives on ozone depletion and global warming.

**Linkages with other Federal Agencies:** NIST provides technical research and services to other government agencies on a cost-reimbursable or cost-sharing basis. In the area CFC Alternatives, NIST provides such research and services to the Department of Energy, The Environmental Protection Agency, The Nation Aeronautics and Space Administration, and the Department of Defense. In addition, NIST staff members occupy important positions on several panels, including the NASA Panel on Data Evaluation.

**Linkages with private sector, NGO'S, and academia (Non-Federal funding):** NIST has uniquely strong linkages with the major United States manufacturers of CFC materials and equipment including industrial and professional organizations such as the Air Conditioning and Refrigeration Institute; The American Society of Heating, Air-Conditioning and Refrigeration Engineers; The Electric Power Research Institute; The Chemical Manufacturers Association, and the Alternative Fluorocarbon Environmental Acceptability Study.

These linkages range from memberships o important committees to financial support for research programs at NIST. NIST also is working closely with individual manufacturers and users of CFCs and CFC-related materials and equipment, including DuPont, Allied Signal, Carrier, and Trane. NIST has received financial and other forms of support from many of these organizations.

**Linkages with international organizations:** NIST occupies prominent positions or has strong linkages with several international organizations, including the International Energy Agency, the Alternative Fluorocarbon Environmental Acceptability Study, the United Nations Environment Program, the International Institute of Refrigeration, and the International Union of Pure and Applied Chemistry.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: CFC, Halons, and Other Ozone Depleting Substances  
**Focused or Contributory:** Focused  
**Program Title:** Stratospheric Ozone Protection  
**Budget (In Thousands):** FY93 \$2,635.3      FY94 \$2,637.6\*  
\*Congressional action may result in a funding increase

**Program Description:** The primary goal of this program is to work cooperatively with industry to provide the scientific and engineering data needed to replace ozone-depleting substances (ODSs) with more environmentally acceptable alternatives. Since the 1970's, the EPA (Environmental Protection Agency) has been examining technical issues related to protecting the stratospheric ozone layer, especially those associated with controlling the use and emissions of CFCs (chlorofluorocarbons), recognizing in the early 1990's that there were projected to be 25 years or more for use of HCFCs (hydrochlorofluorocarbons). Some of the most promising control options that were developed were substitution of CFCs with other, less ozone-depleting HCFCs and the HFCs (hydrofluorocarbons). Then data released by NASA (National Aeronautics and Space Administration) and EPA indicated that the actual rate of stratospheric ozone depletion has been about twice what had been predicted over the last decade. These data have resulted in both a shortening of the schedule for CFC phaseout and a more rapid elimination of HCFCs.

In addition to the scientific reasons for needing this work, there are the legal reasons. The Congress recognized the urgency of this problem by adding a Stratospheric Ozone Protection title to the Clean Air Act when it was amended in 1990. The Clean Air Act Amendments Title VI, have several sections that require EPA research and development activities in support of the Act. Among the research areas to be addressed in stratospheric ozone are determining ways to comply with the Montreal Protocol and the Clean Air Act Amendments limits on ODSs; compliance with international treaty provisions on technology transfer and trade; increasing international participation in the Montreal Protocol; assuring that transition away from ODSs does not create new environmental problems; development of energy efficient substitutes; development of a national recycling program; and evaluation of additional potential requirements in the Protocol and the Clean Air Act Amendments.

In seeking a rapid solution to replacing CFCs, HCFCs, halons, methyl bromide, and other ODSs, risks are posed to energy efficiency, direct greenhouse effects, health and safety. The greenhouse issue has become an important consideration in the ozone depletion work because many replacements for CFCs and HCFCs are greenhouse gases, because energy efficiency will be influenced by the choice of replacements, and because the Clean Air Act Amendments require that environmental effects such as these be addressed.

EPA must be in a position to support the Montreal Protocol and advise the Administrator, who according to the Clean Air Act Amendment, must rule on whether proposed substitutes are safe, whether other alternatives exist, whether exemptions should be granted for areas specifically noted in the Clean Air Act Amendments, and whether certain chemicals should be phased out more quickly. The areas listed below address the above Clean Air Act Amendments requirements by reducing or eliminating emissions of ODSs and global warming gases. Three of the areas (new

chemicals, technologies, and recycling/disposal) discussed below are directed towards finding timely and cost-effective solutions for the ozone depletion problem with a heavy emphasis on pollution prevention.

1. **New Chemicals.** The question is whether new chemicals can have both near zero ozone depletion potential and be acceptable relative to other environmental and performance characteristics. Industry has focused on a limited number of alternatives many of which are HCFCs that will ultimately be phased out necessitating a wider search for alternatives. This area supports the following technologies area. Once properties are sufficiently determined for a given chemical to allow an evaluation of its potential applicability to an end-use, the work will be transferred out of the new chemicals area to that specific technology area. EPA currently is planning to complete screening tests on up to 11 compounds in the following two chemical classes: hydrofluorocarbons and hydrofluorethers. Once these tests are completed, a modest effort will continue to identify additional compounds or mixtures which could be used as replacements in case the 11 compounds are not applicable for all end-users.

2. **Technologies.** The question is what combination of technologies and new chemicals will be acceptable as substitutes for ODSs and their end users. Applications which will be investigated include, but are not limited to refrigeration (home refrigerator/freezers, commercial and retail food preservation, chillers, heat pumps, air-conditioners, and cold storage transport), insulation, foam and fire protection. Not only must alternatives be available, but also according to the Clean Air Act Amendments' requirements, evaluations must be made to determine if other solutions might be better.

3. **Recycle/Disposal and Regulatory Support.** The question is which recycle and disposal techniques will reduce emissions of existing ODSs to the lowest achievable level. Refrigerant recycling requirements in the Clean Air Act Amendments include the need to reduce the use and emissions at ODSs to the lowest achievable level. As some of the interim solutions are commercialized, work will need to be done to accomplish this requirement. At some point, there may be a need to dispose of one or more ODSs through destruction or transformation. One technique that is commercially available is thermal incineration. Whether this is satisfactory or safe or whether it is the most sound disposal technique is being evaluated.

**Linkages with other Federal Agencies:** The EPA program is based on cooperative work with others. In refrigeration, EPA is working with the Department of Energy's National Laboratories in home refrigerator/freezers to evaluate replacing ODSs as the refrigerant and as the blowing agent in the insulation. In heat pumps, EPA is working with NIST (National Institute of Standards and Technology) to replace HCFC-22 as the working fluid. NIST also is assisting in property and atmospheric lifetime measurements for new chemicals. For unique mission critical uses of refrigeration in the DOD (Department of Defense), EPA is pursuing work in DOD in the area of shipboard cooling.

In fire protection, efforts have included work with DOD to find alternatives for flooding agents to replace Halon 1301. These efforts also include work with the Department of Commerce's Coast Guard for their fire protection needs.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** In response to stratospheric ozone needs, the engineering program works with industry in order to help provide alternative technologies that would allow elimination of uses of ODSs. The EPA effort concentrates on the areas which either have highest risk of success, lowest incentives (e.g., lack of profit potential) to industry, or inadequate industry capability. In these areas, EPA is working with academia and industry (both individually and with consortia) to assess, evaluate, develop, and implement solutions as appropriate. The specific project and needs in a given area will determine with whom we are closely working. In refrigeration, we are working with the Association of Home Appliance Manufacturers; Electric Power Research Institute; chemical companies such as Grace and Allied; equipment manufactures such as Trane, Lennox, Hussman, Copeland, and Americold; end users such as Kroger and A&P; universities such as Maryland, Wisconsin, Texas A&M, and Iowa State. In fire protection, we are working with British Petroleum, ARCO, Exxon, and Alyeska Pipeline Service Company specifically for North Slope energy producing evaluation, and integrated system hardware modification and testing. In recycling of refrigerants, a program has been completed that has seen EPA's AEERL (Air and Energy Engineering Research Laboratory) establish (through field sample gathering, in-house chemical analysis, data evaluation, and negotiation) a standard for recycled refrigerant for automotive use. This has been done in cooperation with the Mobile Air Conditioning Society, Motor Vehicle Manufacturers Association of the United States, Society of Automotive Engineers and others. This was accomplished through an agreement on acceptable criteria for recycle refrigerant, EPA designing the laboratory analyses, EPA evaluating and presenting the results, EPA recommending to industry the standard of purity for the recycled refrigerant, and industry evaluating and suggesting changes. EPA's participation provided both the fact and the appearance of unbiased data, a forum for agreement among diverse parties, and assurance to industry the EPA would accept the final results.

The standard was voluntarily accepted by the affected parties, and equipment from at least 22 manufacturers has been certified by Underwriters Laboratories to meet standards. The Clean Air Act Amendments adopted this voluntary standard as the minimum requirement for refrigerant recycle equipment for motor vehicle air-conditioners. For the long term, a replacement chemical or a nonchemical system without stratospheric ozone depletion and minimal global warming potential will be necessary.

**Linkages with international organizations:** Because of the global nature of stratospheric ozone depletion, the U.S. acting alone cannot solve the problem. U.S. leadership however, involves finding ways to encourage other countries to join the Protocol. According to current estimates, developing countries will increase their use of CFCs and halon in the future. Demonstrating to these countries that there are alternatives will encourage them to join the Protocol and alternatives are available to these countries at prices they can afford and if they have direct benefits (such as increased energy efficiency for refrigeration).

We are working with developing countries to help assess their needs and transfer technology so that we can assist in their efforts to reduce use of these chemicals. To extend that it is reasonable from technical and policy viewpoints, cooperative approaches will be sought in these efforts. In the area of home refrigerator/freezers, there is already some cooperation with India and The Peoples Republic of China. We have worked with Mexico on aerosol replacements and automobile air-conditioning refrigerant recycling. We have exchanged information with Egypt on aerosol replacements. To

cover broader needs, we also have worked with the World Bank, United Nations Environments Program, and United Nations Development Program to transfer technology to developing countries.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Methane  
**Focused or Contributory:** Focused  
**Program Title:** Methane Mitigation from Landfills via Fuel Cell  
**Budget (In Thousands):** FY93 \$1,700\* FY94 \$1,343\*  
(\*Special Congressional Appropriation)

**Program Description:** Landfills are a major source of methane emissions. To reduce landfill methane emissions and produce electricity as by-product, a demonstration for operating a 200 kW commercially available phosphoric acid fuel cell on landfill gas has commenced. Fuel cells are potentially a superior technology when compared to commonly used technologies (boilers, internal combustion engines, gas turbines, and flares), because they are both a highly efficient and environmentally clean means of converting landfill gas to electricity and clean heat. However, technical and economic questions remain. This project will answer those questions by developing a landfill gas pretreatment system and testing the pretreatment fuel cell system in one year evaluation.

**Linkages with other Federal Agencies:** Coordinating with the U.S. Department of Energy and the National Renewable Energy Laboratory.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):**

International Fuel Cells Corporation, the project's prime contractor, is cost-sharing 7% of the demonstration project. Pacific Energy Corporation is providing in-kind support through the use at their equipment to supply landfill gas by the project. Coordinating with Westinghouse Corporation and the Electric Power Research Institute. Coordinating with the California South Coast Air Quality Management District regarding program implementation and results.

**Linkages with international organizations:** Coordinating with the Department of the Environment and the Department of Energy of the United Kingdom.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Focused  
**Program Title:** Solar Demand-Side Management Demonstration  
**Budget (In Thousands):** FY93 \$0 FY94 \$320\*+\$250\*\*=\$570  
(\*Special Congressional Appropriation)  
(\*\*Potential SERDP Funding)

**Program Description:** The goal of the program is to demonstrate the technical and economic feasibility of photovoltaic (PV) technologies as a pollution mitigating energy replacement of fossil fuels by reducing electrical demand on buildings. Modular PV units capable of generation 5 to 15 kW per site will be installed at several geographic locations for retail end-users of electricity to demonstrate how well PV-battery power packs can reduce the peak power load and how best the load profile can be improved by shifting some demand usage. The sites will be monitored for one year to obtain demand usage, performance data on all major components of the systems, and economic data on each installation.

**Linkages with other Federal Agencies:** Coordination with the U.S. Department of Energy, Department of Defense, and the National Renewable Energy Laboratory, and Sandia National Laboratory regarding solar technology options contractor, and site selection, and on renewable energy technologies applicable to developing countries.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Coordination with Solar Energy Industries Associations, selected member companies, and the Electric Power Research Institute (EPRI).

**Linkages with international organizations:** None

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Focused  
**Program Title:** Fuzzy Logic Control to Improve the Energy Efficiency of AC Induction Motors  
**Budget (In Thousands):** FY93 \$221\* FY94 \$217 + 250\* = \$467  
Pending Internal EPA and Administration budget decisions  
(\*Pollution Prevention Funding)

**Program Description:** Electric motors use about 60% of the industrial electricity consumed in the U.S. To lower this energy consumption, and thus reduce emissions from electric power generating stations, the objective of the program is to demonstrate fuzzy logic as an approach for controlling AC induction motors in order to enhance the efficiency of their operation, especially when operating at less than noted speeds and torques. At its culmination, the project will provide a set of application specific integrated circuits (ASICs) which will interface with induction motor/adjustable speed drive combinations to provide the advantages of fuzzy decision making to the control process. The ASICs will be demonstrated in a year-long test of a large horsepower (>125 hp) induction motor at a selected industrial site.

**Linkages with other Federal Agencies:** Department of Defense.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The Research Triangle Institute is co-sponsoring (5%) the current program of computer simulation and modeling, and laboratory testing. A Cooperative Research and Development Agreement (CRADA) is being negotiated with a major U.S. auto manufacturer.

**Linkages with international organizations:** None.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Methane  
**Focused or Contributory:** Focused  
**Program Title:** Mitigation of Methane from Coal Mines  
**Budget (In thousands):** FY93 \$75\* FY94 \$100

**Program Description:** The estimate of CH<sub>4</sub> emissions from coal mines is believed to be significant and it would be prudent to utilize CH<sub>4</sub> emissions from coal mines to the extent possible rather than release them to the atmosphere. In current underground coal mining practice, the majority of CH<sub>4</sub> emissions exit with the mine ventilation air but are too diluted to be economically recovered using current technology. Although wells are drilled ahead of and behind the mine workings to relieve some of the costly ventilation air requirements, a consistent program of premine seam degasification and gas recovery is not common practice.

A program of this type will significantly reduce ventilation shaft CH<sub>4</sub> emissions and encourage the practice of premine degasification through a higher rate of CH<sub>4</sub> recovery and utilization or sale of the gas rather than releasing it to the atmosphere. EPA will participate with the Amoco Production Company to demonstrate their nitrogen flooding process to enhance the recovery of CH<sub>4</sub> from coal seams. Although Amoco's interest in developing the technology is focused on CH<sub>4</sub> as the saleable resource, the methods involved will translate fully from the coal bed CH<sub>4</sub>-industry to the coal mining industry. The first goal of the project is to demonstrate that the 50% average CH<sub>4</sub> recovery rate from coal seams using current practice can be increased to 80% or more using nitrogen flooding. The program also will research and demonstrate the use of multicomponent gases to increase efficiency and improve cost effectiveness. Successful use of multicomponent systems may lead to carbon sequestration as well as methane control and utilization. An engineering and economic analysis will be performed to identify optimal utilization strategies for the recovered methane.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia (Non-Federal funding):** EPA will work with the Amoco Production Company, the project's co-sponsor. EPA's role will be to perform gas analyses to determine compatibility of the recovered gas with various utilization technologies. Ultimately we also may join the selection and testing of a utilization in composition with injection gas on methane recover. Finally, engineering and economic analyses will be performed on the process through Southern Research Institute (SRI).

**Linkages with international organization:** None.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Methane  
**Focused or Contributory:** Focused  
**Program Title:** Methane Mitigation from Anaerobic Digesters via Fuel Cells  
**Budget (In thousands):** FY93 \$0 FY94 \$0\*  
(Pending internal EPA and Administration budget decisions regarding allocation of special Congressional appropriation.)

**Program Description:** To determine the environmental benefits and gas clean-up requirements for a commercially available 200 kW phosphoric acid fuel cell (PAFC) power plant used to control methane from the anaerobic digestion of solid waste at a waste water treatment plant. This program would build upon the experience obtained in the landfill/fuel cell demonstration which was initiated in FY91. Three issues to be addressed in this research program are: (1) feasibility of integrating the PAFC power plant operation with the water treatment system, (2) anaerobic digestion waste methane cleanup and processing requirements for fuel cell operation, and (3) improved fuel cell performance on reduced heating value fuel (i.e., waste methane versus natural gas).

**Linkages with other Federal Agencies:** This work is being coordinated with the U. S. Department of Energy and with the National Renewable Energy Laboratory.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** This effort is being coordinated with the Solid Waste Association of North America, the National Solid Waste Association, and the International Solid Waste Association. In addition, coordination has been established with several industry groups including Waste Management, and BFI.

**Linkages with international organizations:** The Department of the Environment and Department of Energy of the United Kingdom, and The International Energy Agency.

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**Agency:** Tennessee Valley Authority  
**Bureau:** National Environmental Research Center  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Focused  
**Program Title:** Analysis of Terrestrial Carbon Sinks  
**Budget (In Thousands):** FY94 \$200

**Program Description:** The degree to which terrestrial systems are able to sequester carbon is an important uncertainty in both modeling of fluxes and development of CO<sub>2</sub> emission mitigation strategies. This program would evaluate sequestration potential over the TVA region. The existing conditions will be evaluated to determine whether further storage potential exists in currently forested areas and the extent of areas that might lend themselves to either afforestation or production of woody biomass fuels. Urban areas will be evaluated to determine how much impact an aggressive urban tree planting program could have within the region. Based on these analyses and other ongoing research activities, the carbon storage potential for the region will be assessed and options for CO<sub>2</sub> emissions offsets will be evaluated. Essentially, the TVA region will be used in a case study (1) to inventory standing pools of carbon in soils and forests in the region, (2) to determine the areas best suited to serve as long term sites for carbon sequestration in soils and plants (including urban areas), and (3) to assess the magnitude of opportunities to create CO<sub>2</sub> offsets using soil and plant sequestration options. This effort will be based exclusively on extant data bases which have been subjected to quality assurance procedures during their development. Data manipulation will be conducted within the standard GIS software frameworks.

**Linkages with other Federal Agencies:** USDA (Soil Conservation Service and U.S. Forest Service), DOE (Oak Ridge National Laboratory), and EPA.

**Linkages with private sector, NGO's, and academia (non-Federal funding):** None at this time, possible future linkages with State regulatory agencies and private environmental organizations.

**Linkages with international organizations:** None

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Focused  
**Program Title:** National Mitigation Action Plan Initiative Implementation  
**Budget (In Thousands):** FY93 \$0 FY94 \$53,300

**Program Description:** The following list generally represents the kind of global climate change mitigation initiatives that have been analyzed over the past year. Detailed descriptions of the initiatives are available upon request.

Energy Efficiency (EE) & Home Building Centers  
Energy-Efficient Mortgages/Home Energy Rating Systems  
Building and Appliance Standards  
Expanded Commercial Energy Demand Cost-Shared Demonstrations  
National EE Education and Training Program  
National EE and Renewable Information Program  
State Revolving Funds  
Enhanced Enforcement of Building Codes  
Cool Communities  
Accelerated Adoption of Energy Efficient Technologies  
Energy Analysis and Diagnostic Centers  
Broad Based Recycling  
Testing/Labeling (of energy efficient appliances)  
Motor Challenge  
One Stop Shopping (information)  
Expanded Integrated Resource Planning for Utilities  
Domestic Joint Ventures - Renewable Energy Projects  
Climate Wise - Recognition of Voluntary Greenhouse Gas Reduction Efforts

By conducting rigorous analysis of greenhouse gas mitigation options, the outcome of implementation of such options may become more apparent. Such analytical exercise is critical to the national climate change mitigation planning process to determine the amount of emission reductions that are possible.

**Linkages with other Federal Agencies:** EPA.

**Linkages with the private sector:** The Energy Efficiency and Renewable Energy Industry.

**Linkages with international organizations:** The U N Intergovernmental Negotiating Committee.

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**B. MITIGATION - CONTRIBUTORY**

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Evaluating the Effect of Climate Change on Rangeland Livestock Production and Ecosystem Sustainability  
**Budget ( In Thousands):** FY93 \$235 FY94 \$275

**Program Description:** The effect of climate change on plant and livestock production in the Great Plains is being investigated using various climate change scenarios and a modified rangeland production model. The SPUR2 model was combined with the Colorado Beef Cattle Production Model to provide complete information on cattle production in a changing environment. Subsequently, the CENTURY soil organic matter model was linked with the SPUR2/CBCPM model to assist in evaluating the sustainability of the rangeland ecosystem under a changing climate and under different management treatments. This model structure allows us to evaluate the effect of stocking rates, grazing systems, and climatic fluctuations on livestock production and total system sustainability.

**Linkages with other Federal Agencies:** EPA (funded part of the research for developing the system), SCS (is currently using the SPUR2/CBCPM model).

**Linkages with private sector, NGO's and academia:** Colorado State University, Texas Agricultural Experiment Station.

**Linkages with international organizations:** International Geosphere Biosphere Program (development of an internationally conceived rangeland model).

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Contributory  
**Program Title:** Soil and Atmospheric Dynamics of C and N On Rangelands: Effects of Stocking Rates and Grazing Systems  
**Budget (In Thousands):** FY93 \$12 FY94 \$12

**Program Description:** Soil cores were taken at depths of 0-3.8, 3.8-7.6, 7.6-15.2, and 15.2 - 30.5 cm along transects on rangeland in the 12th year of grazing by yearling steers. Grazing systems were season-long, 4-paddock rotationally deferred, and 8-paddock time-controlled rotation grazing; stocking rates were heavy (1.8 ha/steer), light (6-7 ha/steer; season-long pastures only), and ungrazed. Soil samples were taken at 5 locations along a transect in each of 2 pastures of each treatment; 5 cores were taken per location and composited. Bulk density, texture, soil moisture, pH, total Kjeldahl N, NH, NO, organic C.P. gravimetric water content, N mineralization potential, and CO respiration during aerobic incubation will be measured. Litter biomass and above and below ground biomass of western wheatgrass, needle-and-thread, blue grama, other grasses, sedges, and forbs were determined at peak standing crop. Litter and forage samples will be analyzed for total Kjeldahl N, P, Ca, Mg, and K. Results will provide data on C and N cycling on grazed (at light and heavy stocking rates) and ungrazed rangelands. These studies are being conducted to evaluate the role of plant litter in sustaining grasslands in the Central Great Plains.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** University of Wyoming.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: Combined  
**Focused or Contributory:** Contributory  
**Program Title:** Southern Plains Range Ecosystem Management  
**Budget (In Thousands):** FY93 \$499 FY94 \$497

**Program Description:** Field test new Woodward chaffy grass seeder. Investigate N use efficiency by grasses on marginal farmland as affected by fire, N source, rates, and time of application. Establish and graze native legumes. Determine effects of land management on quality of runoff and ground water. Use vegetation ordination and soil analyses of 50-year enclosures to test theories of vegetation dynamics, ecosystem stability and predict N balance under grazing management. Evaluate leaf and stem ratio effects on intake and digestibility. Study impact of mefluidide on soil water use and plant physiology response. Evaluate improved eastern gamagrass, Texas bluegrass, and big and Old World bluestem germplasm and stocker genotype-grazing strategy interactions to develop red meat production systems with emphasis on perennial species to complement native rangeland forages. Complete RAPPs (Range Plant Profiles) model with routines for root growth, water balance, and mineral nutrition coupled to current plant growth and development modules.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** Oklahoma State University

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Mitigation: CO<sub>2</sub>  
**Focused or Contributory:** Contributory  
**Program Title:** Mechanisms of Plant Responses to Atmospheric Carbon Dioxide  
**Budget (In Thousands):** FY93 \$379 FY94 \$379

**Program Description:** Two aspects of this project contribute to adaptation of crop plants to climate change, and one aspect contributes toward mitigation. Existing lines of soybeans are being screened for yield under conditions of increased atmospheric carbon dioxide concentration to determine how much variation exists. Mechanisms responsible for differences among lines are being examined, in order to identify physiological traits potentially useful if atmospheric carbon dioxide concentrations continue to increase. The response of crop water loss to elevated carbon dioxide concentrations is being examined by incorporating physiological data into a boundary-layer meteorological model of evapotranspiration. This information will allow evaluation of how much possible water conservation caused by increased atmospheric carbon dioxide may contribute to adaptation of crops to future climates which also may be more subject to drought. The acclimation and direct response of photosynthesis and respiration to increased carbon dioxide concentration with and without increased temperature are being investigated in order to better understand to what extent vegetation may serve as a sink for atmospheric carbon dioxide.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: All Sources  
**Focused or Contributory:** Contributory  
**Program Title:** Development of Global Warming Technology Database Software  
**Budget (In Thousands):** FY93 \$0 FY94 \$150

**Program Description:** This activity will develop a database of greenhouse gas mitigation technologies. Software also will be developed to enable data queries, calculations (e. g., units conversion, base-year cost switching), and sorting of the information in the database. Sorting can be by gas, source, or country and the software will list the technologies in order to user-defined preferences such as cost- effectiveness, applicability, etc. Parameters to be included in the database include cost, performance, applicability, date of availability, and impediments to market penetration.

**Linkages with other Federal Agencies:** DOE has initiated a Technology Characterization Inventory (TCI) which is a database of CO<sub>2</sub> mitigation technology. The EPA GloTech database has been discussed with DOE, and EPA has evaluated TCI and provided comments to DOE. EPA expects to actively participate in further development of a technology database and associated software.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The GloTech database concept has been discussed with representatives from Clark University, the Institute for Resource and Security Studies, Northern Telecom, and Pacific Northwest Laboratories (PNL).

**Linkages with international organizations:** The Glotech database has been discussed with the IPCC, ECD, IEA, the World Bank, UNEP, the Center for Strategic Studies (CSIS), the Energy Research Institute (Moscow, Russia), the German Federal Ministry for Research and Development (BMFT), and other international organizations.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Contributory  
**Program Title:** Biomass Energy Production, Handling, Use, and Application Projects  
**Budget (In Thousands):** FY93 \$0 FY94 \$100

**Program Description:** The U.S. Department of Energy (DOE) has established five regional biomass energy programs to promote the development of effective uses of biomass for energy. These programs provide a method of concentrating funds and efforts in biomass-for-energy technologies best suited to regional biomass resources and regional energy needs. The programs provide a focus for research to enhance regional bioenergy development projects, facilitate communications among the numerous groups involved in biomass research and development, and provide a means of transferring results of research and development to potential users.

**Linkages with other Federal Agencies:** EPA's current involvement with the regional biomass energy program will be through an interagency agreement (in progress) with the Tennessee Valley Authority (TVA) which manages the Southeastern Regional Biomass Energy Program (SERBEP) with DOE funds. EPA will provide funds and personnel to support regional biomass energy and other related activities such as technology and economic assessments and research and development projects. Future plans are to expand these activities to the other regional programs supported by DOE. This work is coordinated with the National Renewable Energy Laboratory study for evaluation of renewable energy technologies for developing countries, sponsored by EPA.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Many of the projects EPA will support through the regional biomass energy programs will be co-funded by the private sector, academia, and other non-government organizations. For example, research and development projects funded through SERBEP by DOE and EPA require at least 50% cost-sharing by private sector contractors.

**Linkages with international organizations:** The regional programs have cooperated with international organizations such as IEA and AID through an informal process of information exchange.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Contributory  
**Program Title:** Advanced Power Generation Systems Fueled with Biomass  
**Budget (In Thousands):** FY93 \$800\* FY94 \$195 + \$750\*\* = \$945  
Pending internal EPA and Administration budget decisions  
(\*Includes \$750 SERDP funding)  
(\*\* Potential SERDP funding)

**Program Description:** The objective of this project is to catalyze and support accelerated commercialization of biomass fueled power generation systems applicable to industrialized and developing countries. Advance power generation systems, such as aeroderivative turbines, are expected to achieve efficiency increases of 25 to 40%. This project will assess the technical, economic, and environmental feasibility of producing power from advanced technologies. Special attention will be given to the aeroderivative turbine fueled by gasified waste biomass since it appears to be a promising technique. The initial phase of the project will involve pilot-scale tests of various biomass wastes to determine their ability to be gasified and the compatibility of the gas with an aeroderivative turbine. This data and information will lead to and support future scale up to pilot and prototype installations. The State of Vermont and Brazil are interested in hosting large scale demonstrations.

**Linkages with other Federal Agencies:** EPA, DOE and AID are funding the pilot test for determining gasified biomass compatibility with turbines. USDA/FS is assisting with resource studies. As part of DOE's regional biomass energy program and other activities, TVA, BPA, ORNL, and NREL are coordinating with EPA to promote biomass production, harvesting, transportation, and utilization technologies.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The current effort is implemented through a Cooperative Agreement with the State of Vermont. Vermont General Electric will conduct the gasification tests and Winrock will provide support for the Brazil development plan. In addition, a private consultant is assessing domestic demonstration opportunities of this technology in Vermont and other U.S. areas. Some biomass preparation was supplied by Briquetting, Marketing and Services, Inc. In addition, Winrock International is encouraging this technology by assisting with coordination between industry, U.S. government, and international governments.

**Linkages with international organizations:** The State of Vermont has a Memorandum of Understanding (MOU) with Brazil. Brazil and EPA are establishing networks for sharing information. In addition, coordination with Canada (Environment Canada and Energy Mines and Resources), Sweden (Vattondall), and Mexico regarding EPA's research in this area.

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**Agency:** Environmental Protection Agency  
**Bureau:** Office of Research and Development  
**Function:** Mitigation: Carbon Dioxide  
**Focused or Contributory:** Contributory  
**Program Title:** Evaluate Biomass for Production of Transportation Fuel  
**Budget (In Thousands):** FY93 \$500\* FY94 \$387 + \$500\*\* = \$887  
Pending internal EPA and Administration budget decisions  
(\* SERDP funding)  
(\*\* Potential SERDP funding)

**Program Description:** The objective is to provide the technical feasibility of producing methanol from domestic resources by the Hydrocarb process. This will be accomplished by small pilot plant testing during the next 3 years. Methanol is a clean alternative fuel that can displace petroleum fuels currently used in motor vehicles reducing health risks and hidden costs associated with exhaust emissions. When produced from biogenic feedstocks by Hydrocarb, CO<sub>2</sub> emissions also are nullified. Preliminary economic analyses indicate that CO<sub>2</sub> emissions can be eliminated at nominal or negative incremental costs relative to gasoline displaced. In-house laboratory research will provide fundamental data to support the development program.

**Linkages with other Federal Agencies:** Coordinating with the U. S. Department of Energy, The National Renewable Energy Laboratory, and the Department of Defense.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The California South Coast Air Quality Management District and the Hydrocarb Corporation are cosponsoring the pilot plant feasibility study.

**Linkages with international organizations:** Coordinating with the Department of the Environment and the Department of Energy, United Kingdom regarding biomass utilization, and with Japanese researchers (RITE, University of Tokyo, Osaka Gas Company) regarding the liquid fuel production from biomass.

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**Agency:** Tennessee Valley Authority  
**Bureau:** Technology Advancements  
**Function:** Mitigation: Carbon Dioxide; Methane; Nitrous oxides; Sulfur Dioxide  
**Focused or Contributory:** Contributory  
**Program Title:** Energy Options, Including Biomass  
**Budget (In Thousands):** FY93 \$0 FY94 \$0

**Program Description:** A number of energy options for TVA to supply electric energy demands for this region, including renewable energy sources and use technologies, are being considered. One example of research in this program area is a study of the economic feasibility of using biomass for electric power generation. An assessment of land use, potential supply, transportation, and market factors is being conducted for woody residues, short rotation woody crops, and herbaceous perennial crops in the TVA region. One aspect of this is the development of a GIS-based linear programming model to optimize use of available woody biomass. TVA is considering either co-firing an existing coal-fired power plant with wood or constructing a dedicated bioenergy facility. The program scope and workplans were developed in FY 1992.

**Linkages with other Federal Agencies:** DOE via Oak Ridge National Laboratory (ORNL) and via Southeastern Regional Biomass Energy Program.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** TVA resource and development funding of \$75,000 in FY 1992, with additional funding of about \$100,000 provided by EPRI, the University of Tennessee, and ORNL as partners. Funding for FY 1993 and subsequent years is by TVA research and development at about \$300,000.

**Linkages with international organizations:** None

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Windows, Glazing and Daylighting Materials  
**Budget (In Thousands):** FY93 \$4,100      FY94 \$5,700

**Program Description:** Windows and Glazing Research addresses the development and characterization of advanced window and glazing technologies (e.g., superwindows, electrochromics, spectrally selective "cool" windows) to reduce heating, cooling and lighting loads in buildings. This research provides industry a technology base (via fundamental research and the provision of user test and evaluation facilities) and support for their product and process development. Research also is conducted to establish the technical basis to determine window performance (thermal and optical properties, energy and peak load impacts) through simulation, testing and evaluation. The application of this research includes the development through the National Fenestration Rating Council of a technically credible window rating and labeling program, support for utility demand side management glazing programs, and the development of design tools and handbooks.

Windows, glazing and daylighting will reduce carbon emissions by reducing electricity and natural gas loads for lighting and space conditioning. Energy Efficiency R&D programs targeting new window, glazing, and daylighting technologies could reduce energy use by 0.16 quads in 2000, 0.474 quads in 2010, and 0.844 quads in 2020. These energy savings would result in carbon emission reductions of 2.5 MMT(C) per year, 7.4 MMT(C) per year, and 13.6 MMT(C) per year in 2000, 2010 and 2020 respectively.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Indoor Air Quality  
**Budget (In Thousands):** FY93 \$1,983      FY94 \$1,919

**Program Description:** DOE's Indoor Air Quality program supports the development of advanced energy conservation technologies that reduce the energy liability associated with air flows into, within, and out of buildings, while maintaining healthful, productive, and comfortable indoor environments. A balanced program of laboratory experimentation, field investigations, mathematical modeling, demonstrations, and criteria development is making major contributions to the nation's effort to improve our indoor environments. The DOE supported research results from the scientific basis of the many standards and guidelines on this topic.

By providing the building science perspective the DOE program allows for full consideration of scientifically valid solutions that optimize energy efficiency and indoor environmental quality. Energy and carbon benefits from the associated energy savings are estimated at 0.236 quads and 0.5 MMT (C) per year in 2000, and 0.575 quads and 3.7 MMT (C) per year in 2010.

**Linkages with other Federal Agencies:** EPA, and the Interagency Committee on Indoor Air Quality.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Walls, Roofs and Foundations, and Materials and Structures  
**Budget (In Thousands):** FY93 \$3,622      FY94 \$3,267

**Program Description:** The program goal is to provide the technology for zero net heating/minimal cooling energy building design options by 2000. To reach this goal the Materials and Structures research focuses on near-term development of CFC-free, high R-value insulations, development of special non-CFC insulation for retrofit applications, the long-term development of building materials with controllable thermal properties, and the development of advanced manufacturing processes for super insulations and controllable envelope materials. The Roofs, Walls & Foundations research addresses application of advanced materials (dynamic, high-R, durable, non-CFC), design tools, new program thrusts (e.g., 30/30 roofs that have an R-30 rating and a 30-year life, moisture forgiving construction elements, and advanced composite walls) in new commercial building wall technology.

In the housing sector, these technologies have the potential to reduce space heating energy loads by 25% to 30% and cooling loads by 3% to 7%. Within the commercial sector, heating energy can be reduced 5% to 10% and the respective cooling loads by 0.5% to 1.5%. Reductions in carbon emissions will be 0.9 million metric tons by 2010 and increase by 2020 to an annual rate of 4.1 million metric tons.

**Linkages with other Federal Agencies:** EPA, DOD.

**Linkages with private sector, NGO's and academia:** EPRI, Polyisocyanurate Insulations Manufacturers Association, Society of Plastics Industry, ASHRAE, home owners, building operators, and architect-engineer community.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Space Heating and Cooling Equipment  
**Budget (In Thousands):** FY93 \$10,000 FY94 \$14,600

**Program Description:** The goal of the heating and cooling program is to move beyond the commercially available efficiency improvements to develop technologies that are twice as energy efficient as current natural gas systems. New natural gas heat pumps such as the Stirling engine driven and internal combustion-driven heat pumps have the potential to meet this goal. Other promising DOE space conditioning technologies include advanced electric heat pumps, energy efficient oil combustion equipment, and duct design improvements.

Currently, space heating and cooling uses about 13 quads of energy (primarily in the form of electricity and natural gas), or about 44% of total building primary energy use, resulting in carbon emissions of about 200 million metric tons/year. Heating and cooling technologies offer numerous opportunities for efficiency improvements. For example, increases in natural gas fired furnace efficiencies have been demonstrated through the use of electronic ignition, vent dampers, and condensing technologies that capture the latent heat of the combusted gas. Improved cooling technologies includes high efficiency electric and gas fired chillers, direct evaporative cooling, and outside air economizers. Technological advances in space heating and cooling have the potential to reduce primary energy use in 2000 by 0.038 quads, resulting in carbon emission savings of 0.6 MMT(C) per year. In 2010 and 2020, energy savings increase to 0.612 quads and 1.658 quads, respectively. The resulting carbon emissions savings are estimated to be 9.6 MMT(C) per year in 2010, and 26.9 MMT (C) per year in 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Advanced Buildings for 2005  
**Budget (In Thousands):** FY93 \$5,600      FY94 \$12,400

**Program Description:** This program addresses a legal requirement to increase building efficiency while maintaining affordability. The program consists of three coordinated areas: Passive Solar evaluated advanced materials and integrated passive solar heating, cooling, daylighting and efficiency design concepts. The most promising designs are tested, financed and built by industry in "Exemplary Buildings." Building Automation Systems addresses the fact that most buildings are operated below optimal performance level because of improper installation, degradation, ineffective operating strategies, or inadequate operator knowledge. This program develops technologies to diagnose system degradation and assist operators in maintaining healthy efficient buildings. Residential housing focuses on determining the optimum mix of factory versus field fabrication, and advanced housing technologies to stimulate early identification and adoption of beneficial new products and processes. Quality improvement and a voluntary program to cut household energy requirement by 50% as compared to standard 1980's homebuilding practice.

Implementing of already proven results and principles on a wide scale will reduce the absolute amount of energy used by the residential and commercial buildings sector. This will give rise to carbon emission reductions of 0.3 MMT(C) per year by 2000, 3.7 MMT(C) per year by 2010, and 8.2 MMT(C) per year by 2020.

**Linkages with other Federal Agencies:** EPA, HUD

**Linkages with private sector, NGO's and academia:** Home owners and builders, utilities, A/E's, commercial building owners and operators, control and equipment manufacturers.

**Linkages with international organizations:** International Energy Agency

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Lighting  
**Budget (In Thousands):** FY93 \$3,100      FY94 \$2,000

**Program Description:** DOE's Advanced Lighting Research Program attempts to develop: (1) efficient building light sources, (2) efficient ways to utilize building light sources, and (3) a knowledge and application base on the impacts of lighting on vision and workplace performance. Currently DOE is conducting research on advanced technologies, very high-frequency (VHF) electrodeless lamps and fixtures that could double the efficiency and lifetime of current fluorescent lamps and be 8 to 10 times as efficient as incandescent bulbs. The program's goal is to commercialize this technology within five years. Another lamp technology under development uses no mercury. This has the potential to be a major new achievement since disposal of fluorescents, all containing mercury, is a growing environmental problem.

Incandescent lamps and fluorescent lamps are the primary building lighting sources. Currently, building lights consume about 4.9 quads/year of primary energy (about 25% of all electricity used in residential and commercial buildings in 1990), resulting in carbon emissions of about 79 million metric tons/year. By 2010, this total is expected to increase to about 6.3 quads/year (99 million metric tons/year of carbon). Lighting and the associated cooling load consumes up to half the electricity used in many new commercial buildings. Thus advance in lighting efficiency will reduce electricity consumption and its corresponding carbon emissions. Installation of lighting technologies are expected to reduce carbon emission by 0.3 MMT(C) per year in 2000, 14.8 MMT(C) per year by 2010, and 32.5 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Appliances  
**Budget (in Thousands):** FY93 \$0 FY94 \$400

**Program Description:** DOE aims to further energy conservation in residential and commercial building applications in water heating, refrigeration, cooking, office equipment, laundry, electronics and integrated systems. DOE plays a key role in developing test procedures and standards for residential appliances (including refrigerators) as mandated by the Energy Policy and Conservation Act of 1975, and test procedures, labels, and standards for commercial appliances, as required by the Energy Policy Act of 1992. In addition, research on vacuum insulation technologies has demonstrated the technical feasibility of constructing compact structures with high insulating properties. Commercially available appliance technical improvements might be achieved through compressor redesign fan and fan motor improvement, compressor relocation, and dual compressors (separate ones for the refrigerator and freezer).

Appliances consumed about 6.6 quads in 1990, almost 20 % of the energy used in the building sector, and about 30 % of total electricity use. Household refrigerators alone consumed about 8.5% of the total primary energy used in homes. Current models use about 1100 kWh per year, reflecting reductions of roughly 55% relative to the typical energy use 20 years ago. Higher appliance efficiency will result in less energy use and its corresponding carbon emissions. More efficient appliances are expected to save 0.053 quads of energy in 2001, 0.589 quads in 2010, and 1.708 quads in 2020. These energy savings will reduce carbon emissions by 0.8 MMT(C) per year in 2000, 9.1 MMT(C) per year in 2010, and 27.0 MMT(C) per year in 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Biofuels  
**Budget (In Thousands):** FY93 \$36,400      FY94 \$46,700

**Program Description:** DOE is conducting research on genetics and physiology research and using applied biotechnology to develop energy feedstocks; conducting R&D on conversion technologies for ethanol and methanol; and sponsoring programs that facilitate the demonstration and commercialization of biomass-fueled vehicles.

The use of biomass-based ethanol and methanol for transportation fuels and as oxygenates for reformulated gasoline will reduce carbon emission by displacing petroleum. On a fuel cycle basis, biomass is estimated to have less than 10% of the carbon emissions of reformulated gas on an energy basis. The price of ethanol biomass has dropped from \$3.60 per gallon in 1980 to \$1.22 currently. DOE projects that the price will drop to 70 cents per gallon by 2003. Carbon emission benefits are estimated at 1.6 MMT(C) per year by 2000 and 6.9 MMT(C) per year by 2010, and 12.6 MMT(C) by 2020. Carbon benefits are for additives only, benefits due to direct use of biofuels is accounted for in the Alternative-Fueled Vehicle program.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Alternative-Fueled Vehicles (AFVS)  
**Budget (In Thousands):** FY93 \$27,700 FY94 \$41,600

**Program Description:** This program focuses on fleet demonstrations of alternative-fueled vehicles, engine optimization research, and sponsoring programs that facilitate the demonstration and commercialization of alternative-fueled vehicles.

The use of alternative fuels (primarily ethanol, methanol, compressed natural gas (CNG), liquefied petroleum gas (LPG), and hydrogen) for transportation fuels will reduce carbon emissions by displacing petroleum. On a fuel cycle basis, alternative-fueled vehicles have the potential to reduce carbon emissions significantly. Currently, flex-fuel vehicles and CNG vehicles are offered by major automakers for a small premium. Some manufacturers are planning to offer flex-fuel vehicles in the upcoming model years for the same price as their conventional counterparts. Carbon emission benefits are estimated at 4.4 MMT(C) per year by 2000 and 32.3 MMT(C) per year by 2010, and 59.5 MMT(C) by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Electric Vehicles (EVS)  
**Budget (In Thousands):** FY93 \$32,700      FY94 \$45,600

**Program Description:** DOE sponsors battery research, with industry, through the U.S. Advanced Battery Consortium; exploratory research on materials and processes, testing of batteries and their components, and analysis of infrastructure and safety issues; and sponsors programs that facilitate the demonstration and commercialization of electric vehicles.

The use of electric vehicles will reduce carbon emissions by displacing petroleum in regions where electricity generation is not heavily based on fossil fuel combustion. On a fuel cycle basis, electric vehicles have the potential to reduce carbon emissions significantly in regions of the country that do not rely heavily on fossil fuel use for electricity generation. Today's EVs are quite limited - a range of less than 100 miles at a cost of over \$30,000 per vehicle. However, DOE projects that EVs will have a range of over 200 miles and cost only 10% more than conventional vehicles by 2003. Carbon emission benefits are minimal due to the expected low penetration of EVs and the carbon emissions of utilities.

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**Agency:** U.S. Department of Energy  
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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Hybrid/Electric Vehicles (HEV)  
**Budget (In Thousands):** FY93 \$14,700 FY94 \$19,900

**Program Description:** This program focuses on research to develop HEVs that can reach early commercialization and have large production volumes. Because this technology is composed of multiple energy conversion subsystems, it integrates the activities of several other related programs, such as battery research, lightweight materials, and advanced engines. Commercialization is being rapidly pursued through a 50% cost-shared consortia with industry to develop hybrid propulsion systems for vehicles.

The use of hybrid/electric vehicles will reduce carbon emissions by displacing petroleum. On a fuel cycle basis, hybrid/electric vehicles have the potential to reduce carbon emissions significantly due to their high efficiency (up to three times that of conventional vehicles) and ability to use fuels other than petroleum. DOE is working with industry to commercialize hybrid/electric vehicles by 2003. Carbon emission benefits are estimated at 9.6 MMT(C) per year by 2010, and 25.8 MMT(C) by 2020.

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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Fuel Cell Vehicles  
**Budget (In Thousands):** FY93 \$11,800      FY94 \$18,000

**Program Description:** DOE's program performs basic R&D on developing on-board reformers, hydrogen storage devices, and power management devices; support research aimed at reducing fuel cell costs and improving reliability; and developing fuel cell vehicles, buses, and locomotives.

The use of fuel cell vehicles will reduce carbon emissions by displacing petroleum. On a fuel cycle basis, fuel cell vehicles have the potential to reduce carbon emissions significantly due to their high efficiency and ability to use hydrogen and biofuels as fuels. Fuel cells for light duty vehicles are in the early stages of development, though larger fuel cells for buildings and heavy duty applications are further developed. Carbon emission benefits are estimated at 0.4 MMT(C) per year by 2010, and 8 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Solar Thermal Electric  
**Budget (In Thousands):** FY93 \$21,400 FY94 \$25,000

**Program Description:** DOE's efforts are organized around a goal of producing electricity for 5 to 6 cents per kWh. Activities include performance testing of key components and a number of cost-shared commercialization efforts for critical emerging technologies such as dish/Stirling, trough systems, and power towers. Current public/private collaborations include a cost-shared venture to convert generating equipment at the Solar One central receiver project to a molten-salt system, and the demonstration of dish/Stirling systems for non-grid applications.

The use of solar thermal electric will reduce carbon emissions by displacing the burning of natural gas for peaking power. Solar thermal electric systems are being developed for grid and non-grid applications. Solar thermal electric systems do not contribute to carbon emissions (unless coupled with a back-up system), thus have the potential to decrease carbon emissions significantly. Currently, there is 354 MW of installed capacity of parabolic troughs. However, dish/Stirling and power tower systems show greater promise in the future. The levelized cost of electricity from parabolic troughs is about 15 cents per kWh currently; it is projected that the cost will drop to below 7 cents per kWh for dish/Stirling and power tower systems by 2010. Carbon emission benefits are estimated at 0.3 MMT(C) per year by 2000 and 0.9 MMT(C) per year by 2010, and 1.9 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Separations  
**Budget (In Thousands):** FY93 \$8,280      FY94 \$13,046

**Program Description:** DOE is conducting process research and development, demonstration and deployment to improve energy efficiency and fuel flexibility in industrial processes for chemicals, petroleum refining, paper, textiles and food processing industries. These programs are responsive to direction of the Energy Policy Act (EPACT) to help develop the "Plant", "Mill", or "Industry of the Future".

Separation technologies are vital in the production processes for petroleum products (e.g., fuels and petrochemical feedstocks), paper, inorganic and organic chemicals, food products, textiles, and fertilizers. Innovative separation technologies offer major crosscutting industrial process opportunities for energy savings and productivity gains. Distillation, evaporation, drying, extraction, and gas absorption and adsorption are critical, energy-intensive processes used to separate one or more components from a solution or mixture. Most of these processes use much more energy than would be thermodynamically required. Distillation and evaporation alone consume 2.6 quads per year, while industrial drying uses another 1.8 quads per year. Carbon emission benefits are estimated at 1.1 MMT (C) per year in 2000, 2.0 MMT (C) per year in 2010, and 3.9 MMT (C) per year in 2020. Energy savings from selected industrial technologies are estimated at 0.148 quad per year in 2000, 0.276 quad per year in 2010, and 0.519 quad per year in 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Industrial Heat Pumps (IHPs)  
**Budget (In Thousands):** FY93 \$2,200      FY94 \$1,700

**Program Description:** DOE develops and encourages implementation of IHPs consisting of advanced chemical/sorption heat pumps, process-integrated heat pumps, and Brayton cycle solvent recovery heat pumps. The current program thrust is to develop advanced heat-driven chemical heat pumps that will lift heat over wider temperature ranges, and will lift heat to higher delivery temperatures more economically and without environmentally damaging chlorofluorocarbons (CFCs). DOE provides industry with technical assistance with tools and manuals developed under International Energy Agency (IEA) Annex 21 initiative, "Global Environmental Benefits of Industrial Heat Pumps."

Over 10 quadrillion BTUs are consumed for industrial process heating and cooling. About 7 quads of this energy are discharged as waste heat. Much of this heat could be economically recycled. By recycling the waste heat primary energy will be conserved, combustion of fuels will be avoided along with the associated greenhouse gas emissions.

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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Biomass Electric  
**Budget (In Thousands):** FY93 \$4,700      FY94 \$5,500

**Program Description:** DOE is conducting research to increase the efficiency of biomass electric technologies so that they will be more economically competitive with conventional technologies. In addition, The Office of Energy Efficiency is sponsoring demonstration projects with industry and conducting analysis of biomass options.

The use of biomass electric will reduce carbon emissions by displacing the burning of fossil fuels. Biomass electric systems are being developed for and used for primarily baseload generation and some intermediate load electricity generation. On a fuel cycle basis, biomass electric systems emit significantly less carbon than do fossil fuel burning power plants. Currently, there is over 6000 MW of installed capacity of biomass electric power. Biomass electric systems are extremely competitive in regions of high biomass resource concentration and where there is a strong pulp and paper industry presence. Carbon emission benefits are estimated at 15 MMT (C) per year by 2000 and 38 MMT (C) per year by 2010, and 44 MMT (C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Wind Energy  
**Budget (In Thousands):** FY93 \$23,300      FY94 \$30,300

**Program Description:** DOE supports applied research in the aerodynamic properties and structural dynamics of wind turbines; the development of the next generation of wind turbines; and efforts to integrate wind generation into utility systems.

The use of wind energy systems will reduce carbon emissions by displacing the burning of fossil fuels for bulk power generation. Wind energy systems emit zero greenhouse gas emissions. Currently, there is over 1500 MW of installed capacity of wind energy, primarily in California. The levelized cost of electricity from wind energy is about 7 cents per kWh currently, though it is expected to drop to less than 4 cents per kWh in less than 10 years. Carbon emission benefits are estimated at 3 MMT (C) per year by 2000 and 5.3 MMT (C) per year by 2010, and 9.2 MMT (C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Geothermal Energy  
**Budget (In Thousands):** FY93 \$22,800 FY94 \$23,900

**Program Description:** In the past, DOE has conducted some basic and applied research in the geothermal area, including the monitoring and modeling of production and environmental impacts. Ongoing efforts in the hydrothermal area support field research oriented toward improving production, improved reservoir modeling efforts, development of exploration methodologies, and research on turbine design. In addition, DOE is actively seeking private-sector partners to participate in commercialization projects using more advanced geothermal technologies.

The use of geothermal power will reduce carbon emissions by displacing the burning of fossil fuels for bulk power generation. Geothermal power results in nearly zero greenhouse gas emissions. Currently, there is over 2100 MW of installed capacity of geothermal power in western U.S. The levelized cost of electricity from wind energy is about 8 cents per kWh currently, though it is expected to drop to less than 3 cents per kWh by 2020. Carbon emission benefits are estimated at 8 MMT (C) per year by 2000 and 13 MMT (C) per year by 2010, and 22 MMT (C) per year by 2020.

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**Agency:** U.S. Department of Energy  
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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Photovoltaics  
**Budget (In Thousands):** FY93 \$63,700      FY94 \$78,000

**Program Description:** DOE's strategy toward the photovoltaic technologies is three-pronged, consisting of device and material research, manufacturing process engineering and market development. In the device and materials area, joint projects with the Office of Energy Research focus on basic crystal-growing techniques for producing higher quality cells; ongoing partnerships with private-sector firms aims to improve the efficiency and performance of existing PV devices. The manufacturing process effort is relatively new, and relies strongly on partnerships with industrial firms actively involved in PV manufacturing. Market development projects include a project to develop and validate specific high-value applications of PV technologies.

Photovoltaics are/will reduce carbon emissions by displacing fossil fuel-based electricity generation for grid and non-grid application — photovoltaics emit zero greenhouse gases. Currently, there is about 60 MW of photovoltaics installed in the U.S. Carbon emission benefits are estimated at 0.1 MMT(C) per year by 2000 and 0.1 MMT(C) per year by 2010, and 1.9 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Hydropower  
**Budget (In Thousands):** FY93 \$1,000      FY94 \$1,000

**Program Description:** DOE's hydropower program focuses on the primary environmental mitigation issues associated with developing and maintaining hydropower production. These efforts include a review and evaluation of regulatory and licensing practices, studies of environmental mitigation strategies, monitoring, and resource assessment. In addition, DOE is exploring the possibility of a joint project with the Electric Power Research Institute (EPRI) to develop advanced turbines with improved efficiency and environmental properties.

Hydropower are/will reduce carbon emissions by displacing fossil fuel-based electricity generation for bulk electricity generation. Currently, there is about 75 GW of hydropower installed capacity and the technology is mature. The costs of the technology are among the lowest of any electricity generation technology — about 3 cents per kWh. Carbon emission benefits for existing generation are about 52 MMT(C) per year, however savings from new installations will result in additional savings of only 1.6 MMT(C) per year.

**Linkages with private sector, NGO's and academia:** EPRI.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Transmission, Storage, and Distribution  
**Budget (In Thousands):** FY93 \$41,400 FY94 \$49,900

**Program Description:** DOE programs provide support in several key areas. Research is oriented toward increasing the understanding of the health impacts of electromagnetic fields and communicating this information to the public. High temperature superconductivity research supports materials research and wire processing, and application studies on devices such as motor generators, and superconducting magnetic energy storage, which will increase the efficiency of generation, transmission, and distribution of electricity. In the shorter term, applications development using conventional battery systems for utility applications will provide significant transmission and distribution efficiency gains. Research on electricity system reliability includes support for the development of real time control systems. In addition, DOE is conducting research in high voltage direct current technology and high phase order transmission to help improve transmission efficiency. Improvements in transmission and distribution efficiency bring environmental benefits by reducing the need to construct new facilities. Advanced technologies also can bring economic benefits to the U.S. as they penetrate overseas markets for transmission and distribution hardware.

Storage technologies are enabling technologies for many renewable technologies that DOE is working on, thus their carbon reduction benefits are included in estimates for those technologies. The potential energy impact of T&D improvements is bounded by total line losses. These losses amounted to 300 billion kilowatt hours in 1990, and are projected by EIA to increase to around 400 billion kilowatt hours by 2010. Investments in T&D improvements are expected to reduce these losses by 40 billion kWh per year in 2020. The concomitant reductions in generation will reduce carbon emissions by 4.2 MMT(C) per year in 2000, by 5.4 MMT(C) per year by 2010, and by 8 MMT(C) per year by 2020.

**Linkages with the private sector, NGO's and academia:** The renewables industry, taxpayers and consumers, EPRI, utilities, environmental groups, and state and local governments.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Materials Processing (includes Metals Initiative)  
**Budget (In Thousands):** FY93 \$25,538      FY94 \$25,366

**Program Description:** Office of Industrial Processes, Materials Processing Division, in conjunction with its industrial partners, conducts applied research and development, demonstration, and deployment of alternative technologies that improve the energy efficiency and cost effectiveness of the industrial processes.

The program goals of increasing energy efficiency, process economics and environment improvements can significantly improve the cost-competitiveness of the high temperature, energy intensive materials processing and electrolytic industries. The Materials Processing program focuses on defining the vision for the steel, aluminum, and glass plants of the future by identifying the technical, market and regulatory challenges that impact the evolution of the next generation plants. The estimated energy savings from presently funded projects in Quadrillion BTU is: 0.093 in 2000, 0.233 in 2010, and 0.440 in 2020. The carbon emission benefits in MMT(C) per year from presently funded projects are: 3.8 in 2000, 8.8 in 2010 and 16.3 in 2020.

**Linkages with other Federal Agencies:** EPA, DOI/BOM, DOC. The metals industries and other commodity industries are energy intensive industries that provide not only some of the highest paid jobs in the U.S. but are the material source and economic foundation for value added manufacturing. Cost competitive, energy efficient technology is by definition more beneficial to the environment and U.S. economy.

**Linkages with private sector, NGO's and academia:** The manufacturing industries, Iron and Steel Aluminum, Copper, Rare Earth metals, Glass, Foundries, Cement, and refractory industries, States and local governments.

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**Agency:** U.S. Department of Energy  
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**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Enabling Materials  
**Budget (In Thousands):** FY93 \$6,834 FY94 \$9,012

**Program Description:** In 1989, in response to National Research Council conclusions that materials such as continuous fiber ceramic composites (CFCCs) were critical to continued growth and prosperity of U.S. industry, the Office of Industrial Technologies began work on the development of a comprehensive strategy and plan for CFCC development. The report of the House Committee on Appropriations accompanying the Interior and Related Agencies Appropriations Act of 1990 (Public Law 101-121) requested the Department of Energy to complete a comprehensive continuous fiber composite research and development plan with financing options. In 1992, DOE signed cost-shared cooperative agreements for the development of continuous fiber ceramic composites with 10 industry teams totaling 42 industry, university, and national laboratory participants. The new program was called a "Model Program" by the United States Advanced Ceramic Association. It is the first and only integrated effort to develop CFCC processing technology in U.S. industry for the manufacture of industrial components.

The availability to U.S. industry of a host of new energy efficient environmentally beneficial equipment is dependent on CFCC development. For instance: application of a CFCC self-lubricating valve guide to diesel engines would reduce particulate emissions 25%; a CFCC radiant burner would boost efficiency of moderate and high temperature ovens by 60 percent; CFCC components would increase energy conversion efficiencies up to 35% over conventional coal-fired steam plants while reducing emissions by 25%; CFCC components in gas-fired turbines would increase efficiency by 6% while almost eliminating NOX emissions. Specifically, employing CFCCs in U.S. industry and power generation can result in the following benefits:

- Energy savings of at least 2.16 Quadrillion Btus (Quads) annually by the year 2010, with an energy cost savings of at least \$8.1 billion.
- Environmental progress in the form of emissions reduction, with minimum reductions for the following pollutants by the year 2010:
  - 917,000 tons annually of nitrous oxide (NOX) emissions.
  - 118.9 million tons annually of carbon dioxide (CO<sub>2</sub>) emissions.
  - Cost savings from reduction in regulated emissions, principally NOX and to a lesser extent SOX. With current environmental regulations and the expectation of stricter regulations, potential annual savings could be several billion dollars.
- Improved component performance and lifetime, resulting in reduced downtime, high-quality and low-cost products; allowing greater domestic and international competitiveness and a positive impact on U.S. employment.
- The competition for an estimated near-term market of between \$700 million and \$1.4 billion annually, with an identified market of over \$6.4 billion by 2010.
- The potential to create or save at least 64,000 industrial sector jobs for U.S. citizens, and a similar amount from multiplier effects, from identified applications where estimates were available.

**Linkages with other Federal Agencies:** DOC/NIST.

**Linkages with private sector, NGO's and academia:** Southern California Gas Company, U.S. industry, U.S. universities, U.S. Advanced Ceramics Association.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Industrial Wastes  
**Budget (In Thousands):** FY93 \$17,292      FY94 \$23,059

**Program Description:** This is an ongoing program legislatively mandated to assist industry in improving energy efficiency, reducing or utilizing wastes, and reducing greenhouse gasses. Projects are cost shared between 20-60 percent with industry, states, other governmental agencies, other organizations and other countries.

U.S. industry produces about 12 billion tons of waste each year with an additional 1.7 billion tons being greenhouse gasses. The cost of handling, cleaning, and disposing of these wastes is at least \$45 billion per year, and is rising rapidly. As much as 9 quads of energy annually is contained in the embodied energy of unused or poorly used raw materials, in the energy content of the waste streams and in the energy required to clean up and dispose of wastes.

The DOE program planned and cost-shared with industrial partners, will develop process technologies which reduce generation of wastes. This approach also should enhance productivity and competitiveness. The program will (1) improve data on industrial wastes; (2) expand partnerships between national laboratories and industry and focus on wastes produced in chemical, petroleum, metals, and pulp & paper processes; (3) analyze barriers to industrial waste reduction; (4) expand efforts in reducing material use and improving recyclability of autos, (5) initiate efforts with industry in recycling carpets, durable goods, and food wastes; and, (6) expand cooperation among EPA, states, and industries on demonstration of waste reduction technologies.

One measure of success is that four technologies have been commercialized by industry and currently are improving energy efficiency, (reducing CO2 emissions) reducing wastes, and improving competitiveness of both small and large companies.

**Linkages with other Federal Agencies:** EPA, DOC, DOI.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Industrial Electric Motor Systems (EMS)  
**Budget (In Thousands):** FY93 \$736                      FY94 \$2,077

**Program Description:** DOE develops and encourages implementation of EMS consisting of energy efficient motors, adjustable speed drives (ASDs), and advanced motor-driven mechanical systems and processes. The current program thrust is to break market barriers through market and technology assessment, and deployment efforts, and to develop advanced system-integrated EMS that will be demonstrated in a variety of industrial applications.

Over 65% of electricity use in the industrial sector is used by electric motors, thus more efficient EMS will result in electricity savings or will drive a process more efficiently than a heat engine; thus carbon emissions will be reduced either at the power generation facility or the industrial site itself. Opportunities of efficient EMS are: more efficient motors (3 to 10% improvement potential); implementation of ASDs (20 to 50% improvement potential); more efficient motor-driven equipment or processes (2 to 20% improvement potential); or improved electrical distribution systems (2 to 5% improvement potential). Carbon emission reductions are estimated at 6 MMT(C) per year by 2000 and 44 MMT(C) per year by 2010.

**Linkages with other Federal Agencies:** EPA.

**Linkages with private sector, NGO's and academia:** Industrial end-users, motor and drive manufacturers, original equipment manufacturers (OEMs), utilities, state agencies, and energy and environmental groups.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency and Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Retrofit Technologies (Existing Building Efficiency Research)  
**Budget (In Thousands):** FY93 \$4,000      FY94 \$4,000

**Program Description:** Retrofit Technologies provides national support for public and private sector effort that improve the energy efficiency of existing residential and commercial buildings. The program develops, validates, and deploys new technology and improved management practices that can significantly increase the energy efficiency and reduce the CO<sub>2</sub> emissions of existing buildings throughout the United States.

In 1990, existing buildings in the United States consumed 30.6 quadrillion Btu of primary energy - 38% of all energy used in the United States - accounting for over 460 million metric tons of CO<sub>2</sub> emissions; 35% of all such emissions in the U.S., and 8% of those worldwide. The potential impact of widespread applications of retrofit practices can be found by closely looking at the middle and upper income single family building sector. This sector consists of over 53 million households, accounts for almost 70% of the total primary residential energy use and consumed about 11.5 quadrillion Btu in 1990; costing \$75 billion. A 25% energy efficiency improvement can be realized throughout this sector, with the potential annual energy savings (1990 base) of almost 3 quads, providing a concomitant reduction of 45 million metric tons of CO<sub>2</sub> emissions.

**Linkages with other Federal Agencies:** EPA

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Solar Domestic Water Heating  
**Budget (In Thousands):** FY93 \$1,900      FY94 \$4,300

**Program Description:** DOE provides technical support to utilities and regulatory agencies that seek to replace electric water heaters with Solar Domestic Water Heating as part of demand-side management programs. DOE SDWH technology research efforts are directed toward simplifying and reducing system costs and identifying insulation that does not contain CFCs. DOE also is developing and validating a voluntary industry-wide rating and certification program to ensure that the current and future generations of SDWH systems meet utility and customer requirements for reliability and cost-effectiveness.

The use of solar domestic water heaters will reduce carbon emissions by displacing electricity and natural gas use for hot water heating. Solar domestic water heaters do not contribute to carbon emissions (unless coupled with a back-up system), thus have the potential to decrease carbon emissions significantly. Solar hot water heaters compete economically with electric hot water systems currently. Carbon emission benefits are estimated at 1.2 MMT(C) per year by 2010, and 2.7 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Process Heating and Cooling  
**Budget (In Thousands):** FY93 \$4,158      FY94 \$6,796

**Program Description:** The DOE process heating and cooling program has two main focuses: (1) recuperators, and (2) solar industrial. For recuperators, DOE is funding research to develop ceramic high-pressure heat exchanger systems (HiPHES). Total savings of feedstock and energy requirements could reach 30% over that of conventional reformers. DOE is sponsoring various projects entailed in the widespread promotion and implementation of industrial heat pumps (IHPs). These projects include process heat integration to identify heat pump applications, individual site heat pump design and demonstration. For solar industrial applications, DOE aims to break these barriers and successfully promote solar technology as a technically and economically viable option. Activities included under this program range from developing new materials that will increase the reliability of solar applications, sponsoring educational activities, providing technical assistance to current and potential users, and helping finance several industrial solar projects.

Thermal processes (heating and cooling) are crucial to many key U.S. industries, including the food, chemicals, petroleum refining, pulp and paper, and primary metals industries. Process heating and cooling are extremely energy-intensive and consume approximately 17 quads per year (over half of total industrial energy use). Hence, even small improvements in the efficiency of various equipment (e.g. heat exchangers) under this program can result in substantial savings of energy and carbon. DOE projects that gains in process heating and cooling will reduce carbon emissions 2.7 MMT(C) per year by 2000, 6.5 MMT(C) per year by 2010, and 12.5 MMT(C) per year by 2020.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Municipal Solid Wastes  
**Budget (In Thousands):** FY93 \$4,568      FY94 \$4,619

**Program Description:** This is an ongoing program to productively use municipal solid waste (MSW) and landfill gas to provide as much as 4 percent of the Nation's energy requirements.

Today, about 15 percent of our 200 million tons of annual municipal waste is combusted to provide 0.3 quads of energy, and 15 percent is recycled to conserve an additional 0.15 quads (mostly from reduced demand for electricity for aluminum smelting.). Waste to energy facilities under contract or in advanced planning could increase energy recovery to 1.2% of the Nation's electricity needs, but are delayed by perceived environmental concerns. Some of the materials collected for recycling are being discarded because of glutted markets. The net environmental effects of various types of recycling are unknown. The cost of discarding municipal waste in landfills is increasing much faster than the rate of inflation, placing severe financial burdens on many municipalities.

During the past few years, the program has had notable successes. In data collection and analysis, a major study on MSW management alternatives has been completed. The conclusion of that study and an earlier assessment of research needs showed that not enough is known on the environmental consequences or the costs of some waste management processes that are currently popular and expanding, such as MSW composting. The program is continuing to fill the data gaps revealed in the earlier studies. Successful pilot plant tests were completed on a novel approach for disposing of sewage sludge in existing waste to energy plants; industry is developing a full scale test with their funding. Tests are being conducted on inexpensive approaches to reduce acid gas emissions. Anaerobic digestion of tuna sludge and MSW has been scaled-up to 1,000 liters. Important data is being developed to recover and use landfill gas as a fuel.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Industrial Combustion Efficiency  
**Budget (In Thousands):** FY93 \$8,567      FY94 \$4,029

**Program Description:** Substantial reductions in greenhouse gas emissions are projected from current and planned industrial Combustion Efficiency Programs. Combustion-related emissions arise from (1) the consumption of less fuel, (2) the conversion from other fuels to natural gas, and (3) from the elimination of the need for post combustion controls which emit greenhouse gases by products. Projects now underway (oxy-fuel firing, advanced porous radiant burner, workpiece analyzer and ferrous scrap preheater among others) are expected to reduce CO<sub>2</sub> emissions by over 20 million tons of CO<sub>2</sub> annually in less than 10 years after their initial use by industry.

A natural gas end-use technologies program authorized by the Energy Policy Act of 1992, EPACT (Pub. L. 102-486), Section 2014, will result in the research development and demonstration of combustion equipment with both very low pollutant emissions and increased efficiency. The former will enable industry to meet 1990 Clean Air Act Amendment emission targets without add-on controls thereby eliminating greenhouse emissions. These projects involve optimizing radiant burner efficiency: catalytic combustion and porous media pebble burners among others. This group of EPACT projects is expected to reduce greenhouse gas emissions by one 20 million tons annually in less than 10 years after their initial use by industry. Additional reductions in CO<sub>2</sub> emissions amounting to several million tons annually are expected to result as industry convert, from coal-and oil-fired units to this gas-fired equipment, due to its environmental attractiveness and rapid payback. Cost share of 50% is required for the demonstration phase of this EPACT-mandated program. This program is expected to start in FY 1994. The benefits to be realized by the year 2000 include energy savings approximately 1 quad/years, reduction of 39 million tons of annual air emissions and doubling of employment for combustion equipment manufacturers.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Cogeneration  
**Budget (In Thousands):** FY93 \$4,416      FY94 \$8,809

**Program Description:** The Advanced Turbine Systems (ATS) program is a joint DOE Fossil Energy and Energy Efficiency project. The program goal is for substantially improved efficiency, reduced emissions, and reduced cost of electricity production. The program is cost-shared by industry with support from national laboratories, research institutions, and universities.

The advanced turbine systems will run on natural gas and replace coal-based central power station electricity production. The systems will operate at 60% combined cycle efficiency for utility scale systems and 50% combined cycle efficiency for industrial scale systems compared to the national average of 34% for central power stations. Emissions of nitrous oxides and carbon monoxide will be reduced over ninety percent; carbon dioxide will be reduced over fifteen percent. New or replacement capacity for the industrial units could exceed 150,000 MW by 2020.

**Linkages with other Federal Agencies:** EPA

**Linkages with private sector, NGO's and academia:** Electric Power Research Institute, Gas Research Institute, American Gas Association, American Cogeneration Association, Gas Turbine Manufacturers Association, United States Advanced Ceramic Association, local agencies such as the Santa Barbara Air Quality Management District, over fifty Universities, National Laboratories, Utilities, Cogenerators, Gas Turbine manufacturers, and other industry suppliers and users of power generation equipment.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Combustion Systems  
**Budget (In Thousands):** FY93 \$34,724      FY94 \$42,837.

**Program Description:** Emissions of carbon dioxide, which is postulated as a greenhouse gas contributing to global climate change, are not currently regulated in the United States. If control requirements are imposed on CO<sub>2</sub> in the future, clean coal technologies would provide power generating utilities with the basis for effective approaches for reducing these emissions. Specifically, since CO<sub>2</sub> formation is inversely related to powerplant efficiency, the replacement of aging, lower-efficiency powerplants with advanced, high-efficiency power systems of equal capacity would result in significantly lower atmospheric emissions of CO<sub>2</sub>.

The technologies that comprise Combustion Systems focus on total system improvements that will yield both far lower emissions and significantly higher efficiencies. The use of these advanced coal-combustion power generation technologies can provide a significant improvement in carbon dioxide emissions. For example, a 100-megawatt powerplant of 40 percent net efficiency will emit 17-1/2 percent less carbon dioxide than a 100-megawatt powerplant of 33 percent net efficiency that uses the same fuel supply. Therefore, the replacement of aging, lower-efficiency powerplants with advanced high-efficiency power generating systems of equal capacity will result in generation of significantly lower amounts of carbon dioxide. The likelihood of future greenhouse gas emissions regulations with respect to global climate change is unknown. If greenhouse gas emissions control requirements are imposed, rapid change over to high-efficiency power generating technologies will be a primary response.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Natural Gas Utilization Research/Advanced Turbine Systems  
**Budget (In Thousands):** FY93 \$13,860      FY94 \$28,284

**Program Description:** The objective of the Advanced Turbine Systems (ATS) Program is to develop ultra-high efficiency, environmentally-superior, and cost-competitive gas turbine systems for base-load application in utility, independent power producer, and industrial markets. Specific performance targets have been set using natural gas as the primary fuel including system efficiency that will exceed 60 percent on natural gas for large-scale utility turbine system; for industrial applications, system that will result in a 15 percent improvement in heat rate compared to currently available gas turbine systems; an environmentally superior system that will not require use of post-combustion emissions controls under full-load operating conditions; busbar energy costs that are 10 percent less than current state-of-the-art turbine systems, while meeting the same environmental requirements; and fuel-flexible designs that will operate on natural gas, but are also capable of being adapted to operate on coal, coal-derived, or biomass fuels.

The ATS Program has four elements:

1. Innovative Cycle Development will lead to concept definition for integrated systems meeting ATS Program goals.
2. Utility System Development and Demonstration will consist of component design and testing, integrated subsystem testing, and full system demonstration of a utility system.
3. Industrial System Development and Demonstration will consist of a 4,000-hour ceramic retrofit engine test program and an advanced cycle industrial-scale system demonstration.
4. Technology Base Development will support the overall program. A university/industry consortium will provide cross-cutting technology support.

**Linkages with other Federal Agencies:** EPA

**Linkages with private sector, NGO's and academia:** Electric Power Research Institute and Gas Research Institute.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Gas Stream Cleanup  
**Budget (In Thousands):** FY93 \$15,801      FY94 \$19,866

**Program Description:** The components being developed will remove contaminants such as sulfur, carbon dioxide, ammonia, particulate, and potentially hazardous materials from the fuel gas for advanced coal-based power systems. In addition, use of high temperature gas cleanup will help improve the system efficiency. The Gas Stream Cleanup (GSCU) Program is part of the Control Technology and Coal Preparation budget activity. Its objective is to develop in-process control technology which will foster utilization of advanced coal-based power systems which are environmentally superior, are significantly more efficient (produce less carbon dioxide), and will be less costly than conventional coal-based plants. The GSCU Program is comprised of process research at several scales to develop subsystems for removal of contaminants and to increase efficiency of advanced coal-based power systems (integrated gasification combined cycle, pressurized fluid-bed combustors). Our 2010 goal is to have developed advanced coal-based systems with at least 50 percent efficiency, which will reduce by up to 40 percent the carbon dioxide produced from today's conventional coal-based powerplants.

**Linkages with other Federal Agencies:** EPA, DOI, DOT, DOC.

**Linkages with private sector, NGO's and academia:** Electric utilities, energy producers engineering corporations, transportation companies; United Mine Workers of America.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Surface Coal Gasification  
**Budget (In Thousands):** FY93 \$10,725      FY94 \$11,850

**Program Description:** The Surface Coal Gasification Program consists of three subprograms—Gasification Power Systems, Synthesis Gas Systems, and Mild Gasification Systems. The Gasification Power Systems Program is focused on developing and demonstrating advanced gasification-based power systems and their component subsystems; objectives are to develop, demonstrate, and commercialize advanced gasification-based power systems having a net system efficiency of at least 45 percent by the year 2000 and of at least 50 percent net system efficiency by the year 2010. Products of this program will be ultra-high efficiency gasification-based power systems that also are environmentally superior with respect to existing and planned environmental regulations. The Synthesis Gas Systems Program is focused on developing and commercializing new coal-based technologies that can lead to low cost, coal-based liquid fuels; the objective is to develop process technology for producing coal-based liquid fuels and chemicals that will, in the future, have cost advantages over their natural gas-based counterparts. The product of this program will be environmentally benign processes for production of fuels and chemicals that can lessen dependence on foreign energy sources. The Mild Gasification Systems Program is focused on developing and commercializing new pyrolysis-based processes for converting coal into a broad spectrum of value-added fuels, chemicals and industrial products; the objective is to develop process technology for producing a broad slate of solid and liquid products from coal that will have cost advantages over their petroleum-based counterparts. The product of this program will be environmentally benign processes for production of fuels, chemicals, and industrial products that can lessen dependence on foreign energy sources.

**Linkages with other Federal Agencies:** EPA, DOT, DOI, DOC.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Clean Coal Technology Demonstration  
**Budget (In Thousands):** FY93 \$0 FY94 \$250,000

**Program Description:** Although this is a demonstration program, not R & D, it does involve activities which are relevant to potential mitigating options for constraining CO<sub>2</sub> emissions. The program involves commercial scale demonstration of advanced coal using electric power generating technologies which offer higher conversion efficiencies than existing and planned powerplants using current technology, with a consequent reduction in CO<sub>2</sub> emissions per unit of electrical output. Operational results from the relevant projects currently in the program are expected in the 1997 - 1999 period.

By demonstrating the technical and economic feasibility of these advanced technologies under realistic utility operating conditions, it becomes possible for institutions involved in policy formulation, climate change modeling, and economic forecasting to more accurately anticipate what is possible over the next 30 years in meeting global demands for additional electricity while limiting emission of greenhouse gasses to the atmosphere.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Advanced Research and Technology Development  
**Budget (In Thousands):** FY93 \$13,123      FY94 \$13,852

**Program Description:** The Advanced Research and Technology Development (AR&TD) Program addresses two types of activities. The first is a series of technical and economic analyses, coal technology export, and international program support. This program would include analyses of the costs associated with the removal, recovery, and disposal of CO<sub>2</sub> from power plants, and the export of more efficient (and therefore lower greenhouse gas producing) technologies to other countries. The second focuses on research that is critical to the successful development of very high efficiency power systems. The development of these technologies permits the continued use of fossil fuels in an environmentally acceptable manner.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Magneto hydrodynamics  
**Budget (In Thousands):** FY93 \$29,919      FY94 \$4,822

**Program Description:** Goals are to develop cost effective, highly efficient, and environmentally benign magneto hydrodynamic systems which operate on coal or other fuels. Objectives are to transfer the technology to the private sector for demonstration and commercial introduction. Products of this program will be a new U.S. manufacturing industry with domestic and export sales of power plants for a wide range of applications with efficiencies up to twice the current utility power plant levels, emissions considerably less than current regulatory levels and carbon dioxide emissions down to one half of current utility power plant levels.

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**Agency:** Department of Energy  
**Bureau:** Office of Fossil Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Fuel Cells  
**Budget (In Thousands):** FY93 \$50,444      FY94 \$49,278

**Program Description:** Goals are to develop cost effective, highly efficient, and environmentally benign fuel cell systems which operate on natural gas and coal based fuels. Objectives are to demonstrate and introduce commercial natural gas fueled units for cogeneration and utility power generation in a range of domestic and export market applications prior to the year 2000 and to introduce commercial units operating on coal based fuels prior to the year 2010. Products of this program will be a new U.S. manufacturing industry with domestic and export sales of power plants for a wide range of applications with efficiencies up to twice the current utility power plant levels, emissions less than 1/10th of regulatory levels and carbon dioxide emissions down to one half of current utility power plant levels. An initiative beginning in FY 1995 will accelerate field testing and bring these environmentally desirable power plants to market. The earliest market entry units are currently available and more advanced units are being developed. Cost reduction and reliability are being emphasized to enable broad market application.

**Linkages with private sector, NGO's and academia:** The Gas Research Institute, the Electric Power Research Institute and the manufacturing companies addressing the development and marketing of these new power plants.

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**Agency:** Department of Energy  
**Bureau:** Office of Nuclear Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Advanced Light Water Reactors (ALWR)  
**Budget (In Thousands):** FY93 \$58,700 FY94 \$57,800

**Program Description:** The ALWR program is a cooperative, cost-shared government/industry program to design and develop standardized, safer, and more economic Light Water Reactors. The Department is supporting energy technology programs for which there is commercial interest. Commercial interest in this program has been clearly demonstrated by the financial commitment of approximately \$150 million made by electric utilities and nuclear vendors.

The goal of this program is to complete ALWR designs to the point where they can be certified (as safe) by the Nuclear Regulatory Commission, and commercially standardized to the point where their costs and schedules can be accurately estimated. This work is expected to be completed and these reactors available to the marketplace later this decade.

This program develops a technology to mitigate anthropogenic greenhouse gas emissions. In particular, this program brings a source of electricity to the marketplace that does not produce greenhouse gases.

Nuclear energy is only one of two large, commercially available technologies that emit no CO<sub>2</sub> (the other being hydro). The current nuclear plants displace over 100 million tons of carbon equivalent, an amount approximately equal to the additional reduction required to meet the Administration's Year 2000 goal. Each large (1000MWE) nuclear plant displaces 1-1.5 million tons of carbon equivalent, depending upon the specific fossil fuel it displaces.

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**Agency:** Department of Energy  
**Bureau:** Office of Energy Research  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Fusion Energy  
**Budget (In Thousands):** FY93 \$313,700      FY94 \$332,500

**Program Description:** The Fusion Program goal is to develop fusion energy as a potential contributor to the Nation's electrical energy production mix. The objectives are to: (1) operate an engineering test reactor about 2005; (2) perform a technology demonstration that verifies the practicability of commercial electric power production by 2010; (3) operate a demonstration power plant about 2025 and, (4) operate a prototype power plant by 2040. The program, if successful will mitigate the concerns about global climate change since the operation of fusion-based electrical production plants will result in the release of no greenhouse gases to the environment. Ongoing experimental and theoretical programs are progressing toward the program objectives. Many reviews of the program have been conducted over the past fifteen years. All of these reviews have found the program to be of high merit with strong technical underpinnings. Each review has resulted in budget recommendations that have not been matched by subsequent appropriations. This situation could be leading to reconsideration of the program's mission, objectives and milestones dates.

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**Agency:** U.S. Department of Energy  
**Bureau:** Office of Energy Efficiency & Renewable Energy  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Americas 21st Century  
**Budget (In Thousands):** FY93 \$0 FY94 \$3,250

**Program Description:** This is an ongoing program legislatively mandated to assist the renewable energy industry in the export of products and services to country markets in Latin America and the Caribbean. Specific projects are cost shared with other countries with the maximum U.S. Federal share being 25%.

Each project has the potential to prevent greenhouse gas emissions thus potentially forestalling, through mitigation measures, global climate change. One recent program accomplishment in Brazil has resulted in installation of photovoltaics in approximately 1,000 rural homes providing necessary but clean energy services for household, education, medical, and irrigation needs. One measure of success has been the request of the host government to replicate such projects for the state and there have been requests from six other states for similar collaboration which will focus on productive uses, including grain grinding, electric fencing, and diesel replacement in the environmentally sensitive Amazon region. An expected 2 billion kWh of energy could be saved in the year 2000 through this effort.

**Linkages with other Federal Agencies:** DOC, USAID, U.S. Export Council for Renewable Energy, U.S. Export-Import Bank.

**Linkages with private sector, NGO's and academia:** U.S. Renewable Energy Industry.

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**Agency:** Department of the Interior  
**Bureau:** National Park Service/National Biological Survey  
**Function:** Mitigation  
**Focused or Contributory:** Contributory  
**Program Title:** Air Quality Research and Monitoring  
**Budget (In Thousands):** FY94 \$835

**Program Description:** The program is a component of a larger NPS program to identify the sources, trends, and effects of atmospheric pollutants on the environment and ecosystems of the National Park System. The component focuses on monitoring research and modelling of atmospheric pollutants known to influence the Earth's radiation and heat budget. Program data improve the scientific basis for assessing options to reduce sources of these pollutants. Principal activities involve: ambient monitoring of ozone sulfur dioxide characterization of variability in atmospheric haze and trends in visibility conditions, estimation of natural and anthropogenic contributions to visibility impairment, identification of the pollutants responsible for visibility impairment, identification of the sources of these pollutants, and quantification of the effects of reducing emissions at these sources.

**Linkages with other Federal Agencies:** Interagency agreements with EPA to co-fund visibility research, Forest Service on pollutant effects on natural ecosystems.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** None

**Linkages with international organizations:** None

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**C. ADAPTATION - FOCUSED**

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry & Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Assessment of Crop Production under Global Climate Change.  
**Budget (In Thousands):** FY93 \$105 FY94 \$75

**Program Description:** The agronomic and economic effects of possible shifts in yield levels of grain and forage crops under global environment changes are being assessed. Mechanistic crop models are being used to investigate likely changes in the productivity of maize, soybean, wheat, and forage with changes in atmospheric CO<sub>2</sub> temperature, and rainfall. Increased interannual variation in crop yields appears to be one of the most significant changes influencing the economics of agriculture. Analyses are being undertaken to investigate specifically the economic importance of the projected changes in inter-annual variations in crop yields. Experimental work to provide basic biological information on the effects of the environmental changes on crops are being researched using the new technology of temperature gradient chambers. These chambers allow crops to be grown in the field to observe the interactive effects of changes in both CO<sub>2</sub> and temperature on crop growth and yield. The quality and productivity of various forage crops will be the focus of much of this experimental work.

**Linkages with other Federal Agencies:** DOE.

**Linkages with private sector, NGO's and academia:** The University of Florida.

**Linkages with international organizations:** International Geosphere Biosphere Program.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry & Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Predicting How to Sustain Managed and Natural Ecosystems as Human Populations and Climates Change.  
**Budget (In Thousands):** FY93 \$192 FY94 \$192

**Program Description:** Measurement of soybean leaf photosynthetic and plant growth responses to enriched CO<sub>2</sub>, temperature, water stress and other climatic factors. Development of logic for a generic plant model for quantifying stress levels, effects and interactions, with emphasis on possible climate change effects on plant response. Approaches include continuous work on a soybean-corn-pest cropping system model, development of a global ecological information base (biophysical logic and associated coefficients, with emphasis on plants and their interactions with pests and herbivores) for quantifying the behavior of both natural and managed (agroforest) ecosystems, and participation in local tallgrass prairie and savanna conservation efforts. Changes taking place in horticulture, landscape design, ecosystem restoration and plant breeding, particularly in the input of hobbyists or volunteers, offer great promise for mitigating climate change effects on natural and managed agroforest ecosystems, as well as for coming up with effective ways of fixing and permanently storing carbon and developing sustainable agroforest and natural ecosystems.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** None.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry & Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Global Change and the Structure and Function of Ecosystems  
**Budget (In Thousands):** FY93 \$100 FY94 \$100

**Program Description:** Experiments are conducted in growth chambers to establish the effects of the doubling of atmospheric carbon dioxide (CO<sub>2</sub>) levels since the last Ice Age and the 28% increase over the last 200 years on plants of importance to agriculture. Increasing atmospheric CO<sub>2</sub> from Ice Age levels, near 150 ppm, to the current ambient, about 350 ppm, sometimes doubled or tripled the growth and yield of agronomic and forage plants. For instance, grain yields of spring wheat increased 300% over the 75% rise in CO<sub>2</sub> from the Ice Age level of about 200 ppm to current ambient when grown under well watered conditions. Wheat grain yields increased by about 50% over the 28% rise in atmospheric CO<sub>2</sub> experienced since the beginning of the Industrial Age. Comparable increases were observed in leaf area and total above ground biomass; forage yields of species such as wheat and oats with the C<sub>3</sub> photosynthetic pathway tripled over the 75% rise in CO<sub>2</sub>. Water stress reduced but did not eliminate the positive effects of rising CO<sub>2</sub> on growth and yield. Positive effects of increasing atmospheric CO<sub>2</sub> were associated with higher photosynthetic rates and higher water, light, and nitrogen use efficiencies. These studies suggest that direct effects of rising CO<sub>2</sub> on plants have played a role in historical increases in agricultural productivity and must be considered when modeling the effects of global change on agriculture and the carbon cycle.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** Texas A&M University.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Water Resources  
**Focused or Contributory:** Focused  
**Program Title:** Effects of Management and Climate on Rangeland Water Supplies  
**Budget (In Thousands):** FY93 \$520 FY94 \$519

**Project Description:** Develop methods to improve our ability to understand and describe the temporal and spatial aggregation of water, energy, and mass fluxes from small watersheds to larger, complex watersheds and to disaggregate water and energy fluxes from general circulation models (GCM'S) through mesoscale models to smaller agricultural watersheds to develop methods of determining effects of global change on rangeland water supplies.

Hydrologic data from small plots to the 150 sq km Walnut Gulch Watershed will be used to calibrate and validate relationships between temporal and spatial scales in hydrologic model components to develop methods of understanding and modeling water, energy, and mass fluxes over this range of scales. The models will be used to extend this process-based knowledge to river basin scales as an adjunct to, and validation tool for, GCM climate change predictions. Time series analyses of global change data from point, watershed, regional, national, and global scales will be used to separate natural variations in climate and weather from anthropogenic effects and from land use and management effects. This information will be used to validate the hydrologic and general circulation model predictions of trends and cycles. Quantified anthropogenic effects and validated models will be used in decision support systems to select the best mitigation strategy from among alternative strategies.

**Linkages with other Federal Agencies:** DOE, NASA, USGS.

**Linkages with private sector, NGO's and academia:** University of Arizona, Alamos and Sandia National Laboratories (Decision Support Systems).

**Linkages with international organizations:** CIDESON (Center for Research and Development of Natural Resources of Sonora, Mexico), LERTS (Toluse, France).

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Global Climate: Effects of Chemical and Physical Changes in the Atmosphere on Crop Productivity  
**Budget (In Thousands):** FY93 \$1,234      FY94 \$1,195

**Program Description:** The overall program mission is to determine the potential effects of selected aspects of global change on crop systems. Primary global change variables currently being investigated include elevated carbon dioxide, tropospheric ozone, and enhanced ultraviolet-B radiation. Research is conducted under field, greenhouse, phytotron and laboratory conditions. Current research includes: 1) studies of elevated carbon dioxide and ozone effects on physiology, growth, and yield, 2) examination of ozone and carbon dioxide effects on plant-pathogen/pest and rhizosphere associations, 3) development of stress-resistant cultivars 4) determination of mechanisms of action of air pollutants and physiological and biochemical mechanisms of resistance for use in mitigative actions, 5) application of environmental, physiological, and growth data in crop growth simulation models for use in mitigative strategies, 6) development of a biomonitoring system for ozone stress, and 7) studies of the extent magnitude, and location of long-term changes in the condition of agroecosystems.

**Linkages with other Federal Agencies:** DOE, EPA.

**Linkages with private sector, NGO's, and academia:** EASE (Environmental Assessment for the Southeast), North Carolina State University (cooperative research, NE-176 (Northeastern Regional Project - Characterization of Plant Responses to Ozone).

**Linkages with international organizations:** German Ministry of Agriculture, ESPACE (European Stress Physiology and Climate Experiment), National Institute of Agro- Environmental Sciences (global change research).

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Development and Validation of Decision Support Systems for Maintenance and Restoration of Rangeland Plant Communities  
**Budget (In Thousands):** FY93 \$120 FY94 \$60

**Program Description:** An interactive climate-vegetation-soil model is being developed to predict the effects of seedbed microclimate on early plant establishment. Methodology is being developed to characterize seedbed microclimatic conditions under any combination of soil condition, vegetation cover, and potential climate regime. Methodology also is being developed to predict seed germination, seedling establishment, and species persistence under potential future seedbed microclimatic scenarios. Model system components are being developed in a modular format to facilitate technology transfer and to enhance compatibility with other terrestrial ecosystems models. This modeling system can be used to evaluate potential climate change effects or early plant establishment in the sagebrush/bunchgrass region of the Great Basin. Modeling technology will be transferred to the Bureau of Land Management as a burn-rehabilitation and plant community restoration tool for the Snake River Plain region of Idaho. This modeling system will form the basis for a larger modeling complex to evaluate hydrologic effects on the structure and function of rangeland ecosystems.

**Linkages with other Federal Agencies:** DOI.

**Linkages with private sector, NGO's and academia:** University of Idaho.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Water Resources  
**Focused or Contributory:** Focused  
**Program Title:** Characterization and Prediction of Water and Energy Fluxes  
**Budget (In Thousands):** FY93 \$586 FY94 \$585

**Program Description:** Improve prediction of water and energy fluxes within terrestrial ecosystems by accounting for spatial and temporal variability as a function of scale. By measuring water and energy fluxes over a range of scales using new conceptual and technological approaches that account for spatial and temporal variability, and by interpreting the results to develop improved characterizations of the temporal and spatial variability of climatic variables, which will enhance physically-based hydrologic models to better represent and assess spatial and temporal variations in water and energy fluxes at various scales. The new models then will be used to estimate the effects of global change on hydrologic processes and to identify potential mitigating and adaptive strategies to address future climatic scenarios.

**Linkages with other Federal Agencies:** DOI.

**Linkages with private sector, NGO's and academia:** University of Idaho and Utah State University.

**Linkages with international organizations:** None.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Focused  
**Program Title:** Nematode Indicators of Global Change: Relationship of Nematode Soil Populations to Climate Change in Grassland Ecosystems.  
**Budget (In Thousands):** FY93 \$25 FY94 \$25

**Program Description:** Nematodes are ideal entities for use as ecological indicators of climatic change. Nematodes are small and have short generation time that allows them to react quickly to food supply changes. They are able to survive extreme desiccation and degrees of pollution. Determinations of seasonal nematode population are used to determine environmental stress resulting in a change in the overall structure of different nematode groups referred to as trophic groups and distinguished by their feeding habits. Trophic groups are classified as: 1) plant parasites, 2) microbivores, 3) fungivores, 4) omnivores, and 5) predacious nematodes, and changes in trophic structure are used to monitor climatic change. An increase in soil bacteria results in an increase in microbivores, while an increase in fungi results in an increase in fungivores, etc. This is an excellent method of determining changes in the soil biology that directly affects plant growth.

**Linkage with other units:** Linkage with N.W. Watershed Research Center. The center has developed a computer model (SPUR) that documents differences in environmental and climatic conditions and plant ecology at different elevations and plant environs. Nematode data from the Global Change Research will be utilized in model development and result in a greater understanding of the effect of global change on flora and fauna.

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**Agency:** National Science Foundation  
**Bureau:** Division of International Programs  
**Function:** Adaptation: Combined  
**Focused or Contributory:** Focused  
**Program Title:** International Programs  
**Budget (In Thousands):** FY93 \$850      FY94 \$890

**Program Description:** The international programs support the work of U.S. scientists and engineers cooperating with those of other countries in mutually beneficial research, education, and related activities.

**Linkages with other Federal Agencies:** Linkages are with AID, State Department and OSTP.

**Linkages with private sector, NGO's and academia (Non-Federal funding):** None.

**Linkages with international organization:** ICSU, SCOPE, IIASA.

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**Agency:** National Science Foundation  
**Bureau:** Division of Biological and Critical Systems  
**Function:** Adaptation: Natural Systems  
**Focused or Contributory:** Focused  
**Program Title:** Effects of Climate Change on Coastal Zones  
**Budget (In Thousands):** FY93 \$0 FY94 \$0

**Program Description:** The purpose of funding research in the area of "Impact of Global Change on Coastal Zones" is to advance the capabilities to predict, assess, and mitigate the effect of possible climate changes on coastal areas, coastal constructed systems, and infrastructures. The major critical research topics are: vulnerability of coastal areas to the action of natural and anthropogenic forces coupled with a possible global climate and sea level changes; effects of these combined stresses on shorelines, estuaries, marshlands, barrier islands, infrastructure, geosystems and constructed systems; improved and new adaptations measures to potential new coastal conditions; and improved and new mitigation and modification techniques and procedures for minimizing the impacts of coastal zones under climate induced changes.

**Linkages with other Federal Agencies:** NOAA, Corps of Engineers, USGS, NASA, FEMA.

**Linkages with private sector, NGO's and academia (non-Federal funding):** Construction industry, insurance industry.

**Linkages with international organizations:** United Nations International Decade for Natural Disaster Reduction, World Meteorological Organization.

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**Agency:** Tennessee Valley Authority  
**Bureau:** National Environmental Research Center  
**Function:** Adaptation: Water Resources; Natural Systems;  
Food, Fiber, and Forestry; and Human Systems  
**Focused or Contributory:** Focused  
**Program Title:** Regional Climate Change Impact Assessment  
**Budget (In Thousands):** FY93 \$20 FY94 \$300

**Program Description:** TVA is conducting assessments of how climate changes and variations may affect its various programs and the resources of the TVA region. The reservoir system, power system, natural resources, agriculture, silviculture, and economic development are all subject to this concern. Improvements in understanding the natural processes in the TVA region and the effects of human activities on them also will be gained from this assessment program. An integrating theme is to improve the capacity to assess the effects of global change at regional scales on intensively managed natural terrestrial ecosystems. The approach involves development and use of regional climate scenarios, analysis of regional-global climate pattern relationships, assessment of potential impacts in each program area and in an integrated manner, and strategic planning to develop options or contingency plans. Initial screening has been conducted and climate scenario impact assessments have been started. An initial regional climatic data base is being expanded. Three future climate scenarios and a "no change" climate scenario have been developed from historical data and are judged to be reasonably applicable to the next 30-50 years. Assessments of low-level atmospheric dispersion conditions for a nuclear plant and heating and cooling requirements for a locality have been conducted. Scenario methods of others and output from regional climate models initialized by output from global climate models will be evaluated to improve TVA region scenarios.

**Linkages with other Federal Agencies:** USDA, DOI, USACE, EPA, DOE, NASA, and NOAA.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Interaction with Southern Appalachian Man and the Biosphere Consortium, EPRI, and academia (e.g., the University of Alabama at Huntsville and the University of Tennessee). Funding of \$20,000 in FY 1993, FY 1994, and expected in FY 1995 from TVA non-appropriated research and development budget.

**Linkages with international organizations:** None.

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**Agency:** Department of the Interior  
**Bureau:** National Park Service/National Biological Survey  
**Function:** Adaptation  
**Focused or Contributory:** Focused  
**Program Title:** Research on Ecosystem Processes and Biological Diversity  
**Budget (In Thousands):** FY93 \$395 FY94 \$395

**Program Description:** The program goal is to improve the scientific basis for adaptive management of the types of ecosystem responses likely to be associated with climatic and other global environmental changes. The program seeks to achieve this goal through coordination of observational and experimental research, modelling, and scientific assessments of management practices to address the effects of natural and anthropogenic influences on the structure and function of terrestrial and aquatic ecosystems, and selected components of biological diversity, represented in the National Park System. It includes parts of programs listed as contributing programs in the U.S. Global Change Research Program (Ecological Systems and Dynamics: Integrated Studies of National Park Ecosystems, and Integrated Ecological Research in Small Watersheds). Program components include: the ecology, physiology, population dynamics, genetics, and management of native species potentially sensitive to changes in climatic and other regional and global environmental influences due to narrow environmental tolerances, strict habitat requirements, limited reproductive potential, or other characteristics; the ecology, physiology, population dynamics and management of native and exotic opportunistic species, such as insect pests and disease organisms, that could become invasive under ecological disturbances associated with global change; fire as a tool for managing ecological succession and landscape dynamics; habitat fragmentation as a factor in landscape management for maintaining native biological diversity; effects of coastal processes on ecological succession on coastal barriers and associated wetlands; experimental restoration of natural ecosystem processes and biological diversity in habitats degraded by prior human disturbance.

The program includes the use of small watersheds for long-term interdisciplinary research to characterize variations in ecosystem structure and function. This program component provides baseline data for developing and testing hypotheses regarding the contributions of natural and human stressors as causes of ecosystem change in protected national park ecosystems. The data facilitate comparative studies with managed watersheds to assess the contributions of these stressors under various ecosystem uses and management practices.

**Linkages with other Federal Agencies:** The National Park Service and the National Biological Survey work cooperatively to accomplish these activities. Other linkages are developed on a project basis and involve coordination with Federal and state land managing agencies, Federal research agencies, and Federally-supported Long-term Ecological Research Sites.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The program includes research conducted under cooperative agreements between the NPS and universities (National Park Service Cooperative Park Studies Units), contract research with universities and research institutions, and some studies conducted under cooperative agreements with nongovernmental organizations (e.g., The Nature Conservancy).

**Linkages with international organizations:** Much of the program involves use of NPS units of the International Network of Biosphere Reserves, which facilitates international linkages through UNESCO's Man and the Biosphere (MAB) Program. Cooperative biosphere reserve research in small watersheds is underway with the Russian Academy of Sciences. The NPS is participating in an effort of European and North American MAB organizations to strengthen use of biosphere reserves as ecological field stations for detecting global change signals.

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**Agency:** Department of the Interior  
**Bureau:** U.S. Geological Survey  
**Function:** Adaptation: All Sources  
**Focused or Contributory:** Focused  
**Program Title:** Land Characterization and Data Management  
**Budget (In Thousands):** FY93 \$7,400 FY94 \$7,400

**Program Description:** This program makes significant contributions to the development, processing, preservation, management, and distribution of land surface-related earth science data for global change research and in developing strategies for responding to the effects of global change. It includes facilitating data use by the research community, and the program supports interagency global change data management activities. The program has three main activities whose products are already in use by global change researchers:

1. Land characterization research: Long-term, consistent land data sets are being developed at regional to global scales. Emphasis is being given to data sets related to land cover characteristics, soils, terrain, and derived data such as vegetation indexes and land surface brightness. Application of these data include modeling land-atmosphere exchange processes, mapping and analyzing vulnerability of arid and semi-arid land to changes in climate, and developing methods to monitor, analyze, and predict patterns of natural and human-induced change in the landscape.
2. Land data directory, catalog, and inventory systems development: The Global Land Information System (GLIS) provides information about and access to global land data sets. An operational workstation version of GLIS provides information about AVHRR satellite data, vegetation index data derived from AVHRR data, Landsat MSS/TM data, and global cartographic and vegetation data.
3. Landsat maintenance and conversion: Current activities include conversion to a stable storage medium of approximately 300,000 scenes of post-1978 MSS data (30% of these data were converted by mid-1993) and 170,000 scenes of Landsat TM data, and the development of improved Landsat data processing capabilities.

Land characteristics data sets are being used to improve the representation of the Earth's land surface in global and mesoscale atmospheric and other models, which are being used to predict the consequences of increases in greenhouse gases, changes in climate, and the effects of desertification and deforestation.

These data sets also are important to the information infrastructure necessary for effective ecosystem management, the preservation of biological diversity, and the development of adaptation and mitigation strategies to address environmental impacts related to the management of sensitive lands. GLIS is improving the efficiency with which users can evaluate the characteristics and coverage of archive as an essential data source for global change research; this program is ensuring that Landsat data are preserved and that the data are made available to the modeling and research communities and the public.

The quality of the program is evident in the dissemination and use of its products, like the Land Cover Characteristics Data Base, GLIS, and the Landsat archive, as well as the successful application of the data by global change researchers.

**Linkages with other Federal Agencies:** Land characteristics research is producing valuable data about the Earth's surface, which are important to several national and international programs including NASA Pathfinder, USFWS GAP, EPA EMAP, USGS NAQWA, and NASA BOREAS programs. Coordination of these efforts occurs through the Working Groups of the USGCRP.

Data management efforts of this program provide the core capability to link DOI with other agencies developing the Global Change Data and Information Systems, which closely coordinated with the IWGDMGC, the EOSDIS program, and other national and international organizations involved with global change data management. Landsat data conversion is closely coordinated with the Landsat Program Office (NASA and DOD) and NOAA.

**Other federal agency coordination includes:** As part of this program, the USGS is collaborating with the USDA (USFS, SCS, ARS) to conduct global change research at the Terrestrial Ecosystems Regional Research and Analysis (TERRA) Laboratory. This laboratory provides an environment for multidisciplinary approaches to problem solving in the earth sciences that integrates issues, stakeholders, data and information, and models of terrestrial systems and processes with visualization capabilities for analysis and use by decision and policy makers.

**Linkages with private sector, NGO's and academia (Non-federal funding):** University and private sector organization also are working with the TERRA Laboratory. Landsat-related activities involve coordination with EOSAT, the commercial Landsat system operator. Land characterization research involves links with several universities. Collaboration is occurring with NCAR as part of their land/atmosphere interactions research.

**Linkages with international organizations:** Links have been established with the IGBP concerning the development of global land cover data, and with UNEP/GRID in providing access to global data sets. Collaboration with USAID in Africa has involved research to establish a multi-level framework for monitoring landscape change in Senegal, West Africa. Data base development land map production activities in arctic regions have involved links with the International Committee of Arctic Flora and Fauna. An archive of global 1-km resolution NOAA AVHRR data is being developed with the cooperation of the European Space Agency, Canada Center for Remote Sensing, and ground receiving stations in many countries. Global soil data set development includes collaboration with the UN-FAO. Collaboration with the WCRP GEWEX Continental-scale Implementation Project has involved development of elevation and other land characteristics data.

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**D. ADAPTATION - CONTRIBUTORY**

**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Water Resources  
**Focused or Contributory:** Contributory  
**Program Title:** Quantification and Integration of Basin Scale Hydrologic Fluxes  
**Budget (In Thousands):** FY93 \$200 FY94 \$200

**Program Description:** Methods are being developed to characterize the spatial and temporal variation of various hydrologic processes and variables in a basin using new techniques like remote sensing and geographic information systems. These processes and variables include snow cover and snow water equivalent, soil moisture, evapotranspiration, vegetation, and other factors in the energy and water budgets. Complementary methods for aggregation and disaggregation of hydrologic processes and variables over a range of scales are being developed based on large area field experiments. Workshops developing scenarios of hydrologic climate change for water supply managers are being conducted. Climatic change in temperature, precipitation, cloudiness, and solar radiation will be considered in developing future scenarios for water resource managers and decision makers.

**Linkages with other Federal Agencies:** USGS (cooperative snowmelt modelling and intercomparisons)

**Linkages with private sector and academia:** University of Maryland, Electric Power Research Institute, Pacific Institute.

**Linkages with international organizations:** University of Berne, Switzerland; HAPEX-Sahel; National Hydrologic Research Institute, Canada; GEWEX.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Contributory  
**Program Title:** Germplasm Enhancement to Complement and Conserve Southern Plains Range Ecosystems  
**Budget (In Thousands):** FY93 \$753 FY94 \$749

**Program Description:** Controlled hybridizations by appropriate breeding techniques, i. e., emasculation, controlled pollinations, selfings, intermatings and backcrosses, will be used to intensify and combine desirable characteristics into improved cultivars of eastern gamagrass. Random mating populations of adapted genotypes of Texas bluegrass and mixtures of big bluestem with sand bluestem will be developed. The above grasses with sexual modes of reproduction will undergo recurrent selection procedures for increased forage and seed yield, forage quality and establishment capability between polycross generations. The above species and adapted genotypes of Old World bluestems will be evaluated for tolerance to soil salinity, iron deficiency, temperature and moisture extremes, and insect and disease damage in greenhouse and field studies. Promising genotypes will be screened for beef production potential.

**Linkages with other Federal Agencies:** None.

**Linkages with private sector, NGO's and academia:** Oklahoma State University.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Agricultural Research Service  
**Function:** Adaptation: Combined  
**Focused or Contributory:** Contributory  
**Program Title:** Intelligent Farm Management System Support  
**Budget (In Thousands):** FY93 \$640 FY94 \$640

**Program Description:** This project supports the ARS Intelligent Farm Management System initiative, which seeks to provide integrated knowledge and technology to managers of agricultural systems to help them tailor management of crop systems to take maximum advantage of environmental conditions - resulting in improved resource management and competitiveness in international markets. We deal with the potato production system, which includes not only the potato, but all of the crops grown in rotation with it. There are two broad areas of research: 1) component research - developing new knowledge, technologies and cultivars to solve specific potato disease, pest and stress problems identified by growers; and 2) integration research - developing and validating crop simulation computer models that incorporate these and other basic science components into packages that can serve as foundations for computerized decision support systems for production managers.

Research under (2) includes the development and validation of a potato crop growth model for the mid-Columbia area. Work is evolving in the formation of a "government-academia-industry team" to develop information and management technologies for the highly productive potato industry in the Pacific Northwest. Through this team's efforts, validated crop simulation models for all crops within the potato production system will be integrated into commercial crop management decision-support systems as a means of packaging and transferring science knowledge to production managers.

**Linkages with other Federal Agencies:** DOE (Supports ARS CO<sub>2</sub> vegetative responsive research at Beltsville, MD, which cooperates with us).

**Linkages with private sector, NGO's and academia:** Members of our Intelligent Farming Team of approximately 50 are drawn from government, academia, and private industry.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Forest Service  
**Function:** Adaptation, Economic, and Social  
**Focused or Contributory:** Contributory  
**Program Title:** Ecosystem Management Research and Assessment  
**Budget (In Thousands):** FY93 \$15 FY94 \$15.5

**Program Description:** Ecosystem Management Research and Assessment supports the Forest Service's commitment to implement ecosystem management on the national forests and grasslands by providing the necessary knowledge, technology, and scientific assistance. It relies heavily on scientific knowledge provided by the Foundation Program. Practices developed through this research will place more emphasis on ecological relationships, conservation of biological diversity, sustained productivity, forest health, socio-economic considerations, and new forest management techniques. Research emphases are to: better understand the impacts of resource management and use on ecosystem structure, composition, and function; provide information on integrating resource uses and ecological values across a range of spatial and temporal scales; develop knowledge and technologies needed to maintain and enhance biological diversity and ecosystem productivity while maintaining resources for human uses; determine the biological, physical, and socio-economic implications of ecosystem management; develop the knowledge and technologies to monitor management impacts on ecosystems at multiple spatial and temporal scales; and to provide syntheses of current knowledge about ecosystem structure and function and apply this knowledge to ecosystem management. Timely forest inventory information is essential to forest management and to monitor forest ecosystem changes. Understanding how forest ecosystems respond to change will provide a rational basis for improved management of our Nation's forests. We will: maintain the forest inventory cycle; provide long-term permanent sample data for ecosystem management; continue to develop and provide universal data protocols across ownerships for our regional, national, and global clients; develop techniques to provide critical baseline information to monitor the wildland/urban interface; and continue to develop remote sensing/videography and sampling technology to improve forest ecosystem monitoring.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Forest Service  
**Function:** Adaptation  
**Focused or Contributory:** Contributory  
**Program Title:** Threatened & Endangered Species Research  
**Budget (In Thousands):** FY93 \$8,300      FY94 \$8,500

**Program Description:** Although over 200 federally listed T&E species exist on National Forest Land lands, recovery plans exist for less than half. Research has conducted studies on fewer than 20. We have a legal obligation to conserve T&E species in the Endangered Species Act and the National Forest Management Act. At the FY 1994 President's Budget level, the scope of research will broaden slightly to encompass approximately 25 individual species. At this level, salmon and steelhead stocks proposed for Federal listing receive only marginal attention. Broadening the program to cover more species is absolutely essential if research is to get ahead of future species population declines. We are emphasizing research in areas where we envision receiving the most questions in the future. The goals of our FY 1995 T&E Species research program are to:

- o Provide stronger scientific support for development of inter-Regional conservation strategies;
- o Strengthen scientific credibility of recovery plans and management guidelines; and
- o Provide objective, scientific status information for listing and de-listing decisions.

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**Agency:** U.S. Department of Agriculture  
**Bureau:** Forest Service  
**Function:** Adaptation, Mitigation, Economic, and Social  
**Focused or Contributory:** Contributory  
**Program Title:** Global Change Research Program  
**Budget (In Thousands):** FY93 \$22,100      FY94 \$22,000

**Program Description:** The USDA Forest Service, in partnership with eight Federal Departments and Independent Agencies, began its Global Change Research Program in FY 1989. It contributes much of the necessary research on the forestry aspects of global change. The Forest Service Global Change Research Program (FSGCRP) is managed through four cooperative programs and a forest products component with national coordination from Washington, DC. The FSGCRP emphasizes an ecosystem approach and cooperative arrangements with other agencies, universities, and industry. Forest and forestry practices have become major areas of interest in international negotiations to slow global change. Increased carbon sequestration through more productive forest management, afforestation, and urban tree planting are seen as ways to mitigate global change. The FSGCRP ensures that scientists who understand multiple-use forestry continue to play a significant role in the development of the scientific knowledge required for global change management and policy decisions.

**Linkages with other Federal Agencies:** Through the US Department of Agriculture's Global Change Research Program and the Committee on Earth and Environmental Science's Global Change Committee, FSGCRP is linked with all other agencies participating in the U.S. program.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The FSGCRP works with and funds cooperators at universities throughout the United States as well as private industry.

**Linkages with international organizations:** North American Forestry Commission, IPCC, International Union of Forestry Research Organization

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**Agency:** National Science Foundation  
**Bureau:** Directorate for Mathematical and Physical Sciences  
**Function:** Adaptation: Water Resources; Food, Forestry,  
and Fiber  
**Focused or Contributory:** Contributory  
**Program Title:** Division of Materials Research  
**Budget (In Thousands):** FY93 \$163 FY94 \$175

**Program Description:** The Division of Materials research supports research to advance the fundamental understanding of the physics and chemistry of materials to promote the development of new materials with novel or superior properties, and to further the understanding of interrelationships among synthesis and processing, structure and composition, properties, and performance of materials at molecular, microscopic and macroscopic levels. Activities of the Division of Materials Research are inherently inter-disciplinary and involve the cooperative interactions of scientists and engineers from many disciplines, including mathematics, condensed matter physics, chemistry, materials science, engineering, and biological sciences. To optimally balance disciplinary and multidisciplinary activities, individual investigator research is supported through the Materials Research Project Support Program; multi-investigator research is supported through the Materials Research Science and Engineering Centers; and national user facilities and major instrumentation is supported through the National Facilities and Instrumentation Program. Focused investment in the development and retention of human resources is an essential component of each of these modes of support.

**Linkages with other Federal Agencies:** Coordination with other Federal agencies is carried out through several working groups of the Subcommittee on Materials (COMAT) of the FCCSET Committee on Industry and Technology (CIT), Office of Science and Technology Policy (OSTP).

**Linkages with private sector, NGO's and academia (Non-Federal funding):** Private sector and NGO linkages through collaborations with NSF supported university research activities; linkages to academia through grants and cooperative agreements.

**Linkages with international organizations:** None

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**Agency:** National Science Foundation  
**Bureau:** Division of Civil and Mechanical Systems  
**Function:** Adaptation: Food, Forestry and Fiber  
**Focused or Contributory:** Contributory  
**Program Title:** Geotechnical and Geo-Environmental Technologies for Waste Management  
**Budget (In Thousands):** FY94 \$750

**Program Description:** Solid wastes are a by-product of industrialized, urbanized societies: municipal refuse has been piling up in "sanitary" landfills, and hazardous wastes from industries can be found in a proliferation of hazardous wastes sites. Several programs have been evolving over the past 15 years for the clean-up of the pollution caused by earlier disposal practices; and for the modern treatment and disposal of the continuously generated hazardous waste stream. We are at the cross-roads where new Environmental Technologies are required to accelerate the pace and reduce the clean-up cost of existing sites; and to devise innovative approaches for the treatment/management of new industrial wastes. At the Geo-Environmental group of NSF, a multifaceted program has been adopted covering the following developments: new landfill designs concepts that include innovative technologies for the protection of groundwaters, deformability and stability of geomedia, cap design, and monitoring; new models to enhance selection process of a waste site (managing risk), identify hidden soil conditions, macropores and other discontinuities; new geoenvironmental technologies for waste treatment and minimization assessment procedure including source reduction and recycling (how certain type of soils can enhance this method); new hazard analysis and hazard identification techniques; new technologies for perpetual storage (such as, underground injection, waste piles, surface impoundments, salt formations, arid region unsaturated zone, use of geosynthetics), new models to predict long-term effects of contaminants; and use of fully automated geo-robots to dispose of highly contaminated soils. The focus of our Hazardous Waste Management program is on developing state of the art procedures that will greatly enhance the existing time-consuming and expensive procedures used for an overall waste reduction plan.

**Linkages with other Federal Agencies:** FHWA, EPA, AFOSR .

**Linkages with private sector, NGO's and academia (Non-Federal funding):** None

**Linkages with international organizations:** None

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**Agency:** National Science Foundation  
**Bureau:** Directorate for Mathematical and Physical Sciences  
**Function:** Mitigation: All Greenhouse Gases  
Adaptation: Water Resources; Natural Systems;  
Food, Forestry, Fiber; Human Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Division of Chemistry  
**Budget (In Thousands):** FY93 \$18,783      FY94 \$19,300

**Program Description:** The Division of Chemistry supports programs in research, training and education through focused investment in disciplinary research projects, shared multi-user instrumentation, human resource development, and interdisciplinary research. Disciplinary program activities are directed toward discovery and characterization of new substances, selective separation and purification, synthesis of new materials with designed properties, elucidation of how chemical processes occur, and formulation of general laws governing chemical structure and activity. This portfolio of disciplinary projects includes research on the interactions of greenhouse gases (GHGs) with light, other atmospheric gases, surfaces, and other relevant substances. Also included are investigations of the complex chemical processes, both natural and industrial, which lead to GHG production and release. Additionally, research to develop a knowledge base which will allow complete determination of the state and fate of environmentally sensitive chemical substances in the biosphere, and prediction of behavior of new substances is supported in disciplinary projects. Large, multi-user instruments which are provided on a cost-sharing basis as a component of chemistry department support facilities enable research teams to develop analytical techniques and improved instrumentation as part of their chemistry problem-solving research. Interdisciplinary research activities include initiatives in advanced materials, biotechnology, and environmentally benign chemical synthesis, and the support of two NSF Science and Technology Centers.

**Linkages with other Federal Agencies:** Coordination through Federal Interagency Chemistry Representatives; MOU with EPA on environmentally benign synthesis.

**Linkages with private sector, NGO's, and academia:** Private sector and NGO linkages through NSF Science and Technology Centers; linkages to academia through grants and cooperative agreements.

**Linkages with international organizations:** None

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**Agency:** National Science Foundation  
**Bureau:** Directorate for Mathematical and Physical Sciences  
**Function:** Mitigation: All  
Adaptation: All  
**Focused or Contributory:** Contributory  
**Program Title:** Division of Mathematical Sciences  
**Budget (In Thousands):** FY93 \$8,950 FY94 \$8,500

**Program Description:** The Division of Mathematical Sciences supports research activities through grants and cooperative agreements with academic institutions, research centers, professional societies and individual scientists for disciplinary and interdisciplinary research, for support of students from undergraduates through post-doctoral fellows, for conferences and other special projects. The thrusts of these activities lie in three directions: the creation and development of mathematical ideas, methods and techniques; the application and interaction with theory and practice in substantive science or engineering; and/or their diffusion into the infrastructure for education and human resource development and the technology base. Particularly relevant to mitigation and adaptation is the research in mathematical modeling for both physical and stochastic contexts, simulation, control, imaging, and algorithm development. These research efforts cut across the program structure of the division with greatest concentrations in applied mathematics, statistics and probability, computational mathematics and special projects, and with significant efforts within classical analysis and geometric analysis.

**Linkages with other Federal Agencies:** The Interagency Committee for Extramural Mathematics Programs (ICEMAP). Other links are direct, with NSF support of fellowships, research undertaken at Federal agency facilities (e.g., NISI), and coordinated joint support of proposals of interest to more than one agency (such as DOE ONE and NSA).

**Linkages with private sector, NGO's and academia (Non-Federal Funding):** Private sector and NGO linkages through Institutes, NSF Science and Technology Centers; linkages to academia through grants and cooperative agreements.

**Linkages with international organizations:** None.

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**Agency:** Tennessee Valley Authority  
**Bureau:** National Environmental Research Center  
**Function:** Adaptation: All Sources  
**Focused or Contributory:** Contributory  
**Program Title:** Constructed Wetlands Research Center  
**Budget (In Thousands):** FY93 \$1,400 FY94 \$1,400

**Program Description:** Current TVA activities involving constructed wetlands primarily involve treatment of municipal wastewaters, animal and septic wastes, and acid mine drainage. The constructed wetlands research and development program provides basic process information for such applications of constructed wetlands technology. In addition, this center focuses on treatment of wastewaters from agribusiness and other industrial operations and on treatment of contaminated storm and runoff waters. To further these objectives, the research and development facility provides opportunity for laboratory, greenhouse, and replicated field research of both an applied and basic nature, conducted by staff working on interdisciplinary teams.

**Linkages with other Federal Agencies:** Through direct cooperative and/or contractual projects and indirect associations, this NERC program will link with appropriate programs of USDA (CSRS, SCS), EPA, Bureau of Mines, Bureau of Land Management, U.S. Army Corps of Engineers, and universities (State/Federal projects).

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Funding will be solicited for appropriate projects from industry, and an extensive cooperative research program with academia (using matching funds) is being fostered.

**Linkages with international organizations:** Cooperative projects will be planned in cooperation with the International Fertilizer Development Center. Also, opportunities exist for hosting visiting international scientists for periods ranging from 6 to 12 months.

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**Agency:** Tennessee Valley Authority  
**Bureau:** Engineering Services  
**Function:** Adaptation: Water Resources; Human Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Development of Enhanced Methods for Integrated Analysis (INTEGRAL) of Water Resource Systems and Power Operations  
**Budget (In Thousands):** FY93 \$50 FY94 \$100

**Program Description:** TVA, as part of a tailored collaboration program with EPRI, is developing improved tools for the coordinated planning and scheduling of hydro and thermal power generation and multipurpose reservoir operations. A decision support system will be developed to aid in the collection, analysis, and display of reservoir and power system data. To improve planning and forecasting capabilities, a system of enhanced models will be linked to the decision support system. The modeling system will include hydrologic models, an enhanced reservoir system model capable of assessing tradeoffs among multiple reservoir uses, and a river system temperature model to address thermal compliance issues. The decision support and model systems should improve integration of reservoir and power operations, facilitate incorporation of environmental concerns into power generation, and enhance decisionmaking.

**Linkages with other Federal Agencies:** DOI/Bureau of Reclamation partnership currently in negotiating state, nearing agreement.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** EPRI funding of about \$355,000 in FY 1993, and FY 1994, dropping to about \$100,000 for the ensuing years. TVA Power revenues funding of about \$355,000 in FY 1993, \$300,000 in FY 1994, and \$100,000 for the ensuing years.

**Linkages with international organizations:** None.

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**Agency:** Tennessee Valley Authority  
**Bureau:** Land Management  
**Function:** Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Contributory  
**Program Title:** Forest Health Monitoring  
**Budget (In Thousands):** FY93 \$0 . . . FY94 \$0

**Program Description:** In cooperation with the USFS Forest Health Monitoring Program and the EPA's EMAP-Forests Program, TVA established forest health monitoring plots in the southern Appalachians in 1992. The purpose of this program is to assess the effects of regional scale environmental threats on an annual basis. We also are involved with forest health indicator development research.

**Linkages with other Federal Agencies:** EPA, USFS and NPS. EPA funding was \$150,000 in FY93, and is expected to be about \$150,000 in FY94 and ensuing years.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Southern Appalachian Man and the Biosphere (SAMAB) Cooperative. TVA research and development funding was \$150,000 in FY93, and is expected to be about \$150,000 in FY 94 and ensuing years.

**Linkages with international organizations:** International Man and the Biosphere Program.

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**Agency:** Tennessee Valley Authority  
**Bureau:** Water Management  
**Function:** Adaptation: Water Resources; Natural Systems; Human Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Water Quality-Watershed Inventories  
**Budget (In Thousands):** FY93 \$500 FY94 \$500

**Program Description:** Detailed inventories of land use and nonpoint source pollution in watersheds are conducted using low altitude color-infrared aerial photography. Inventories include conservation practices, topography, riparian vegetation status, erosion estimates, etc. Interpretation of land use from LANDSAT satellite imagery is being integrated into GIS and PC data bases, for use in nonpoint source pollution analysis of watersheds.

**Linkages with other Federal Agencies:** Coordination with the EPA and the USGS.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Information supplied to lake user groups and watershed cleanup organizations. Training on the application and significance of technical results.

**Linkages with international organizations:** None

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**Agency:** Tennessee Valley Authority  
**Bureau:** Water Management  
**Function:** Adaptation: Water Resources; Natural Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Water Resources and Ecological Monitoring  
**Budget (In Thousands):** FY93 \$3,800      FY94 \$2,500

**Program Description:** TVA conducts numerous water resources activities ranging from operating an interconnected system of some 35 reservoirs to assisting other Federal and State agencies in their efforts to control pollution sources. Monitoring water quality and aquatic biological conditions in those reservoirs and the streams that drain into them is a significant part of TVA's stewardship responsibilities. The current monitoring program has been developed over the last nine years. It consists of three categories of activities with the general objectives of producing information useful for natural resource management and for advising the public about the condition of the Valley's water resources. Activities conducted under this program include water quality and aquatic biological sampling to evaluate the ecological health of major streams and reservoirs, monitoring of fish flesh contamination and bacteriological conditions at sites throughout the valley, and providing opportunities for schools to participate in TVA's monitoring efforts.

**Linkages with other Federal Agencies:** Coordinated with USGS and EPA national monitoring programs. Cooperative efforts with the Bureau of Reclamation, U.S. Corps of Engineers, NOAA, and EPA on developing and evaluating new monitoring techniques.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Results provided to all who request them. Program coordinated with State agency monitoring programs.

**Linkages with international organizations:** None

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**Agency:** Tennessee Valley Authority  
**Bureau:** National Environmental Research Center  
**Function:** Mitigation: Ozone and Precursors  
Adaptation: Natural Systems; Food, Forestry, and Fiber; Human Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Regional Ozone, Factors Affecting Its Formation, and Its Impact upon Forested Ecosystems  
**Budget (In Thousands):** FY93 \$500 FY94 \$1,300

**Program Description:** Current TVA research efforts address ozone formation in both rural and urban areas of the region. Projects are aimed at understanding (1) the chemistry of natural hydrocarbons, (2) whether hydrocarbons or NOX are rate-limiting for ozone production in this region, (3) interaction between rural and urban emissions, and (4) the relationship between NOX emissions and ozone production. An atmospheric reaction chamber is used to study the chemistry of natural hydrocarbons and NOX under controlled conditions. Field studies of rural ozone formation are being conducted to obtain ground-based data. Volatile hydrocarbon emissions from forest systems are being quantified, and their potential role in ozone formation and global climate change is being investigated. The role of plant stress in rates and forms of organic hydrocarbons emitted is being studied. Ozone effects on several important hardwood species are being investigated with emphasis on how plant processes are affected and growth altered. Ozone effects research on seedlings and mature trees is ultimately aimed at scaling experimental results up to the forest stand level. Modeling impacts of ozone on forest stands as well as individual trees will facilitate predictions of change in composition and productivity of forests.

**Linkages with other Federal Agencies:** Much of this research is part of the Southern Oxidant Study, which includes 30 organizations, some Federal (such as EPA), and others that are private or academic. Funding from Federal agencies is \$300,000 in FY93 and thereafter.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** EPRI funding for FY93 and ensuing years is about \$400,000; and TVA research and development funding is about \$600,000 in FY93, \$900,000 in FY94 and FY95 and expected to escalate in ensuing years.

**Linkages with international organizations:** Involvement with the North American Research Strategy for Ozone.

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**Agency:** Tennessee Valley Authority  
**Bureau:** National Environmental Research Center  
**Function:** Mitigation: Ozone & Precursors; Nitrous Oxides  
Adaptation: Food, Forestry, and Fiber  
**Focused or Contributory:** Contributory  
**Program Title:** Reduction of N<sub>2</sub>O Emissions from Fertilizers  
**Budget (In Thousands):** FY93 \$30 FY94 \$400

**Program Description:** The objectives are to create a soil NOX and N<sub>2</sub>O emissions inventory for the Tennessee Valley region and to support development of technology and methodology for reducing N<sub>2</sub>O emissions from fertilizers. Sampling strategies have focused on making measurements in the 6 major physiographic provinces that constitute 80 percent of the land base and from soil types with respect to the 3 major land uses of the region: forest, row crop agricultural, and pasture. A specific effort is now underway to remove some of the uncertainties about the contribution of nitrogen fertilizers to greenhouse gas emissions from different types of fertilizers, including organic. Determination of what contributes to the variability in emission rates, such as effects of timing of application, placement, and rate of application will be made. This program will help to support the development of mitigation actions and land use policies that would lead to reductions in the U.S. contribution of this greenhouse gas. Such actions could include limiting the use of nitrogen fertilizers or favor use of slower denitrifying fertilizers and changes in agricultural practices to slow the denitrification process or make it more efficient.

**Linkages with other Federal Agencies:** Partnerships with USDA and EPA.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** Experiment stations in Mississippi, Tennessee, Georgia, and North Carolina. TVA Power revenues funding of \$80,000 in FY 1993, FY 1994, and FY 1995.

**Linkages with international organizations:** International Fertilizer Development Center at Muscle Shoals, Alabama.

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**Agency:** Department of the Interior  
**Bureau:** U.S. Geological Survey  
**Function:** Adaptation  
**Focused or Contributory:** Contributory  
**Program Title:** National Mapping, Geography, and Surveys  
**Budget (In Thousands):** FY93 \$49 FY94 \$52

**Program Description:** The USGS National Mapping Program provides a variety of cartographic, geographic, and remotely sensed data, products, and services in support of Federal, State, and public interests. These data and products provide essential base information for mitigation and adaptation research, and would be useful for studying the impact of global change processes on natural and human systems. The National Mapping Program also conducts cartographic and geographic research to develop improved capabilities for analyzing different types of spatial data. The following components of this program contribute to mitigation and adaptation research:

1. **National Map and Digital Data Production:** The USGS provides current, accurate cartographic data and maps at primary, intermediate, and small scales for the United States. Digital cartographic data from the National Digital Cartographic Data Base include base categories of boundaries, hydrography, transportation, and the Public Land Survey System, as well as three-dimensional digital elevation data sets representing the terrain. These data, as well as digital image data (digital of the photoquadrangles), also may be produced for use in Geographic Information Systems in support of natural resource policy decision-making. USGS land-use and land-cover maps and digital data for the coterminous United States and Hawaii are used for Federal, State, and private sector activities related to land resource inventory, planning, and development.
2. **Information and Data Systems:** The USGS disseminates its cartographic, water resources, geologic, and general earth science data and information to a variety of users. The USGS also collects, analyzes and disseminates information about the domestic cartographic and geographic data products of other Federal and State agencies and private sector organizations. Examples of data bases managed under this program include the Map and Chart Information System, Cartographic Catalog, and the Aerial Photography Summary Record System.
3. **Geographic and Spatial Information Analysis Research:** The USGS develops new capabilities in remote sensing and spatial data analysis of cartographic and earth science data. This research leads to improved geographic information systems, image processing, and techniques to monitor and manage earth resources. Techniques such as data merging, integration of diverse data sets, and data modeling provide valuable tools for mitigation and adaptation research.

**Linkages with other Federal Agencies:** This program is actively coordinated with a wide range of Federal agencies. The documented needs of 40 Federal agencies and 50 States are considered when map and cartographic data production is scheduled to ensure that the highest priority requirements of the Nation's major users are addressed each year. USGS has cooperative agreements with Federal agencies for activities such as map and digital data production and geographic/cartographic/remote sensing research. The USGS provides leadership in coordination of spatial data activities at the Federal level by chairing the Federal Geographic Data Committee (members include 14 department

and independent agencies). The USGS also chairs a counterpart organization within the Department of the Interior, the Interior Geographic Data Committee.

**Linkages with private sector, NGO's and academia (Non-Federal funding):** This program has interactions with many professional societies and national organizations, including the American Cartographic Association, American Congress on Surveying and Mapping, American Society for Photogrammetry and Remote Sensing, Association of American Geographers, Automated Mapping/Facilities Management Association, Geosat Committee and the Urban and Regional Information Systems Association. The USGS also supplies map products to over 3,000 authorized dealers in the private sector.

**There are three main types of State government linkages:** (1) 47 State agencies in 33 States participate in cooperative agreements with the National Mapping Program; (2) 42 informal coordinating bodies such as State Mapping Advisory Committees and GIS Coordination Boards provide a forum for coordinating State-wide mapping and GIS data needs in the States having those mechanisms; and (3) 63 Earth Science Information Center State Affiliates provide information regarding the availability of cartographic data and services.

Cooperative agreements exist with many universities, often supported by grants, to conduct research that augments the geographic, cartographic, remote sensing, and global change research conducted by the USGS. Research linkages also exist with groups such as the National Research Council and the National Center for Geographic Information and Analysis.

**Linkages with international organizations:** The USGS has protocols or agreements for cooperation in surveying, mapping, and remote sensing with several countries including Canada, African and Latin American nations, and China. Linkages exist with many international societies and organizations, including the International Cartographic Association, International Federation of Surveyors, International Geographic Union, International Society for Photogrammetry and Remote Sensing, Pan American Institute of Geography and History, Scientific Committee on Antarctic Research, United Nations Environment Programme, and the International Geosphere-Biosphere Program.

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**Agency:** Department of the Interior  
**Bureau:** National Park Service  
**Function:** Adaptation: Water Resources, Natural Systems  
**Focused or Contributory:** Contributory  
**Program Title:** NPS Global Change Research Program  
**Budget (In Thousands):** FY93 \$3,018 FY94 \$3,014

**Program Description:** The program both focuses on the global change research priorities established by the Committee on Earth and Environmental Sciences (CEES) and also strengthens the scientific basis for developing park management responses to global climate change. The program objective is to develop a national network of global change sites representative of the ecosystems and biodiversity of the National Park system. As of FY 1993 more than 25 (focused) research projects are underway in diverse fields, including surface and groundwater hydrology, small watershed studies, plant demography, stand and regional modeling, landscape analysis, fire history, paleoecology, aquatic systems, geomorphic change, nutrient cycling, tree-line patterns, and sea level rise. Projects focus on ecosystem components and processes likely to change first in response to climatic change. A long-term goal is to integrate these studies with each other and with related studies by other agencies and institutions to provide predictive understanding of the effects of global change on the ecosystems and biological diversity of particular biogeographic areas. The program includes a thematic initiative to improve understanding of the impacts of expected sea level rise and changing storm patterns on coastal barrier ecosystems.

NPS has identified the 20 Biogeographic Areas (BGAs) that comprise its global change network. As of FY 1992, research has been initiated in BGAs. No new research is planned for FY 1994

**Linkages with other Federal Agencies:** The program involves cooperation with other Federal agencies in planning and funding research. As of FY 1992, the NPS is participating in cooperative research with the Forest Service, USGS, USFWS, and NASA in one or more of its BGAs. The NPS also co-supports principal investigators who are supported by other agencies (EPA, NOAA). This provides synergism that enhances NPS GC research.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The program supports primarily cooperative research with academic institutions. The NPS also is working with the Nature Conservancy. EPRI is supporting research at one of our sites.

**Linkages with international organizations:** International linkages remain to be developed. Linkages will be facilitated through use of existing and proposed NPS units of the International Network of Biosphere Reserves as core research areas.

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**Agency:** Department of Interior  
**Bureau:** National Park Service  
**Function:** Adaptation: Natural Systems; Human Systems  
**Focused or Contributory:** Contributory  
**Program Title:** Man and the Biosphere Program - Biosphere Reserves  
**Budget (In Thousands):** FY93 \$200 FY94 \$200

**Program Description:** The program facilitates NPS participation in interagency and international research, educational, and demonstration activities to support management of ecosystems and biodiversity on a sustainable basis. The NPS is one of 12 cofunding agencies in the national U.S. MAB Program (USMAB). USMAB supports interdisciplinary research involving natural and social sciences to develop models for maintaining biological diversity within the context of sustainable types, levels, and patterns of human uses under conditions of regional and global change. The program emphasizes use of units of the International Network of Biosphere Reserves as research and demonstration sites.

USMAB has established interdisciplinary Directorates of government and private sector scientists to implement research that demonstrates the integration of the natural and social sciences. Ongoing Directorate projects use NPS and other biosphere reserve units to model factors in landscape change (Olympic Peninsula and Southern Appalachians) and ecosystem sustainability (Pinelands, Virginia Coast, and Everglades) in biogeographic areas of particular conservation importance. In addition to the core research projects of the Directorates, the national program also supports extramural research that complements the Directorates' research missions.

The majority of the 47 U.S. biosphere reserves include one or more National Park System units as core research areas for long-term studies of changes in natural ecosystems and biodiversity. The areas provide suitable control areas for developing and testing research hypotheses to understand the interactive effects of human and natural systems in representative biogeographic areas. Biosphere reserves are principal centers for coordinating NPS programs on biotic inventory, environmental and ecosystem monitoring, and research on biodiversity and global change; and for linking these activities with public education and adaptive management of ecosystem change.

**Linkages with other Federal Agencies:** National linkages are with Federal research and management agencies in MAB program development; information exchange, technology transfer, and comparative research linkages are facilitated through the Biosphere Reserve Network at scales from local to global.

Regional linkages are facilitated through cooperative organizations for planning and coordinating biosphere reserve activities that usually involve conservation, science, and economic development agencies in particular biogeographic areas.

**Linkages with private sector, NGO's, and academia (Non-Federal funding):** The national MAB program gives NPS access to the academic community through the U.S. MAB National Committee and the USMAB Directorates. Regional biosphere reserve organizations provide linkages with participating organizations, institutions, and agencies concerned with research, conservation, public education, and economic development in particular biogeographic areas.

**Linkages with international organizations:** MAB provides access to the technical capabilities of United Nations agencies and international nongovernmental organizations concerned with conservation, research, and sustainable development; as well as MAB organizations in more than 110 countries. The program has long-established ties with ICSU-IGBP, IUCS, and SCOPE that, in recent years, have emphasized ecological research on global change, including the role of the biosphere reserve network in global change research at regional and biome scales. The NPS is participating in efforts of European and North American national MAB organizations to increase use of biosphere reserves for long-term monitoring and research on global change effects.

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**Agency:** Department of the Interior  
**Bureau:** Bureau of Reclamation  
**Function:** Adaptation: Water Resources  
**Focused or Contributory:** Contributory  
**Program Title:** Sensitivity of Hydrologic Systems  
**Budget (In Thousands):** FY93 \$1,160 FY94 \$464

**Program Description:** This program is studying changes in hydrologic processes under scenarios of global climate change and determining the potential impacts on temperature, precipitation, snow-pack, snowmelt, evaporation, and runoff in the 17 Western States. The research will develop a set of nested models for determining the impacts on precipitation on a regional and local scale. The program includes a joint study with the Geological Survey of the impacts on the Gunnison River Basin. This ongoing joint study includes research in the areas of atmospheric processes, precipitation and runoff patterns, water demands, ground-water/surface water interactions, water quality, aquatic ecology, and reservoir systems operations. This program is critical to understanding and predicting the impacts to water supplies, water management, and national and international policies that drive Bureau of Reclamation river systems operations and water management responsibilities. In this capacity, the research directly supports the overall goal and objectives of the USGCRP.

**Linkages with other Federal Agencies:** The Bureau of Reclamation and Geological Survey have been joint working on this program since FY90. Both Bureaus have discussed the research plans with state and local water officials and will consult with them as studies proceed. In addition, the overall program is coordinated with other water resources agencies and Department of the Interior bureaus.

**Linkages with private sector, NGO's and academia (Non-Federal funding):** Model development will be accomplished in conjunction with the National Center for Atmospheric Research. A portion of the research will be performed in cooperation with universities and water districts. The overall program is peer reviewed by the National Academy of Sciences, Water and Science Technology Board.

**Linkages with international organizations:** None

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**Agency:** Department of Interior  
**Bureau:** Bureau of Reclamation  
**Functions:** Adaptation: Water Resources  
**Focused or Contributory:** Contributory  
**Program Title:** Regional Studies  
**Budget (In Thousands):** FY93 \$1,340      FY94 \$536

**Program Description:** This program is studying the changes in the hydrologic characteristics of regional storms under scenarios of climate change and gathering data and developing the models and technology necessary for understanding the nature, extent, and scope of potential global climate change impacts on water resource on a regional basis.

This program will study the changes in frequency, distribution, and depth-area-duration of precipitation producing storms and determine the potential impacts on the quantity and distribution of precipitation and the depth, extent, and water content of snow cover. Research will determine the adequacy of existing water supplies to meet present and anticipated water supply needs in the Western U.S. The program will develop models and improve existing models to determine the impacts on water demands and water project operations including the spread of aquatic weeds and the impacts on fishery resources in Western reservoirs.

This program is critical to understanding and predicting the impacts to water supplies, water management, and national and international policies that drive Bureau of Reclamation river system operations and water management responsibilities.

**Linkages with other Federal Agencies:** Research includes joint studies with other Department of the Interior bureaus, the Department of Agriculture, Environmental Protection Agency, and Tennessee Valley Authority. In addition, the overall program is coordinated with other water resources agencies and Department of the Interior bureaus.

**Linkages with private sector, NGO's and academia (Non-Federal funding):** Research will be accomplished in cooperation with water districts, water managers, and universities throughout the Western U.S. The overall program is peer reviewed by the National Academy of Sciences, Water and Science Technology Board.

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## **IV. SUMMARY TABLES**

Mitigation and Adaptation  
 FY 91 - FY 94  
 FOCUSED PROGRAMS  
 Summary  
 (in thousands)

Mitigation					Adapt.			
	FY91	FY92	FY93	FY94	FY91	FY92	FY93	FY94
EPA	2,725	5,386	4,631	5,418				
DOE		335		53,300		50		
USDA	500	4,339	6,626	6,603		4,352	2,782	2,651
DOC	300	300						
NSF			2,650	1,300			850	890
TVA				200			20	300
DOI							7,400	7,795
<b>TOTALS</b>	<b>3,525</b>	<b>10,360</b>	<b>13,907</b>	<b>66,821</b>	<b>0</b>	<b>4,402</b>	<b>11,052</b>	<b>11,636</b>
<b>Combined</b>					<b>Totals</b>			
	<b>FY91</b>	<b>FY92</b>	<b>FY93</b>	<b>FY94</b>	<b>FY91</b>	<b>FY92</b>	<b>FY93</b>	<b>FY94</b>
EPA					2,725	5,386	4,631	5,418
DOE	66	82			66	467	0	53,300
USDA			319	324	500	8,691	9,727	9,578
DOC					300	300	0	0
NSF	5,666	5,200			5,666	5,200	3,500	2,190
TVA	50	20			50	20	20	500
DOI					0	0	7,400	7,795
<b>TOTALS</b>	<b>5782</b>	<b>5302</b>	<b>319</b>	<b>324</b>	<b>9,307</b>	<b>20,064</b>	<b>25,278</b>	<b>78,781</b>

Mitigation and Adaptation  
 FY 91 - FY 94  
 CONTRIBUTORY PROGRAMS  
 Summary  
 (in thousands)

Mitigation						Adapt.			
	FY91	FY92	FY93	FY94		FY91	FY92	FY93	FY94
EPA	297	695	1,300	2,082					
DOE			985,153	1,377,638					
USDA			1,125	1,163		39	41	9,908	10,304
DOC						300	300		
NSF						680	1,000	163	925
TVA						3,800	3,830	5,750	4,500
DOI						2,300	4,300	5,767	5,101
<b>TOTALS</b>	<b>297</b>	<b>695</b>	<b>987,578</b>	<b>1,380,883</b>		<b>7,119</b>	<b>9,471</b>	<b>21,588</b>	<b>20,830</b>
Combined						Totals			
	FY91	FY92	FY93	FY94		FY91	FY92	FY93	FY94
EPA	112	390				409	1,085	1,300	2,082
DOE		550				0	550	985,153	1,377,638
USDA			22,100	22,000		39	41	33,133	33,467
DOC						300	300	0	0
NSF	26,658	27,900	27,733	27,800		27,338	28,900	27,896	28,725
TVA	1,000	730	530	1,700		4,800	4,560	6,280	6,200
DOI	14,090	15,884				16,390	20,184	5,767	5,101
<b>TOTALS</b>	<b>41,860</b>	<b>45,454</b>	<b>50,363</b>	<b>51,500</b>		<b>49,276</b>	<b>55,620</b>	<b>1,059,529</b>	<b>1,453,213</b>

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

AGENCY	PROGRAM TITLE			FOCUSED	M/A	BUDGET (1,000)	
				/CONTRIBUTORY		FY93	FY94
USDA	Regional Analysis of Controls on Soil Carbon Levels			Focused	M	40	40
USDA	Long-term Changes in Carbon Storage			Focused	M	285	273
USDA	Impacts of Climate & Env. Change on Agricultural Resources & Watershed Processes			Focused	M	345	306
USDA	Global Change & Structure & Function of Ecosystems			Focused	M	600	600
USDA	CO2 Fluxes Above Ag. Lands			Focused	M	52	52
USDA	Effects of Land Use & Mgmt. Practices on Atmospheric CO2			Focused	M	90	90
USDA	Assess, Predict & Mitigate Trace Gas Fluxes Impacts on Environmental Quality			Focused	M	456	456
USDA	Sequestration & Release of C in the Terrestrial C Cycle			Focused	M	60	70
USDA	Shortgrass Prairie Response to Climate Change			Focused	M	47	28
USDA	Dynamics of GHGs & Cl. Ch. in Subarctic Land Mgmt. and Cropping Systems			Focused	M	726	723
USDA	Gl. Ch. Research, Modeling, & Data Base Mgmt.			Focused	M	295	295

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

USDA	Belowground Responses to Cl. Ch. & Biogeochemical Dynamics of C		Focused	M	372	372
USDA	Crop Responses to Cl. Ch.		Focused	M	272	312
USDA	Recycling & Wood Uses		Focused	M	2,500	2,500
USDA	Nutrient Transport Effect		Focused	M	486	486
<b>Subtotal</b>					<b>6,626</b>	<b>6,603</b>
USDA	Crop Production Assessment under Climate Change		Focused	A	105	75
USDA	Climate Effect on Rangeland Water Supply		Focused	A	520	519
USDA	Sustaining Managed & Natural Ecosystems		Focused	A	192	192
USDA	Effects of Atmospheric Changes on Crop Production		Focused	A	1,234	1,195
USDA	Decision Support Systems for Rangeland Plant Communities		Focused	A	120	60
USDA	Characterization & Prediction of H2O & Energy Fluxes		Focused	A	586	585
USDA	Nematode Indicators of Cl.Ch.		Focused	A	25	25
<b>Subtotal</b>					<b>2,782</b>	<b>2,651</b>
USDA	CO2 & Cl. Ch. Effects on Crops		Focused	M&A	319	324
<b>Subtotal</b>					<b>319</b>	<b>324</b>
<b>TOTAL USDA Focused</b>					<b>9,727</b>	<b>9,578</b>

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

NSF	Combustion & Thermal Plasmas		Focused	M	850	800
NSF	Power Systems Engineering		Focused	M	1,800	500
<b>Subtotal</b>					<b>2,650</b>	<b>1,300</b>
NSF	International Programs		Focused	A	850	890
<b>Subtotal</b>					<b>850</b>	<b>890</b>
<b>TOTAL NSF Focused</b>					<b>3,500</b>	<b>2,190</b>
NIST	Chlorofluorocarbon Alternatives		Focused	M		*
EPA	Stratospheric Ozone Protection		Focused	M	2,635	2,638
EPA	Fuel Cells for Methane Emissions		Focused	M	1,700	1,343
	Reductions					
EPA	Solar Demand-Side Mgmt.		Focused	M	0	570
EPA	Photovoltaic Technologies		Focused	M		300
EPA	Fuzzy Logic Control for Motors		Focused	M	221	467
EPA	Coal Mine Methane Recovery		Focused	M	75	100
EPA	Methane Mitigation from		Focused	M	0	0
	Anaerobic Digesters					
<b>Subtotal</b>					<b>4,631</b>	<b>5,418</b>
<b>TOTAL EPA Focused</b>					<b>4,631</b>	<b>5,418</b>
TVA	Terrestrial C Sinks Analysis		Focused	M		200
<b>Subtotal</b>						<b>200</b>
TVA	Regional Cl. Ch. Impact Assess.		Focused	A	20	300
<b>Subtotal</b>					<b>20</b>	<b>300</b>
<b>TOTAL TVA Focused</b>					<b>20</b>	<b>500</b>

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

DOE	Nat'l Mitigation Action Plan		Focused	M	0	53,300
<b>TOTAL DOE Focused</b>					<b>0</b>	<b>53,300</b>
DOI	Ecosystem Processes & Biological Diversity		Focused	A	0	395
DOI	Land Characterization & Data Mgt.		Focused	A	7,400	7,400
<b>Subtotal</b>					<b>7,400</b>	<b>7,795</b>
<b>TOTAL DOI Focused</b>					<b>7,400</b>	<b>7,795</b>
USDA	Cl. Ch. Impact on Rangeland Livestock Production		Contributory	M	235	275
USDA	Soil & Atmospheric Dynamics of C & N on Rangelands		Contributory	M	12	12
USDA	Southern Plains Ecosystems		Contributory	M	499	497
USDA	Mechanisms of Plant Responses to Atm CO2		Contributory	M	379	379
<b>Subtotal</b>					<b>1,125</b>	<b>1,163</b>
USDA	Quantification & Integration of Basin Scale		Contributory	A	200	200
USDA	Germplasm Enhancement		Contributory	A	753	749
USDA	Intelligent Farm Mgmt Syst.		Contributory	A	640	640
USDA	Hydrologic Fluxes		Contributory	A		200
USDA	Ecosystem Mgmt R & A		Contributory	A	15	15
USDA	T&ES Research		Contributory	A	8,300	8,500
<b>Subtotal</b>					<b>9,908</b>	<b>10,304</b>
USDA	Global Change Research		Contributory	M&A	22,100	22,000
<b>Subtotal</b>					<b>22,100</b>	<b>22,000</b>

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

<b>TOTAL USDA Contributory</b>					<b>33,133</b>	<b>33,467</b>
NSF	Materials Research		Contributory	A	163	175
NSF	Waste Management		Contributory	A		750
<b>Subtotal</b>					<b>163</b>	<b>925</b>
NSF	Division of Chemistry		Contributory	M&A	18,783	19,300
NSF	Division of Mathematical Sciences		Contributory	M&A	8,950	8,500
<b>Subtotal</b>					<b>27,733</b>	<b>27,800</b>
<b>TOTAL NSF Contributory</b>					<b>27,896</b>	<b>28,725</b>
EPA	Technology Database Software		Contributory	M	0	150
EPA	Biomass Energy Production		Contributory	M	0	100
EPA	Advanced Power Generation Systems		Contributory	M	800	945
EPA	Biomass for Transportation Fuel		Contributory	M	500	887
<b>Subtotal</b>					<b>1,300</b>	<b>2,082</b>
<b>TOTAL EPA Contributory</b>					<b>1,300</b>	<b>2,082</b>
TVA	Energy Options, incl. Biomass		Contributory	M		**
<b>Subtotal</b>					<b>0</b>	<b>0</b>
TVA	Constructed Wetlands		Contributory	A	1,400	1,400
TVA	Integrated Analysis of H2O Resource Systems & Power Oper.		Contributory	A	50	100
TVA	Forest Health Monitoring		Contributory	A		**
TVA	H2O Quality & Watershed Invent.		Contributory	A	500	500
TVA	H2O Resources & Ecol. Model.		Contributory	A	3,800	2,500
<b>Subtotal</b>					<b>5,750</b>	<b>4,500</b>
TVA	Regional Ozone/Forested Ecosys.		Contributory	M&A	500	1,300
TVA	Reduction of N2O Emissions		Contributory	M&A	30	400

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

<b>Subtotal</b>						<b>530</b>	<b>1,700</b>
<b>TOTAL TVA Contributory</b>						<b>6,280</b>	<b>6,200</b>
DOE	Solar Domestic H2O Heating		Contributory	M		1,900	4,300
DOE	Windows, Glazing & Daylighting		Contributory	M		4,100	5,700
	Materials						
DOE	Retrofit Technologies		Contributory	M		4,000	4,000
DOE	Indoor Air Quality		Contributory	M		1,983	1,919
DOE	Walls, Roofs, Foundations, and		Contributory	M		3,622	3,267
	Materials and Structures						
DOE	Space Heating & Cooling Equipment		Contributory	M		10,000	14,600
DOE	Advanced Bldgs for 2005		Contributory	M		5,600	12,400
DOE	Lighting		Contributory	M		3,100	2,000
DOE	Appliances		Contributory	M		0	400
DOE	Biofuels		Contributory	M		36,400	46,700
DOE	Alternative Fueled Vehicles		Contributory	M		27,700	41,600
DOE	Electric Vehicles		Contributory	M		32,700	45,600
DOE	Hybrid/Electric Vehicles		Contributory	M		14,700	19,900
DOE	Fuel Cell Vehicles		Contributory	M		11,800	18,000
DOE	Advanced Materials		Contributory	M		26,000	30,800
DOE	Solar Thermal Electric		Contributory	M		21,400	25,000
DOE	Industrial Separations Technology		Contributory	M		8,280	13,046
DOE	Industrial Heat Pumps		Contributory	M		2,200	1,700
DOE	Biomass Electric Energy		Contributory	M		4,700	5,500
DOE	Wind Energy		Contributory	M		23,300	30,300
DOE	Geothermal Energy		Contributory	M		22,800	23,900
DOE	Photovoltaics		Contributory	M		63,700	78,000
DOE	Hydropower		Contributory	M		1,000	1,000

Mitigation and Adaptation  
FY 93 and FY 94  
(Budget in thousands)

DOE	Energy Transmission, Storage & Distribution Technologies	Contributory	M	41,400	49,900
DOE	Enabling Materials (Continuous Fiber Ceramic Composites)	Contributory	M	6,834	9,012
DOE	Industrial Waste Technologies	Contributory	M	17,292	23,059
DOE	Industrial Electric Motor	Contributory	M	736	2,077
DOE	Process Heating and Cooling	Contributory	M	4,158	6,796
DOE	Municipal Solid Wastes	Contributory	M	4,568	4,619
DOE	Industrial Combustion Efficiency	Contributory	M	8,567	4,029
DOE	Cogeneration	Contributory	M	4,416	8,809
DOE	Combustion Systems	Contributory	M	34,724	42,837
DOE	Natural Gas Utilization	Contributory	M	13,860	28,284
	Advanced Turbine Systems				
DOE	Gas Stream Clean-up	Contributory	M	15,802	19,866
DOE	Surface Coal Gasification	Contributory	M	10,725	11,850
DOE	Clean Coal Technology Demonstration	Contributory	M	0	250,000
DOE	Fossil Energy Advanced Research	Contributory	M	13,123	13,852
DOE	Magnetohydrodynamics	Contributory	M	29,919	4,822
DOE	Natural Gas Fuel Cells	Contributory	M	50,444	49,278
DOE	Advanced Light Water Reactors	Contributory	M	58,700	57,800
DOE	Fusion Energy	Contributory	M	338,900	332,500
DOE	Materials Processing	Contributory	M		25,366
DOE	Americas 21st Century	Contributory	M	0	3,250
<b>Subtotal</b>				<b>985,153</b>	<b>1,377,638</b>
<b>TOTAL DOE Contributory</b>				<b>985,153</b>	<b>1,377,638</b>
DOI	Nat'l Mapping, Geo. & Surveys	Contributory	A	49	52

Mitigation and Adaptation  
 FY 93 and FY 94  
 (Budget in thousands)

DOI	NPS Gl. Ch. Res. Program		Contributory	A	3,018	3,014
DOI	Man & Biosphere		Contributory	A	200	200
DOI	Air Quality Res. & Monitoring		Contributory	A	0	835
DOI	Sensitivity of Hydrologic Systems		Contributory	A	1,160	464
DOI	Regional Studies		Contributory	A	1,340	536
<b>Subtotal</b>					<b>5,767</b>	<b>5,101</b>
<b>TOTAL DOI Contributor</b>					<b>5,767</b>	<b>5,101</b>
<b>Summary</b>						
			<b>FY93</b>	<b>FY94</b>		
<b>TOTAL FOCUSED</b>			<b>25,278</b>	<b>78,781</b>		
<b>TOTAL CONTRIBUTORY</b>			<b>1,059,529</b>	<b>1,453,213</b>		
<b>TOTAL EXPENDITURES</b>			<b>1,084,807</b>	<b>1,531,994</b>		
<b>TOTAL MITIGATION</b>			<b>1,001,485</b>	<b>1,447,704</b>		
<b>TOTAL ADAPTATION</b>			<b>32,640</b>	<b>32,466</b>		
<b>TOTAL COMBINED</b>			<b>50,682</b>	<b>51,824</b>		
<b>TOTAL EXPENDITURES</b>			<b>1,084,807</b>	<b>1,531,994</b>		
<b>Notes</b>						
<b>*=DOC/NIST</b>	<b>Non-Federal funding.</b>					

## **V. APPENDICES**

## **A. Agency Role Statements**

## Appendix A

### Agency Role Statements

#### U. S. Department of Agriculture:

The U. S. Department of Agriculture (USDA) has responsibility for security of the Nation's natural resources and food and fiber supply, including the following sectors: supply of goods and services, protection of natural resources, production, storage, processing, transportation, marketing and policy. USDA provides the world's finest research, education, and technology transfer system consisting of a professional Federal research staff, in partnership with the land grant university system's agricultural experiment stations and state forestry schools. This system is closely coupled to the technology transfer and continuing education agencies to aid in the management of this Nation's public and private lands.

USDA conducts research to assess how agriculture, range, and forest systems, known as cultural and natural ecosystems, may impact atmospheric gas composition and the effects of potential global change on the food and fiber systems, grazing systems, and forests and forest ecosystems of the United States and worldwide. USDA research focuses on the economic and environmental sustainability of the world's managed and natural renewable food, fiber, and forest resources. USDA research directly supports economic and management strategies and policy decisions. USDA integrates basic and applied research on biological, physical, economic and social, and management systems. Also included, but not limiting, are basic research on the biological response mechanisms to global change, response of water systems to global change, and the research and development of plans for terrestrial management systems to ameliorate the observed and expected increases in greenhouse gases or adapt to such changes.

#### Department of Energy:

The Department of Energy is moving forward with measures that are justified for providing the Nation with adequate, secure, and environmentally acceptable supplies of energy at a reasonable cost, including helping to reduce or eliminate greenhouse gas emissions. As a consequence, the bulk of the Department's measures are not focused mitigation and adaptation strategies, per se, but are technologies and practices which, if implemented, contribute to mitigation and adaptation.

Contributing technology development measures include cost-effective energy conservation actions, research in magnetic fusions, advanced fission reactors, and renewable energy technologies that produce little or no greenhouse gases. DOE also is researching advanced coal technologies and energy end-use technologies that could reduce greenhouse gas emissions, and cooperates in international efforts to reduce the use of chlorofluorocarbons.

Contributing scientific research (reported under the U. S. Global Change Research Program) include expanded research to understand how oceans can store heat and greenhouse gases and thus moderate global climate change, and multifaceted studies to understand how various terrestrial ecosystems adapt and change in response to greenhouse gases. The Department of Energy responds both directly and indirectly to potential global climate change through policy development - evaluating new policies and programs to reduce gas emissions and to mitigate or adapt to climate impacts associated with energy production and use.

#### Environmental Protection Agency:

The major contribution of the Environmental Protection Agency (EPA) to mitigation and adaptation activities

is to sponsor research, development and evaluation of (1) prevention, control and mitigation technologies and practices for reducing the emission of greenhouse gases, (2) practices to enhance natural sinks for greenhouse gases, (3) institutional and economic barriers and/or incentives to the adoption of mitigation technologies, and (4) techniques and practices for adapting to the effects of global change. EPA also can sponsor technology transfer and technical support to accelerate commercialization and deployment of these technologies and practices in industrialized countries and especially in developing countries.

EPA's role includes research carried out in coordination or cooperation with other Federal agencies and other public and private sector organizations, both domestic and international, to develop, evaluate, and commercialize technologies and strategies to prevent or reduce the emissions of gases to the atmosphere and to enhance natural sinks. In the case of global change, EPA plans to sponsor research on technologies to prevent or reduce emissions of greenhouse gases and increase commercial/residential, transportation, and forestry/agriculture sectors. It also will develop and evaluate methods for estimating current and future emissions under domestic and international control scenarios.

EPA Conducts research on way to enhance the natural sinks for greenhouse gases. EPA will carry out research to study and evaluate the technical and institutional feasibility of reforestation and other techniques for increasing natural sinks for carbon dioxide.

EPA plans to sponsor, as appropriate, research on institution and economic barriers and/or incentives to the adoption of mitigation technologies. Some of the institutional factors that can influence the diffusion and adoption of technological change include Federal and State regulations, local ordinances, the tax code, and communication of information through education and public information services.

EPA also will sponsor research concerning the effectiveness, feasibility, and costs of adapting to the effects of global change. For example, the Agency has focused upon engineering and land use adaptation to sea level rise and alteration of practices and techniques for agriculture, water resources management, forest management and ecosystem management in the face of regional climate change.

#### **National Institute of Standards and Technology - Department of Commerce:**

The National Institute of Standards and Technology (NIST) was established by Congress "to assist industry in the development of technology.....needed to improve product quality to modernize manufacturing processes, to ensure product reliability,... and to facilitate rapid commercialization.... of products based on new scientific discoveries." A principal agency of the Department of Commerce Technology Administration, NIST's goals are to aid industry through research and services, to support the United States scientific and engineering research communities, and to contribute to the public health, safety, and the environment. In pursuit of these goals, NIST conducts basic and applied research in the physical sciences and engineering and develops measurement techniques, test methods, standards, and related services. The Institute does generic and pre-competitive research and development work on new advanced technologies.

NIST's goals with respect to mitigation and/or adaptation are to provide the generic measurement methods, data, and models needed to phase-out the chlorofluorocarbons (CFCs) as quickly as possible and to replace the hydrochlorofluorocarbons (HCFCs) early in the 21st century. NIST is in a unique position to address critical aspects of both problems - from helping industry to identify and implement alternatives in end uses to obtaining a better understanding of the effects of alternatives on the environment.

NIST is performing research in three principal areas. First, NIST is providing generic thermophysical properties data and state-of-the-art microcomputer-based predictive models for promising CFC alternatives and their mixtures. These data and models are helping in the choice of alternatives for specific applications and in the design and optimization of equipment to use them. Second, NIST is developing generic engineering measure

ment methods and data to assist in the design of refrigeration systems. These methods and data will ensure that current and future refrigeration systems perform efficiently with alternative refrigerants and refrigerant mixtures. Finally, NIST is providing benchmark experimental data and models for the kinetic and thermodynamic properties of CFC alternatives and related compounds and by-products. These data and models are needed to understand the chemical stability of alternatives in end uses and to calculate atmospheric lifetimes to assess the potential impacts of alternatives on ozone depletion and global warming.

#### **Department of the Interior:**

The Department of the Interior will conduct research on mitigation and adaptation technologies and practices to deal with potential climate change and its impact, as well as any policies that may be undertaken to respond to climate change (or its impacts). Such efforts will focus on techniques that would affect (or be affected by) water, land, biological and other natural resources (e.g., coal, oil, gas and other extractive resources), and the Department's trust responsibilities towards Native Americans and territories.

The research will be aimed at improving existing techniques as well as research and developing new ones. In addition to developing and/or refining techniques, the research will study their broad social, environmental, and economic consequences; any social, institutional, legal, cultural, economic or other barriers to their acceptance; and methods of reducing such barriers. The Department also will seek to educate, disseminate information and engage the broader community on related activities.

Specific efforts, many of which will be undertaken in cooperation with other Departments or agencies, will include, but not be limited to, research on hydrologic resources; land use; biological habitat, resources, and diversity; grazing; agriculture; forestry; cultural resources; sea level rise; recreation and other environmental amenities; oil, energy, and mineral resource supply and demand; and related economic issues.

#### **National Science Foundation:**

The National Science Foundation is principally a supporter of research and education in science and engineering. No in-house research is carried out except in the area of science and engineering resources, the predominant performers of research being academic institutions. The research is almost exclusively basic or fundamental and is submitted to the agency in the form of unsolicited proposals.

Only a limited amount of research is supported that is focused on mitigation and adaptation issues, being research activities that also form part of the Foundation's overall program such as in the biological and behavioral science areas, namely how animal feeding and reproductive habits change due to environmental changes, and studies of historic and prehistoric adaptation to changing environmental conditions. Science and engineering resource studies are conducted to track public attitudes to science and engineering including attitudes to components of global change such as ozone loss. In engineering there are studies that deal with the impact of sea level change, the development of industrial chemical processes that minimize the generation of greenhouse gases, etc. However, much current NSF research contributes to mitigation and/or adaptation research.

NSF is the most effective conduit for tapping the large potential of the academic research community for research on mitigation and adaptation. Through the unsolicited proposal process, which can be directed to specific areas or topics, the experience, resources, innovative thought, and creativity of that community can be tapped. At the same time, conducting research through the academic community sensitizes students and academic opinion leaders to the problems and issues in mitigation and adaptation.

#### **Tennessee Valley Authority:**

Tennessee Valley Authority (TVA) responsibilities are focused in a region defined by the Tennessee River Basin and the associated larger power service areas. The statement of purpose for TVA is to serve the region

and the Nation by leading the way to quality economic growth based on a competitive energy supply, effective management of the Tennessee River system, demonstrated environmental excellence, and innovative partnerships for community development. The five vital mission areas focus on work force, energy, community partnership, river, and environmental areas. The wide range of TVA programs includes such diverse examples as multipurpose reservoir and river management, power generation, cultural resources, economic development, biomass, and a cross-section of inland natural resource programs involving such areas as air, water, ecology, wildlife, forests, and agriculture.

Given this wide range of program interests, global change research areas relevant to TVA include climatic and hydrologic systems dynamics, biochemical dynamics, ecological system dynamics, earth system history, global observations and data management, human interactions, and global change economics. Most of the research performed by or for TVA is oriented to regional or local scale and toward applied aspects for use in programs and operations. Two examples are reservoir and river systems ecological monitoring and energy use technology research and development. Nearly all the work that relates to global change issues is contributory. The small amount of focused research is centered in climatic and hydrologic systems and involves climate change impacts assessments and regional climate scenarios development and evaluation. Development of mitigation and adaptation strategies is anticipated to be an important part of ongoing strategic planning for the agency in serving the needs of the region and the Nation. Research to support such development will increasingly require cooperative efforts with Federal and State agencies, academic institutions, and nongovernmental organizations. Interactions thus far, including limited funding from some, have involved EPA, USDA, DOI, DOE, NOAA, NASA, NCAR, and EPRI.

## **B. List of Acronyms**

## List of Acronyms

AID - Agency for International Development  
CENR - Committee on Earth and Natural Resources  
CFC - Chlorofluorocarbons  
CH<sub>4</sub> - Methane  
CO<sub>2</sub> - Carbon Dioxide  
DOC - Department of Commerce  
DOD - Department of Defense  
DOE - Department of Energy  
DOI - Department of the Interior  
DOJ - Department of Justice  
DOS - Department of State  
DOT - Department of Transportation  
EPA - Environmental Protection Agency  
FEMA - Federal Emergency Management Agency  
HCFC - Hydrochlorofluorocarbons  
HHS - Department of Health and Human Services  
HUD - Department of Housing and Urban Development  
IPCC - Intergovernmental Panel on Climate Change  
N<sub>2</sub>O - Nitrous Oxide  
NAS - National Academy of Science  
NASA - National Aeronautics and Space Administration  
NOX - Nitrogen Oxides  
NRC - Nuclear Regulatory Commission  
NSTC - National Science and Technology Council  
NSF - National Science Foundation  
O<sub>3</sub> - Ozone  
OMB - Office of Management and Budget  
OSTP - Office of Science and Technology Policy  
PEGI - Private Enterprise Government Interactions  
SGCR - Subcommittee on Global Change Research  
TVA - Tennessee Valley Authority  
TREAS - Department of Treasury  
UNEP - United Nations Environmental Program  
USDA - Department of Agriculture  
VOC - Volatile Organic Compounds  
WMO - World Meteorological Organization



**C. Technology Transfer  
Mechanisms**

## TECHNOLOGY TRANSFER MECHANISMS AND REGULATIONS

W. H. TALLENT\*

The 1958 National Aeronautics and Space Administration (NASA) Space Act is generally cited as the first Federal technology transfer law, and Space Act Agreements are often considered forerunners of the Cooperative Research and Development Agreements (CRADAs) that are widely used today. Speaking on behalf of the U.S. Department of Agriculture (USDA), I must point out that actually the first technology transfer law was the Smith-Lever Act which established formal agricultural extension programs in 1914.

More modern emphasis on technology transfer from Federal laboratories to industry began with the Stevenson-Wydler Act of 1980 (PL 96-480). This Act provided the philosophical underpinning of the current technology transfer programs in place in Federal agencies with research laboratories. It also chartered the Federal Laboratory Consortium and mandated offices of research and technology assistance (ORTAs) for Federal laboratories with over 200 scientists and engineers.

Another important law passed in 1980 was the Bayh Dole Act (PL 96-517). This is most widely recognized as the law that gives to universities the rights to patents on inventions made with Federal financial assistance, subject to certain march-in provisions. It can be credited with stimulating much university-industry cooperation in research and development. Important for Federal technology transfer programs was a lesser known provision in Bayh-Dole Act, which allows us to grant exclusive or partially exclusive licenses to patents on inventions made by Federal laboratory employees when we can establish that this is necessary to achieve commercialization of the invention.

All of the above set the stage for the defining event for Federal technology transfer programs—the enactment of the Federal Technology Transfer Act (FTTA) of 1986. This act authorized Federal laboratories to enter into CRADAs with private industrial firms. The CRADAs may include up-front commitments for exclusive licenses or assignment of rights to inventions made in the cooperative project. Under CRADAs, Federal laboratory scientists may work as closely as necessary with industrial firms to achieve successful technology transfer. Federal laboratories and industrial cooperators may exchange personnel, services, information, data, research materials, equipment, etc. Industrial cooperators may provide funds to the Federal partners to offset added expenses incurred under CRADAs, but not vice versa. Hence CRADAs are not Federal procurement or assistance instruments. As a consequence many stringent requirements for advertisement and competition are avoided. However, most Federal agencies strive to achieve fairness of access by widely distributing information about opportunities for cooperation under CRADAs in specific areas of technology.

CRADAs represent a new paradigm of Government-industry cooperation. The question is still raised by some as to why results of research at taxpayers' expense should be transferred to individual firms rather than being given to all companies that want it. Those of us who have been involved since before the FTFA of 1986 in trying to get technology from Federal laboratories picked up and commercialized by industry know that what is available to everyone is generally not of much interest to anyone in industry.

The latest major technology transfer law was the National Competitiveness Technology

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Transfer Act of 1989. This extended authority to enter into CRADAs to Government owned contractor operated laboratories (GOCOs). This brought the Department of Energy (DOE) into the CRADA scene in a big way. At last count DOE laboratories collectively had entered into over 500 CRADAs (vs 400 for the U.S. Department of Agriculture.) Another important provision of this Act was the exclusion of information of proprietary value generated under CRADAs from requirements of the Freedom of Information Act (FOIA) for five years.

The Federal Laboratory Consortium for Technology Transfer (FLC) has published a useful compilation of these laws. The address and phone number of the FLC is given below.

A considerable body of literature is developing on the subject of technology transfer. Aside from financial and tax policy issues, experts identify three main institutional barriers to technology transfer. These are cultural differences, the not-invented here (NIH) syndrome, and the research-commercialization gap.

Cultural differences can be succinctly stated as the short lead-times industry faces vs the long range view of scientists in Federal (and academic) laboratories. Industrial scientists and engineers are concerned about profits—how soon and how much, protecting proprietary information, and securing intellectual property rights through patents or trade secrets. Federal laboratory scientists are apt to prefer to emphasize scientific rather than economic impact, open communication rather than secrecy, and publication or presentation to gain recognition for research accomplishments. Not surprisingly these differences in attitude can interfere with free and easy communication and effective rapport between industrial and Federal laboratory scientists.

The NIH syndrome reflects the justifiable and understandable pride industrial scientists have in their own research programs and organizations. They often question the need to use research results from Government laboratories and may even see doing so as reflecting negatively on their own research.

The research-commercialization gap is simply the disconnection between where Federal laboratories usually carry a research project along the basic research-applied research-development-commercialization continuum and where industrial firms are sure enough of the technical and economic feasibility to commit financial, manufacturing and marketing resources.

Cooperation between Federal laboratory and industrial scientists under CRADAs can address all three of these barriers. The interaction can enhance familiarity with each other's perspectives and help overcome cultural differences through better mutual understanding. If the industrial partner is brought into the research project early enough, advantage can be taken of valuable input from the commercial perspective and intellectual ownership can be shared, thereby alleviating the NIH syndrome. Under CRADAs, Federal laboratories are apt to be willing to move a bit further than usual along the continuum; and involvement and familiarity with the research may induce the industrial partner to pick up farther upstream than normal. Some additional Government programs to help bridge the research-commercialization gap are mentioned below.

Among industry complaints about CRADAs, probably the most often expressed is frustration with excessive processing time and red tape. We can reduce these by use of generic agreements and minimizing clearance levels. Another concern relates to confidentiality.

Industrial firms often do not wish to advertise their research and technology interests and certainly do not want proprietary information they bring to the cooperative project made available to competitors. Provisions can be included in CRADAs to protect such information, and the five-year FOIA exemption in the 1989 technology transfer law extends this to new information of a proprietary nature. Companies also do not like Government march-in rights to exclusively licensed technology from CRADAs. Most Federal agencies exercise such rights seldom if at all, but we are required by law to include them in patent licenses.

An article in the October 22, 1993, issue of Science entitled, "Rocky Road for Federal Research Inc.," discusses additional criticisms from industry. These include the need for a better fit with industry's needs, unbalancing rivalries through CRADA deals that effectively subsidize only one or some but not all competitors, and controversial clauses prohibiting transfer of technology to foreign components of multinationals. With regard to the last-named issue, the FTTA requires Federal agencies to "give preference to business units located in the United States..." Hence it is the location, not the ownership, that is determining. Also, the language "give preference to" allows us to enter into CRADAs with businesses outside the U.S. if no firm or business entity in the U.S. is interested.

The law also requires preference to be given to small businesses. In addition, though not specified in the FTTA, most if not all Federal agencies will show preference for female or minority owned businesses. In USDA we also give preference to rural firms. Other agencies may have other mission related preferences, e.g. energy related businesses by DOE, environment-related businesses by the Environmental Protection Agency. It should be emphasized that all of these are preferences, not exclusive requirements.

They come into play, other things being equal. Something else that should be mentioned at this point is the presumption in favor of non-exclusive licenses for non-CRADA patents. This follows from the Bayh-Dole Act, which allows exclusive licenses only if a case can be made that this is necessary to interest an industrial firm in commercializing the technology. As already mentioned, the FTTA makes an exception to this. An up-front commitment can be made in a CRADA for an exclusive license to any patentable invention coming out of the cooperative research.

While Federal agencies cannot provide financial assistance to companies under CRADAs, there are several Government programs that do provide grants or other kinds of financial assistance for commercialization of new technologies. For example, all Federal agencies that have research and development budgets must have Small Business Innovation Research (SBIR) programs. In addition, the Department of Commerce (DOC) has an Advanced Technology Program (ATP) and five Federal departments (Department of Defense, DOC, DOE, the National Science Foundation, and NASA) participate in the Technology Reinvestment Project (TRP). DOE has an Energy Inventions Program, and USDA has the Alternative Agricultural Research and Commercialization Center (ARCC). More information on TRP can be obtained by calling 1-800-DUAL USE. Regarding ARCC call (202) 401-4860. Further information on any technology transfer program in the Federal government can be obtained from the following sources:

The Federal Laboratory Consortium  
for Technology Transfer  
PO Box 545  
Sequim, Washington 98382-0545  
Phone: (206) 683-1005

The National Technology Transfer Center  
Wheeling Jesuit College  
316 Washington Avenue  
Wheeling, West Virginia 26003  
Phone: (304) 243-2455  
FAX: (304) 243-2463

**D. Federal Emergency  
Management Agency**

Research and development activities related to the mitigation of, or adaptation to, global climate change are vital to the world's future. But research and development alone does not guarantee widespread use of the technologies developed.

Assessments of the state-of-science, as well as assessments of societal impacts of technologies are just as vital to the future. One Federal agency, the Federal Emergency Management Agency (FEMA), has issued a report on a study by a panel of experts on the impact on society of the Earthquake Hazards Reduction Act of 1977.

The methods used, and conclusions of, the study and report should be of interest to any agency reviewing impacts of research, development, mitigation or adaptation activities. The Executive Summary of "Improving Earthquake Mitigation: Report to Congress" is herein appended. A copy of the complete report can be obtained from FEMA.

**EXECUTIVE SUMMARY**  
**IMPROVING EARTHQUAKE MITIGATION: REPORT TO CONGRESS**  
As Required Under Public Law 101-614, Section 14(b)  
National Earthquake Hazards Reduction Program Reauthorization Act  
January 1993

The Earthquake Hazards Reduction Act of 1977, as amended in 1990 (the Act), directed the Federal Emergency Management Agency (FEMA) to convene a panel of experts to study the adequacy of mitigation capabilities with respect to a catastrophic earthquake, and to provide to Congress a report on that study (mitigation study). The 1990 amendments to the Act (P.L. 95-124) reflect in part, congressional concern about the lack of progress throughout the United States in implementing earthquake hazards mitigation measures as contemplated by the 1977 Act.

An essential conclusion of the mitigation study is that the degree of nationwide earthquake hazard mitigation envisioned by the 1977 Act has not been achieved. There are many reasons why the program has fallen short of its goals, but one of the most important is that implementation of the mitigation techniques that are most likely to reduce the hazard is voluntary. In encouraging the adoption and enforcement of mitigation measures, NEHRP must devise a new national strategy. This strategy should tie seismic mitigation to all federal financing programs available to state and local governments. The strategy should include: (1) expanding Executive Order 12699 for new construction to include both direct and indirect federal financing; (2) incorporating mitigation into federal rehabilitation financing programs; (3) linking receipt of federal disaster assistance to mitigation actions; and (4) identifying appropriate incentives to stimulate mitigation actions, particularly for the existing built environment.

The study panel concluded that the 1977 Act promoted real gains in knowledge about the earthquake hazard and about the techniques that need to be applied to reduce earthquake losses. Implementation of loss-reduction measures, however, has not kept pace with advances in knowledge. The panelists agreed that despite clear confirmation of the losses caused by earthquakes, and despite heightened attention to the consequences of earthquakes in the last few years, most state and local governments are unlikely to launch significant efforts to improve mitigation in the absence of stronger federal requirements, guidance, and incentives.

Some states and local jurisdictions have made important advances in earthquake hazard mitigation. Many areas at significant earthquake risk, however, have done little or nothing to address the problem. The lack of mitigation activity could be explained by the inability of communities to accurately assess risks, the perception that mitigation costs are excessively high, and the expectation that the government will provide federal disaster assistance after an earthquake. Among the most prominent impediments to mitigation identified by the study team are:

1. the low priority given to earthquake hazard by the many state and local governments, many private-sector entities, and the public at large;
2. the absence of incentives, particularly financial, for the adoption of earthquake mitigation policy; and
3. Limited leadership, coordination, and direction at the federal level, particularly with respect to mitigation activities it can affect through existing programs.

To begin to overcome these impediments, a new national strategy for earthquake hazard mitigation must be devised that includes at a minimum a program requirement that seismic considerations be applied in all new construction to any structure that receives either direct federal support. A federal guarantee of financing, or federal insurance for that financing. A second phase to the new strategy must provide concrete incentives to those who undertake earthquake mitigation actions to address the existing built environment.

Although increasing the seismic resistance of existing construction is, in many ways, more important and difficult than improving the resistance of new construction, pragmatic considerations suggest that the greatest gains can be made by focusing, at least initially, on new structures. Fourteen years after passage of the 1977 Act, the three most dominant model building code groups in the US. had incorporated basic seismic safety provisions for new construction that are substantially equivalent to those of the NEHRP *Recommended Provisions* (the Provisions). Although the panel welcomed this major success of NEHRP, its view is that the mere existence of building codes does not measure implementation of earthquake mitigation measures. The Provisions accomplish less than they should because: (1) in adopting model codes, localities often delete the seismic provisions; (2) even where codes are adopted, enforcement is not given a high priority and needed expertise is lacking in many jurisdictions; and (3) the model seismic codes are directed primarily at preserving life safety. Costly property damage will still occur unless stronger measures are adopted.

The panel points out that uniform, visible progress has not been achieved nationally because, despite the risk of destruction from earthquakes, mitigation requires restraints on the freedom to build structures at the lowest possible cost and in the locations deemed most desirable. Until the balance between the relatively unfettered exercise of this freedom and the risk of loss of life and property is changed to give more emphasis to avoiding such losses, mitigation on a broad, nationwide basis will not occur.

Economic interests predominate when seismic building codes are considered. Unless the federal government is willing to demonstrate its support for mitigation by requiring that states and localities exercise their authority to ensure that action is taken; and unless the federal government is prepared to place conditions on the disbursement of public funds for the prevention of losses in earthquakes, or to provide incentives to encourage local action, it is wishful thinking to expect subfederal governments to improve their mitigation performance.

Governmental authority already has been exercised to a limited degree in Executive Order 12699, which requires that appropriate seismic design and construction standards and practices be adopted for any new construction of buildings owned, leased, constructed, assisted, or regulated by the federal government. Although the Executive Order does not apply to existing buildings or to lifelines such as bridges, highways, and utility systems, it is a good start in the view of the expert panel.

Active enforcement of the Executive Order by appropriate federal agencies is, of course, basic to its success. Even with adequate enforcement, much of the nation's new construction will not be covered by the Executive Order. The panel believes that, for the Executive Order to be truly effective, federal "assistance" as defined by the Order should include structures covered by conventional mortgages issued by institutions insured by agencies of the federal government such as the Federal Deposit Insurance Corporation (FDIC).

Model codes for new construction do not address the very serious problems posed by existing hazardous buildings and by other potentially vulnerable elements in the built environment such as bridges, highways, and utility lifelines. As noted earlier, even if the Executive Order were implemented to its full potential, it still would not cover existing structures or lifelines. As was dramatically evident in the collapse of the Cypress Street Viaduct after the Loma Prieta earthquake, this critical problem cannot be ignored. On the other hand, costs for the retrofit of structures can be significant, and the gaps in our knowledge about cost-effective retrofitting strategies and standards for many types of structures must be recognized and remedied.

The panel agreed that, particularly in this context, a properly structured program of incentives could produce significant improvement in the seismic safety of existing structures. An effective incentive program could be tied to the availability of disaster assistance, to federal programs that provide funds to state and local governments for housing construction or infrastructure improvements (both before and after an event), or to any insurance program that receives federal support, or it could be connected more closely to the nation's tax structure.

One approach could be to use negative incentives, such as prohibitions against the issuance of conventional mortgages by a federally insured lender to households or businesses in an earthquake-prone area if state or local governments fail to adopt or enforce appropriate seismic mitigation standards for new and existing construction. This type of negative incentive authority was exercised by the federal government in the 1973 Flood Disaster Protection Act and was the sole reason that the number of communities adopting flood mitigation measures increased from fewer than 3,000 in 1973, to almost 18,000 less than five years later.

The panel of experts made clear to FEMA that the need to develop a national strategy to mitigate earthquake hazards is beyond dispute. Voluntary measures have not worked. The national strategy, therefore, needs to incorporate at least three basic components: (1) it should capitalize on the large number of federal government programs that support construction and grants by requiring that seismic safety be incorporated into these programs; (2) it should explore how federal disaster assistance can be used to enhance mitigation; and (3) it should identify appropriate incentives to mitigate (particularly in the existing environment). To continue using approaches that have proved to be ineffective would be to acquiesce in future earthquake losses that could otherwise be avoided.

## **E. Private Sector Interactions**

In 1991, several Federal agencies, under the direction of the U. S. Global Change Research Program, began to look at means for encouraging collaborative relationships between Federal government research institutions and private sector organizations conducting research of common interest. From this initial *ad hoc* group was formed the Working Group on Private Sector - Government Interactions (PEGI).

For the last 3 years PEGI has fostered and facilitated global change research interactions and collaborative efforts between the private and Federal sectors. This type of effort was given broad endorsement by the current Administration. In February 1993, President Clinton and Vice-President Gore released the document "Technology for America's Economic Growth, A New Direction to Build Economic Strength". One of the principle directions set forth in this document was to forge closer working partnerships among groups representing industry, federal agencies, state governments, workers, and universities. While most of PEGI's efforts, thus far, have been directed toward private industry and academia, future efforts will be directed toward fostering Federal and state and local governments interactions.

Given the nature of basic research, most of the successful collaborative efforts, thus far, have been in the expanded USGCRP program of mitigation and adaptation, principally in mitigation research and development. Many of the programs listed in this FY 93-94 Directory are continuations of previously successful cooperative projects. For example, the Electric Power Research Institute (EPRI) continues to work with the Environmental Protection Agency (EPA) on a study to evaluate CFC and halon substitutes for the protection of the ozone layer. The Association of Appliance Engineers, and the Motor Vehicle Manufacturers of America also are partners in this Stratospheric Ozone Protection study.

It is encouraging to note that past successes have led to the number of new collaborative efforts annotated in this Directory. For example, the U. S. Department of Agriculture (USDA) has a number of partners in its research aimed at guaranteeing the continued production of food and fiber in the face of change. In addition to extensive networks with the land-grant university system, USDA is working with the Masstock Southern Dairies as well as with universities in Australia, Canada, and the Netherlands on studies addressing nutrition transport. A study on carbon dioxide and climate change effects on crops and trace gas exchange with the atmosphere involves USDA and the International Rice Research Institute. USDA research on climate change modeling and on the ability of soils to sequester carbon is being conducted in cooperation with the International Geosphere-Biosphere Program.

The U. S. Department of Energy (DOE) has a growing number of private sector partners on research and development of materials and structures for walls, roofs, and foundations. These include the Southern California Gas Company and the U. S. Advanced Materials Association on research on advanced materials, particularly fiber composites; and with the Gas Research Institute and EPRI on development of advanced fuel cell systems.

Federal agencies participating in the PEGI Working Group include:

Agency for International Development  
Department of Commerce  
Environmental Protection Agency  
Department of the Interior  
National Science Foundation

Department of Agriculture  
Department of Energy  
Department of Housing and Urban Development  
National Institutes of Health  
Tennessee Valley Authority