Learning From an Acid Rain Program

As federal scientists embark on a massive program of climate change research, they should take a hard look at what went wrong with NAPAP

IN 1980, WHEN ACID RAIN WAS PITTING NEW Englanders against Midwesterners and the U.S. government against the Canadian, Congress created a new program, the National Acid Precipitation Assessment Program. NAPAP was intended to marshal the best available science to figure out the causes and effects of acid rain and how to control it. NAPAP spent a decade and more than a half billion dollars on the challenge. Some 2000 scientists studied everything from lake sediments to atmospheric processes to damage to chain link fences. But last year, when Congress and the Bush Administration were haggling over the president's acid rain bill—especially over who should control sulfur dioxide emissions—NAPAP was nowhere to be found.

The elaborate, multimillion-dollar computer models it had built to aid in answering just the sorts of policy questions Congress had to deal with were only partially complete. And NAPAP's long-awaited "integrated assessment," intended to synthesize a decade's worth of science as the basis for evaluating different policy options, was not finished. Now, more than 6 months after the acid rain bill passed as part of the Clean Air Act Amendments of 1990, that report is still not out in final form. While NAPAP created an impressive body of scientific research over the decade, in terms of policy, says one congressional aide, it was "totally irrelevant." Others say, however, that while NAPAP may have fallen short of its policy goals, its scientific research helped define the parameters of the debate early in the decade.

What went wrong? The answer is complicated but can be traced to a number of factors, say many NAPAP participants and observers. For one, the program never recovered after publishing a 1987 interim report that was widely perceived as a biased attempt to downplay the problem—a sobering reminder of just how fragile credibility can be when dealing with such a highly emotional issue as acid rain. More than that, however, NAPAP strove for scientific perfection and lost policy relevance in the bargain.

NAPAP scientists built the biggest models, conducted the most extensive surveys, swooping down on thousands of lakes in helicopters with near-military precision. NAPAP research elucidated some of the intricacies of the atmospheric mixing and transport of various pollutants and helped determine the extent of the damage from acid rain. But in the end, the program never got around to the nuts and bolts questions about the costs and benefits of control strategies—or the politically charged issue of which states or industries should be hit with those costs—at least not in time. And that fundamental failing, warn NAPAP critics and supporters alike, may be repeating itself in the fledgling climate change program.

"NAPAP became obsessed by the need to have the best science, but the best science and the best models aren't always the best way to get answers to the things that matter most for policy," says Edward Rubin, a NAPAP participant in the engineering and public policy department at Carnegie-Mellon University. Milton Russell, who chairs NAPAP's oversight committee, agrees with Rubin's analysis but feels that critics should not be too hard on NAPAP. "In retrospect, we can see all the problems," says Russell, who is an economist at the University of Tennessee and Oak Ridge National Laboratory and former assistant administrator for policy at the Environmental Protection Agency during the second Ruckelshaus era. "But in 1980, there were no models for doing this: NAPAP was the first big effort at marrying science and public policy."


NAPAP

Winter damage. *Acidic cloud water makes red spruce trees more susceptible to damage by cold temperatures* (left).

When NAPAP was created in 1980, largely at the urging of Senator Patrick Moynihan (D–NY), acid rain's effects were in considerable dispute. In terms of controls, it was not at all clear whether small reductions in emissions—say, a cutback of just 10% or 20%—would protect the sensitive ecosystems, or whether huge reductions were needed. The idea behind NAPAP was to focus the expertise of all the relevant federal agencies (12 were involved) and four of the national laboratories on these and other policy-related questions.

But NAPAP ran into trouble almost from the beginning. Although the program had its origins in the Carter era—actually, in a report drafted for Gus Speth at the Council of Environmental Quality in 1977—it didn't get up and running until the early days of the Reagan Administration, which immediately made it suspect to environmental groups and many scientists as well. With Reagan in the White House and Ann Gorsuch at the helm at EPA, NAPAP was soon widely perceived as a stalling tactic to delay any action on acid rain, recalls Ralph Perhac of the Electric Power Research Institute and a member of NAPAP's oversight committee.

No one accuses the first executive director, Chris Bernabo of the National Oceanic and Atmospheric Administration, of having any political ax to grind. "But at that point," recalls Michael Oppenheimer, an atmospheric scientist at the Environmental Defense Fund, "it was clear that Bernabo was keeping his head low to see that it did not get shot off."

Bernabo's problems were complicated by NAPAP's somewhat unwieldy structure. It was run by a Joint Chairs Council, which included representatives of the six sponsoring agencies,* all of which had different scientific and political agendas. Not surprisingly, the program was plagued by incessant squabbling among the agen-

* EPA, the National Oceanic and Atmospheric Administration, the Department of Agriculture, the Department of Energy, the Department of the Interior, and the Council on Environmental Quality.

cies, especially between the Department of Energy and EPA, which often derailed progress for months. Almost from day one, NAPAP fell behind schedule.

Most of NAPAP's eventual shortcomings, however, can be traced to how it defined its universe—which was by and large in terms of scientific curiosity and not policy relevance. From the outset, say Russell and others, NAPAP saw itself as a scientific research program, not an assessment program—and there is a big difference. Explains Russell: "Instead of asking, What do we really need to know to make the wisdom-type calls Congress will be called on to answer over the next 10 years?, NAPAP managers asked, What are the intriguing and seminal scientific questions we can answer in 10 years?" What's more, they seemed to operate on the naive assumption that Congress would wait for their answers.

That scientific mind set encountered little opposition from the Reagan Administration, notes David Hawkins, who has been involved in the acid rain debate almost from the start, first as the assistant administrator for air programs at EPA and then as a lobbyist for the Natural Resources Defense Council. "Because the Administration was not interested in a rapid answer, the longer it took, the more convenient it was politically for them. They could say, just wait, our science program will have the answer in 6 years." The bottom line, Hawkins says, is that "NAPAP managers were never told by the people paying the bills that it was important to produce policy-relevant information in a reasonable amount of time."

Indeed, when William Ruckelshaus took over at EPA after Gorsuch resigned in 1983, one of the first questions he asked of NAPAP scientists was: How many lakes are in jeopardy? "Our answer was we don't know," recalls Bernabo. NAPAP scientists could describe lake chemistry in excruciating detail, but no one had bothered to look at the big picture. Largely under the guidance of Ruckelshaus, who chaired the Joint Chairs Council, NAPAP began to redirect some of its efforts toward more policy relevant questions. And by 1985, when Bernabo left NAPAP to set up his own company, the first interim assessment, which took an initial stab at evaluating the costs and benefits of different sulfur emission reduction scenarios, was essentially done.

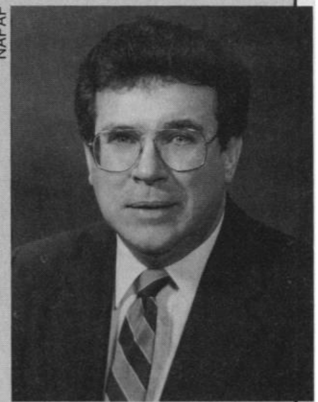
At that point the Joint Chairs Council decided that, if NAPAP was ever to meet its goals on time, it needed a stronger leader. They brought in Lawrence Kulp, then vice president for research and development at the Weyerhauser Corporation, and redefined the director's position to give him more authority. By all accounts, Kulp turned out to be a

How Bad Is Acid Rain?

"The sky is not falling," said James Mahoney at a February 1990 meeting of the National Acid Precipitation Assessment Program. Mahoney, who directed the program for the last 2 years, went on to say that 10 years of research had shown that while acid rain is a problem, "the good news is that it is not as bad as we thought."

Mahoney's comments triggered numerous news stories, like the one in *The New York Times*, "Worst Fears On Acid Rain Unrealized." His comments were also the impetus for a controversial "60 Minutes" program aired last December, which blasted Congress and the Bush Administration for ignoring NAPAP's findings and wasting the taxpayer's money by passing legislation to control the pollutants that cause acid rain. But while Mahoney's comments played well with the press, they received mixed reviews among his colleagues. Although some viewed his "sound bite" as a pithy summation of what the 10-year, $570-million research program found, others saw it as, at best, a misleading oversimplification and, at worst, a blatant mischaracterization.

NAPAP



James Mahoney. *"The sky is not falling."*

No one is arguing over NAPAP's basic scientific findings, which are described in its massive 6,000-page report. Those findings, in brief:

■ Acid rain has adversely affected aquatic life in about 10% of eastern lakes and streams.

■ Acid rain has contributed to the decline of red spruce at high elevations by reducing that species' cold tolerance.

■ Acid rain has contributed to erosion and corrosion of buildings and materials.

■ Acid rain and related pollutants, especially fine sulfate particles, have reduced visibility throughout the Northeast and in parts of the West.

What's at issue, rather, is the interpretation of those facts. Depending on your reference point, says Gene Likens, director of the Institute for Ecosystem Studies of the New York Botanical Garden, acid rain looks about the same as or perhaps worse than most scientists—if not the media and the public—believed a decade ago.

Michael Oppenheimer of the Environmental Defense Fund agrees. Granted, he says, in the early 1980s there was widespread concern that without reductions in sulfur emissions, lakes would continue to decline. That, by and large, has not been borne out. "But on the other hand, the problem is so much broader than we thought in 1980 or 1984. At the time, acid rain was thought of as a problem with lakes and nothing else."

The most vociferous arguments are over NAPAP's characterization of forest effects—not the full report, but the one-sentence summaries such as: "There's no evidence of a general or unusual decline of forests in the United States or Canada due to acid rain," a statement picked up by "60 Minutes." Ecologists Ellis Cowling of North Carolina State University and Orie Loucks of Miami University in Ohio are concerned about changes in forest soils caused by acid rain—changes that could lead to long-term deficiencies in soil nutrients, as the NAPAP report itself states. At this early stage in forest research, they say, sweeping pronouncements are premature. Says Loucks: "Yes, what Mahoney says is true. We don't have evidence of widespread effects, but he is basing that on the first half of 5-year studies." Adds Cowling: "You can say no symptoms were found, and we looked hard"—but that is different from saying that no problem exists.

Mahoney seems resigned to the hoopla, noting that on acid rain, "it is exquisitely difficult to write something neutral in tone. I am not saying there is no effect. But there was a great deal of literature in the early 1980s that painted a much harsher picture than what we found in the field. The bottom line is that some of the effects are clearly less severe than the allegations." Even so, says, Mahoney, "there is abundant indication that we need [sulfur emission] controls."

Others say Mahoney could have avoided the ruckus by summing up what NAPAP found, instead of what it didn't. Art Johnson, a forest researcher at the University of Pennsylvania, takes a stab at it: "It is the marginal ecosystems, the tenuous ones on the edge, that are affected by acid rain at current levels. I think control measures are justified. They will probably go a small way toward restoring some of the ecosystems that have been altered. And they will largely prevent more harm from occurring." ■ **L.R.**

more powerful force than anyone bargained for. Bernabo and others call him a "czar."

Kulp brought in a disdain for anything less than "hard science." His view, from the outset, was that NAPAP should stick to the facts and leave the interpretation to someone else. Likewise, he considered economic analysis of the costs and benefits of controlling acid rain to be squishy and premature and abolished that part of the program. Russell concedes that economic analysis is messy and complicated, compared to analyzing lake sediments, for instance. But, he adds, "it would have been very useful for Congress to know, in a rough and ready form, the benefit of one level of emissions reductions versus the costs."

Says Carnegie-Mellon's Rubin, who was involved in the early assessment efforts: "Kulp essentially dismantled assessment and policy analysis at NAPAP. It was really at that point that NAPAP lost the game."

Soon after he arrived, Kulp discarded the interim assessment prepared under Bernabo—with the express approval of the council, he says. "It was half-baked," Kulp told *Science*. "It had no sound scientific basis. It contained a great deal of stuff that was more hypothesis and philosophy than hard science." He also disbanded the assessment group, which from the start had been conceived of as distinct from the research group, and put himself in charge. Kulp then set out to redo the assessment, a revision that would take 2 years.

"Assessment should be by a separate group of scientists, not attached to the manager of research," says Oppenheimer of the Environmental Defense Fund. "That was the fatal flaw. It gave a black eye to both ends."

When the interim report was finally released in 1987, it raised howls not just from environmentalists but also from many scientists, as well as the Canadian government,


NAPAP

Scientific overkill? *NAPAP's final report was 6000 pages long.*

which dismissed it as "voodoo" science. (*Science,* 18 December 1987, p. 1404). No one questioned the quality of the research or the integrity of the scientists; rather, it was the tone of the executive summary, which Kulp wrote personally, that tended to downplay the effects of acid rain. Kulp left shortly thereafter.

"It was deserving of criticism. It was not balanced," says James Mahoney, a meteorologist who was brought in to replace Kulp and salvage NAPAP. "We faced a massive credibility challenge," he says with understatement. Mahoney set out to restore NAPAP's image, going first to National Academy of Sciences president Frank Press to see if the academy would take on an oversight role. Says Mahoney: "The feeling was that the problems were so bad that NAS would not do it" for fear of being tarnished.

Instead, Mahoney set up his own oversight committee, chaired by Milton Russell. Mahoney also set up an elaborate—some say excessive—process for both public and scientific review. Along the way, he regained the respect of the scientific community, if not all of Congress or the environmental groups. "He did a superhuman job," says Tom Brydges of Environment Canada, one of NAPAP's toughest critics in the early days. Even so, that has not spared Mahoney from charges that NAPAP has again downplayed the extent of the problem (see box on page 1303).

But in his struggle to restore NAPAP's standing, Mahoney perpetuated the pattern that had plagued the program from the outset: He went for the most definitive science, with every assumption spelled out, every uncertainty quantified. And when it became apparent that Congress was finally going to move on acid rain last year, NAPAP had grown so unwieldy and was so set on its course that Mahoney was unable to turn it around in time to provide the quick answers Congress needed.

Indeed, when the president's acid rain bill was introduced in Congress last year, NAPAP's model for assessing the costs of different emission control scenarios, the Advanced Utilities Simulation Model, could not be used to analyze it. And when EPA officials, who were heavily involved in crafting the Administration bill, wanted information on the health effects of acid aerosols, they couldn't get it from NAPAP, whose relatively small research effort had not started until

Going for Broke on a Megamodel

In a sense, the Regional Acid Deposition Model, RADM, epitomizes the best and the worst of NAPAP. It is an extraordinary model, capable of dazzling resolution, yet even NAPAP's director says it was developed at the expense of simpler models that would have been more useful for policy analysis.

In all fairness, says NAPAP director James Mahoney, the extraordinary effort that went into RADM was justified because the model was designed to answer a vexing—and critical—question: Whether a reduction in sulfur dioxide emissions would lead to a similar reduction in acid rain. The National Academy of Sciences (NAS) had tackled the issue in 1983 and was unable to resolve it conclusively. Nonetheless, the NAS committee hazarded a carefully qualified guess: that, over a large enough temporal and spatial scale, the relation between emissions and acid deposition is essentially linear—or, in other words, what goes up, comes down.

NAPAP scientists built RADM to nail down that answer, spending years and many millions of dollars in the process. That model, in essence, takes hourly emissions from all pollution sources simultaneously and simulates each pollutant's atmospheric transport, its interactions with other emissions, and the site where it will ultimately land.

"It might be a feat of computation, but who cares, from a policy standpoint?" asks David Hawkins of the Natural Resources Defense Council, who points out that the most effective way to control acid rain is to reduce sulfur emissions over a broad area. "We said that 10 years ago, when NAPAP proposed to spend scores of million of dollars to build a model capable of doing research that no one really needed." Edward Rubin of Carnegie-Mellon University also questions whether RADM's level of resolution was needed, pointing out that Congress is interested in annual averages, not daily or hourly. "It is a lovely piece of science, but again, it is a matter of resource allocation and focusing on priorities." RADM eventually showed that while the relation between emissions and acid deposition is not exactly linear, it's close enough. But meanwhile, EPA and Congress had already turned to other models to figure out control strategies.

Mahoney staunchly defends RADM: "We needed it to advance the science." But he does say the program's near-exclusive reliance on that model was a mistake. In retrospect, he says, NAPAP should have started with some simpler models that could have been finished by 1985 or 1986 and then used RADM to validate them. Indeed, when he arrived at NAPAP in 1988, Mahoney tried to reorient the effort to provide some quick answers for Congress but encountered strong resistance from the modelers, who looked askance at anything less than the most definitive science. ■ L.R.

fairly late in the game.

What Mahoney concentrated on instead was compiling the most authoritative scientific document yet on acid rain: the 27 "State of Science and Technology" reports, numbering more than 6000 pages, which were released in draft form in February 1990. But by that time, Congress was grappling with political issues—like who was going to pay—and not scientific ones, says Michael Rodemeyer, a key aide on the House Science Committee. "There had not been any real scientific debate for a good 5 or 6 years, in terms of where the stuff was coming from and how to get rid of it."

Mahoney did steer NAPAP back to its original mandate of policy analysis, but by that time, says Rubin, "it was too little, too late." NAPAP's final integrated assessment, evaluating likely emission reduction scenarios, was released in draft form last September, almost at the moment Congress was passing a bill mandating a 10-million ton reduction in sulfur emissions.

Because policy concerns had rarely been used to shape the research agenda over the years, NAPAP staff had to cobble together the final assessment from the pieces they had on hand. The patchwork shows, says Rubin, who says it is "embarrassingly short" on economics. It also gives fairly cursory treatment to what turned out to be two major policy issues: visibility loss and the effects of acid aerosols on human health.

Mahoney doesn't argue with the criticism but simply explains: "I wanted to create a highly credible set of scientific documents. We kept on track and made a sound contribution that will stand well. And we did it at the expense of greater policy relevance. I had the sense that if we tried to do both, we would have failed at both."

With the benefit of hindsight, Mahoney says he would have done things differently, like diverting some of the resources away from NAPAP's enormously complicated atmospheric transport model toward simpler models that could have provided answers sooner (see box on page 1304). But the scientific mind set at NAPAP militated against it, he says.

Mahoney, Rubin, and others warn that the scenario is already repeating itself in the new federal climate change program, coordinated by the interagency Committee on Earth and Environmental Sciences. "Global change is driven too much by raw science," says Mahoney, referring to the current push to improve the general circulation models. "The real aim [of that work] is to understand atmospheric physics. Any questions about effects or policy exist in a separate sphere. That is the kind of thing that happened to NAPAP." ■ LESLIE ROBERTS

NIH Takes Heat for Lax Investigation

Several top officials at the National Institutes of Health took a beating at the hands of Representative John Dingell (D–MI) last week over NIH's performance in investigating allegations of financial wrongdoing. At a 6 March hearing, Dingell lambasted acting director William Raub, cancer etiology director Richard Adamson, and audit director Howard Hyatt for failing to investigate thoroughly an intramural scientist suspected of what Dingell called "an extraordinary series of potential felonies."

The case that drew Dingell's ire involves Prem Sarin, who until last December served as Robert C. Gallo's chief lab deputy at the National Cancer Institute (NCI) (*Science*, 11 January, p. 151). NIH had twice investigated Sarin's relationship with the Wisconsin–based Responsif Corporation and found little to warrant concern. But two General Accounting Office (GAO) investigators, brought in by Dingell, presented evidence last week that Sarin may have lied to Congress last April when he testified that he represented Reponsif without pay at a 1985 hearing before the Food and Drug Administration. In fact, said the GAO investigators, Reponsif had paid Sarin to represent the company at the hearing. Furthermore, they testified, Sarin may have improperly received $31,000 from two other pharmaceutical companies—the Pfizer Corporation and Degussa/ASTA Pharma—for testing drugs at Gallo's lab, and they said he apparently attempted to disguise his consulting income by using a dummy account and asking ASTA Pharma to describe a consulting fee as a research award. The GAO investigators also said Sarin may have forged signatures on financial disclosure forms.

Sarin declined to testify last week. NIH has suspended him without pay pending investigations by the inspector general of the Department of Health and Human Services and the U.S. Attorney's office in Baltimore.

But Dingell wasn't satisfied. His subcommittee uncovered these alleged misdeeds "with relatively little effort," he declared. By contrast, a 1987 NIH inquiry never questioned Reponsif officials or verified the signatures on Sarin's financial disclosure forms. NCI officials interviewed Sarin after his testimony last April but decided the matter merited no further action. Only after Dingell's subcommittee requested records from NCI last December pertaining to collaborations with ASTA Pharma and Pfizer did officials there find evidence of Sarin's financial dealings with the three companies.

Apparently taken aback by the GAO evidence, Raub, Adamson, and Hyatt were abject in declaring that NIH had handled the case badly, particularly in taking Sarim's explanations at face value. "In hindsight, sir, the level of trust was too high," Raub testified. Raub also suggested that the greater autonomy given to scientists over the past two decades in research matters had carried over into the administrative realm. "We need to develop a greater talent for directed suspicion," he said.

Raub described Sarin's alleged misdeeds as "isolated events." Dingell and his staff are skeptical, however. Last April, a similar investigation into the financial affairs of Syed Zaki Salahuddin, a former Gallo researcher, ended in a guilty plea to two felonies—conflict of interest and accepting an illegal gratuity. "We hope they get their act together over there," says a Dingell staffer. "We've tried to impress on NCI that we don't want to keep doing this."

■ DAVID P. HAMILTON

If at First, We Don't Succeed...

1. If $\frac{2}{3} - \frac{1}{2} = \frac{y}{4}$, then y =

(A) 3/2 (D) 2/3

(B) 1/12 (E) none of these

(C) 1

3. If $x^2 + kx + 10 = (x + 2)(x + 5)$, then k =

(A) 2 (D) 7

(B) 5 (E) 3

(C) 10

4. In triangle ABC, angle C is a right angle with $a = 6$ and $c = 12$. What is b?

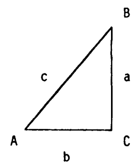
(A) $6\sqrt{3}$

(B) 6

(C) $6\sqrt{5}$

(D) $6\sqrt{7}$

(E) 9



You can save some postage: Yes, we goofed last week (p. 1173), but not because we can't do elementary math. The problems were "wrong"; not the answers. Late in production, our original problem 1 was replaced with a different one and the positions of problems 3 and 4 were switched. Unfortunately, the answers were not changed accordingly. The correct answers are, of course: (1) D; (3) D; and (4) A.