

# The Federal Research Program on Global Change

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**I**t has been nearly 5 years since the establishment of the U.S. Global Change Research program (USGCRP).<sup>1</sup> USGCRP was instituted to respond to

scientific data and research results that strongly indicate that there are changes in the Earth's environment that could lead to global warming, ozone depletions, changes in biodiversity and forest distributions, desertification, and other global environmental issues, all of which have potentially significant local, regional, and global effects of vital importance to mankind.<sup>2</sup>

The USGCRP research plan was developed by the Committee on Earth Sciences (now the Committee on Earth and Environmental Sciences), an interagency group under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) in the Office of Science and Technology Policy (OSTP) in the Office of the President (figure 1-1).<sup>3</sup> It was the first

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<sup>1</sup>The USGCRP was formally announced as a Presidential Initiative in a January 1989 report of the Committee on Earth Sciences: *Our Changing Planet: A U.S. Strategy for Global Change Research*, which accompanied President Bush's fiscal year 1990 Budget request.

<sup>2</sup>Robert W. Corell, Chairman, CEES Subcommittee on Global Change Research and Assistant Director for Geosciences, National Science Foundation testimony before the House of Representatives, Committee on Science Space and Technology, Subcommittee on Space, Mar. 30, 1993.

<sup>3</sup>The FCCSET is composed of cabinet secretaries, deputy secretaries, and heads of independent federal agencies. The director of the White House Office of Science and Technology Policy serves as its chairman.

of several FCCSET initiatives to which the Bush administration gave the status of “Presidential Initiative.

From its inception until fiscal year (FY) 1994, three “activity streams,” or program elements, defined the mission of USGCRP:<sup>5</sup>

1. Documentation and Analysis of Earth system changes, which includes observation—using both ground- and space-based observation systems—and data management;
2. Process Research to enhance the understanding of the physical, geological, chemical, biological, and social processes that influence Earth systems behavior; and
3. Integrated Modeling and Prediction of Earth systems processes.

In FY 1994, USGCRP officials added a fourth activity stream, Assessment.

Originally, organizers envisioned USGCRP as a complete *global change* research program, covering research on most aspects of natural and human-induced change and their impacts. However, in designing USGCRP and setting its research priorities, the Committee on Earth and Environmental Sciences (CEES) drew heavily from the existing activities of several organizations reviewing global change issues, especially the Intergovernmental Panel on Climate Change (IPCC-box 2-A).<sup>6</sup> This accounts, in part, for the decision by the CEES Subcommittee on Global

### Box 2-A-The Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC), chartered in 1988, is an intergovernmental body Sponsored jointly by the World Meteorological Organization and the United Nation's Environmental Programme. The group's three working groups are charged with:

1. assessing the scientific understanding of natural and human-induced climate change;
2. assessing likely impacts resulting from such change; and
3. considering possible response strategies for limiting or adapting to climate change.

In 1990, the IPCC produced three documents outlining the current state of knowledge about climate change entitled: *The IPCC Scientific Assessment*, *The IPCC Impacts Assessment* and the *IPCC Response Strategies*. The IPCC published an update of the science assessment in 1992 and is scheduled to complete another full assessment in 1995.

SOURCE: Office of Technology Assessment, 1993

Change Research, which is responsible for the overall direction of the USGCRP, to designate research programs aimed at improved understanding of Climate and Hydrologic Systems as USGCRP'S highest priority (figure 2-1).

CEES evaluates USGCRP programs according to several criteria: relevance and contribution to the overall goals of the program, scientific merit,

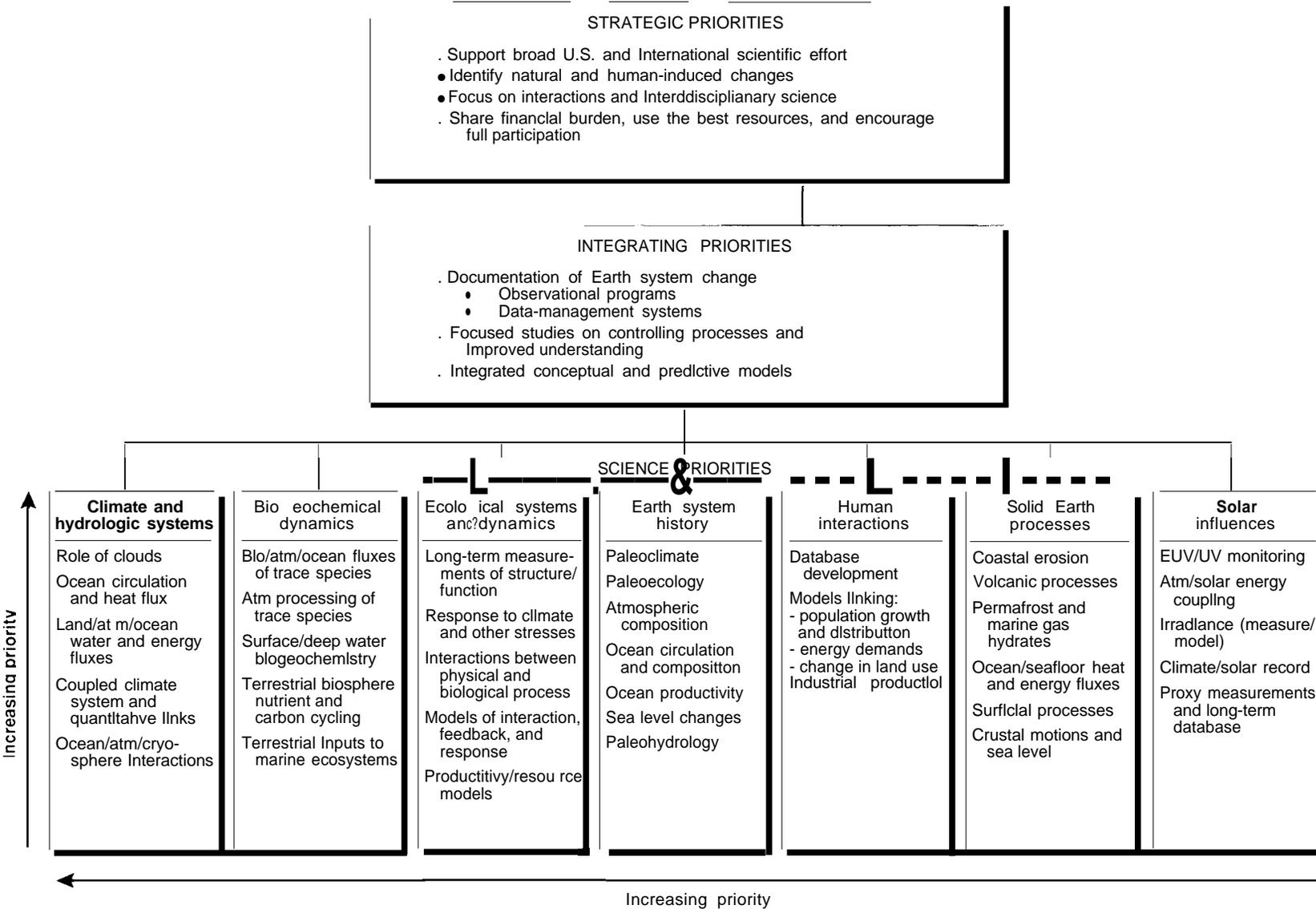
<sup>4</sup>The Clinton administration now refers to these as Strategic Initiatives. They are: advanced materials and processing, high performance computing and communications, global climate change, manufacturing technology and science, biotechnology research and science, and math and engineering education. D. Allan Bromley, Assistant to then President Bush for science and technology, developed the FCCSET initiatives as a means to pursue a select few high-profile, relatively high cost programs, requiring coordination among multiple Federal agencies and departments.

Some scientists, especially in academia, have criticized FCCSET's focus on a few applied research and technology initiatives on grounds that they divert funds from basic research. Proponents of the FCCSET initiatives counter that basic research may, in fact, benefit from FCCSET initiatives because basic research performed in support of a highly visible applied objective is more likely to be immune from congressional or agency funding reallocations.

<sup>5</sup>Committee on Earth and Environmental Sciences (CEES), *Our Changing Planet: The FY 1994 U.S. Global Change Research Program* (Washington, DC: CEES, 1993).

<sup>6</sup>In addition to the IPCC, USGCRP was influenced by studies undertaken by National Academy of Sciences @AS), the World Climate Research Program (WCRP) of the World Meteorological Organization (WMO), the International Council of Scientific Unions (ICSU), and the International Geosphere-Biosphere Program (IGBP).

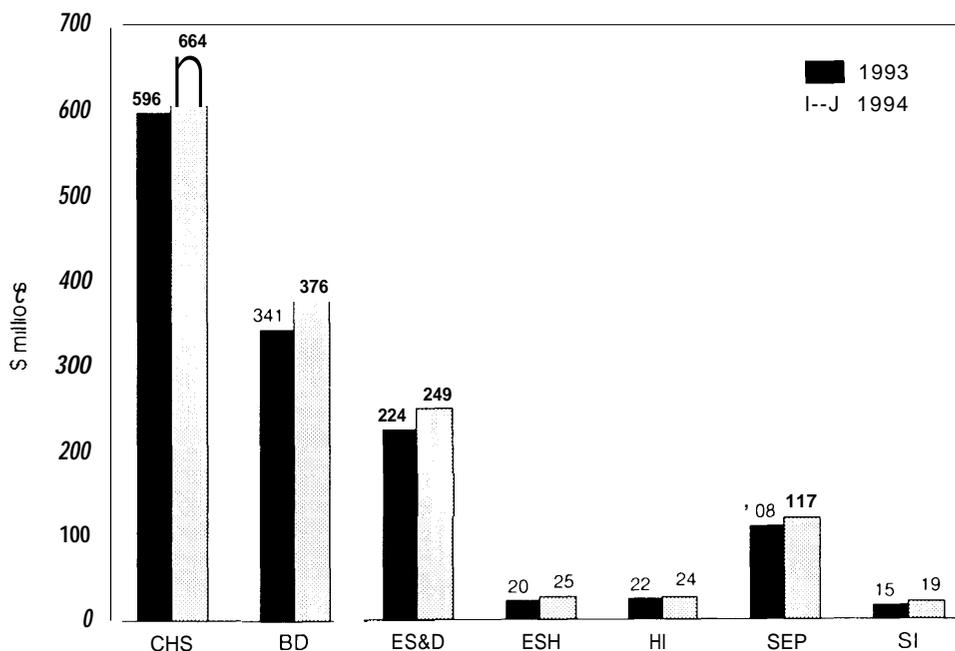
Figure 2-1—Priority Framework for USGCRP



NOTE: atm=atmosphere; EUV/UV=extreme ultraviolet/ultraviolet.

SOURCE: Committee on Earth and Environmental Sciences (CEES), *Our Changing Planet: The FY 1993 U.S. Global Change Research Program* (Washington, DC: CEES, 1992).

Figure 2-2--USGCRP Budget by Science Element



NOTE: CHS=Climate and Hydrologic Systems; BD=Biogeochemical Dynamics; ES&D=Ecological Systems and Dynamics; ESH=Earth System History; HI=Human Interactions; SEP=Solid Earth Processes; SI=Solar Influences. FY 1994 values are the requested, not the appropriated, amounts.

SOURCE: Committee on Earth and Environmental Sciences (CEES), *Our Changing Planet: The FY 1994 U.S. Global Change Research Program* (Washington, DC: CEES, 1993).

ease or readiness of implementation, linkages to other agencies and international partners, cost, and agency approval. The priorities of the seven research areas shown in figure 2-2 and the activity streams (observation, understanding, prediction, and assessment) are intended to help guide budget decisions. To date, funding levels have followed

these priority areas with the exception of assessment, which took effect in FY 1994 (figure 2-2).<sup>7</sup>

Eleven different Federal agencies currently contribute to USGCRP (table 2-1). They are coordinated through a budget “cross-cut” and through the presentation of participating agencies’ global change budgets to the Office of Management and Budget (OMB) for considera-

<sup>7</sup> In FY 1993, focused research activities under the highest priority research area, Climate and Hydrologic Systems, comprised about 43 percent of USGCRP budget, Biogeochemical Dynamics (priority area 2) comprised about 24 percent, and Ecological Systems and Dynamics (priority area 3) comprised about 17 percent. The remaining four research areas comprised about 16 of the USGCRP budget. These figures are relatively unchanged for the FY 1994 budget request. See *Our Changing Planet: The FY 1993 U.S. Global Change Research Program*.

<sup>8</sup> The budget cross-cut begins with each agency identifying preexisting research programs that pertain to the USGCRP mission. At its inception in FY 1989, approximately 70 percent of the proposed budget for USGCRP consisted of research funds from existing projects. Each agency can also propose additional “new” research programs for inclusion in USGCRP. These programs are submitted to the Subcommittee on Global Change Research of CEES for review and then forwarded with recommendations to both OMB and the participating departments and agencies. OMB returns the USGCRP budget with its own recommendations to the agencies when it returns the whole agency budget. At that point, deliberations between OMB and the agencies proceed as normal. As agencies work to meet OMB-established budget targets, all projects, including USGCRP projects, suffer possible modification.

**Table 2-1—List of Departments and Agencies or Bureaus Involved in USGCRP Research**

<b>DOC</b> Department of Commerce	NASA National Aeronautics and Space Administration
NOAA <b>National Oceanic</b> and Atmospheric Administration	OSSA Office of Space Science and Applications
<b>DOD</b> Department of Defense	<b>NSF</b> National Science Foundation
CRREL Cold Regions Research and Engineering Laboratory	BiO Directorate for Biological Sciences
ONR Office of Naval Research	GEO Directorate for Geosciences
<b>DOE</b> Department of Energy	SBE Directorate for Social, Behavioral, and Economic Sciences
<b>OHER</b> Office of Health and Environmental Research	<b>SI</b> Smithsonian Institution
<b>DoI</b> Department of Interior	IC international Center
BIA Bureau of Indian Affairs	NASM National Air and Space Museum
BLM Bureau of Land Management	NMNH National Museum of Natural History
BOM Bureau of Mines	NZP National Zoological Park
BOR Bureau of Reclamation	SAO Smithsonian Astrophysical Observatory
<b>FWS</b> Fish and Wildlife Service	SERC Smithsonian Environmental Research Center
<b>NPS</b> National Park Service	STRI Smithsonian Tropical Research Institute
<b>Os</b> Office of the Secretary	<b>TVA</b> Tennessee Valley Authority
USGS U.S. Geological Survey	RBO River Basin Operations
<b>EPA</b> Environmental Protection Agency	<b>USDA</b> Department of Agriculture
ORD Office of Research and Development	<b>ARS</b> Agricultural Research Service
<b>HHS</b> Department of Health and Human Services	CSRS Cooperative State Research Service
NIEHS National Institute of Environmental Health Services	ERS Economic Research Service
	Forest Service
	: : s Soil Conservation Service

**SOURCE:** Committee on Earth and Environmental Sciences (CEES), *Our Changing Planet: The FY1993 U.S. Global Change Research Program* (Washington, DC: CEES, 1992).

tion as a single document. The principal budget review and decisionmaking body in the CEES is the Subcommittee on Global Change Research. Agencies participating in USGCRP develop their proposed contributions with guidance from CEES, OSTP, and OMB. The budget cross-cut, rarely used in the Federal Government, has been reasonably successful in facilitating cooperation and securing new funding for global change research. Since the program began, the total annual USGCRP budget has grown from \$660 million to its current \$1.3 billion. The administration has proposed a fiscal year 1994 USGCRP budget of \$1.47 billion.<sup>9</sup>

Reducing uncertainties about the natural and human-induced changes occurring in the Earth's environment will require the study of phenomena occurring over a range of spatial scales and time scales (figure 2-3). A recurrent theme at the OTA workshop was the necessity for measurement programs that would provide both short-term information as well as multidecadal, continuous information relevant to policy and science needs.<sup>11</sup> Several participants believed the long-term success of USGCRP rests on the resolution of several issues, including:

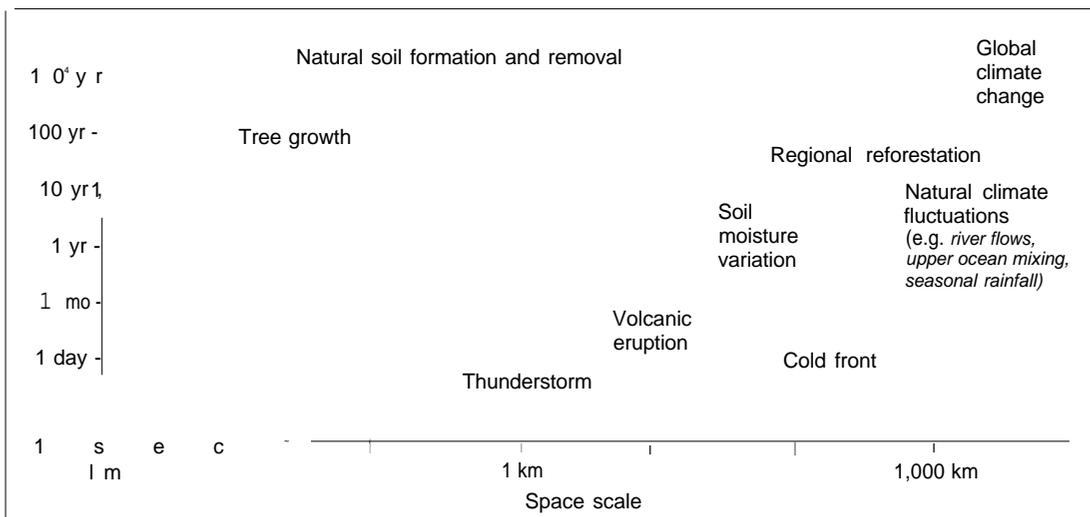
1. how best to order and review scientific priorities within and across disciplines,

<sup>9</sup> The National Acid Precipitation Assessment Program (NAPAP) also used such a mechanism (see app. B).

<sup>10</sup> Committee on Earth and Environmental Sciences, *Our Changing Planet*, op. cit., footnote 5.

<sup>11</sup> Documents developed by CEES to direct USGCRP for the long-term indicate a desire to sustain the program for at least 40 years. See Robert W. Corell, Assistant Director for Geosciences, National Science Foundation Testimony before the House of Representatives, Committee on Science, Space and Technology, Subcommittee on the Environment, May 5, 1992.

Figure 2-3-Scales of Natural Change



The Earth undergoes natural changes that vary from regional to global extent and over periods ranging from seconds to thousands of years.

SOURCE: GlobalChange Scaler, Quarterly Report of the Global Climate Change Program at Argonne National Laboratory. ANGCS-1, February 1993, p. 26.

2. how to broaden the program beyond its narrow focus on climate change,
3. how to ensure an appropriate balance in the participation of the National Aeronautics and Space Administration (NASA) and other agencies (especially the natural resource management agencies), and
4. how to maintain a long-term funding commitment from Congress and the administration despite the political reality of short election cycles and 1-year budget cycles.

global change for the natural and human environment to support national and international policy making activities over a broad spectrum of global and regional environmental issues (figure 2-4).<sup>12</sup>

Workshop participants welcomed the explicit inclusion of an assessment element, but noted that USGCRP still lacked a detailed plan of assessment activities. Furthermore, several noted that USGCRP'S current research agenda is too narrow to support integrated (end-to-end) assessments of global change.

USGCRP focuses on understanding the physical and chemical make-up and processes of the atmosphere and places relatively little emphasis on assessing the ecological or economic impact of climate change.<sup>13</sup> As a result, USGCRP may not

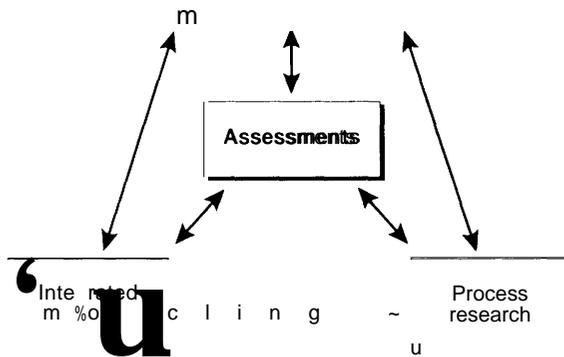
### NEW DEVELOPMENTS IN USGCRP

CEES added an assessment element in FY 1994 to document the state of scientific knowledge and uncertainties and the implications of

<sup>12</sup> See testimony of Robert W. Corell, Chairman, CEES Subcommittee on Global Change Research, before the Committee on Science, Space, and Technology, Subcommittee on Space, Mar. 30, 1993. According to Corell, these elements support the USGCRP objective to produce "a predictive understanding of the Earth system to support national and international policymaking activities across a broad spectrum of global and regional environmental issues."

<sup>13</sup> Study of the impact of climate change should not be confused with study of climate sensitivity. Climate sensitivity is a high-priority area for USGCRP; for example, understanding the sensitivity of the climate system to changes in radiative forcing.

Figure 2-4-Activity Streams of USGCRP



SOURCE: Committee on Earth and Environmental Sciences (CEES), *Our Changing Planet: The FY 1993 U.S. Global Change Research Program* (Washington, DC: CEES, 1992).

be able to contribute significantly to near-term national and international policy discussions. Indeed, nearly all workshop participants agreed that USGCRP should give greater emphasis to research on the *impacts* of climate change on society and the natural world.

Workshop participants expressed a particular concern that the current emphasis on understanding atmospheric change would lead to inadequate research on understanding how biological systems might respond to climate change. For example, USGCRP'S ecological research focuses on important components of ecosystems function, but gives comparatively little attention to potential *changes in ecosystem range, species composition, and ability to adapt to climate change.* USGCRP research has also largely ignored issues of biodiversity, changes in land use, and increases in industrial pollution, addressing them only to the extent that they interact with the climate

system. Nor does USGCRP examine the potential socioeconomic impacts of changes in resource production and distribution, and potential adaptation strategies for society.

Beginning in FY 1995, CEES intends to broaden the USGCRP'S research scope to address some of these concerns. New research areas could include the impacts of climate change on social systems and biological resources, as well as research on possible mitigation and adaptation strategies and technologies, topics that the original research plan explicitly left out (box 2-B).<sup>14</sup> Policymaking would benefit if USGCRP were to include an expanded FCCSET/CEES mechanism to coordinate the various components of USGCRP and establish formal links to the policy process. The administration plans to announce complete details of this expanded USGCRP program in conjunction with the fiscal year 1995 Presidential budget request.

USGCRP officials also plan to give increased attention to the study of the socioeconomic impacts of climate change. Currently, this is supported through the Research Program on the Economics of Global Change, a distinct component of the USGCRP.<sup>15</sup> While workshop participants supported increased attention to the three "thrust areas" of this program they questioned the wisdom of a distinct Federal Economics Initiative.<sup>16</sup> In their view, the separation of this effort from the rest of USGCRP was artificial and made the study of the inherently interdisciplinary problems of global change more difficult.

## BALANCE AND THE FUTURE OF USGCRP: ISSUES AND CONCERNS

Each of the agencies participating in the USGCRP decide how much research money they

<sup>14</sup> See Corell, *op. cit.*, footnote 12. For the original research plan, see *Our Changing Planet: The FY 1990 Research Plan*.

<sup>15</sup> See Committee on Earth and Environmental Sciences, *Economics and Global Change: The FY 1993 Research program on the Economics of Global Change* (A Supplement to the U.S. President FY 1993 Budget) (Washington DC: Committee on Earth and Environmental Sciences, 1993).

<sup>16</sup> For fiscal year 1993 the three thrust areas were: 1) global economic models for the analysis of global environmental change; 2) uncertainty and the value of information; and 3) the economic effects of global change.

### Box 2-B-Mitigation and Adaptation Research in the Federal Government

As originally envisioned, issues **related to mitigation of, and adaptation to, global change were to be addressed under the committee on Earth and Environmental Sciences (CEES) Working Group on Mitigation and Adaptation Research Strategies (MAR- figure I-I)**. CEES originally excluded research on mitigation and adaptation to global change from USGCRP to keep the program primarily focused on science and clearly distinct from the policymaking process.

MARS was eliminated by 1992 despite recognition by CEES that a complementary program of mitigation and adaptation research was critical to an effective national response to global environmental issues.<sup>1</sup> Participants at the OTA workshop believed the MARS program had been largely ineffective. Among the reasons cited was the working group's lack of authority to perform a budget cross-cut, and to develop an interagency research program on mitigation and adaptation research. In addition, the MARS working group did not benefit from having the status of a Presidential initiative.

Although the MARS working group provided a forum for agencies to discuss global change programs of mutual interest it was unable to exercise any influence over project selection and funding. Consequently, MARS served primarily to catalog existing agency programs and projects that addressed mitigation, adaptation, social dynamics, and economic issues either as a main focus of a project or as a contributing element of a project. This situation might be remedied by folding some of the original MARS functions, including those designed to stimulate research on mitigation and adaptation strategies, into an expanded USGCRP or a reinstated MARS-type program.

<sup>1</sup>Initial responsibility for development of a MARS program was given to EPA and DOE—two of the more “mission-oriented” agencies in the USGCRP, but, as noted above, little was accomplished. Some workshop participants attribute this partly to the previous administrations' skepticism towards the problem of human-induced global change, SOURCE: Office of Technology Assessment, 1993.

intend to spend annually on research relevant to global change. Agency USGCRP projects are classified as “focused” —directly relating to global change—or “contributing” justified on a basis other than global change, but having the potential to contribute to the global change knowledge base.

No standardized criteria exist for classifying contributing research, and each agency uses its own system. CEES classifies much of the research on impacts and effects—for example, the effects of drought on vegetation and the corresponding impacts to crops and ecosystems—as contributing research because agencies pursue it for reasons other than climate change. Currently, much of the Department of the Interior and the Department of Agriculture global change research consists of contributing programs not included in the USGCRP budget cross-cut of

focused research programs; this includes programs to characterize ground and surface water flows and to monitor ecosystem change.

Over 50 percent of funding for focused research under the category of Ecological Systems and Dynamics supports NASA projects (e.g., Landsat and some aspects of Earth Observing System (EOS)) that primarily address ecological *functions and characterization*, rather than *impacts and effects* of climate change on ecological systems. To date, fiscal support for research on climate impacts has not been reflected in the ordering of the seven scientific research areas that guide implementation of the USGCRP. However, CEES officials expect to include more research on the social, economic, and environmental impacts of global changes in FY 1995.

The majority of USGCRP funding is embodied in NASA programs, most of which are related to

environmental monitoring using satellites. In FY 1993, NASA's focused global change research programs accounted for over 60 percent of the focused global change research program budget.<sup>17</sup> As chapter 3 discusses, many workshop participants voiced concerns that the current EOS program ignores correlative, in situ, and process-oriented studies vital to understanding the mechanisms responsible for global change and for verifying satellite measurements.<sup>18</sup> In addition, they argued that program restructuring and a decrease in the EOS budget has resulted in a narrowing of the USGCRP research agenda and the sacrifice or postponement of programs necessary for the development of an effective global environmental monitoring system.<sup>19</sup>

Workshop participants struggled with the questions of how and where to allocate new resources for USGCRP. In terms of funding and scope, NASA has become the de facto lead agency for global change research. Thus, for example, NASA is now the lead agency not only for space-based global change measurements (its assigned role<sup>20</sup> but, in terms of funding, it is also the lead agency for ecological research. NASA's comparatively large budget for ecological research is a consequence of its heavy investment in satellite-based research instrumentation, and is not the result of deliberations by scientists within the ecological research community on how best to allocate Federal funds for ecological research.<sup>21</sup>

Agencies typically find it difficult to secure large percentage increases in their budgets. At the same time, relatively small percent increases in the NASA USGCRP budget translate into substantial funding increases relative to any other agency's budget. For example, a 5-percent increase in NASA's USGCRP budget for FY 1993 would have translated into nearly \$45 million in new money whereas a 5-percent increase for the National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and the Department of Energy (DOE) would have contributed approximately \$4 million, \$8 million, and \$5.5 million, respectively.<sup>22</sup>

USGCRP programs such as the World Ocean Circulation Experiment (WOCE), Tropical Oceans Global Atmosphere (TOGA), and the Joint Global Ocean Flux Study (JGOFS) are interagency research programs whose success depends on contributions from NASA, NOAA, and NSF. However, in a recent budget cycle, NASA received more funds than requested for these programs while NOAA and NSF received no funds. To maintain continuity in these programs, NASA was able to redirect some of its money to fill the financial gap left by inadequate funding for NOAA and NSF. The problem of securing multiple agency funding for new cross-disciplinary projects is exacerbated by a congressional authorization and appropriations process that approves agency budgets inde-

<sup>17</sup> NSF and DOE accounted for 12 percent and 8 percent, respectively. The remaining roughly 15 percent was distributed among NOAA, DOI, USDA, EPA, DOD, the Smithsonian, HHS, and TVA.

<sup>18</sup> The synergism between aircraft and satellite measurements is discussed in Jose M. Rodriguez, "Probing Stratospheric Ozone," *Science*, vol. 261, Aug. 27, 1993, pp. 1128-1129.

<sup>19</sup> That is, one that addresses the full range of environmental issues, which extend beyond just climate change.

<sup>20</sup> The space component of the USGCRP is referred to as the S-GCOS (Space-based Global Change Observation System). National Space Policy Directive 7 (NSPD-7), signed by then President Bush on June 1, 1992, assigned NASA the lead role in S-GCOS. NSPD-7 directs other agencies—including the Departments of Defense, Energy, and Commerce—to cooperate in the development and operation of spacecraft and data systems. A interagency S-GCOS committee has been established to execute this directive.

<sup>21</sup> This is reflected in the breakdown of funds by agency for USGCRP's Ecological Systems and Dynamics program element. Ecological Systems and Dynamics receives \$224 million, or 17 percent of the USGCRP budget. NASA receives 66 percent of this money, while only 11 percent goes to the Department of Agriculture and 3.5 percent to the Department of the Interior.

<sup>22</sup> Agency budgets from figure 5, "U.S. Global Change Research Program Budget by Agency," in *Our Changing Planet: the FY 1993 U.S. Global Change Research Program*, p. 54.

pendent of each other and has no formal mechanism to evaluate programs in their entirety.

### Funding Across the Agencies

Questions of balance among USGCRP research efforts are directly related to issues involving funding allocations among participating USGCRP agencies. Currently, NASA, NOAA, and DOE control about 79 percent of the focused research budget for USGCRP.<sup>23</sup> The remaining funding is distributed among NSF, Department of Interior (DOI), U.S. Department of Agriculture (USDA), Environmental Protection Agency (EPA), Department of Defense (DOD), the Smithsonian, the Department of Health and Human Services (HHS), and Tennessee Valley Authority (TVA).

The lack of participation in USGCRP by non-NASA agencies has led to gaps in the overall program. For example, DOI, which manages large tracts of lands that could be affected severely by climate change, requested a decrease in USGCRP funds for both FY 1993 and FY 1994. DOI's position reflects a stance common to most agencies participating in USGCRP—budgets are tight and climate change does not present an immediate management concern. Another dimension of the problem of funding an appropriate mix of satellite and nonsatellite measurement pro-

grams is the historical attraction of Congress and the administration to space-based research. Workshop participants noted that Federal agencies may correctly perceive that it is easier to get financial support for large, space-based projects than for other research.<sup>24</sup>

### M Producing Timely "Answers" for Policymakers

The timetable for governmental decisions is driven by the yearly budget cycle and an election cycle that ranges between 2 and 6 years. Not surprisingly, policymakers funding global change research often have a shorter time horizon for "answers" than researchers. This disparity leads to tension between government officials who are required to formulate annual budgets and make immediate decisions, and the scientific community, whose long-term research depends on continuous and reliable funding. Workshop participants stated that when scientists cannot answer the questions of policymakers in 1 or even a few years, they find it more difficult to "sell" a program as relevant to policy needs. The result may be annual budget fluctuations and/or rapidly shifting priorities—both of which are detrimental to the development of a sound scientific program.

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<sup>23</sup> When contributing programs are included, NASA, DOD, and NOAA account for roughly 60 percent of funding allocations

<sup>24</sup> Even agencies doing space-based research may not necessarily be viewed as equal partners. NASA has been tasked to lead the space-based component of USGCRP, but NOAA and DOE participation is essential to complement NASA's effort. The example cited above, in which NSF and NOM received no funding for their part of an interagency program, while NASA received more than they requested for the same programs, illustrates how differently Congress may view some agencies in funding decisions.