

# Federal Report on Acid Rain Draws Criticism

*A new report, showing minimal effects from acid rain, has scientists grumbling about selective reporting*

**I**N 1980, when emotions were high and answers were scarce, Congress established a 10-year interagency research program to examine the causes and effects of acid rain and recommend actions to limit or reduce its harmful effects. On 17 September, some 5 years and \$300 million into the research effort, the National Acid Precipitation Assessment Program (NAPAP) is scheduled to release its long-awaited "interim assessment."

Although many of the results of NAPAP's extensive research have been published before, the interim assessment is NAPAP's first attempt to synthesize and interpret them. The assessment was originally scheduled for release in 1985, but the publication date was slipped a half dozen times while the report was being substantially revised by the new director of research. *Science* obtained an 18 August draft of the executive summary, a 71-page document that is the first volume of the four-volume assessment. It was originally scheduled for release on 8 September.

The impression that emerges from the summary is that there is not much to worry about. Acid rain has negligible or no effects on crops and forests, though tropospheric ozone may be a serious problem. Only a small number of lakes have been acidified, and no further significant acidification is likely in the Northeast. No abrupt increase in damage to crops, forests, and lakes is likely at current emissions. Emissions are likely to hold steady or decline, and new "clean coal" technologies are emerging that are so efficient that they may be adopted for economic reasons alone, without mandated controls.

Several scientists who are familiar with the draft are not at all happy with it. "I was very disappointed in the document I read. It seems rather highly politicized," says Gene Likens, director of the Institute of Ecosystem Studies of the New York Botanical Garden.

The quality of NAPAP's research effort is generally considered to be quite good, perhaps first rate, and there is little quarrel with the individual facts. But the way they are presented—which tends to minimize the extent of the problem—is causing some

consternation. "It is the way things are put, the order they are in, the way they are phrased," says Likens, who notes that findings that contradict NAPAP's generally rosy view are often found at the back of the summary. He notes that he has only seen the executive summary, not the full report, "but the executive summary is what congressmen and journalists read."

To David Schindler of Environment Canada, the Canadian equivalent of the U.S. Environmental Protection Agency, "it looks like a deliberate effort to downplay the effects. But it is not due to the scientists involved." Several U.S. researchers agree with Schindler but did not want to be quoted.

There is little doubt that the final product is very much shaped by J. Laurence Kulp, the director of research, who is widely noted

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for his strong personality and micromanagement style. A geochemist, Kulp was formerly vice president for research and development at Weyerhaeuser Company. It was at Kulp's urging, and following his specific instructions, that the 1985 assessment was extensively revised.

At NAPAP's annual meeting in July, Kulp explained that the earlier version needed revision "to make it substantive rather than speculative." Some of the researchers who suffered through the numerous rounds of revisions have different views. "Larry has strong opinions that may or may not be true," says one of the researchers. "Larry is pushing his own beliefs on oxidants. He alienates people on both ends of the spectrum," says an Administration official closely associated with the program. Others believe Kulp has brought needed focus to the program, however, and has strengthened the

research effort. Clearly, he has had a pronounced impact on it. Kulp did not return phone calls from *Science*.

Since he took the helm in 1985, Kulp has substantially changed the program's focus, pulling back from policy analysis in general and economic analysis in particular, as the General Accounting Office (GAO) described in an April 1987 report, "Acid Rain: Delays and Management Changes in the Federal Research Program." Kulp has also taken an "active role" in managing the assessment, GAO said, working individually with the authors of each chapter (senior scientists in the participating agencies) and "having them provide him with drafts that respond to his specific comments."

Most of the criticisms center on the report's depiction of aquatic effects—to date, the best understood effect, and the one that galvanized the scientific community and captured public attention in the 1970s. Now the question is not whether atmospheric deposition has led to the acidification of sensitive lakes, but how many are affected, and how severely.

To address these questions, NAPAP has conducted the most extensive lake survey yet, sampling many hundreds of lakes in sensitive regions of the country. With near military precision, researchers swept down on lakes in helicopters to collect water samples, which were analyzed at the site and then retested later. They have compiled a huge data set, on which most of their conclusions are based. "Absolutely first-class work," says Environment Canada's Schindler, who is an aquatic ecologist and who chaired the landmark 1981 National Academy of Sciences (NAS) report on acid deposition, "Atmosphere-Biosphere Interactions."

But the problem, says Schindler and everyone else *Science* spoke with, is that the data are presented in a way that underestimates the number of acidic or sensitive lakes and essentially ignores the biological effects. First, NAPAP uses pH 5.0 (and an acid-neutralizing capacity of 0) as its cutoff point for defining an acidic lake. "Research in the past 10 years has shown that those numbers are meaningless with respect to damage to aquatic biota," Schindler says. "There is evidence of damage at pH 6.0, an order of magnitude less acidic," and most fish species stop reproducing at a pH of 5.3 or 5.6. Some 30 to 50% of a lake's natural biota is gone by pH 5.0, Schindler says. The first to go are generally the smaller organisms that fish feed on, such as mollusks and minnows.

If NAPAP used what would be considered a more representative pH, 5.5 or 5.8, the agency would have found considerably more lakes with chemistry of concern. But

by using pH 5.0 as its measure NAPAP found "only a small fraction" of lakes to be acidic. In the Adirondacks, for instance, 1.7% of the lake area is acidic, or roughly 10% of the lakes, NAPAP says. "This puts the entire thing in perspective as far as the U.S. is concerned," Kulp said at NAPAP's annual meeting in July. One of the scientists involved in NAPAP's aquatic research, however, believes a more realistic number of Adirondack lakes of concern is 15 to 20%.

Other factors contribute to this underestimation of the number of acidic lakes. For instance, the survey was conducted in the fall, when the pH is highest. (Fall is a good time for sampling, however, because lakes are well mixed.) The pH drops significantly in the spring, after rainstorms or snowmelts. "The people who did the science are well aware of this," says Schindler. "It is the political people in NAPAP who use the numbers differently." Indeed, NAPAP researchers are now sampling in the spring, and are attempting to use computer models to predict the spring pH from the fall pH.

NAPAP also concludes that at current deposition levels, further significant surface water acidification in the Northeast is unlikely because most watersheds "are at or near steady state with respect to sulfur deposition." Schindler thinks that it is not at all clear that watersheds are at steady state. In fact, he says, a new study by Peter Dillon of the Ontario Ministry of the Environment shows that lakes are continuing to acidify at current emission levels because of cation depletion in the watersheds.

But even if a watershed is *chemically* at a steady state, Schindler says, the biology can lag behind by a couple of decades. "To say all the [biological] damage has been done is ridiculous." Tom Bridges, Environment Canada's science adviser on acid rain, concurs. He believes that "biological health of these systems is still deteriorating under conditions of constant chemistry."

In the southeastern United States, by contrast, NAPAP notes, watersheds are not in a steady state and "gradual increases in surface water sulfate and decreases in ANC [acid-neutralizing capacity] may occur as the sulfur absorption capacity of the soil decreases." James Galloway of the University of Virginia agrees, but thinks that NAPAP is underestimating the future acidification problem in the Southeast.

NAPAP reports that in the Southern Blue Ridge Province, which receives "moderate to high levels of acidic deposition," no acidic lakes or reservoirs were detected. Moreover, a survey of 54 small streams "showed none with a pH below 6.0."

"I say they haven't looked hard enough and maybe not in the right place," responds

Galloway, who has sampled all the streams in the Shenandoah National Park. "We find very low-pH streams, large numbers below 6.0. One-third of the streams are sensitive to acidification."

Perhaps the biggest oversight in NAPAP's discussion of aquatic effects, Galloway says, is that it fails to mention Canada, where the aquatic effects are far more serious than in the United States. Eastern Canada has far more lakes and a much higher proportion are sensitive to acidification.

Since the early 1980s, what role, if any, acid deposition plays in the unexplained forest declines in the United States has also been the subject of considerable debate and research. Concern is fueled by the far more serious and widespread decline of West German forests. The problem is complex, however, and most researchers agree that sorting



**Stressed trees.** Spruce trees on Whiteface Mountain, New York, are believed to have been damaged by acid rain and high winds.

out the relative roles of air pollutants and natural stresses, such as climate, drought, disease, and pests, will take years.

In 1985 NAPAP launched a major, and highly regarded, forest effort, in addition to its ongoing research on crop effects. Under the Forest Response Program, four research cooperatives, involving scientists from the national laboratories, federal agencies, and universities, are studying four different forest types and regions: spruce-fir, southern commercial (pines), western conifers, and eastern hardwoods.

In its assessment NAPAP states that no effects of acidic deposition have been found on crops or forests, and it is unlikely that regional sulfur dioxide is causing damage to crops and forests. Tropospheric ozone, however, may play a major role. At ambient

levels ozone can retard forest growth and at high levels can lead to severe effects and mortality. NAPAP estimates that ozone causes \$1 billion in crop damage each year.

NAPAP's evidence on acid rain comes from experiments in which seedlings were exposed to simulated acid rain. No injury or adverse effects on the foliage of conifers and hardwoods were observed down to pH 3.5, NAPAP reports. Because the average annual pH of rainfall in the United States rarely falls below pH 4.1, NAPAP says, short-term direct foliar effects on healthy forests are unlikely.

However, many researchers are concerned about acid rain effects on unhealthy trees, such as high-elevation forests that are exposed to multiple natural and pollutant stresses. High-elevation forests, some of which are in serious decline, are enshrouded in low-pH fog or mist or are exposed to acidic clouds about half of the time. Ozone concentrations are typically higher too. NAPAP notes that "it is impossible to draw conclusions concerning the effects on above-cloudbase forests." At the annual meeting, however, Kulp said that acid deposition could be "all but ruled out" and that the evidence points to ozone and hydrogen peroxide instead.

Art Johnson of the University of Pennsylvania agrees that there is no strong evidence of a direct effect on the health of forests from acid rain. But in his view, the key question to address is the interaction between natural stresses, which are very acute, and air pollution stresses, which represent a sort of "background stress." Air pollution may be "an added burden on already-stressed trees."

In what may become one of the more controversial statements in the assessment, NAPAP asserts that the relationship between emissions and acid deposition may be nonlinear. The relationship is key because it determines whether controlling sulfur dioxide emissions will reduce acid deposition. In a 1983 report, "Acid Deposition: Atmospheric Processes in Eastern North America," the National Academy of Sciences concluded that "there is no evidence for a strong nonlinearity in the relationship between long-term average emissions and depositions." Thus, the Academy found, a uniform reduction in sulfur emission in North America should lead to a similar reduction in sulfur deposition.

NAPAP asserts, however, that in the northeastern part of the country, the formation of acid deposition appears to be limited by the availability of hydrogen peroxide in winter and perhaps in other seasons. As a result, a "reduction in sulfur dioxide emissions in the northeast in winter is unlikely to result in a proportional decrease in the for-

mation and subsequent deposition of sulfuric acid over northeastern North America." In a leap that is not explained in the summary, NAPAP then concludes that "although reducing the emissions of sulfur dioxide in any season is likely to result in the reduction of dry and wet deposition of sulfur compounds, the magnitude and extent of the reduction cannot yet be evaluated."

According to Tom Bridges, "on a regional scale, over time, if you reduce sulfur dioxide emissions, you get a corresponding change in sulfate concentration in surface waters. You may not find this one-to-one relationship in January, but field experiments show that it is an approximate linear relation through time." Moreover, he says, both NAPAP and Canadian officials agreed to that conclusion in the February 1987 "Joint Report to the Bilateral Advisory and Consultative Group."

At NAPAP, Paul Ringold, the associate director of research, agrees that "over large areas and long periods of time, what goes up comes down. But how relevant those time and space scales are is a different matter. If it comes down in the Atlantic and not in the Adirondacks, it probably doesn't matter."

According to NAPAP, many of the major questions—such as source-receptor relationships, the cause of high-elevation forest decline, and the effect of episodic pulses on aquatic life—will not be resolved until NAPAP's final, 1990 assessment. And until that time, any policy recommendations or the implementation of sulfur dioxide controls would be premature.

The implication is clearly that nothing needs to be done before then anyway, given the minimal effects observed to date. NAPAP describes emerging technologies, such as integrated gasification combined cycle (IGCC), that appear to be so efficient that "their implementation may proceed steadily based on economics alone." IGCC can achieve "99+%" removal of sulfur dioxide from high- and low-sulfur coal, NAPAP asserts, though others say this has yet to be demonstrated. If these new technologies are adopted, NAPAP says, by 2030 utility emissions would be reduced to 3 million metric tons a year, down from the current level of about 22 million metric tons.

Many members of Congress do not plan to wait for these technologies to be adopted or, for that matter, for NAPAP to resolve the outstanding questions in 1990. In mid-September the Senate Committee on Environment and Public Works is scheduled to mark up an acid rain bill that calls for about a 14-million-ton reduction in sulfur emissions. NAPAP's timing for the release of its interim assessment that same week is probably not coincidental. ■ **LESLIE ROBERTS**

# Choppin Takes Reins at Howard Hughes

*The new president of the Howard Hughes Medical Institute has plans to support individuals at schools without big HHMI units and to offer stipends to select graduate students*

THE presidency of the Howard Hughes Medical Institute (HHMI) has been called the most influential biomedical research job in the world. With his recent appointment as Hughes' new president, Purnell W. Choppin, a virologist and physician of modest demeanor, has assumed leadership of a \$5-billion philanthropy with the resources and clout to shape medical research in America for decades. He succeeds Donald S. Fredrickson who recently was forced to resign as a result of an administrative scandal.

As Hughes vice president and chief scientific officer for the past 2 years, Choppin has already made his mark by leading the institute into the area of structural biology. In a recent interview with *Science* in his Bethesda, Maryland, office a couple of miles from the National Institutes of Health,\* Choppin talked about other plans he has for HHMI—plans that include the support of younger scientists, including graduate students, as well as programs at institutions that do not have medical schools of their own.

In terms of the science it supports, Hughes, which was founded in 1953 by the reclusive billionaire aviator, has always limited itself to carefully chosen disciplines. Human genetics has long been its mainstay, along with cell biology and regulation, and immunology. Then neuroscience was added to the list, and now structural biology, with its emphasis on the use of advanced x-ray crystallography, magnetic resonance imaging, and computer graphics as tools of the trade. Six new structural biology units with state-of-the-art equipment have been established at Baylor, Columbia, Harvard, the University of California at San Francisco, the University of Texas at Dallas, and Yale.

Choppin's own research has included work on the structure of viruses, nearly all of it done at Rockefeller University, which he joined in 1957 when it was still the Rockefeller Institute. When he left Rockefeller in 1985 to join Hughes, he was senior physician, vice president for academic programs,

and dean of graduate studies. Choppin, 58, is a graduate of Louisiana State University and its School of Medicine. He is a member of the National Academy of Sciences and of the Institute of Medicine, on whose governing council he serves.

Choppin takes over at Hughes at a crucial moment in the institute's history. As trustee chairman George W. Thorn has pointed out, the fiscal year that began on 1 September "can be viewed as the first year of the institute's maturity." All of its legacy of financial and legal burdens are now behind it. For years, HHMI was in a state of limbo while Howard Hughes' heirs argued over his will. When that was finally settled and new court-appointed trustees were named, HHMI was able to find out how much it was really worth by selling its only asset—the Hughes Aircraft Company—to General Motors for more than \$5 billion (*Science*, 21 June 1985, p. 1414). And, perhaps most important, last year the institute settled a decades-long dispute with the Internal Revenue Service (*Science*, 13 March, p. 1318) with a resultant agreement to spend a minimum of 3.5% of its assets annually as a "medical research organization (MRO)," and to spend \$500 million during the next 10 years in the more traditional foundation mode.†

The institute's operating structure is central to the way it does business on university campuses and is of particular concern because of speculation that as the Hughes presence grows, so will its power to shape, and possibly distort, the biomedical research enterprise.

Under the law, a medical research organization must spend 3.5% of its assets in the *actual conduct* of research. Thus, Hughes' scholars are not grantees, but employees. The institute actually owns laboratories on university campuses. Instead of paying an indirect cost rate to university administration, it pays directly for items such as heat and light. A Hughes unit at Harvard or Yale, for instance, is simultaneously part of the university (Hughes people must have

\*HHMI, 6701 Rockledge Drive, Bethesda, MD, 20817.

†Details about the new HHMI grants program will be released early next month.