

GAO

Report to the Chairman, Subcommittee on Oversight and Investigations, Committee on Energy and Commerce, House of Representatives

April 1987

ACID RAIN

Delays and Management Changes in the Federal Research Program



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Resources, Community, and
Economic Development Division

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April 29, 1987

The Honorable John D. Dingell
Chairman, Subcommittee on Oversight
and Investigations
Committee on Energy and Commerce
House of Representatives

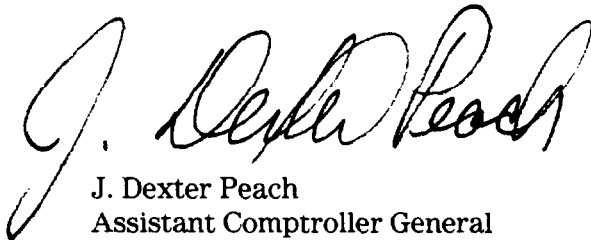
Dear Mr. Chairman:

This report is in response to your February 10, 1986, letter in which you requested we review several issues concerning the National Acid Precipitation Assessment Program. The report discusses the program's delays in producing assessments and other documents, the effects of recent management changes, and the status of the research program.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to interested parties and make copies available to others upon request.

This work was performed under the general direction of Hugh J. Wessinger, Associate Director. Other major contributors are listed in appendix V.

Sincerely yours,



J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

The debate continues: to what extent are acid rain controls needed to protect valuable resources? In 1980 the Congress established a 10-year, multiagency research program—the National Acid Precipitation Assessment Program (NAPAP)—to help resolve the scientific uncertainties associated with acid rain and determine if and how it should be controlled. Concerned about NAPAP’s progress to date, the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, requested that GAO review

- the extent to which NAPAP has conducted and issued assessments or analyses of its research,
- the impact that the September 1985 appointment of a director of research has had on NAPAP’s operations, and
- the status of NAPAP’s plans to address the research uncertainties associated with acid rain by 1990.

Background

Acid rain is formed when sulfur dioxide and nitrogen oxides emitted by coal-fueled power plants, motor vehicles, and other man-made or natural sources enter the atmosphere and return to the earth as acid components in rain, snow, or gases. Between fiscal years 1982 and 1987, the federal agencies involved with NAPAP spent about \$303 million researching the causes and effects of acid rain. The research is funded primarily by the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, and the Departments of Agriculture, Energy, and the Interior. Overall direction for NAPAP is provided by a Joint Chairs Council comprised of top-level officials from these five agencies and the Council on Environmental Quality. The Joint Chairs Council is chaired by the Environmental Protection Agency Administrator.

NAPAP research is conducted through seven task groups that are studying the causes and effects of the acid rain problem. These task groups are headed by senior scientists from the five funding agencies. Besides conducting research, NAPAP is also responsible for issuing (1) “assessments” that analyze the research findings; (2) annual reports that describe the progress of the research program; and (3) operating research plans that detail the scope of each research project. These are the major vehicles by which the public is kept informed about NAPAP research.

Results in Brief

NAPAP has yet to issue its first assessment report—originally scheduled for release in 1985 and now delayed until June 1987—because the new director of research has been extensively revising the document. NAPAP annual reports have also been issued late and have not included policy recommendations. NAPAP officials stated that the reports (1) are late because of the extensive reviews and staffing constraints and (2) do not contain recommendations because the scientific uncertainties are still too great to reach control strategy conclusions.

Federal scientists and research managers associated with NAPAP have mixed opinions about the effectiveness of having a single individual direct the research program. Several told GAO that having a central decisionmaker has provided needed focus to the research program. Others, however, said that (1) communication problems have increased between the various task groups and the director's office and (2) his office has become a bottleneck to the completion of key documents.

NAPAP officials believe that, by 1990, their ongoing research program will provide sufficient new information about the causes and effects of acid rain to serve as the basis for policy recommendations on acid rain controls. However, they acknowledge that they will not have answered all scientific unknowns in several areas, such as the effects of acid rain on forests and man-made materials. NAPAP has also substantially reduced its research on the economic effects of acid rain. Given these problems and the delays in reaching consensus on its first assessment, it is unclear whether NAPAP will meet its 1990 objective.

Principal Findings

Delays in Issuing Documents

Although NAPAP's enabling legislation requires it to issue annual reports by January 15 of each year, NAPAP has repeatedly missed that date by 6 to 13 months. According to NAPAP officials, these reports have not included policy recommendations because the scientific uncertainties have not been sufficiently resolved to allow such recommendations to be formulated.

NAPAP annual reports and plans through 1985 stated that NAPAP would issue periodic assessments in 1985, 1987, and 1989. These assessments represent NAPAP's only attempt to synthesize and analyze its overall research results for the general public. Through fiscal year 1985, NAPAP

spent \$6.7 million developing assessments. However, no assessment has yet been issued because the incoming director of research decided to significantly rework the 1985 assessment document. In December 1985 NAPAP officials told the Senate Committee on Environment and Public Works that the 1985 assessment would be issued in the spring of 1986. As of February 1987, the assessment release had been delayed to June 1987 because, according to the director of research, he has not had sufficient staff and he underestimated the time involved in getting the document reviewed and approved by the many NAPAP agencies.

According to NAPAP officials, the scope of NAPAP assessments will not be as broad as once envisioned. For example, although required by law to evaluate the economic effects of acid rain, NAPAP has reduced its efforts in this area considerably since 1985 and will probably include only minimal economic effects information in its first assessment. NAPAP officials believe that at this point it is more important to fund scientific than economic research.

Impact of Management Changes

When hired in September 1985, the director of research was given power to direct the program through a memorandum of understanding signed by the NAPAP Joint Chairs Council. He has tried to make several changes to the program, including refocusing the forest effects program to obtain short-term research results on the effects of ozone and acids on forest decline.

Some of the federal scientists and research managers associated with NAPAP told us that centralizing NAPAP's management under a single director has made the program stronger, better directed, and more organized. Others have stated that (1) communication problems between NAPAP task groups and the director have hampered NAPAP's effectiveness and (2) the director's office has contributed to delays in issuing key documents.

The director agrees that these problems exist, and he is taking steps to improve the situation, such as hiring additional senior scientists to help write the assessments. Several other factors beyond the director's control have contributed to these delays, including (1) difficulties in obtaining agreement on major issues among the participating agencies and (2) the large number of agency reviews involved in issuing the documents.

Status of NAPAP Research

NAPAP officials believe that its ongoing research program will answer many key unknowns and provide sufficient new information by 1990 to serve as the basis for policy recommendations on acid rain controls. NAPAP is focusing its research on several areas, including (1) validating regional air pollution models; (2) measuring dry deposition (deposition of gases and particles that occur apart from rain, snow, and fog); and (3) quantifying the effects of acid rain on lakes, forests, and man-made materials. NAPAP officials acknowledge, however, that uncertainties about the causes and effects of acid rain will remain beyond 1990. Uncertainties are also likely to exist concerning the economic effects of acid rain. Given these uncertainties, GAO notes, as it has in the past, that decisionmakers will continue to be faced with weighing the risks of further, potentially avoidable environmental damage against the risks of economic impacts from acid rain controls that may ultimately prove to be ineffective.

Recommendations

GAO makes recommendations on pages 39 and 53 to improve the program. Among its recommendations are that the Chairman of the Joint Chairs Council should (1) take necessary steps, such as the hiring of a deputy director for assessments, to ensure that key NAPAP documents are issued on a timely basis and (2) ensure that NAPAP sufficiently assesses the economic effects of acid rain, as required by law, so that decisionmakers will have improved information on the benefits and costs associated with various policy options.

Agency Comments

GAO discussed the factual material in the report with NAPAP officials, and their comments were incorporated where appropriate in preparing this report. At the Subcommittee Chairman's request, GAO did not obtain their views on the report's conclusions and recommendations.

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Abbreviations

DOE	Department of Energy
DOI	Department of the Interior
EPA	Environmental Protection Agency
GAO	General Accounting Office
NAPAP	National Acid Precipitation Assessment Program
NOAA	National Oceanic and Atmospheric Administration
RADM	Regional Acid Deposition Model
RCED	Resources, Community, and Economic Development Division
TVA	Tennessee Valley Authority
USDA	United States Department of Agriculture

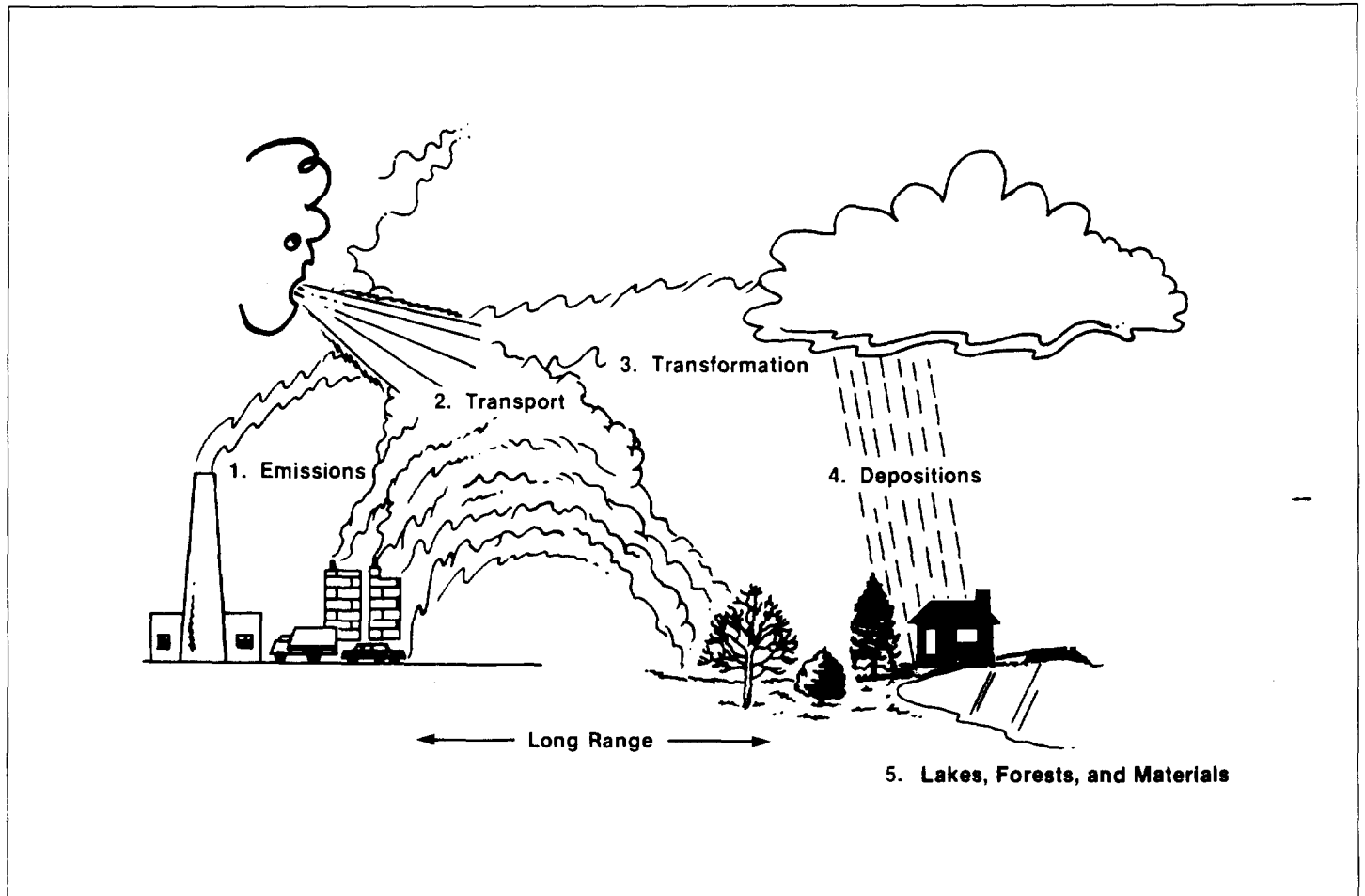
Acid Rain and the National Acid Precipitation Assessment Program

Acid rain remains one of the most controversial environmental issues of our time. Properly known as acidic deposition,¹ it has been the focus of scientific symposia, international conferences, and presidential summit meetings. Each year several acidic deposition-related bills to control its potentially harmful effects are introduced in the Congress.

Acidic deposition is formed when sulfur dioxide and nitrogen oxides emitted by coal-fueled power plants, motor vehicles, and other man-made and natural sources are transported in the atmosphere and return to earth as acid compounds. These compounds can be part of wet deposition, such as rain, snow, and fog, or dry deposition, such as particulates and gases. Figure 1.1 illustrates the atmospheric cycle of sulfur dioxide and nitrogen oxides from emission points to their deposition on forests, aquatic systems, and man-made structures.

¹Over time, several terms have been used to describe this phenomenon, including acid rain, acid precipitation, acid deposition, and acidic deposition. For purposes of this report, we use the more technically correct term, acidic deposition, which refers to the deposition of acidic material in both wet and dry forms.

Figure 1.1: Acidic Deposition Atmospheric Cycle



Source: Environment Canada.

There has been considerable debate over the linkages between these emissions, the observed damages, and responsibility for dealing with the problem. Acidic deposition has been linked to a number of environmental problems, including (1) declining fish populations in the north-eastern United States, southeastern Canada, Sweden, and Norway; (2) forest damage in West Germany, the eastern United States, and Canada; and (3) material damages, such as building erosion. However, the primary sources of the emissions that may be causing much of this damage are thought to be hundreds of miles away. For example, sulfur dioxide emissions from older coal-burning power plants in the Midwest are suspected of contributing to damage to aquatic systems in New York, New England, and eastern Canada. Central issues in this debate are:

- What is the extent of damage attributable to acidic deposition?
- What controls should be implemented to contain or reverse this damage?
- Who should pay for the controls needed to reduce emissions?

This debate has spotlighted the need for better scientific information concerning the causes, extent, and effects of acidic deposition. Much of this additional information is expected to come from the federal government's interagency acidic deposition research program.

The National Acid Precipitation Assessment Program

Concerned over the need for better and more complete information, the Congress passed the Acid Precipitation Act of 1980 (Title VII of the Energy Security Act of 1980, Public Law 96-294), establishing the National Acid Precipitation Assessment Program (NAPAP). The act also created an Acid Precipitation Task Force and directed it to develop and implement a comprehensive, 10-year national program to research the causes and effects of acidic deposition and recommend actions to limit or reduce its harmful effects.²

Formally organized in October 1980, the 20-member task force includes senior officials from the National Oceanic and Atmospheric Administration (NOAA); the Environmental Protection Agency (EPA); the Departments of Agriculture (USDA), Commerce, Energy (DOE), Health and Human Services, the Interior (DOI), and State; the National Aeronautics and Space Administration; the Council on Environmental Quality; the National Science Foundation; and the Tennessee Valley Authority. The remaining eight statutory members are the directors of four DOE national laboratories—Argonne, Brookhaven, Oak Ridge, and Pacific Northwest—and four presidential appointees.

NAPAP is directed by the Joint Chairs Council, comprised of agency heads or designees of DOE, DOI, EPA, NOAA, USDA, and the Council on Environmental Quality.³ The EPA Administrator is the chairman of the Joint Chairs Council. The primary responsibilities of NAPAP are to

- establish research goals for the program;

²For purposes of this report, we use the abbreviation, NAPAP, to represent the organization established by the Acid Precipitation Act of 1980. NAPAP is comprised of the Acid Precipitation Task Force, the Office of the Director of Research, the Joint Chairs Council, and the various interagency committees and task groups.

³The act specifies that the task force should be jointly chaired by the Secretary of Agriculture and the Administrators of EPA and NOAA. According to NAPAP's associate director, the other agency officials were added to assure their agencies' representation and reflect their funding contributions.

- develop and update research plans;
- coordinate research activities with the private sector and environmental groups, states, and other countries;
- maintain a listing of federally-funded research projects;
- develop an annual interagency budget for program research; and
- assess the implications of research results.

NAPAP developed and issued the 10-year national acid precipitation assessment plan required by the act in 1982. In 1984 NAPAP issued an updated plan outlining technical and programmatic details explaining how NAPAP's objectives were to be met in each research area. NAPAP has also issued five annual reports to the President and the Congress. Required by the act, these reports summarize, among other things, the major issues being addressed by the NAPAP research program.

NAPAP Budget

As we reported in our December 1985 report,⁴ the funding for NAPAP's acidic deposition research program has increased significantly since the program's inception. Five agencies—DOE, DOI, EPA, NOAA, and USDA—fund virtually all of the research. Table 1.1 shows EPA has provided \$186 million, or about 60 percent of the total research funds provided through fiscal year 1987.

Table 1.1: Total Acidic Deposition Research Funding by Agency Through Fiscal Year 1987

Dollars in thousands							
Agency	FY82	FY83	FY84	FY85	FY86	FY87	Total
EPA	\$9,125	\$11,436	\$14,608	\$34,512	\$60,507	\$55,608	\$185,796
DOI	2,110	3,567	4,995	8,396	6,387	5,200	30,655
DOE	2,544	2,060	3,929	8,736	8,622	9,002	34,893
USDA	1,349	2,963	2,808	9,100	5,333	11,039	32,592
NOAA	1,900	2,250	2,336	4,148	4,148	4,176	18,958
TVA	325	640	965
Total	\$17,353	\$22,276	\$28,676	\$64,892	\$84,997	\$85,665	\$303,859

NAPAP's Management Structure Was Changed in 1985

NAPAP's management structure has evolved over the 6-year life of the program. In October 1985 the Joint Chairs Council decided to change NAPAP from a decentralized program directed on a day-to-day basis by an executive committee of officials from the five major funding agencies to a more tightly structured program headed by a director of research. The director's duties include directing the research program and developing

⁴Acid Rain: Federal Research Into Effects on Waters and Forests (GAO/RCED-86-7, Dec. 17, 1985).

a series of assessment documents that analyze scientific understanding on acidic deposition.

NAPAP Organization Prior to 1985

From NAPAP's creation until 1984, the Research Coordination Council, a committee composed of various agency representatives, developed NAPAP research plans and budgets. From 1984 to 1985, the Executive Committee, consisting of senior science program managers from DOE, DOI, EPA, NOAA, and USDA was responsible for formulating, planning, and implementing decisions. The executive director, a NOAA official, was responsible for managing NAPAP's Program Coordination Office, implementing the Joint Chairs' and the Executive Committee's decisions through day-to-day directions, and communicating with the task groups.

Rather than directing the program, the executive director served primarily as a coordinator and facilitator. The official who served as executive director told us that he managed NAPAP by consensus. According to the December 1983 report of an ad hoc committee that reviewed NAPAP's operations, NAPAP's research objectives and plans were established through an interagency process. Under this management structure, no single individual had the responsibility to execute and integrate the NAPAP research program.

1985 Memorandum of Understanding Changed NAPAP's Management Structure

When NAPAP's executive director resigned in the spring of 1985, the Joint Chairs Council decided to replace him with someone who would have authority to direct the research program. According to NAPAP officials, the Joint Chairs Council had determined that the program needed a single individual who could be held responsible for the direction and operation of NAPAP and could act as the main spokesperson for the research program. In September 1985, the Joint Chairs Council hired an individual from private industry and gave him the title "director of research."

In October 1985 the Council signed a memorandum of understanding that provides for more centralized direction and gives the director of research more authority than the executive director had. The memorandum provided for the director of research to report directly to the Joint Chairs Council.

Under the 1985 memorandum, the director of research has greater responsibility for developing and implementing program plans and budgets, as well for directing development of the assessments. The director

also serves as NAPAP's chief scientist and principal spokesperson. The Joint Chairs Council continues to provide overall priorities and direction for NAPAP and to oversee its implementation.

Under the memorandum, the Executive Committee, now called the Interagency Scientific Committee, assists the director of research in planning and carrying out the program, and acts as the primary liaison between the Office of the Director of Research and the agencies. Under the prior organization, the Executive Committee was responsible for developing research plans. According to members of the Interagency Scientific Committee, the committee is more advisory and less involved in decision-making than it was prior to the establishment of the 1985 memorandum of understanding.

**Research Program
Reorganized**

After assuming his duties, the director of research and the Joint Chairs Council reorganized the management structure for the research program. Research is now conducted through seven task groups staffed by program managers and experts from the various federal agencies and national laboratories participating in NAPAP. Each task group is headed by a task group leader from the NAPAP agency designated as being responsible for coordinating the federal research effort in that area. The research is funded through a number of entities, including consulting firms, universities, and national labs. Table 1.2 shows the lead agencies and program responsibilities of each NAPAP task group.

Table 1.2: NAPAP Task Groups and Responsibilities

Task group	Lead agency	Responsibility
1. Emissions and control technology	DOE	Develop a data base showing past, present, and anticipated emissions that influence acidic deposition and devise methods to estimate the effects and costs of control strategies.
2. Atmospheric chemistry	NOAA	Determine how sulfur dioxide and nitrogen oxide emissions combine and chemically transform into acidic deposition.
3. Atmospheric transport	NOAA	Estimate the transportation of acid compounds through atmospheric and climatic models.
4. Atmospheric deposition and air quality monitoring	DOI	Develop a nationwide program to monitor the chemical composition of wet and dry atmospheric deposition.
5. Terrestrial effects	USDA	Determine the extent of, and acidic deposition's role in, damage to forests and other terrestrial resources—soils, vegetation, and crops.
6. Aquatic effects	EPA	Determine acidic deposition's effects on lakes, streams, groundwater, and aquatic life, and develop methods for restoring acidic lakes.
7. Materials effects	DOI	Determine acidic deposition's role in damage to man-made and natural materials, and develop methods to protect these materials from further damage.

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In addition to the Interagency Scientific Committee, NAPAP's management structure includes an Interagency Policy Committee comprised of senior policy officials from the funding agencies; it reviews NAPAP activities to ensure their responsiveness to policy needs. Figures 1.2 and 1.3 show the changes in NAPAP's management structure.

Figure 1.2: NAPAP Organizational Structure Prior to October 1985

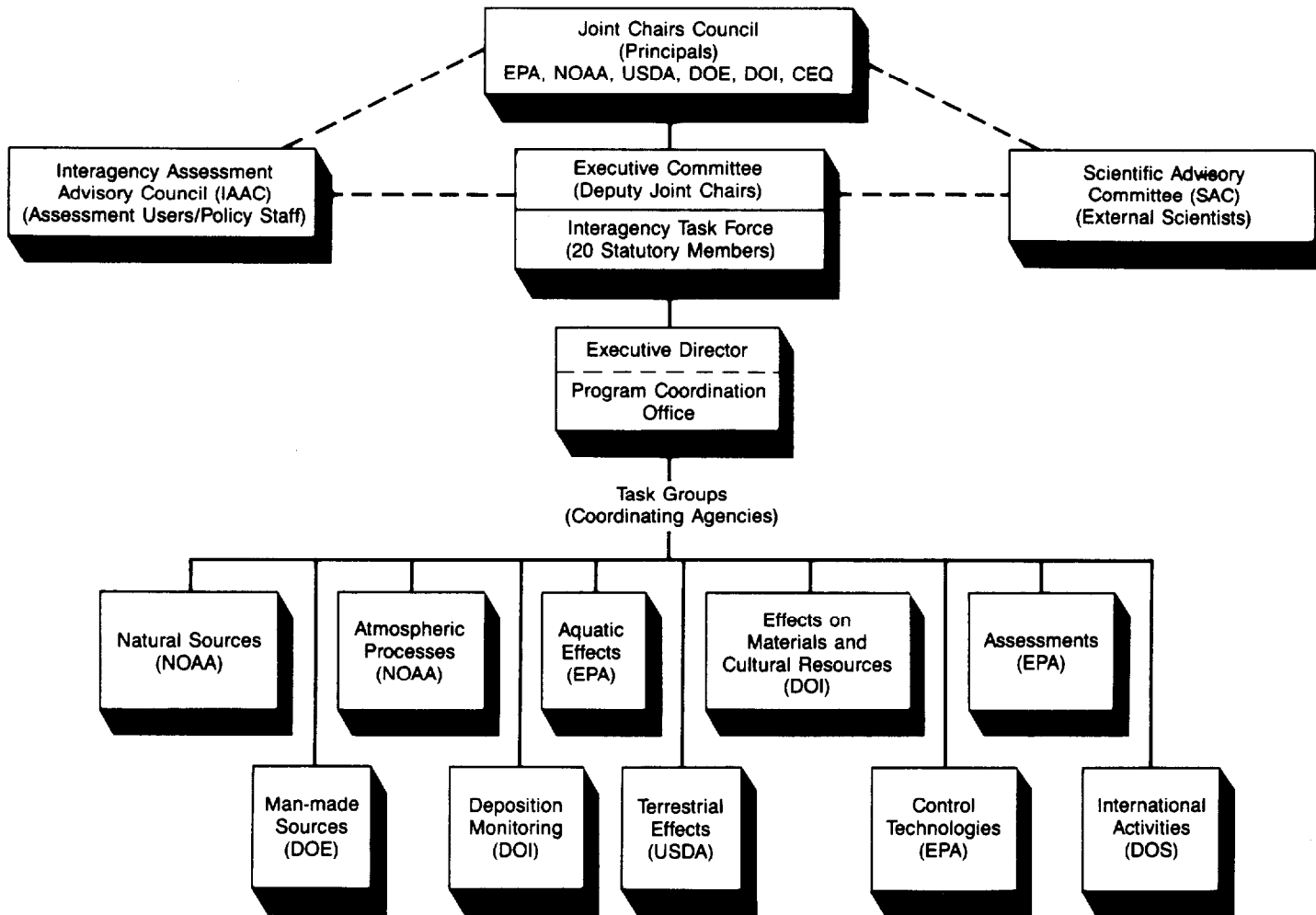
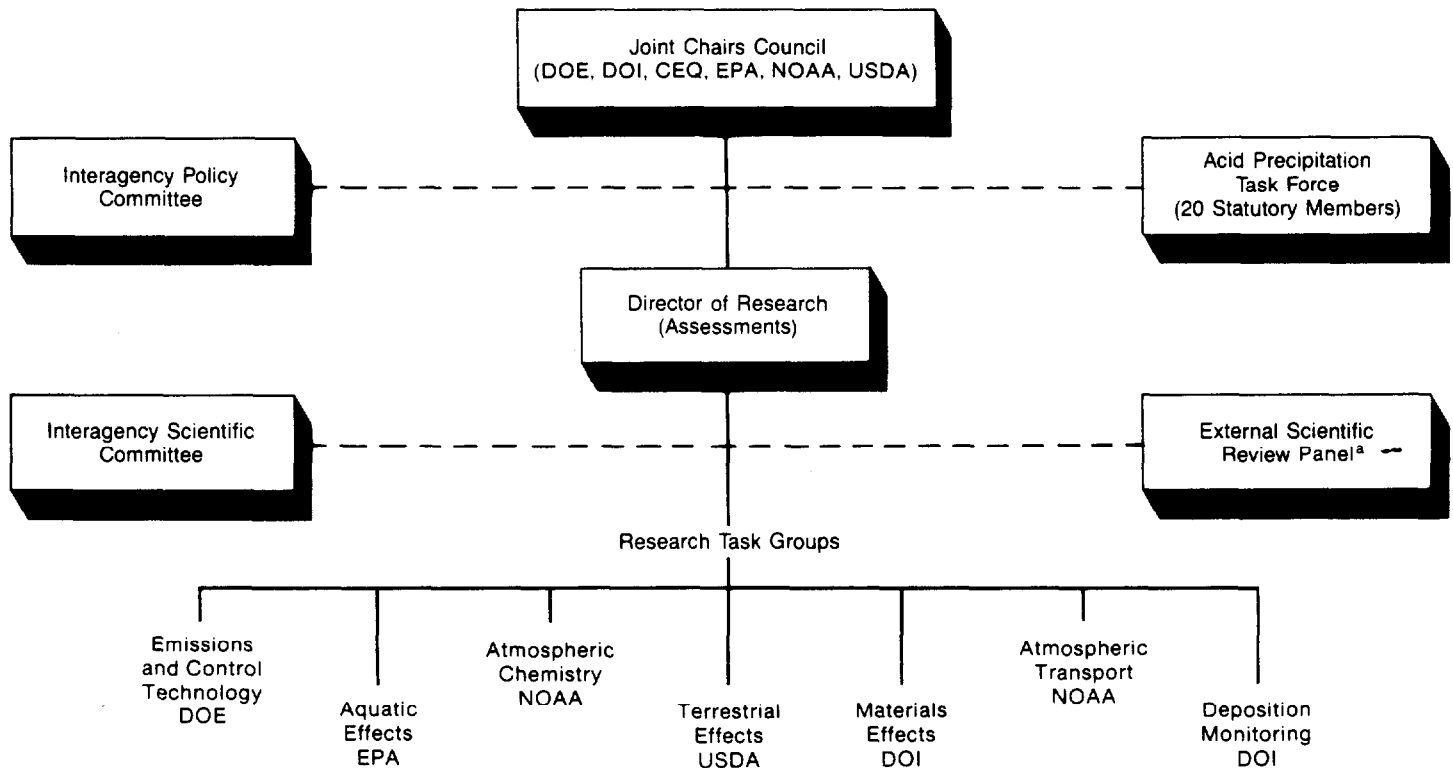


Figure 1.3: NAPAP Organizational Structure After October 1985



^aNot established as of February 1987. See chapter 3.

Objectives, Scope, and Methodology

In a February 10, 1986, letter and subsequent discussions with his office, the Chairman, Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, asked us to review the progress of the national acid precipitation assessment program, including

- the overall assessments or analyses that NAPAP has conducted and issued on its research into the causes and effects of acidic deposition;
- the impact that the September 1985 appointment of a director of research has had on the direction of its research program, including the travel costs of the Office of the Director of Research; and
- the status of NAPAP's plans to address the research uncertainties associated with acidic deposition by 1990.

We performed our review between May 1986 and January 1987 at the following locations:

- the Washington, D.C., headquarters of DOE, DOI, EPA, NOAA, USDA, and the Council for Environmental Quality;
- NAPAP's Office of the Director of Research in Washington, D.C.;
- the National Center for Atmospheric Research and NOAA's Aeronomy Laboratory in Boulder, Colorado;
- DOI offices, including the Bureau of Mines in Avondale, Maryland, and the U.S. Geological Survey in Reston, Virginia; and
- The Toronto, Canada, offices of Ontario's Ministry of the Environment and the Atmospheric Environment Service, Environment Canada.

To review the assessments and analyses developed by NAPAP, we reviewed documentation from NAPAP files of the now-disbanded Assessments Task Group. These included production schedules, drafts of various chapters, and comments from participating agencies. We also reviewed the draft 1985 assessment document prepared by the Assessments Task Group.

We discussed the development of the assessment with the director of research, the former NAPAP executive director, officials from NAPAP's Interagency Scientific Committee and Interagency Policy Committee, and members of the Office of the Director of Research and the Assessments Task Group.

We reviewed NAPAP plans for developing assessments and policy-relevant information in NAPAP operating plans, annual reports, and minutes from Joint Chairs Council and Interagency Scientific Committee meetings.

We discussed the value and content of annual reports with officials from NAPAP, environmental groups, industry organizations, and outside scientists. We also reviewed NAPAP documents and congressional hearings for information on NAPAP annual reports. We discussed the development and review of annual reports with the NAPAP associate director who is responsible for compiling the document. We also reviewed files of comments and drafts of the 1985 NAPAP annual report and production schedules for the annual report and the NAPAP operating research plans.

We reviewed economic analyses developed for the NAPAP assessments and discussed the need for such information with NAPAP officials,

including those from the Office of the Director of Research, the inter-agency scientific and policy committees, and the economists responsible for conducting the assessment work.

To assess the impact of the new director of research on the research program, we examined the October 1985 memorandum of understanding signed by the Joint Chairs Council giving the director new responsibilities. We discussed the development and implementation of the memorandum with officials from NAPAP's Interagency Scientific Committee and Interagency Policy Committee. We discussed the role and influence of the director of research with the director and officials in his office. We also discussed the management of NAPAP with the organization's former executive director and other current and former officials. We also reviewed the travel records for NAPAP's Office of the Director of Research for fiscal year 1986 in order to help determine the effect of travel time on other aspects of NAPAP's operations.

We also reviewed the December 1983 report of an ad hoc committee established by the Administrators of EPA and NOAA and the Secretary of USDA to review NAPAP research and management activities. We discussed the report and its recommendations with the chairman of the ad hoc committee and with the NAPAP director of research, members of the NAPAP Interagency Scientific Committee, and the former NAPAP executive director. We also reviewed the 1984 NAPAP memorandum of understanding that was signed by the Joint Chairs Council and implemented after the report of the ad hoc committee was released. We discussed the 1984 and 1985 memoranda of understanding with NAPAP officials and reviewed minutes of meetings from the Joint Chairs Council, the Interagency Policy Committee, and the Interagency Scientific Committee.

We also examined peer review reports of various aspects of the NAPAP research program. These periodic reviews are sponsored by NAPAP to obtain input on various aspects of the research program by national and international experts. We discussed the peer reviews and the need for a NAPAP external scientific committee to review NAPAP's direction and operations with 10 peer reviewers who have participated in 1 or more of the NAPAP peer reviews. We also discussed NAPAP attempts to use the National Academy of Sciences to establish an external scientific committee with NAPAP officials, officials from the National Academy of Sciences, and the chairman of the 1983 ad hoc committee to review NAPAP activities.

To review the extent to which NAPAP is on schedule for addressing research unknowns by 1990, we reviewed NAPAP's enabling legislation, the Acid Precipitation Act of 1980. We also reviewed the National Acid Precipitation Assessment Plan that NAPAP issued in June 1982 and the NAPAP Operating Research Plan issued in October 1984.

We discussed the research priorities outlined in these plans, as well as current goals and future research needs, with the task group leaders from each of the NAPAP task groups. We also discussed the status of the research programs with other officials from the task groups, former task group leaders of those groups that had recently changed leadership, the former NAPAP executive director, and the NAPAP director of research.

We reviewed documentation on research projects obtained from NAPAP files and other NAPAP documents, including annual reports and draft assessment documents. We discussed the major atmospheric model being developed for NAPAP with its project manager at the National Center for Atmospheric Research.

We visited a NAPAP forest project at the Mountain Research Center in Colorado and a NAPAP materials effects monitoring station in Washington, D.C. We also discussed the Electric Power Research Institute's acidic deposition research program, including coordination of its program with NAPAP, with an official from the Institute.

We discussed the NAPAP research program and management structure with representatives of several outside organizations involved with the acidic deposition issue, including the Environmental Defense Fund, the National Wildlife Federation, the Izaak Walton League, the Natural Resources Defense Council, the Utility Air Regulatory Group, the Electric Power Research Institute, the National Council for Air and Stream Improvement, the Edison Electric Institute, and the National Coal Association. We also discussed these issues with Canadian officials from the Atmospheric Environmental Service of Environment Canada and the Ontario Ministry of the Environment.

We discussed the matters contained in the report with NAPAP officials, and their comments have been incorporated where appropriate. In accordance with the chairman's wishes, we did not discuss our conclusions or recommendations with NAPAP officials nor did we request official agency comments on a draft of this report. With this exception, our

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review was performed in accordance with generally accepted auditing standards.

Assessments and Other Key NAPAP Documents Have Been Delayed

NAPAP has been sponsoring and conducting scientific research on the causes and effects of acidic deposition since 1982 but, as of February 1987, had not released any assessments or analyses of the program's overall research results. NAPAP has also experienced delays in issuing two other key documents—annual reports and research plans.

NAPAP issued a 10-year research plan in 1982, which it planned to update annually to accurately describe the evolving nature of its research program. However, as of February 1987, the plan had not been updated since 1984, and, as a result, it bears little resemblance to the current research program.

The Congress requires NAPAP to analyze the available information on acidic deposition and include any recommendations it develops in annual reports to be issued each January. However, NAPAP has not made any policy recommendations to the Congress in the reports it has issued to date because it believes the science has not advanced sufficiently to support firm conclusions. Furthermore, the reports have consistently missed the January deadlines because of insufficient staff and conflicting staff responsibilities as well as extensive agency reviews. NAPAP annual reports generally describe the status of the research program and do not analyze research results.

Since 1982 NAPAP has planned to publish its analysis of NAPAP's overall research results in a series of assessment reports to be issued in the mid- to late 1980's. The first of these assessments was planned for release in 1985 but, as of February 1987, had not yet been issued. According to NAPAP officials, the first assessment will be released to the public in June 1987. In addition to the delayed release dates, the scope of these proposed assessments has been scaled back over the years. For example, NAPAP's plans to include economic analyses in its first assessment document have been revised, and it is not clear how much, if any, economic work will be included in future NAPAP assessments. Also, NAPAP officials told us they are uncertain whether NAPAP will be able to meet its long-stated goal of producing by 1990 an "integrated" assessment that estimates the costs and benefits of various control options.

Lack of Research Plan Makes It Difficult to Determine Whether NAPAP Research Is on Schedule

In 1984 NAPAP issued a research plan that updated its original 1982 plan. The 1984 plan stated that NAPAP would publish annually an updated plan to reflect changes in the program. It is difficult to determine whether NAPAP's research program is on schedule because the program's priorities have changed over time and NAPAP has not issued updated annual plans that reflect these changes. As of January 1987, NAPAP's director of research planned to publish in the near future an operating plan covering fiscal years 1986, 1987, and 1988.

1982 Plan Updated in 1984

The Acid Precipitation Act of 1980 required NAPAP to develop and implement a 10-year interagency research plan to identify the causes and effects of acidic deposition and determine ways to mitigate its harmful effects. In 1982 NAPAP submitted the National Acid Precipitation Assessment Plan to the Congress.

The 1982 plan described the current state of scientific knowledge about acidic precipitation, as well as ongoing federal research activities. It also identified information needs, future research objectives, and timetables for completing research. The plan emphasized that research would be focused on the timely development of scientific information necessary for policy-oriented decisionmaking. This plan, together with any subsequent updates and revisions, was intended to guide the federal interagency research effort during the course of NAPAP's 10-year authorization.

In 1984, NAPAP updated this plan with an operating research plan that was designed to supplement the more general 1982 plan. It described all ongoing and planned research projects, their relationship to other research activities, and their contribution to NAPAP program objectives in each research area.

The 1984 plan was to serve as a key management tool for NAPAP in its planning and implementation of the acidic deposition research effort. It was also intended to guide NAPAP and member agencies in setting research goals, proposing new initiatives, developing the annual interagency budget, and assisting in the coordination of research with the activities of states, private sector groups, research institutes, environmental organizations, and other countries.

**NAPAP Research Plans
Have Not Been Updated
Annually**

The 1984 plan stated that it would be updated annually in order to reflect the evolving state of acidic deposition research, and any changes in NAPAP research priorities, objectives, and plans for future years. Although the 1984 plan stressed the importance of annual updates, as of February 1987, a more current plan had yet to be issued. According to NAPAP's director of research and research task group leaders, the 1984 plan bears little resemblance to the focus, goals, and priorities of the current NAPAP research program. For example, the terrestrial research in the 1984 plan emphasized more research on crop effects than forest effects. Since then, new information about forest decline has become available, and crop research has not indicated major impacts from acidic deposition. As a result, by 1985 the terrestrial effects research on forests was increased, and by 1986 research on the effects of acidic deposition on cash crops was cut back. Also, the materials section of the 1984 plan discussed planned work on economics and cultural and historic structures. According to the materials task group leader, the research priorities have changed, and the group is no longer conducting economic or historical structures work.

The NAPAP official responsible for assembling the operating research plan told us NAPAP had developed a draft 1985 operating plan updating the 1984 version. However, the incoming director of research determined in November 1985 that the plan should not be issued because the year it covered was ending. He decided NAPAP should update the plan to cover the 1986-88 time frame. As of February 1987, NAPAP planned to issue an updated operating research plan in early 1987 that would cover 1986, 1987, and 1988.

According to NAPAP's associate director, the updated plan has been delayed in part because of disagreements between the director of research and the task group leaders over the implementation of certain projects outlined in the plan. Another official in the Office of the Director of Research, who is responsible for helping compile the operating research plan, said the plan is a low priority in NAPAP; its primary value is informing outsiders about ongoing research. The NAPAP researchers have a clear understanding of what they are planning to accomplish without having a publically issued plan.

NAPAP Annual Reports Are Late and Do Not Include Policy Recommendations

Like the updated research plans, NAPAP's annual reports have also been delayed. NAPAP's enabling legislation requires it to evaluate the causes and effects of acidic deposition and issue annual reports each January that contain any recommendations it develops to the Congress and federal agencies. NAPAP annual reports have been issued up to 13 months late and have not included any recommendations.

Delays in Issuing NAPAP Annual Reports

The Acid Precipitation Act of 1980 requires NAPAP to evaluate the environmental, social, and economic effects of acidic deposition. Additionally, the act requires NAPAP to submit to the President and the Congress by January 15 of each year a report that (1) details the progress of the research program and (2) contains any recommendations it develops to the Congress and federal agencies about actions needed to alleviate acidic deposition and its effects.

Annual reports are important because, other than the research plans, they are the only NAPAP reports required by the Acid Precipitation Act of 1980. Since they provide the Congress and the President with periodic status reports of the program, it is important that they be timely. In a February 15, 1985, letter to the NAPAP task group leaders complaining about delays in issuing annual reports, the NAPAP Executive Committee (now the Interagency Scientific Committee) underscored the importance of the annual report, stating that it is an important document that gives the Congress, the Administration, and the public an essential statement of NAPAP's progress to date. In a November 1985 memorandum to task group leaders and other NAPAP officials, the director of research proposed publishing the 1985 report by April 1986, stating that publishing the results of the fiscal year work 6 months after that fiscal year has ended is a reasonable goal that will help demonstrate the program's productivity.

NAPAP has issued five annual reports. They describe the status of the program as of the previous fiscal year. For example, the report issued in June 1984 described the program for fiscal year 1983. In February 1987, NAPAP issued its most recent annual report, covering fiscal year 1985. The report described the program as of September 30, 1985, and did not reflect task group organizational changes made in late 1985.

With the exception of 1982, each NAPAP annual report has been issued 5 to 13 months beyond the January deadline established by law. As shown in table 2.1, subsequent reports were released at increasingly later intervals.

**Table 2.1: NAPAP Annual Report
 Release Dates**

Fiscal year covered in report	Report release date
1981	January 1982 ^a
1982	June 8, 1983
1983	June 11, 1984
1984	November 14, 1985
1985	February 25, 1987

^aNAPAP officials do not have records showing the exact issue date in January 1982.

NAPAP's associate director told us annual reports are written by officials in the NAPAP Office of the Director of Research and each of the seven NAPAP research task groups. Sections are redrafted to incorporate review comments and then sent back through the NAPAP agencies for a final review by members of the NAPAP task force. Fifty-nine officials from 12 government agencies and 4 task force presidential appointees were involved in reviewing the 1985 annual report. According to NAPAP's associate director, the 1985 annual report cost about \$68,000 to develop.¹

Several NAPAP officials told us the annual reports have been delayed because of insufficient staff in the NAPAP Office of Director of Research and extensive agency reviews. The NAPAP associate director—the official responsible for managing the preparation of the 1984 and 1985 annual reports—told us the completion of the two reports was slowed because of staffing problems. The 1984 report was not issued until November 1985 because the NAPAP executive director and other staff in the office resigned in the middle of the year and the work load became strained, delaying the annual report. The 1985 report was partially delayed because a person hired to work on the report left and had to be replaced. The annual reports have also been delayed because the task group leaders from the different participating agencies have busy schedules and are not always able to meet deadlines for authoring and reviewing drafts.

To improve the timeliness of future annual reports, NAPAP's associate director plans to (1) reduce the number of task group leaders who author the report and (2) have most of it drafted in the Office of the Director of Research. By reducing the number of officials responsible for developing the document, he believes the document should be released earlier in the year. He added that the planned addition of more senior

¹This includes estimates of the amount of money spent on the annual report by the Office of the Director of Research. See appendix III for a breakout of this cost. It does not include the cost of writing and reviewing the report by task group officials.

scientists in the Office of Research could help ensure that the 1986 annual report would be issued by April 1987. In December 1986, the NAPAP director of research told us that, by implementing these measures and giving his personal attention to the annual reports, he will ensure that the fiscal year 1986 report is issued in April 1987 and future reports are issued in January, as specified by law. He explained he spent much of his first year refocusing the research effort and, as a result, did not spend a great deal of effort ensuring that the annual report be issued in a timely manner.

Annual Reports Have Not Included Recommendations

The Acid Precipitation Act of 1980 requires NAPAP annual reports to include any recommendations NAPAP has developed for controlling acidic deposition and its effects. To date, NAPAP annual reports have not included any such recommendations. In an April 15, 1986, letter to the Chairman of the Senate Committee on Environment and Public Works, the EPA Administrator stated that the reports have not included recommendations because "the Administration does not believe that a decision regarding additional controls can reasonably be made, given the uncertainties in the science."

NAPAP annual reports have provided a general description of the federal research program during the prior fiscal year but have not attempted to analyze research findings or make policy-related assessments. Scientists and other officials external to NAPAP have complained not only about the timeliness but also the content of annual reports. A representative from the National Wildlife Federation told us NAPAP annual reports are very general and outdated by the time the report is issued. An industry group representative told us that, because the annual reports are issued a year after the fiscal year has ended, they are not very useful. A scientist who served on NAPAP peer reviews said the annual reports are bland and lack analysis. NAPAP officials stated they have decided to leave analysis of research results to a series of assessment documents.

NAPAP Has Not Released Any Assessment Reports

Over its lifetime, NAPAP has issued hundreds of documents in the form of project reports, agency reports and articles published in peer review journals on various aspects of the acidic deposition question. Since 1982 NAPAP has planned to issue a series of "assessments" that would go beyond the scope of these documents and the annual reports to examine the overall issue and develop policy-relevant analyses on how best to control sources of acidic deposition. To do so, NAPAP established an Assessments and Policy Analysis Task Group, which was responsible for

analyzing the research conducted by the other task groups and developing a series of assessments.

Although these assessment documents were not legislatively mandated, NAPAP reported to the Congress and the public on several occasions that it planned to issue these assessment documents. For example, NAPAP annual reports to the President and the Congress for 1983 and 1984 and the 1984 operating research plan all reported NAPAP plans to issue a series of these assessments in 1985, 1987, and 1989.

Evolution of the 1985 Assessment

The Assessments and Policy Analysis Task Group was comprised primarily of officials from EPA and DOE. It began work on the 1985 assessment in fiscal year 1983. According to task group estimates, by the end of fiscal year 1985 it had spent about \$6.7 million planning for and developing assessments. Most of this was spent on the 1985 assessment document. In 1984 the task group changed its name to the Assessments Task Group, deleting “policy analysis” from the title because, according to task group officials, NAPAP agencies determined that such analysis should be left to the policy offices in the various federal agencies. Between fiscal years 1983 and 1985, the task group prepared a series of outlines and drafts of the proposed 1985 assessment. The task group also began planning the format of the 1987 and 1989 assessments.

By the fall of 1985, NAPAP had compiled an assessment document (referred to as the draft 1985 assessment) to be published in three sections—an executive summary, a “main body” assessment document, and a series of technical documents supporting each chapter of the main body. By late 1985, all but the executive summary was written and reviewed by the NAPAP agencies. However, the newly-hired director of research met with officials from the NAPAP task group responsible for assessments in November 1985 and decided to significantly rework the document. According to the director of research, the draft 1985 assessment was not satisfactory because it had too many data gaps and was based on too many assumptions.

After the November meeting, the NAPAP assessments staff began reworking their chapters to respond to the comments of the director of research. In October 1985 the NAPAP Joint Chairs Council had signed a memorandum of understanding that disbanded the Assessments Task Group and moved the assessment function under the new director of research. However, the task group staff did not remain intact to work with the director on the assessment. Initially, much of the staff

remained involved in reworking the document, but during 1986 some were reassigned to other responsibilities in their respective agencies, and others contributed only on a part-time basis.

**Some NAPAP Officials
Believe the First
Assessment Could Have
Been Issued in 1985**

NAPAP documents and officials repeatedly emphasized the program's intention to release its first assessment in 1985. For example, in April 1985 remarks to the NAPAP Executive Committee, the Chairman of the Joint Chairs Council, noting the importance of completing the assessment in 1985, stated that NAPAP was 5 years into its program and that it was important that the report summarize and interpret the science to date.

According to the NAPAP official responsible for coordinating development of the 1985 assessment, it could have been released by December 1985. Other members of the Assessments Task Group agreed that the assessment, though uneven in some areas, could have been released and that the release would have given the program increased credibility with the Congress and the public.

Other NAPAP officials had mixed reactions about releasing the assessment in 1985. For example, one member of the Interagency Scientific Committee told us it was not a high quality document and should not have been released. Other committee members explained that the assessment could have been released after a good editing; that parts of the draft 1985 assessment were inadequate; or that the document should have been released in 1985. Two committee members told us NAPAP credibility would have been enhanced by meeting the 1985 deadline.

The NAPAP director of research told us that upon assuming his position in 1985 he found NAPAP agency officials, except those in EPA, were widely dissatisfied with the draft 1985 assessment. He explained that the draft 1985 assessment was not a consistently high quality document; several sections needed to be rewritten; and the effort he has put into the document during 1986 will make it more scientifically defensible.

**Delays in Completing the
First Interim Assessment**

The director of research has been responsible for the assessment function since he was hired in October 1985. He has repeatedly moved back deadlines for its release since then. In December 1985 he told the Senate Committee on the Environment and Public Works that the 1985 assessment would be released in spring 1986. In an April 1986 letter to the Chairman of the House Committee on Energy and Commerce, the

director of research stated that the assessment would be released in October 1986; in a July 1986 letter to the Chairman, he stated that it would be released by the end of 1986. In October 1986, NAPAP officials told us the assessment would be released in early 1987. In December the Chairman of the Joint Chairs Council wrote a letter to the director of research complaining about delays in producing the assessment and requesting the director to develop a detailed schedule for its completion. The director responded to the Chairman's letter with a schedule to issue the assessment by June 1987.

The director of research told us the delays have been caused, in part, by his lack of government experience and his need for more staff. He plans to add more senior scientists to his staff to help with the assessment effort. Several NAPAP officials agreed but added that the delays have also resulted from the director's personal review and approval of every detail of the assessment document. The extent of the director's involvement in reviewing documents is further discussed in chapter 3.

The process for developing the assessment changed after the Joint Chairs Council abolished the Assessments Task Group and moved the assessment function under the director of research. In writing the draft 1985 document, the Assessments Task Group developed several outlines and drafts of chapters that it sent out for comment to various NAPAP officials. In rewriting the 1985 assessment, the director of research has used a different process. He has worked individually with the authors of each chapter, having them provide him with drafts that respond to his specific comments. The NAPAP officials we interviewed had not seen drafts of any of the assessment chapters until December 1986 when the chapter discussing acidic deposition's effects on crops was released for review. Some of them expressed concern that considerable delays would result from the review process after the draft was available from the Office of the Director of Research. The associate director of NAPAP told us that he hopes the extra time spent will result in a higher quality document that will not require reviews as lengthy as those for the draft 1985 assessment.

In March 1986 the director of research renamed the 1985 assessment the "first interim assessment." The 1987 assessment is now referred to as the second interim assessment, and the 1989 assessment will be called the final assessment. In a September 5, 1986, letter to the Chairman of the Subcommittee on Oversight and Investigations, House Committee on Energy and Commerce, the director wrote that the second interim

assessment is planned for release in spring 1988 and the final assessment for fall 1990.

NAPAP Assessments May Omit Important Information

The scope of the NAPAP assessment effort has changed over the life of the research program. As discussed earlier, NAPAP plans to issue a series of assessment documents. NAPAP documents stated that the assessments would attempt to tie together the costs of controls with the benefits of emissions reductions. It is unclear whether NAPAP will be able to accomplish this objective in future assessments.

Prior to 1986 NAPAP Planned to Conduct Integrated Assessments

NAPAP has long planned to focus its assessment efforts on the development of an integrated assessment document. NAPAP annual reports and operating research plans released prior to 1986 indicated that a primary objective of the program was the issuance of a series of integrated assessments. NAPAP's 1984 operating research plan defined an integrated assessment as an analysis that combines available information on the (1) emission, transport, transformation, deposition, and effects of acidic materials or their precursors; (2) costs of emission control strategies; and (3) benefits of reduced acidic deposition or mitigated damage achieved by these strategies. By tying together the costs of emission controls with the benefits those controls will provide in the form of reduced damages to forests, lakes and other ecosystems, and man-made structures, NAPAP could give decisionmakers some indication of the benefits that would be derived from various control alternatives. For example, an integrated assessment might address the question: What benefit to terrestrial, aquatic systems, and man-made materials could be derived from a 10 percent reduction in sulfur dioxide emissions or a 15 percent reduction in emissions of volatile organic compounds?

NAPAP documents have described plans for conducting integrated assessments. The 1984 operating research plan stated that the 1985 assessment would focus on

- an assessment of current damages attributable to acidic deposition;
- an analysis of the degree of uncertainty remaining in key scientific areas, especially emissions and atmospheric processes;
- the implications of uncertainty in these areas for policy alternatives; and
- a description of the framework for the integrated assessment methodology.

The 1985 assessment, then, was to be a state-of-the-science document with some economic and uncertainty analysis included. The plan stated that more comprehensive assessments based on an integrated framework that combines emission models, source-receptor relationships, and dose-response functions were planned for 1987 and 1989.²

The idea was to attempt this integration in 1987 and improve it for a final integrated assessment in 1989. From 1982 to 1985, NAPAP focused a great deal of effort on meeting these objectives. With the assistance of the four national laboratories and Carnegie-Mellon University, NAPAP began designing a framework for future integrated assessments. This included developing a simplified model for integrated analyses of all aspects of the acidic deposition problem and more detailed models for analyzing the effects of acidic deposition on forests, aquatic systems, and materials. In February 1984, NAPAP convened a peer review panel to examine its assessment activities. The peer review panel reported it was impressed with the breadth and quality of the work presented but believed NAPAP was being too conservative in integrating and assessing the state of knowledge for policymakers.

Future of Integrated Assessments Is Uncertain

It is unclear whether NAPAP will release an integrated assessment document by the end of the 10-year program, as previously planned. Several NAPAP officials told us they were uncertain of NAPAP's plans for conducting integrated assessments. The DOE representative of the Interagency Scientific Committee stated that there may not be enough information available to complete integrated assessments. The USDA representative told us that NAPAP is moving away from a goal of integrated assessments. The NOAA representative agreed that focusing on an integrated assessment is important, but he is unsure whether NAPAP will be able to reach that goal. The DOI representative told us he is "moderately optimistic" that NAPAP's final assessment will be an integrated one. Additionally, NAPAP is not funding any of the integrated assessment modeling work that was initiated prior to fiscal year 1986. The EPA representative to the Interagency Scientific Committee explained that the modeling work proved to be too uncertain, and NAPAP would rather spend its limited funding on other research.

NAPAP's associate director told us the integrated assessment concept has not been completely rejected, and NAPAP will go as far in that direction

²Dose-response work involves quantifying the relationship between acidic deposition and changes in the environment, such as tree growth rates and crop yields.

as the science will permit. However, he stated that NAPAP faces two major obstacles in its efforts to complete an integrated assessment: developing a credible source-receptor model and developing dose-response functions.

NAPAP Plans to Limit Economic Analysis in the Assessment Document

The Acid Precipitation Act of 1980 requires NAPAP to evaluate the environmental effects of acidic deposition. The act calls for the development and implementation of a plan that includes a comprehensive program for assessing the economic effects of (a) acidic deposition on crops, forests, fisheries, and recreational and aesthetic resources and structures and (b) alternative technologies to remedy or otherwise ameliorate any harmful effects that may result from acidic deposition. Such analysis would provide the Congress with additional information needed to help make educated policy decisions concerning acidic deposition control strategies.

Economic analysis is also an important element in developing an integrated assessment. Of particular importance is the development of methodologies that can be used to generate reliable estimates of the costs and benefits associated with specific policy options. NAPAP's draft 1985 assessment included an analysis of the economic impact of acidic deposition on aquatic systems, crops, forests, and man-made materials. However, because of flaws in the scientific methodology and gaps in the data supporting the economic effects analysis, NAPAP plans to include little of this information in the first interim assessment scheduled for release in 1987. Moreover, NAPAP is currently conducting very little economic analysis of the effects of acidic deposition, and it is unclear how much of this work it will support in the future.

NAPAP Conducted Economic Damage Assessments Prior to 1986

Since 1982, NAPAP annual reports and plans have indicated that an analysis of the economic benefits and costs associated with acidic deposition controls was an important part of NAPAP's overall research and assessment agenda. For example, the 1984 operating research plan stated that NAPAP planned to include, in its first assessment document, estimates of the economic damages to at least one region of the country in the areas of recreational fishing, commercial timber, ecosystem values, and structural and cultural materials.

Between 1982 and 1985, the Assessments Task Group developed information on economic methodologies in order to help assess the economic impact of acidic deposition on natural and man-made resources. The

estimates of economic damages were then to be used to estimate the economic benefits of reductions in the rate of acidic deposition. Additionally, there were plans to develop the capability to perform integrated control strategy analyses, thus enabling the development of regional cost/performance data for selected mitigation options.

The Assessments Task Group conducted economic analyses on each of the effects areas and planned to include this work in its first assessment document planned for release in 1985. These analyses estimated the economic impact of the effects of acidic deposition on various man-made and natural resources. The resulting studies indicated that the economic costs attributable to acidic deposition may be substantial in some areas. This is especially true of materials damages, particularly painted surfaces. However, as discussed below, peer reviews of these efforts suggest that substantial additional work is necessary to support the validity of these findings.

Materials Damage Information in the Draft 1985 Assessment

NAPAP's economic estimates for man-made materials were the most controversial of those estimates included in the draft 1985 assessment. This work has been criticized in peer review panels and, according to the director of research, will not be represented in NAPAP's first interim assessment. The materials damage assessment prepared for the draft 1985 assessment estimated that the total annual costs of damages resulting from acidic deposition could range from \$0.7 billion to \$6.7 billion, with a best guess estimate of \$2.25 billion. These figures suggest that the economic impact of acidic deposition on materials may be quite substantial.

These estimates were questioned within NAPAP and became the focus of a peer review organized by DOE's Oak Ridge National Laboratory. The peer review report concluded that any empirical results based on the damage functions used in the estimates would be generally suspect. The report particularly criticized the analysis concerning the effects of acidic deposition on painted surfaces and stone and mortar. To the extent that the damage functions employed incorrectly model the rate and extent of materials damage due to acidic deposition,³ any empirical estimates of the costs incurred would be biased accordingly.

³A damage function consists of an equation that describes the relationship between the degree, or rate, of damage to a particular resource and the ambient pollution concentration to which the resource is exposed.

NAPAP Economic Analysis of
Aquatics Effects

NAPAP's economic analysis on aquatics has concentrated on the effects of acidification of lakes in the Adirondacks and the associated potential losses in recreational fishing. In the draft 1985 assessment, NAPAP used standard econometric techniques to estimate a loss ranging from \$0.7 to \$12 million annually in recreational benefits as a result of acidification of the lakes in question. However, to the extent that there are non-user values associated with the existence of fish populations in the Adirondacks, this figure may well understate the total losses in the Adirondacks attributable to acidic deposition.

Economic Analysis of Terrestrial
Effects

Because NAPAP does not have conclusive results on the effects of acidic deposition in forests, its estimates of the economic damages incurred have been based on hypothetical decreases in tree growth rates ("what if" scenarios). For example, although the exact dose-response function is unknown, a range of possibilities showing possible economic impacts could be presented. NAPAP economists used models of the forest products market to analyze the effects of hypothetical declines in tree growth rates. They generated dollar estimates of the losses in forest output that could be attributed to acidic deposition under each of the scenarios considered.

NAPAP's economic analyses regarding the effects of acidic deposition on crops completed thus far suggest that such effects are minimal. However, as discussed in chapter 4, only a limited variety of crops—primarily different strains of soybeans—have been analyzed. On the basis of this information, the analysis prepared for the draft 1985 assessment concluded that, given the growth-stimulation effects of nitrogen, the economic impact of acidic deposition on crops may actually be of some small benefit.

NAPAP Has Deemphasized
Economic Analysis In Its
Assessment

Several events occurred during 1986 that reflected a trend to downplay the role of economic effects research in NAPAP. When the assessment function shifted from the Assessments Task Group to the Office of the Director of Research, the economists working on the assessment eventually left the staff and were not replaced. Furthermore, according to the director of research, most of the economic analysis on the effects of acidic deposition prepared for the draft 1985 assessment would not be included in the first interim assessment, to be released in 1987. It is unclear how much economic analysis will be included in future assessments. The director of research told us that until the effects of acidic

deposition can be quantified, NAPAP will not be funding any economic analysis efforts.

In order to develop cost-benefit information to compare potential control strategies, it is necessary to obtain both scientific (in the form of damage functions or dose-response relationships) and economic data. The former would estimate the rate of damage to a resource from acidic deposition and the latter would estimate the cost of that damage to the public.

Prior to October 1985, NAPAP was spending about \$300,000 per year to examine the economic effects of acidic deposition. These relatively modest efforts were managed primarily by two economists assigned to the Assessments Task Group. The economists' terms of appointment to NAPAP's assessment staff lapsed, and they were not replaced.

Since late 1985 NAPAP officials have planned to concentrate on improving the science while reducing the economic work. The director of research told us that the science of acidic deposition and media damage is not sufficiently advanced to support economic assessments at this time. Several NAPAP officials told us that they agree with the decision to downplay economic analysis at present, arguing that the damage functions must be improved before economic work can be continued. According to these officials, economic estimates that provide a range of costs based on "what if" analyses may be misinterpreted by the public and, as a result, damage the validity of the research program. They are concerned that the caveats associated with such an analysis would be ignored and that any numbers generated would be taken out of context.

In December 1986, NAPAP's director of research told us the only economic estimates on pollution effects to be included in the first interim assessment will be the effects of ozone on crops.⁴ More economic estimates will be included in the final 1990 assessment if the science has progressed sufficiently to support its inclusion. The director said until the effects of acidic deposition can be quantified, NAPAP will not be funding any additional efforts between now and 1990, but he would encourage the federal agencies to conduct this work independently of NAPAP.

⁴In contrast to the economic estimates on effects of acidic deposition, NAPAP's first interim assessment will probably include more information on the cost of controlling emissions of sulfur dioxide and nitrogen oxides. NAPAP has developed (1) cost data on control technologies and (2) electric utility models to generate estimates of costs incurred in varying emission rates.

Other NAPAP officials we interviewed were concerned that the economic effects analysis is being downplayed in NAPAP. They told us such information is important and that the assessment was intended to be more than a scientific document; it should actually assess the issue and include such information as the estimated cost of various control options.

The officials involved in developing the economic effects assessments for the draft 1985 assessment have expressed concern over the decision to postpone further economic analyses. They cite both the amount of additional research necessary to support sound economic analyses and the requirement for such analysis in NAPAP's enabling legislation as reasons for continuing with economic research at this time. Additionally, economists involved in NAPAP's efforts to date have pointed out that work still needs to be done on the methodologies and models used to assess the economic impacts of acidic deposition. They argue that this work should proceed now so that analysts will be in a position to utilize the results of the scientific analyses once they are available.

This concern—as it relates to materials research—was echoed by a report of an April 1986 external peer review panel of NAPAP's materials effects research program. The report criticized NAPAP's lack of focus on the economic aspects of materials damages. It said that the economics effects work is critical to the development of the 1990 assessment and needs considerable financial resources and talented analysts.

**Economic Work Needed to
Improve Analysis by 1990**

There are a number of research topics that NAPAP should pursue to improve its economic analyses, according to a NAPAP peer review panel report, economists formerly associated with NAPAP, and industry representatives. They stated that, while damage functions are being improved and other scientific studies are being conducted, NAPAP should improve its economic data to be better prepared to undertake improved economic assessments once reliable damage functions are available. The needed studies include:

- work on how often individuals and businesses repair painted surfaces damaged by acidic deposition;
- a disaggregated model of the forest industry to analyze the possible effects of growth declines on specific regions of the forest products market;
- an analysis of the economic aspect of the health effects of acidic deposition;

- a model capable of valuing the aquatic effects of acidic deposition outside of the Adirondacks, including the development of information on the contingent valuation of the non-user aspects of the effects of aquatic damages; and
- additional analysis of the fertilizer effect of acidic deposition on crops and the potential impact of adding lime to soil to offset the adverse effects of acidic deposition on crop yields.

Federal Agencies Are Conducting Some Economic Analysis Outside of NAPAP

NAPAP officials told us that NAPAP is currently sponsoring limited economic research on materials and forests and none on aquatics or crops. We contacted officials at EPA and USDA, which fund research on these issues to determine whether these agencies are independently conducting economic research on the effects of acidic deposition. According to EPA officials responsible for research on crops and aquatics, there are currently no efforts underway to determine the economic effects of acidic deposition on these resources. A representative from EPA's Corvallis laboratory stated that the lab is involved in doing economic analyses of the effects of ozone on crops, but it is not examining the possible economic effects of acidic deposition. The Corvallis laboratory no longer has an agricultural effects program in acidic deposition and is not providing any economic analyses to NAPAP.

EPA officials indicated that work is ongoing, independent of NAPAP, to develop techniques to determine the economic impacts of ozone on the aesthetic value of forests. While it might be possible to extend this work to the effects of acidic deposition on forests, there are no plans to do so in the near future. As part of its efforts under NAPAP, the U.S. Forest Service is also working with EPA's Corvallis laboratory to develop methodologies for estimating the economic impact of acidic deposition on forests.

EPA is also conducting research on the benefits of reductions in a variety of air pollutants, such as sulfur and volatile organic compounds. An EPA official told us, however, that while the methodologies being developed could be used to assess the economic effects of reductions in acidic deposition, the work currently underway is not motivated by the needs of NAPAP; instead, it is being developed in response to other regulatory needs.

With respect to materials damages, as part of its efforts under NAPAP, EPA is in the process of revising the paint damage function developed for the 1985 draft assessment. EPA also completed a materials survey in four

northeastern cities. The purpose of this work was to inventory the quantity and distribution of various materials in the northeast that could be adversely affected by acidic deposition. However, while the study concluded that additional work is necessary in this area, there is no money in EPA's fiscal 1987 budget for it.

Additional work in the area of materials damages is being undertaken by the Electric Power Research Institute. Specifically, the Institute plans to conduct a survey in the second half of 1987 to generate information on consumer behavior with respect to increased maintenance requirements associated with the effects of acidic deposition on man-made materials. According to an Institute official, while the Institute is attempting to coordinate these efforts with EPA and other organizations, NAPAP is not currently involved in these efforts.

In summary, while some work is underway to examine the economic effects of acidic deposition and methodologies for estimating the magnitude of those effects, NAPAP does not appear to be coordinating these efforts so they can be used in future assessments. Consequently, it is not certain that the results of these efforts will be easily integrated with the results of NAPAP's scientific inquiries in time to be included in NAPAP's final two assessments, scheduled for 1988 and 1990.

Summary and Conclusions

Acidic deposition remains a highly visible and controversial issue in the 1980's. Over the past few years, members of the Congress have introduced bill after bill in an attempt to deal with the problem. NAPAP is in a critical position to address many of the uncertainties that cloud the debate over control of emissions that contribute to acidic deposition.

The agencies participating in NAPAP will have spent over \$303 million dollars through fiscal year 1987 conducting research into the causes and effects of acidic deposition. However, NAPAP has not yet provided the Congress or the public with a comprehensive assessment of what it has learned to date.

Annual reports, operating research plans, and assessment documents are the key vehicles by which the public and the Congress can be kept informed about NAPAP research. As a result, it is critical that they be informative and be issued in a timely manner.

The Acid Precipitation Act of 1980 requires NAPAP to issue annual reports each January and to include any recommendations that NAPAP

may have developed; the reports have been issued up to 13 months late and have not included recommendations. In addition, NAPAP's operating research plans have not been updated annually as planned. As a result, it is difficult to gauge NAPAP's research progress in light of changing priorities, expected results, and remaining uncertainties.

NAPAP has spent a great deal of time and money developing an assessment document, but it has repeatedly missed its deadlines for issuing the document. NAPAP officials plan to issue the first interim assessment in 1987, with future assessments to be issued in 1988 and 1990.

The assessment concept has evolved over time, and it is not clear that what is currently being planned for the assessment will meet the goals established in previous NAPAP annual reports and plans. There is also some question as to the meaning of the term "assessment" and how it applies to NAPAP's ongoing effort. Some NAPAP officials believe an assessment should actually provide economic data and policy alternatives. Others believe it can be no more than a state-of-the-science document that discusses what the research has found to date. According to NAPAP officials, the first interim assessment document will provide a high quality peer-reviewed status report of what the scientific research has shown to date.

According to NAPAP officials, the first assessment will include minimal economic analysis of the effects of acidic deposition, and NAPAP is planning to sponsor only limited economic research in this area between now and 1990. An analysis of the economic effects of acidic deposition is required by the Acid Precipitation Act of 1980 and would be a critical component of an integrated assessment or any other effort to weigh the costs and benefits of acidic deposition control.

We recognize that there is a great deal of uncertainty associated with economic analysis and that such efforts may not provide any more than ranges of benefits associated with controlling acidic deposition. We also recognize that improving the scientific knowledge of the effects of acidic deposition is critical. However, we believe that with some additional efforts NAPAP can work towards improving its economic effects information while simultaneously concentrating on improving the scientific damage functions. At a minimum, the improved economic information could help to indicate where future scientific research efforts may be most beneficial.

Recommendation

To ensure that the Congress is provided with the best information available concerning the economic effects of acidic deposition, we recommend that the Chairman of the NAPAP Joint Chairs Council identify economic information needed to assess the acidic deposition issue and ensure that the associated analyses be undertaken. This effort should include (1) the review and coordination of the economic effects assessment work currently being conducted by federal agencies and organizations outside of NAPAP and (2) the identification of gaps that remain to be addressed to meet NAPAP goals in such work.

Chapter 3 discusses the director of research's role in reviewing NAPAP documents, such as the assessment, and includes a recommendation addressing delays in issuing annual reports, operating research plans, and assessment documents.

Recent Management Changes Have Had Mixed Effects on NAPAP Operations

When the Joint Chairs Council determined that more centralized management was needed for the multi-agency program, it hired a director of research and gave the director more authority than his predecessor, the executive director, had to direct NAPAP's research effort. It also gave the director responsibility for managing the program's assessment effort. The director of research has used this authority to help concentrate the research program on obtaining policy-relevant information by 1990 and on addressing issues such as the role of oxidants in the acidic deposition phenomenon.

In the memorandum of understanding outlining NAPAP's new management structure, the Joint Chairs Council agreed that an external scientific committee should be established to review the major scientific issues NAPAP was addressing. NAPAP has not established this committee because it could not work out an acceptable arrangement with the National Academy of Sciences. As of January 1987, NAPAP officials had not decided whether to use other groups to staff this committee or whether to abandon the concept altogether.

NAPAP officials have mixed opinions about the effectiveness of having a single individual direct the research program. Most agree that it is important to centralize the assessment function under the director of research and that the new director has done a good job of focusing the research program. Some officials, however, are concerned about communication problems between task groups and the Office of the Director of Research, as well as delays in issuing key NAPAP documents. There are also a variety of factors outside the director's control that have contributed to these problems. They include difficulties in getting agreement from the many agencies involved in NAPAP and the director's lack of control over the research budget.

NAPAP's New Director Has Refocused the Research Program

NAPAP's director of research told us he was given four objectives upon assuming the job: redirect the research program; improve NAPAP's focus; improve the program's coordination; and improve the quality of research. To accomplish these objectives, the director has taken an active role in learning about the various research projects, attending numerous task group meetings, and reviewing NAPAP documents. As we discussed in chapter 2, the director has assumed responsibility for managing NAPAP's assessment effort. He has also been involved in developing the fiscal year 1988 budget. To increase the capabilities of his office, the director has hired two scientists and would like to hire additional scientists in the future.

To date, the director has influenced several aspects of the research program, including (1) focusing NAPAP research on obtaining key information on the causes and effects of acidic deposition by 1990, (2) increasing the emphasis on researching the effects of oxidants in the acidic deposition phenomenon, and (3) helping restructure the materials research program.

Setting 1990 Goals

The director of research told us that when he assumed his position in NAPAP, he found the program had no plans to meet specific objectives by 1990, the last year of the 10-year research program. To remedy this problem, he developed a list of goals for NAPAP to accomplish by that time. (See app. II for a list of these goals.) The goals are structured to provide NAPAP with information on what the director calls "first order effects"¹ on all major scientific uncertainties by 1990.

The director of research said his biggest single accomplishment has been to focus NAPAP's research to get results by 1990. By defining goals, NAPAP can structure its program to get specific answers in an acceptable time frame. NAPAP funds can be used more productively, with money going to research projects that will help meet the 1990 goals.

Increased Emphasis on Oxidants Research

According to members of the Interagency Scientific Committee and the Interagency Policy Committee, the director has emphasized increasing NAPAP's research into the role of oxidants in acid formation and the effects of ozone on forest decline. The director wants to focus on ozone because he believes that the damage observed in high-elevation forests may be attributable to ozone rather than acidic deposition. Created by emissions of volatile organic compounds and nitrogen oxides, ozone is present in the clouds that often bathe the mountain tops where forest decline has been observed. Although NAPAP was conducting some ozone-related research before October 1985, the new director has emphasized the need for increased study of ozone's effects.

At the director of research's urging, NAPAP has begun to gather information on the amount of ozone in rural areas. (EPA and states already operate an extensive program to monitor ozone levels in urban areas.) NAPAP is developing a dry deposition monitoring network, which will monitor for ozone as well as the precursors to acidic deposition. The

¹Determining a first order effect involves identifying the cause that has a high degree of certainty of being the major contributor to a given effect.

Interagency Scientific Committee agreed with the director to move 5 of the proposed 30 dry deposition and ozone monitoring stations to south-eastern forest areas.

The director of research is supporting chamber studies on tree seedlings to determine what pollutants are causing decline in forests. From these experiments NAPAP hopes to develop first order effect information about the relative impact of ozone, as well as sulfur dioxide and nitrogen oxide, on seedlings. The director told us this information will provide some short-term answers to the forest damage problem by 1990.

There has been some disagreement among NAPAP's various agencies concerning the director's emphasis on ozone research. For example, since EPA and the Forest Service already have ozone research programs, representatives of these agencies have questioned whether NAPAP should expand its research to include ozone. Representatives of these agencies told us that they were unsure whether ozone research was within the purview of NAPAP. These representatives do not want NAPAP to increase its research on ozone at the expense of its research to determine the effects of sulfur dioxide and nitrogen oxides. The director told us it is important to research ozone effects, as well as the effects of sulfur and nitrogen, because ozone has long been known to damage crops and is suspected of contributing to observed forest decline.

To clarify the extent to which NAPAP should address oxidants, the director of research and the Interagency Policy Committee drafted a scope of work statement outlining NAPAP's research responsibilities. The statement says that in order to understand the acidic deposition issue, NAPAP should conduct research as appropriate on pollutants other than compounds of sulfur and nitrogen. According to the director, the statement provides NAPAP with flexibility to review other pollutants that could be suspected of causing damage, including ozone.

Restructured Materials Program

The director of research told us he has restructured the NAPAP materials program to determine the incremental effects of acidic deposition on materials. The materials task group had based its work on damage functions derived from existing literature. The August 1985 peer review of the materials program determined that these damage functions, which estimate the extent of the effect of acidic deposition on materials, are inadequate and unreliable. To develop accurate damage functions,

NAPAP, with the director's encouragement, has initiated controlled experiments to determine the incremental effect of acidic deposition on various metals, paints, and building stone. A member of the Interagency Scientific Committee noted that, although NAPAP had begun to look at incremental effects before the director was hired, the director has been influential in developing the program. The director brought in a new task group leader and took the lead in developing the task group's work plan.

External Scientific Committee Has Not Been Established

As of December 1986, NAPAP had not implemented its plans to establish an external scientific committee. The establishment of the committee was agreed upon by the Joint Chairs Council in the 1985 memorandum of understanding, as well as in a similar 1984 memorandum. The committee was to have scientists outside of NAPAP review acidic deposition issues.

NAPAP Planned to Establish a Committee Staffed by the National Academy of Sciences

In the early 1980's, NAPAP and the National Academy of Sciences initiated discussions concerning the possibility that the Academy could serve as an external review committee for NAPAP. In 1983, the ad hoc committee established to review NAPAP activities recommended that an advisory committee be established to provide top-down technical advice to the Joint Chairs Council. The committee would advise on such matters as the effectiveness of the research program and the adequacy of the NAPAP budget. The 1984 memorandum of understanding provided for the creation of a scientific advisory committee to provide NAPAP with high-quality, independent advice on all aspects of the acidic deposition issue, and the scientific effectiveness of the federal research program. The memorandum noted that NAPAP was considering a proposal from the National Academy of Sciences to create such a committee. The 1985 memorandum of understanding gave the director authority to use the Academy to review scientific questions related to NAPAP as requested by the Joint Chairs Council.

NAPAP set aside \$100,000 in its budgets for fiscal years 1985 and 1986 to provide for such a committee. After the director of research was hired in September 1985, negotiations between NAPAP and the Academy continued but eventually fell apart. According to an official from the Academy, the negotiations collapsed primarily because NAPAP's director of research wanted control over who served on the review committee and over what issues the committee would review. The Academy

decided that unless it could serve as an independent committee that determined its own agenda, it would not participate.

NAPAP officials noted additional reasons for the collapse of the negotiations. For example, one member of the Interagency Scientific Committee stated that the Academy works too slowly to be an effective committee for NAPAP. It often takes between 1 and 2 years for the Academy to complete a review. Another argued that the Academy should not serve as a review committee because some of its members already have expressed their views on the need to control acidic deposition and, therefore, cannot be considered neutral reviewers. A member of the Interagency Policy Committee also told us that the Academy has a high overhead and is expensive to hire as a contractor.

In responding to these comments, an Academy official stated that the Academy is no more expensive than any other government contractor and that it works diligently to maintain objectivity. Further, the Academy costs are in fact reduced because the scientists serving on its committees are not reimbursed for their services, but only for their travel and expenses. To minimize the potential for a biased committee, the Academy requires its potential ad hoc committee members to submit all public statements and articles they have made on a given issue. This allows the people on the committee to know each others' biases, and it assures that NAPAP would get representation on all sides of an issue.

As of December 1986, the status of NAPAP's plans to establish an external scientific committee was unclear. The director told us there is a possibility that such a committee might be established in the future. However, an official on NAPAP's Interagency Scientific Committee commented that there was no possibility that NAPAP would create the committee. According to NAPAP officials, since a contract with the Academy was never signed, NAPAP used the money set aside to fund task group peer reviews in fiscal year 1985 and for other expenses in fiscal year 1986.

**Need for an External
Review Committee May Still
Exist**

Another reason given by some NAPAP officials for its decision not to establish an external scientific committee was that NAPAP sponsors peer review panels that meet periodically to review portions of its research program. For example, a NAPAP-established peer review panel reviewed the status of NAPAP's aquatic and terrestrial research program in November 1984. Since these peer reviews provide for expert review of

research projects, some NAPAP officials are uncertain as to the possible role of an external review committee.

Other NAPAP officials see the external scientific committee fulfilling a broader role than the individual peer review panels. Members of the Interagency Scientific Committee and a number of scientists we interviewed stated that such a committee would be useful in providing a comprehensive look at the overall program and in addressing specific issues as requested. Although NAPAP conducts numerous peer reviews of individual research projects and areas, these reviews do not provide a comprehensive review of the NAPAP research program. For example, 7 of the 10 participants on NAPAP peer reviews we interviewed stated that, while NAPAP provided the peer reviewers with some information on the entire NAPAP program, the peer reviews are designed to be project- and task group-specific. The peer reviewers do not examine the entire NAPAP program and do not necessarily understand how the projects they are reviewing fit into the whole research program. Seven of the peer reviewers thought establishing an external review committee would be useful to NAPAP. According to the reviewers, such a committee is needed to be certain that the research pieces fit together and are proceeding to some conclusion. An external review committee would provide continuity for and overall perspective on the research program.

Interagency Scientific Committee members told us an external review committee could be useful for certain purposes. For example, one member stated that an external review committee could help by reviewing NAPAP's first interim assessment document. This idea was discussed in April and June 1985 by NAPAP's Executive Committee. Others suggested such a committee would be useful in reviewing NAPAP's budget and in providing technical advice on research issues, such as developing an approach to measure dry deposition and an approach to measure, sample, and quantify acidity from snow deposition in the West.

Although NAPAP has not created the external scientific committee, it does plan to have its assessment document undergo outside scientific peer review. The director of research plans to have each chapter of NAPAP's first interim assessment reviewed by outside experts. The first draft chapter available—acidic deposition effects on crops—was reviewed by five experts during December 1986 and January 1987.

In an October 1985 proposal to establish the external review committee, the Academy listed services such a committee could provide. The proposal noted the committee would provide scientific and technical assistance as requested by NAPAP, and it might address both program management and technical questions. For example, the committee could examine the effectiveness of the NAPAP research program, as well as determine whether or not specific research projects will yield definitive results.

The chairman of the 1983 ad hoc committee told us NAPAP needs an external review committee to address overall research and management issues. He did not believe the National Academy of Sciences should perform this review, however, because an advisory committee should report directly to the federal officials it advises. The Academy operates as an independent committee.

In summary, NAPAP has not fulfilled its earlier plans to establish an external scientific committee. NAPAP conducts peer reviews of specific research areas and projects and is planning to have outside experts review its first interim assessment. At the same time, several NAPAP officials and outside scientists see a role for a broader-based review panel that could provide technical advice on NAPAP's management or overall research program.

Observations on NAPAP's New Management Structure

During our review we developed a series of observations about the usefulness of NAPAP's management structure and the role of the director of research. Many NAPAP officials believe the director of research is providing guidance the research program needed and is acting as a focal point for people in and outside of NAPAP. At the same time, key documents are being delayed, and communication between the task groups and the director appears to have suffered. Finally, we noted that there are several difficulties inherent in managing a multi-agency research program that have affected NAPAP's operations.

Establishing a Stronger Director of Research Has Had Benefits

Many of the NAPAP officials we interviewed believe that bringing in an individual to serve as a director of research has had a positive effect on the program. For example, one member of the Interagency Scientific Committee stated that NAPAP's research program is stronger, better directed, and more organized with one person in charge. Another noted the research is much more focused and NAPAP has benefited from having

one central decisionmaker. A member of the Interagency Policy Committee stated that the organization is functioning better with a director of research. He thinks that, with the director's energy and with the support of the Joint Chairs Council, the director is providing the program with much needed direction. Others noted that NAPAP meetings, including the annual meeting and Joint Chairs Council meetings, are more organized and efficiently run than they were previously.

**Research Program Has
Communication Problems**

Communication has been difficult under the new organization. For example, several task group representatives told us the director has not informed them of NAPAP's assessment goals. (See chapter 2 for a discussion of NAPAP's plans for an assessment of the acidic deposition issue.) Without an assessment framework, they do not always clearly understand how the research they are conducting relates to NAPAP's overall plan. These task group leaders expressed the need for a written plan that would clearly show how NAPAP will meet its objectives by 1990.⁷ Without such a plan, some task group leaders feel as if they are working in a vacuum.

The status and content of the assessment have also been the subject of communication problems. At the time of our interviews with Interagency Scientific Committee and Interagency Policy Committee members, none had seen drafts of the first interim assessment. They were uncertain about what information would be included in the assessment and when it would be available. An official writing a chapter of the assessment told us the authors of the various chapters had not met as a group, and he did not know what was being written in any other chapters. Another author stated that he was uncertain how the overall assessment would be organized and how his input would be incorporated. Members of the aquatics task group stated in November 1986 that they were unclear as to the status of their assessment chapter. They had provided a draft to the director in January 1986 and had met only once with him to discuss the chapter in 1986. In November 1986 they told us they were concerned because they had not discussed the status of the chapter with the director in several months, and the information was becoming dated.

In December 1986, the director of research agreed communication within NAPAP has been a problem. To improve communication, he is holding meetings with each task group leader and the Interagency Scientific Committee member from the task group leader's agency to get clear agreement on the responsibilities of each individual. He also plans to

send drafts of each assessment chapter as they become available to all of the NAPAP agencies for their review and approval.

Reorganization Has Delayed Production of Key NAPAP Documents

Several NAPAP officials indicated that some of the delay in the publication of NAPAP documents (see chapter 2) can be attributed to the director's (1) lack of staff; (2) amount of time spent fulfilling his responsibilities, including visiting research projects and attending task group peer review meetings; and (3) personal, detailed review of NAPAP documents.

Several NAPAP officials stated that the director does not have sufficient staff to produce the assessment. During fiscal year 1986, only two staff members in the Office of the Director of Research worked on the assessment, and they spent part of their time on other management tasks. Portions of the draft first interim assessment have been written by former assessment task group members and officials from NAPAP agencies who have other job responsibilities. The director agrees that staffing has been a major contributor to delays in issuing some NAPAP documents and hopes to be able to increase staff in the next fiscal year.

The director's multiple responsibilities—managing the assessment effort, directing the research program, and acting as principal spokesperson for the program—limit the amount of time he can spend writing and reviewing assessments and other documents. During his first year in NAPAP, the director spent a great deal of time out of the office, visiting research projects, attending task group peer reviews, and representing NAPAP. As requested by the office of the Chairman, Subcommittee on Oversight and Investigations, House Energy and Commerce Committee, we reviewed the fiscal year 1986 travel vouchers for the Office of the Director of Research and found that he spent 153 days on travel.² The director told us it was necessary to travel extensively during his first year on the job to learn about the NAPAP research program. In order to fulfill his mandate to take control of the research program, he needed to get first-hand information about the ongoing projects. He did not anticipate the need to travel as much during upcoming years.

Some NAPAP officials attributed the delays in issuing documents to the director's management style, which includes his detailed reviews of

²In fiscal year 1986, the associate director traveled 39 days and other officials funded by the Office of the Director of Research (4 administrative staff members, 2 scientists, and 3 non-NAPAP scientists) traveled a total of 98 days.

assessment chapters and other documents. Several NAPAP officials noted that the director of research is a relentless worker who has put long hours into fulfilling his many responsibilities. Officials working on the first interim assessment told us the director of research reviews in detail each draft of the assessment chapters they develop. This often requires considerable time and can delay the assessment process. Two assessment chapter authors told us that these delays can become exacerbated because, as new research results continually become available, the assessment drafts waiting for review become dated and need further updates. The director also extensively reviews other NAPAP documents, such as the operating research plan. According to the associate director, the director is reviewing the descriptions of each of the approximately 175 research projects being written for the operating research plan. If the director does not agree with the project description or the research plans, he may attempt to get the agency to change the research project.

Some NAPAP officials stated that these delays might be reduced if NAPAP had an assistant director for assessments in the Office of the Director of Research. This assistant director would report to the director and would concentrate on working with NAPAP staff to develop assessments and plan for the final 1990 assessment. With some help on the assessment, the director could be freed to concentrate on other matters. In December 1986 the director agreed that he has spent considerable time reviewing the first interim assessment. Since he is responsible for the assessment, the director considers the detailed review a necessary part of his job in order to produce a professional document. However, he agreed that the addition of such a position could be helpful for the development of future assessments.

**Multi-Agency Management
Structure Has Contributed
to Several Problems**

Several of the problems in managing NAPAP have resulted from its inter-agency structure. Staffing positions at the Office of the Director of Research are funded by NAPAP's five main funding agencies. NOAA, for example, pays the director's salary. Additional positions for the Office of the Director of Research would come from the budgets of the five funding agencies after approval by the Joint Chairs Council.

Although the director has substantial responsibility, he has limited authority to carry out the program. For example, since the agencies participating in NAPAP independently fund NAPAP research projects, the director has minimal control over NAPAP's budget, which limits his ability to shape the research program. The director can encourage agencies to fund particular projects, but actual funding decisions are made

by the agencies. Since each agency has its own interests to defend, it may not agree with the director concerning funding decisions. Conflicts over which projects to fund produce tension between the various agencies and between the agencies and the director.

NAPAP officials agree the expertise provided by the various participating agencies has been extremely beneficial to the program. For example, NOAA has atmospheric modeling expertise, and EPA has an established aquatics program. However, the multi-agency structure causes some problems. For example, the five agencies funding the majority of NAPAP research sometimes have conflicting positions on the policy implications of issues related to acidic deposition. According to NAPAP officials, this has been particularly true for EPA and DOE. Because the agencies often have different perspectives given their different roles within the government, it is sometimes difficult to obtain a consensus on certain issues such as content of the assessment. For example, the agencies may disagree on how much can be concluded on the basis of research to date.

The director of research must attempt to incorporate sometimes conflicting views into documents such as assessments or letters to the head of congressional committees. The director must operate in an atmosphere where (1) issuing a document with which a NAPAP agency disagrees could create significant conflict or (2) issuing a document with which all the agencies agree may result in a “lowest common denominator” or a document that has limited conclusions.

Besides being unable to control the budget, the director has little authority to direct task group leaders. Task group leaders have two bosses—their supervisor in the agency in which they are employed and the NAPAP director of research. Some NAPAP officials told us that when faced with assignments from both bosses, the task group officials sometimes make NAPAP a secondary priority. According to NAPAP officials, this situation has contributed to the delay in producing some NAPAP documents, such as the annual report. With numerous responsibilities within their own agencies, task group leaders have not always met the Office of the Director of Research’s deadlines in providing the office with their segments of the report. For example, the materials effects group underwent three leadership changes between February 1986 and February 1987, contributing to delays in completing the materials portion of the assessment and annual reports. These changes were made by DOI, outside of the NAPAP director’s control.

Since the director of research has no real authority over the agency representatives participating in NAPAP, he has to rely on his power of persuasion and his intellectual leadership to get the agencies to go along with his direction. The director does report directly to the Joint Chairs Council and can elevate disagreements with agency staff to the council. Although the director has this option, he told us he does not want to appeal decisions or refer problems to the council on a regular basis. As top-level managers of their individual agencies, the members of the council have numerous other responsibilities. It is unrealistic to expect them to become involved with day-to-day management issues within NAPAP. However, the council has pivotal control over NAPAP because it has direct line authority over the director and officials from NAPAP committees and task groups.

NAPAP's interagency structure, along with the director's initial lack of federal government experience, have contributed to the difficulties the director has had in hiring staff. The director told us that before he was hired, he was under the impression that he would be able to quickly hire six or seven scientists for his office. However, it took about 6 months until the Joint Chairs Council agreed to approve two positions for the director's office. The director believes that there was some interagency conflict over whether his office should get additional staff. In 1986, the Joint Chairs Council approved two additional positions for his office for fiscal year 1987. Besides these two scientists, the director hopes to hire three more scientists in fiscal year 1987, but as of December 1986 these positions had not yet been approved.

Given the problems of managing an interagency program, the director of research indicated that the program might have been better implemented if the Congress had given funding and responsibility to one agency. The responsible agency could have used interagency agreements to involve other agencies in acidic deposition research. According to NAPAP's associate director and a member of the Interagency Policy Committee, another option that could help reduce some of the interagency conflict would be to provide the Office of the Director of Research with a research budget of its own. The director could use this budget as leverage to better direct the research program and to support research that the agencies will not fund.

Summary and Conclusions

Having a director, rather than a coordinator, has had some advantages for NAPAP's research program. Most NAPAP officials agree it is beneficial to place the assessment function under a director of research rather

than to continue the assessment work under a separate agency-level task group. NAPAP officials also thought it was an advantage to have a single NAPAP spokesperson to deal with the Congress, the states, and the public.

However, significant problems remain in NAPAP's management structure. As we discussed in previous chapters, key NAPAP documents have repeatedly missed deadlines. Those delays were occurring before the director of research was hired, but they have continued to worsen for over a year since he has had responsibility for the documents.

The director of research and other NAPAP officials have pointed out that there are limitations hampering the director's ability to manage the programs. Foremost among these is the director's lack of control over the research budget. When the director and the funding agencies disagree about the direction of certain research projects, the director has two options to resolve the situation—personal persuasion or an appeal to the Joint Chairs Council.

NAPAP officials agree the director has done a good job of articulating where NAPAP is and where it is going. However, communication problems between the director of research and the NAPAP agencies have hampered NAPAP's performance. The director's detailed review of key documents has also contributed to delays in the production of these documents, particularly NAPAP's first interim assessment. The director believes these reviews are necessary to ensure that NAPAP documents are of high quality and worthy of public release.

The director is planning to expand his staff to help accelerate the production of assessments, annual reports, and operating research plans in the future. We believe that additional staff to work on these documents will be helpful. Furthermore, NAPAP officials need to give high priority to the timely completion of these documents so that the Congress and the public understand how the \$303 million NAPAP budget has been spent.

NAPAP also needs to determine whether to establish an external scientific committee to provide comprehensive advice on NAPAP's research program. The Joint Chairs Council 1984 and 1985 memoranda of understanding called for the establishment of such a committee. NAPAP tried to reach an agreement with the National Academy of Sciences to staff the external science committee; the negotiations broke down after disagreements arose about the scope of the proposed reviews. Some NAPAP officials and outside scientists told us that such a committee would benefit

the research program. NAPAP's director of research stated that the committee could be established in the future, but other senior NAPAP officials told us that they did not think the idea was still being considered.

Recommendations

To ensure that key NAPAP documents are issued on a timely basis in the future, the NAPAP Joint Chairs Council should direct the director of research and NAPAP task group officials to give high priority to the development of assessment documents, annual reports, and operating research plans. The Joint Chairs Council should also examine the staffing situation in the Office of the Director of Research and determine where delays occur and take steps to eliminate the bottlenecks. This could include, for example, the establishment of the position of deputy director for assessments who would report to the director and who would be responsible for planning future assessments and ensuring that assessment schedules are met.

The Joint Chairs Council should also determine whether the establishment of an external scientific committee would benefit NAPAP. Such a committee could review critical scientific issues associated with acidic deposition and provide a top-down review of the objectives and implementation of NAPAP's science program. If the council believes that such a committee would be beneficial, it should direct the director of research to establish it.

NAPAP Plans to Have Policy-Relevant Information on Acidic Deposition by 1990

NAPAP is about halfway through its 10-year authorization for sponsoring and conducting federal research into the causes and effects of acidic deposition. NAPAP officials say research results are beginning to become available, and major scientific uncertainties should be better understood during the next 4 years.

NAPAP is conducting or sponsoring research in two major areas—atmospheric processes (from emissions of pollutants, through chemical transformations in the air, to the transportation and deposition of acid compounds on the ground) and effects (impact of deposition on trees, lakes, etc.). Much of NAPAP's funding between now and 1990 will be used to develop and validate an acidic deposition model that will predict long range transport and deposition rates and provide data for making policy decisions.

Although NAPAP is conducting research in a number of areas to reduce the scientific uncertainties associated with acidic deposition, it will not have definitive answers on key issues by 1990. According to NAPAP officials, the scientific complexities involved in understanding the atmospheric processes and effects of acidic deposition are so great that research will be needed beyond 1990. Among the unknowns that will remain beyond 1990 are the effects of acidic deposition on forest ecosystems and many man-made materials.

NAPAP's director of research plans to have reduced scientific uncertainties sufficiently by 1990 to have policy-relevant conclusions in NAPAP's final assessment document. However, for reasons discussed in this chapter, it is unclear whether NAPAP will be able to meet its goal of obtaining and analyzing research to be used as a basis for policy decisions.

NAPAP Focusing on 1990 Goals for Reducing Uncertainty

The NAPAP research program did not actually get underway until 1982, when NAPAP published a comprehensive research plan as required by law. The plan was to be implemented over 9 fiscal years. By late 1986 the program was about halfway through that 9-year period. NAPAP officials told us that the first 2 years of the program were spent planning the research effort and that initial NAPAP-funded research results began to be available by 1984 or 1985. The overall funding of NAPAP research increased significantly between 1982 and 1986, and the results of a great deal more research will be available over the next few years. In studying the acidic deposition question, NAPAP is also relying on research

sponsored and/or conducted by a variety of other non-federal sources, including industry groups, other nations, and various states.

According to the director of research, NAPAP should have better information regarding all of the major uncertainties associated with acidic deposition by 1990.¹ He explained that the seven NAPAP task groups are concentrating on reaching key objectives by 1990. In 1986 the director developed a list of these research goals. The list outlines the objectives of each NAPAP task group and is included in appendix II of this report.

NAPAP Goals for Research on Atmospheric Processes and Acidic Deposition Effects

NAPAP's seven task groups are funding research under two general categories—atmospheric processes research and effects research. Atmospheric processes research involves determining sources and rates of emissions, collecting data on wet and dry deposition, developing an understanding of chemical transformations in the atmosphere through time and space, and incorporating these components into the creation of models for predicting atmospheric deposition. Effects research focuses on determining the rates and types of environmental damage associated with acidic deposition and related pollutants. NAPAP's effects research is concentrated on crops and forests, lakes and streams, and selected building materials.

Status of Atmospheric Processes Research

Four NAPAP task groups are conducting atmospheric processes research related to acidic deposition. They are studying the acidic deposition process from the emission of the pollutants, through the chemical transformations in the clouds and atmosphere, through long-range transportation to the deposition of the pollutants on the ground. The Emissions and Control Technology Task Group's goals are to provide estimates of emissions for both man-made and natural sources; gather data on emissions control technology and associated costs; and develop a model for predicting emissions and control costs under alternative assumptions of production, technology, and economics.

¹There is some uncertainty as to whether NAPAP's legislative authority expires at the end of fiscal year 1990 or 1991. The Acid Precipitation Act of 1980 envisioned NAPAP's comprehensive research plan being published by about April 1981; because of delays in getting the multi-agency program off the ground, the plan was not issued until June 1982. Because the act provides for legislative funding 9 years beyond the publishing of the plan, it could be interpreted that the program should run through fiscal year 1991. However, NAPAP's director of research told us that, on the basis of a review of the issue by NOAA, he believes the legislative authority will end after fiscal year 1990 and is focusing the program's completion on September 30, 1990.

The Atmospheric Chemistry Task Group's goals are to develop an understanding of chemical transformations in the atmosphere—from precursors to acidic deposition for both wet and dry forms²—and determine other information, such as process rates (wind speed and fluxes, for example). Research work on chemical reactions involves gas-phase chemistry, aqueous-phase chemistry, and in-cloud chemistry. Additionally, research work on air/surface exchange involves obtaining measurements for natural source emissions and dry deposition.

The Atmospheric Transport Task Group's main goal is the development, evaluation, and application of atmospheric models. The task group has over the years, evaluated and discounted numerous empirical approaches to reliably describe the linkages between emissions and effects for policy analysis. Because of the high costs involved with these options, the task group concentrated on developing a mathematical model to characterize these environmental parameters. Successful model development is essential because precursors and acidic components in the atmosphere are not measured continuously because of technical and economic considerations. The major effort for this task group is the Regional Acid Deposition Model (RADM), discussed in the next section. This model represents a mathematical relationship that links emissions and deposition estimates. The model can then develop prediction scenarios—how changes in emissions might lead to changes in deposition—which can be used as a tool for policy analysis.

The Atmospheric Deposition and Air Quality Monitoring Task Group's goals are to establish a national trends network for monitoring wet deposition and to deploy an air quality network to measure dry deposition. Currently, the task group has established about 150 wet deposition sites collecting field data for the network. The task group is also responsible for data management and analysis of results from the two networks.

Regional Acid Deposition Model

The RADM project is designed to predict source-receptor relationships—from the emission of acid precursors, to their chemical transformation to acids in the atmosphere, through the transportation and deposition of acidic compounds at receptor sites, such as the Adirondack forests. According to NAPAP officials, the RADM will be the most comprehensive and sophisticated state-of-the-art atmospheric model ever developed.

²Wet deposition is the depositing of pollutants through rain, snow, etc. Dry deposition is the depositing of pollutant particles and gases not associated with precipitation. Dry deposition is important because NAPAP researchers project that 30 to 50 percent of all acidic deposition occurs through "dry" processes.

NAPAP estimates that it will spend over \$27 million developing and evaluating the RADM through fiscal year 1987. (See appendix IV.) Ultimately, NAPAP hopes to use the RADM to simulate scenarios that show how changes in emissions might relate to changes in deposition and its effects on the environment.

The four task groups involved in NAPAP's atmospheric processes research are linked together by the RADM project. The RADM information needs drive much of the research efforts. For example, the Emissions and Control Technologies Task Group develops detailed inventories of natural and man-made emissions and formats the information into detailed data bases for the RADM. The Atmospheric Chemistry Task Group updates scientific information on issues such as dry deposition and provides it to the Atmospheric Transport group in a way that can be adapted for use in the RADM. The Atmospheric Deposition and Air Quality Monitoring Task Group collects wet and dry deposition data to help validate the RADM.

Uncertainties Remain in Atmospheric Processes Research

Two major uncertainties remain in NAPAP's atmospheric processes research efforts. One deals with uncertainty over dry deposition measurements, which are important inputs for the RADM, and the other is the completion and validation of the RADM itself.

The Atmospheric Chemistry Task Group is responsible for developing techniques to measure dry deposition. While NAPAP researchers have long understood and been able to collect wet deposition with rain gauges, researchers have had problems collecting dry deposition with these methods. NAPAP decided to focus on deriving dry deposition data indirectly through measuring various air quality factors, such as air fluxes, to establish mathematical relationships of deposition rates and concentrations.

A coleader of the task group told us that some dry deposition data have been generated from a network of four field sites. However, because of the site-specific and technical requirements of the research, data generated from the field sites cannot be extrapolated to other areas. The task group plans to expand the network to 15 sites; increase the number of

field sites; and establish some "satellite" sites, which require less specificity but provide supporting data.³ Once the sites are established, the data will be collected, and the task group will work to improve the credibility of the results.

As for the completion of the RADM, a coleader for the Atmospheric Transport Task Group explained that the final RADM development has been delayed 1 year, from 1987 to 1988. A 2-year evaluation program for the RADM is planned in 1988. A specialized monitoring network will be established to gather more detailed information to verify the capabilities of the RADM predictions. In 1989, after the first year of evaluation, the RADM will be evaluated and compared against the field data, and, if needed, improvements will be made to the model to reduce uncertainties within its modules. If the RADM is improved, a second evaluation will be conducted with field data collected from the second year of the evaluation program.

Atmospheric Processes Task Group officials estimate that the model will be operating by the 1989 time frame, although it will not yet be fully evaluated. However, since the RADM depends on the input of other task groups, any delays encountered in those groups would also hinder the validation process. As of January 1987, NAPAP planned to use the 1989 version of the RADM for its final assessment,⁴ assuming all deliverables are on schedule and the uncertainties associated with the RADM are not too large for assessment purposes.

A report summarizing a March 1985 peer review of the RADM concluded that, while the panel was, in general, very favorably impressed with the quality of the work, it had serious concerns about the timeliness of the research products for the assessment purposes. The task group leader responsible for the RADM told us that NAPAP will have a running model in time for the final assessment. However, the model may not be completely validated or evaluated.

Status of Effects Research

The three task groups involved in effects research are terrestrial effects, aquatic effects, and materials effects. Their main goal is to determine

³This dry deposition network from the Atmospheric Chemistry Task Group differs from the Atmospheric Deposition and Air Quality Monitoring network. While the atmospheric chemistry network conducts specialized research, the deposition and monitoring network collects routine field data.

⁴As we discuss in chapter 3, NAPAP is planning to issue three assessment documents between 1987 and 1990. These documents will analyze NAPAP's knowledge to date regarding the causes and effects of acidic deposition.

the extent and rates of damage that can be associated with acidic deposition on the environment. Although NAPAP does not have a task group for human health effects, NAPAP is developing a chapter on these effects for its first interim assessment, primarily on the basis of outside research. According to NAPAP officials, the effects research involves short-term projects for results by 1990 and long-term projects that may go on beyond NAPAP's deadline. We discussed the status of NAPAP's terrestrial and aquatic research program extensively in our December 1985 report, Acid Rain: Federal Research Into Effects on Water and Forests (GAO/RCED-86-7).

NAPAP's terrestrial effects task group has concentrated its research activities in two major program areas—agricultural crops and forest effects. The primary goals for both programs are to determine the impact of acidic deposition and oxidants on crops and forests. Studies conducted over the past decade have demonstrated that ozone can reduce the productivity of various agricultural crops.

NAPAP has sponsored crop research to look at the quantity and quality of the marketable yield of economically important crops. Varieties of major national cash crops that had the greatest immediate potential for economic loss, such as corn, wheat, and soybeans, were chosen for study. On the basis of limited results gathered to date, NAPAP has found no significant effect of acidic deposition on yield reduction on these annuals. As a result, in 1986 NAPAP did not expand the level of effort for research on national cash crops.

The forest effects research in NAPAP has only recently received more emphasis. Prior to 1984, most of NAPAP's terrestrial effects research focused on crops. After the much-publicized reports of European forest decline, especially from West Germany, NAPAP increased its research on forest effects. In 1985, a Forest Response Program was established to coordinate and sponsor research to determine the effects of atmospheric deposition on forest structure, function, and composition. To implement the program, research cooperatives have been set up according to forest ecosystems—spruce-fir, southern commercial (pines), western conifers, and eastern hardwoods—to coordinate research programs. A major research effort, according to the director of research, involves short-term controlled exposure studies to address forest dieback at high elevations. These dose-response experiments of tree seedlings exposed to acid compounds and oxidants are needed to find first order effect answers to forest dieback. The director believes that NAPAP will be able to provide these answers by 1990.

The major research goal of the Aquatics Effects Task Group is to quantify and predict the chemical (ability of aquatic systems to neutralize acids) and biological (plant and fish responses) effects of acidic deposition on lakes, streams, and groundwater. The task group has completed both the National Surface Water Survey and the National Streams Survey, which sampled lakes and streams across the country for their acid-neutralizing capacities. Current efforts include continuing analysis of the field data collected from the survey. According to NAPAP, there is no longer any question that acidic deposition has negatively affected some surface waters. NAPAP plans to look at the additional number of lakes that may acidify over time if current deposition levels continue, the rate of recovery of presently acidified lakes, and the relative importance of acidic "episodes" (such as snow melts or storm events) in streams or lakes on biota.

According to the Aquatics Effects Task Group leader, research plans until 1990 involve watershed manipulation and verification of watershed models. Watershed manipulation is the direct deposition of acidifying compounds into a selected region where water drains to a particular watercourse or body of water. The task group plans to monitor selected sites to gather data on chemical and biological changes. Models currently being developed to make predictions for watershed changes will be verified with the field data. The task group plans to be able to use the watershed models to predict effects responses from specific aquatic systems.

The Materials Effects Task Group's main goal is to provide a quantitative understanding of the effect of acidic deposition and associated oxidants incremental to natural background on materials degradation. The purpose of this effort is to be able to measure the effects of acidic deposition and oxidants exposure on selected materials such as metals, stone and paint. The task group has established a field and laboratory program to develop damage functions for materials important for construction and cultural purposes.

According to NAPAP's list of objectives for 1990, the development of damage functions is the task group's first priority. The task group leader told us in January 1987 that his group is developing damage functions for seven metals, stone, and some paints.

NAPAP Will Not Be Able to Address Certain Issues by 1990

NAPAP officials agree that, although scientific uncertainties will be reduced by 1990, it will be years beyond that before research will be able to produce definitive results. Among the reasons for this additional time are (1) the complexity of scientific issues (2) changes in research priorities, and (3) limited funding for materials research.

Complexity of Issues and Remaining Uncertainties

While research results continue to become available, the scientific uncertainties involved with understanding the causes and effects of acidic deposition remain. Acidic deposition research involves understanding a complex combination of meteorological, chemical, and biological phenomena. For example, an understanding of the effects of acidic deposition on forests involves understanding the relationship between a complex array of several pollutants on root systems and leaves; the buffering capacity of various soils over time; the interaction of pollutants with natural stresses, such as climate and disease; and the relative impacts of dry and wet deposition.

As a result, acidic deposition research will probably continue beyond 1990. In our December 1984 report, An Analysis of Issues Concerning "Acid Rain" (GAO/RCED-85-13), we stated that further scientific work on acidic deposition will be needed for a number of years, no matter what decisions are made on control actions in the short run. Some current task group leaders for NAPAP research told us that their agencies' research efforts will extend beyond the 1990 deadline.

The leader of the Atmospheric Deposition and Air Quality Monitoring Task Group told us that the U.S. Geological Survey would be a logical organization to continue monitoring wet deposition beyond 1990. He added that the extent of data collection depends on the funding effort available. A member of the Emissions and Control Technologies Task Group told us that DOE plans to continue collecting monthly emissions data from utilities and tracking fuel use patterns. He said DOE would be interested because of its concern with energy needs and the effect of acidic deposition on the use of coal.

According to the Terrestrial Effects Task Group leader, most of the forest effects research is considered a long-term effort. By 1990 the task group will have results from short-term seedling exposure studies. The Forest Service and EPA plan to extend their research efforts to study mature trees and ecosystems. The Forest Service, for example, plans to conduct monitoring, perhaps for the next 20 to 30 years, in order to get reliable trends data.

The Aquatic Effects Task Group leader told us he plans to propose long term monitoring efforts in 1988, and EPA will most likely continue this activity after 1990. Long-term monitoring will provide additional data, including nitrate deposition, to provide good trends data for science research and to fill data gaps in case another NAPAP-like effort is undertaken in the future.

Research Priorities Have Changed

NAPAP's major research effort in terrestrial effects prior to 1985 had been on crops research. NAPAP increased its emphasis on forest research in 1985 and established the Forest Response Program. Because of the late start, in relation to NAPAP's 1990 deadline, the task group leader told us that NAPAP would have only results of short-term controlled exposure experiments on seedlings, and extrapolation of these results to the natural ecosystems may be tenuous at best.

As a result of the redirection of terrestrial research toward forests, NAPAP began phasing down its efforts on annual cash crops. The senior scientist for crops assessment told us NAPAP had planned to sponsor research on regional crops, including perennials (fruit trees and grapes) which may have a significant economic impact on a local scale. However, she said that forest effects work currently drives the task group's research activities; therefore NAPAP is not likely to undertake large-scale efforts on crops. The director of research confirmed that the crops effort is being completed, and he does not think there will be any more research planned under NAPAP.

The Aquatics Effects Task Group leader told us NAPAP will not provide any information on actual biological changes as previously planned. He explained that the task group could not establish the historical trend of biological effects changes because the existence of biological populations prior to the onset of the acidic deposition problem could not be determined. Therefore, the task group could not determine the extent of biological changes in aquatic systems resulting from acidic deposition. The task group has now redirected its research to monitor chemical changes in aquatic systems and plans to develop models to predict the biological effects as the systems change.

Limited Funding for Materials Effects Research

NAPAP's efforts in materials research has not had as much support as the other task group efforts. In our December 1985 report, Acid Rain: Federal Research Into Effects on Water and Forests (GAO/RCED-86-7), we reported that NAPAP officials generally believe that acidic deposition

research funding is adequate for all areas except effects on man-made materials. At that time, we were told that the task group needed increased funding to expand field monitoring sites, initiate research on concrete and paint damage, and intensify work on damage functions for certain materials and air pollutants.

During our current review, we again noted the adverse effects of limited funding. For example, the task group had hoped to set up a western station to get a more representative picture of deposition effects. The Materials Effects Task Group leader told us that while funding had increased from \$2.1 million in 1985 to \$3.7 million (about 4.3 percent of the total budget) in 1987, no new monitoring sites were established because it was now too late to obtain and analyze data before the 1990 deadline. The task group still has not been able to conduct research on concrete, nor on other materials such as brick or caulking. The task group recently initiated paint damage research but does not expect credible results for damage functions by 1990. The task group leader hopes to have damage functions for galvanized steel and limestone by 1990 but is not optimistic that damage functions for other materials will be established by then.

The task group leader and other NAPAP officials agreed NAPAP's materials research had been a low priority from the beginning. Consequently, they believed that much of the research effort has been underfunded and spread too thinly. As a result, by 1990, the Materials Effects Task Group will not be able to advance its research results as far as anticipated early in the program.

**Federal Materials Research May Not
Continue Beyond 1990**

It is uncertain to what extent materials effects work will continue after 1990 if NAPAP is disbanded. Unlike other issue areas, federal research on materials may not continue after the NAPAP deadline. Task groups on atmospheric processes and effects research have "natural" constituencies of lead agencies, such as the Forest Service for terrestrial effects and NOAA for atmospheric chemistry. Materials effects research does not have any such agency participating in the national program.

During the course of our review, several former and present NAPAP officials expressed concern over the future of materials effects research beyond NAPAP's 1990 deadline. Some feared that no work would be continued. However, according to NAPAP's associate director, EPA plans to continue some ongoing research after 1990. He estimated that EPA might continue to fund about 70 percent, or about \$2.6 million of the present

1987 research budget of \$3.7 million after 1990. However, these funds would be used to complete ongoing studies and would not include new research efforts. Therefore, federal research previously planned but not currently funded under the materials task group, such as cement, mortar, and caulking, may not be funded after 1990.

In summary, NAPAP officials assert NAPAP will have answered many of the research unknowns associated with controlling acidic deposition by 1990. However, they acknowledge that NAPAP will not have definitive answers to a number of issues by 1990 and that long-term research will be needed to improve NAPAP's understanding of the acidic deposition phenomenon. Moreover, as discussed below, it is unclear whether NAPAP will meet its objective of providing and synthesizing, by 1990, sufficient additional information so that agencies can make policy decisions on control measures.

Policy Decisionmaking in an Atmosphere of Scientific Uncertainty

Members of the Congress, environmental groups, and others have criticized NAPAP for delays in issuing conclusions about the need to control acidic deposition. Many of these critics believe enough is known about the scientific uncertainties to warrant control programs. Some have stated, for example, that although continued NAPAP research is important, the Administration should simultaneously take steps to begin addressing the acidic deposition problem. Others believe that NAPAP has been limiting its flow of information to policymakers to assure that no control action will be taken. Over the past several years, members of the Congress have proposed numerous bills to control sources of acidic deposition.

NAPAP officials, however, believe such action may be premature because sufficient research results are not yet available to make any decisions about the need for controls. In December 11, 1985, hearings on NAPAP management, the chairman of the NAPAP Joint Chairs Council told the Senate Committee on the Environment and Public Works that over the following 2 to 4 years, uncertainties should be reduced to the point at which policy recommendations could begin being made. NAPAP officials note that the Office of the Director of Research is responsible for scientific assessment and research. They state that, as such, NAPAP's various assessment documents will not include policy recommendations, but will include policy-relevant scientific information that can serve as a basis for policy recommendations to be developed by EPA, DOE, and other federal agencies. The NAPAP director of research told us that he is focusing the research program on obtaining policy-relevant information for

NAPAP's final 1990 assessment. He believes that over the next 3 years NAPAP will have developed answers to a variety of research questions and that this new information will be critical to educated policymaking.

It is unclear whether NAPAP will be able to provide sufficient additional information for agencies to make policy recommendations and policy decisions on control measures by 1990. On one hand, NAPAP will have the benefit of additional research results on a variety of acidic deposition effects and atmospheric processes questions by 1990. NAPAP's 1990 goals should also help drive the program towards obtaining key information by 1990.

On the other hand, the history of the debate on this issue demonstrates how difficult it is to identify a specific target date by which control decisions can be recommended or implemented. To begin with, what constitutes "sufficient information for policy decisionmaking purposes" has proven to be a subjective matter. As noted above, some believe that sufficient information has been available for years, while others may remain unconvinced about the need for controls regardless of what NAPAP concludes by 1990. Second, NAPAP has had difficulty reaching a consensus on and issuing policy-relevant assessments in the past. As we discussed in chapter 2, NAPAP has experienced a variety of delays in issuing its first assessment document, originally scheduled for release in 1985. These problems suggest that NAPAP could experience similar delays in developing and issuing its final assessment, which is to analyze the results of all the research completed by 1990. As we discussed in chapter 2, there is also some uncertainty as to what extent future NAPAP assessments will be "integrated" and address the economic effects of acidic deposition.

Finally, past predictions for the timely availability of policy-relevant information on this issue have proven to be too optimistic. For example, in October 1981 hearings before the Subcommittee on Health and the Environment of the House Committee on Energy and Commerce, EPA's Assistant Administrator for Air, Noise, and Radiation stated that the first of the policy recommendations specified by the Acid Precipitation Act of 1980 would be developed within 2 to 3 years (i.e. the 1983 to 1984 time frame). In a February 10, 1982, statement before the Senate Subcommittee on Arms Control, Oceans and International Operations, and the Environment of the Committee on Foreign Relations, she stated that EPA anticipated the ambiguities and uncertainties associated with acid rain would be reduced in the following 3 to 5 years (i.e. by 1985 to 1987).

EPA's and the other NAPAP agencies' continuing revisions of predictions on the availability of such policy-relevant information underscores the difficulty of making accurate predictions in this area. Furthermore, control decisions on acidic deposition will always be framed in scientific uncertainty because, as with other science policy issues, definitive answers on the causes and effects may never be known. As we concluded in our 1984 report,⁵ given this uncertainty, decisionmakers will continue to be faced with weighing the risks of further potentially avoidable environmental damage against the risks of economic impacts from acidic deposition control programs that may ultimately prove to be ineffective.

Summary and Conclusions

Despite calls for immediate action to ameliorate the harmful affects of acidic deposition, NAPAP officials believe current knowledge is not yet sufficient to recommend implementing any further control programs. They expect to have sufficient information to be used as a basis for recommending control options over the next 2 to 4 years.

NAPAP's director of research told us that NAPAP research will have better information on all of the major uncertainties associated with acidic deposition by 1990. NAPAP's research is being directed towards two areas— atmospheric processes and effects of acidic deposition on lakes, streams, forests, crops, and man-made structures. Much of NAPAP's efforts between now and 1990 will be focused on the completion and validation of the RADM; the measurement of dry deposition; and the development of damage functions for terrestrial, aquatic, and man-made structures.

Although NAPAP is working on key unknowns, NAPAP officials acknowledge that they will not have definitive answers to a number of them by 1990. Research in several areas, including the effects of acidic deposition on forests and man-made materials will be needed for several years to better understand the complexities involved in damage caused by air pollution.

There are a variety of factors that affect on NAPAP's plans to provide policy-related information to decisionmakers by 1990. These include NAPAP's success to date in issuing its first assessment, the extent to which future NAPAP assessments address economic effects, and the subjectivity involved in determining how much data is enough to make policy decisions. As a result, it is unclear whether NAPAP will meet its

⁵An Analysis of Issues Concerning "Acid Rain" (GAO/RCED-85-13, December 1984)

goal of obtaining and synthesizing information needed to make policy recommendations by 1990.

Given these uncertainties, we conclude, as we have in a previous report, that decisionmakers will continue to be faced with weighing the risks of further potentially avoidable environmental damage against the risks of economic impacts from acidic deposition control programs that may ultimately prove to be ineffective.

Fiscal Years 1986 and 1987 Budgets Broken Out by NAPAP Task Group

Task Group Breakout Prior to 1986				
Task Group	1986 Total (\$000)	NAPAP (Percent)	1987 Total (\$000)	NAPAP (Percent)
Natural sources	\$1,155	1.4	\$927	1.4
Man-made sources	4,113	4.8	4,033	4.8
Atmospheric processes	18,596	21.9	19,607	22.9
Deposition monitoring	10,994	12.9	10,668	12.9
Aquatic effects	20,569	24.2	24,291	28.8
Terrestrial effects	22,905	26.9	19,819	23.3
Effects on materials and cultural resources	2,111	2.5	3,695	4.4
Control technologies	623	.7	344	.4
Assessments	3,931	4.6	2,281	2.7
Total	\$84,997	100	\$85,665	100

Task Group Organization After 1986		
Task Group	1987 Total (\$000)	NAPAP (Percent)
Emissions and control technologies	\$4,377	5.1
Atmospheric chemistry	12,207	14.2
Atmospheric transport	10,523	12.3
Atmospheric deposition and air quality monitoring	8,472	9.9
Terrestrial effects	19,819	23.1
Aquatic effects	24,291	28.3
Materials effects	3,695	4.3
Assessment, ^a	2,281	2.7
Total	\$85,665	100

^aAssessment work is conducted in the Office of the Director of Research.

NAPAP 1990 Objectives as of October 1986

Task Group I - Emissions and Controls

1990 Objectives

1. Assess emissions of sulfur dioxide, nitrogen oxides, and volatile organic compounds

Historical seasonal/state 1900-1990

Monthly by state 1975-1989

Detailed by month, typical hourly profiles, all relevant chemical species, and 20 kilometer grid for 1980 and 1985

Natural sources by region.

2. Develop a comprehensive model for predicting emissions and control costs of sulfur dioxide, nitrogen oxides, and volatile organic compounds under alternative assumptions of production, technology, and economics.

3. Compile a current summary of existing and potential control technologies and costs.

Task Group II - Atmospheric Chemistry

1990 Objectives

1. Estimate with adequate accuracy the natural background flux of sulfur dioxide, nitrogen oxides, ammonia, volatile organic compounds, and alkaline dust into air and the corresponding pH of precipitation on a regional basis by season.

2. Produce an adequate understanding of chemical processes in clear air that produce acids and related oxidants from the precursors sulfur dioxide, nitrogen oxides, and volatile organic compounds.

3. Produce an adequate understanding of the chemical reactions in the aqueous phase of clouds, fog, and precipitation, and the scavenging of acidic species in vapor of particulates from the atmosphere.

4. Establish the concentration of acidic species and oxidants in mountain clouds and ground-level fogs.

5. Determine the relevant processes that produce dry deposition. Develop a quantitative monitoring system from dry deposition. Estimate the relative contribution of dry to wet deposition of sulfates and nitrates by distance from source and by season.

6. Develop and validate atmospheric chemistry modules that will link efficiently into comprehensive mesoscale of regional acid deposition models being developed by Task 3.

Task Group III - Atmospheric Modeling and Transport

1990 Objectives

1. Provide efficient source-receptor models for both regional and mesoscale that are fully documented.
 2. Complete validation of these models to determine their level of accuracy.
 3. Demonstrate the application of these validated models to
 - predict deposition and air quality at sensitive areas from given emission sources,
 - establish relative importance of local vs. distant sources, and
 - examine non-linearities in source-receptor relationships.
-

Task Group IV - Atmospheric Deposition and Air Quality Monitoring

1990 Objectives

1. Determine the spatial and temporal variations in the composition of atmospheric deposition within the United States by means of nationwide monitoring networks.
2. Estimate the background composition of atmospheric deposition worldwide through operation of deposition monitoring and research sites at remote locations.
3. Provide air-quality measurements needed for the evaluation of atmospheric models and for assessment of effects due to atmospheric deposition.
4. Develop methods for reliable measurement of dry deposition.
5. Install an integrated storage and retrieval system for atmospheric deposition and air-quality data for the United States.

Task Group V -
Terrestrial Effects

1990 Objectives

1. Determine the effect on productivity of representative agricultural crops from exposure, near-ambient levels, to acidic deposition and associated oxidants.
2. Determine the effect on productivity and health of major tree species from exposure of the foliage to near-ambient levels of acidic deposition and associated oxidants.
3. Estimate the long-term effect on productivity and forest health from acidic deposition on a wide variety of forest soils at near-ambient levels.
4. Identify the major factors causing visible damage to forests above cloud base in the high mountains of the eastern United States.

Task Group VI -
Aquatic Effects

1990 Objectives

1. Quantify the extent, location, and characteristics of sensitive and acidic lakes and streams in the United States.
2. Quantify the factors that control sensitivity of surface waters to acidic deposition.
3. Adequately predict the rate of change of the chemical composition of streams and lakes as a function of acidic deposition.
4. Determine the relationship between surface water acidification and stress on biological populations.
5. Determine the potential effects of freshwater acidification on human health.
6. Produce an ecological evaluation of techniques for restoring or protecting acidic lakes and streams.

**Task Group VII -
Effects on Materials
and Cultural Resources**

1990 Objectives:

1. Quantify the effect of acidic deposition and associated oxidants incremental to natural background on materials degradation.
2. Estimate the quantity and geographic distribution of materials that are significantly impacted by incremental deposition.
3. Estimate the cost of the incremental impact on materials damage where measurable.
4. Evaluate the feasibility of substitution, protection, and other strategies to mitigate materials damage.

The Task Group's priority is to focus on goal 1, the development of damage functions. Progress towards meeting the other objectives is contingent upon satisfactory progress towards meeting this first objective.

Estimated Cost of Developing 1985 NAPAP Annual Report

External^a:	
Preparation costs	\$22,248
Printing costs	14,900
Subtotal	\$37,148
Internal^b:	
Office of the Director of Research	\$31,299
Subtotal	\$68,447

^aBased on the cost of the 1984 annual report.

^bBased on estimates provided by NAPAP's associate director, the official responsible for developing annual reports. These estimates do not include review and drafting time spent on the annual report by task group officials for NAPAP agencies.

NAPAP Funding for the Regional Acid Deposition Model (RADM), Fiscal Years 1982-87

Fiscal year	RADM development ^a	RADM application ^b	RADM evaluation ^c	Total
1982	\$2,177,000	\$330,000	\$-0-	\$2,507,000
1983	1,811,000	460,000	542,000	2,813,000
1984	2,720,000	543,000	786,000	4,049,000
1985	3,176,000	940,000	830,000	4,946,000
1986	2,595,000	1,363,000	500,000	4,458,000
1987	1,706,000	2,183,000	4,665,000	8,554,000
Total	\$14,185,000	\$5,819,000	\$7,323,000	\$27,327,000

^aExpenditures include design of the architecture, programming, interfacing with the modules that describe the science, testing, and documentation. They also include development of a fast-turn-around version of the RADM, the engineering model.

^bExpenditures involve work in direct support of the application of the RADM, including an exercising engineering model and the development of a detailed emissions inventory.

^cExpenditures involve the planning and execution of intensive field studies to determine the quality of the model predictions.

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