ACID SOLUTIONS

Both scientifically and politically, the answers to the acid rain problem promise to be hard-won

The second of two articles
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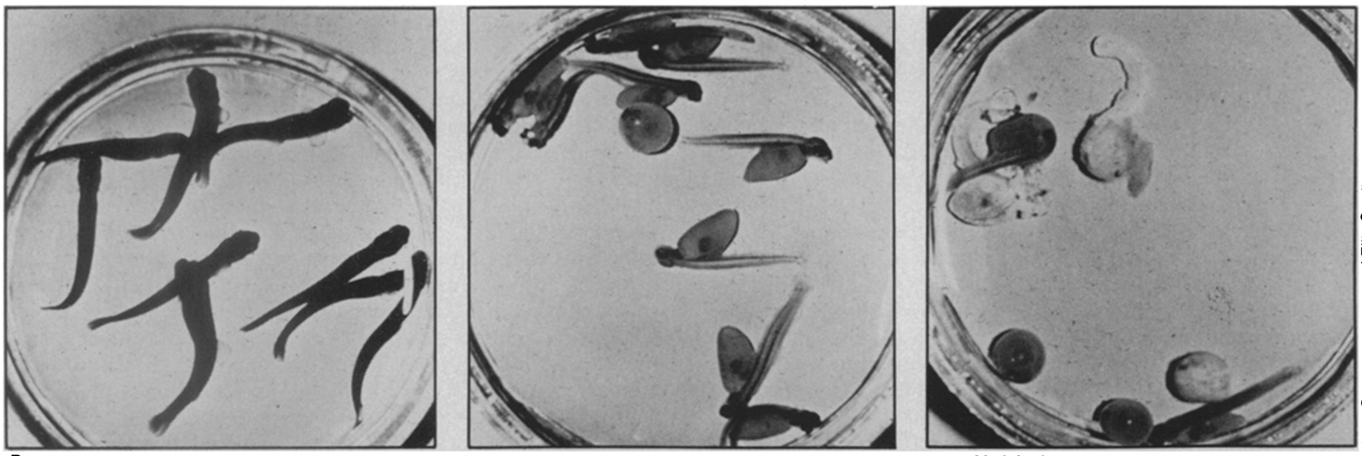
Lars Overrein, courtesy of Ellis Cowling

Brown trout development in acid lake water: Left to right, normal fry at pH 5.5; impaired at pH 5.0; fatally damaged at pH 4.5.

There will come soft rains and the smell
of the ground,
And swallows circling with their
shimmering sound;

And frogs in the pools singing at night,
And wild plum trees in tremulous white;

Robins will wear their feathery fire,
Whistling their whims on a low
fence-wire . . .

Not one would mind, neither bird nor
tree,
If mankind perished utterly . . . .

—Sara Teasdale, 1920

Today, Teasdale's words carry a sad irony. Because of a phenomenon called acid precipitation, rain is no longer soft; it can be as acid as vinegar. Frogs and wild plum trees can no longer be blithely indifferent; they, not humans, may perish of acid rain (SN: 2/2/80, p. 76).

But Teasdale did not know about acid rain. It was not detected until the late 1950s and early 1960s by English and Scandinavian researchers who quickly associated it in their countries with uncontrolled emissions of sulfur and nitrogen oxides from fossil fuel combustion. Thrown high into the air and carried perhaps thousands of kilometers, such pollutants often are converted to sulfuric and nitric acids before they are finally washed out in rain, snow, sleet or hail. By the early 1970s, research showed that acid rain was also falling in the northeastern United States and in eastern Canada.

The associated ecological woes are staggering. More than 100 lakes in the Adirondack Mountains of New York State are so acidified that they no longer contain fish. Experiments have shown that acid rain can strip the waxy coating from plant leaves and bare them to disease and pests. When acid rain runs through soils, it may whisk away nutrients and leave toxic metals in its wake. Implicated in this environmental scandal are the nation's growing hunger for energy and the accompanying concentration of uncontrolled midwestern power plants that fling their pollutants to the prevailing westerly winds.

And there's the rub. The list of horrors piles up quickly; the solutions are not so easy to come by. Acid rain lies smack in the middle of a treacherous intersection of science and big business; public policy must negotiate the crossing. The evidence that prompts a scientist to declare that such a problem exists and that it is probably human caused is not sufficient to convince industry of its responsibility or policy makers that something needs to be done.

Recent comments by the American Petroleum Institute about nitrogen oxides and their role in acid rain illustrate the dilemma. In evaluating a November 1978 Environmental Protection Agency draft report on the subject, API consultants blasted the inadequacy of data that show a trend of increasing acidity, contended that natural sources of nitrogen oxides (such as volcanoes and ocean spray) may have more impact on acid rain than fossil fuel combustion and maintained that acid rain is only one of many environmental factors that might be responsible for the observed effects. At the September 1979 meeting of the American Chemical Society, the consultants, Mary L. Miller and A. Gordon Everett of Everett and Associates in Rockville, Md., argued that "it seems clear that *if* there is indeed a significant trend towards either increasing acidity or nitrate concentrations in rainfall, there *may* be a serious threat to the ecosystem. However, it seems equally clear that we do not presently have the necessary knowledge to confirm either the trend or the magnitude of the threat." (Emphasis added.)

On the other side of the intersection, EPA's Norman Glass comments, "They [API and others] seem to be following the typical pattern. First they say there's no problem. When they accept that there is, they say, 'Well, it must be someone else.' And when you really nail them down, they say, 'But our contribution is so small compared to natural sources.'" Or as another researcher puts it, "You can't argue with a dead fish."

But groups such as API have a point. When it comes to talking billions of dollars for controlling the supposed sources of acid rain, you have to be sure. At that price, few researchers are willing to be dogmatic.

So being sure is the reason for the boom in acid rain research. Says Eville Gorham, one of the first researchers to identify the problem, "It's a real bandwagon effect." The word bandwagon causes visions of boondoggle to dance in some heads. But whether because of a recognition that the days of Big Science are gone or because many believe a finite amount of time exists to deal with the problem, the growth of acid rain research seems to be remarkably controlled.

Research plans reflect the knowledge that acid rain is a multi-headed and slippery beast. Like carbon dioxide and ozone depletion, acid rain is one of a growing breed of problems that affects the entire globe and every part of an ecosystem. It is also a silent and invisible marathoner: Its effects are cumulative and may not surface for decades. It forces a sort of anticipatory science: In order to give public policy machinery a direction, scientists must produce the best quantitative and predictive data they can as quickly as possible. And in order to persuade groups such as the API, acid rain researchers have to nail down all corners of their hypotheses. Clearly, acid rain forces scientists into an uncomfortable and increasingly familiar position. Says Christopher Cronan, soil researcher at Dartmouth College, "We may have to get on a few limbs and give government and legislators something to work with. Otherwise, they will have to sit at their desks with less than we have."

On the federal level, acid rain research appears to be receiving attention worthy of its complexity and urgency. In his Aug. 2, 1979, environmental message to Congress, President Jimmy Carter said acid rain is second only to carbon dioxide as the current most serious environmental threat, and directed the reprograming of $10 million per year into acid rain research and the creation of a Federal Acid Rain Assessment Program. That program, under the aegis of the Council on Environmental Quality, is expected to be outlined within a week and will form the basis for research to be handled through the interagency Acid Rain Coordinating Committee cochaired by EPA and the Department of Agriculture. In addition, a Senate bill cosponsored by Sen. Daniel Moynihan (D-N.Y.) and Sen. John Heinz (R-Pa.), which has since become an amendment to the controversial synfuels bill, would establish an 11-year program on acid rain and would provide $68 million during the first seven years. The amendment, which is currently with the synfuels bill before a House-Senate conference committee,

George Hendry/Brookhaven National Laboratory

Acid rain runoff collected from pinto bean leaf to determine nutrient leaching.

would add more agencies and regional offices to the coordinating committee and probably would incorporate the research outline expected from the CEQ.

Whatever form its administration takes, the research is expected to be modeled after and to expand on several current programs. The prototype of the long-term, whole-ecosystem approach is work conducted by Gene Likens of Cornell University, F. Herbert Bormann of Yale University and others at the 75,000-acre Hubbard Brook Experimental Forest in the White Mountains of New Hampshire. Established in 1963, the precipitation network at Hubbard Brook provides the longest continuous record of rain chemistry in the United States. Using data from this network, Likens and Bormann became the first researchers to alert the scientific community to the threat of acid rain in the United States. The researchers use an entire watershed — the whole area that drains into a river or other body of water — as their primary unit of study. In 1977, for example, Likens and Ronald J. Hall experimentally acidified a stream called Norris Brook in order to measure the chemical and biological effects. At a pH (a measure of acidity) like that recorded for the stream during the spring flush of meltwater, Likens and Hall saw "remarkable changes in the chemistry and biology within an hour or so." Equally important, they found that because of constant flushing, the stream quickly returned to its original state. Only because of their "holistic" approach, says Likens, were they able to detect unexpected changes such as a striking increase in fungi in the stream sediments.

Ironically, one of the most complete whole-ecosystem acid rain projects was begun in 1977 by the Electric Power Research Institute, the research arm of the electric industry. (The project now also receives funding from EPA, the Department of Energy and others.) The more than $4 million project is managed by a California-based consultant firm called Tetra Tech, Inc., and despite the opportunity for self-serving research, it is regarded as quite objective. Originally called the Adirondack Lakes Project, now more abstractly dubbed the Integrated Lake Watershed Acidification Study, the study compares three Adirondack Mountain lakes and their surrounding watersheds. The three lakes, Woods, Sagamore and Panther, weigh in at high, medium and low acidity, respectively. In addition to determining "what makes a good lake go bad," says George Hendry of Brookhaven National Laboratory, the 4-year project is trying to quantify the effects of acid rain on a lake system with the aim of designing a model to predict what will happen if air quality is changed. To this end, researchers from various institutions analytically follow precipitation in the air, as it falls on treetops, after it hits the trees, when it reaches the forest floor, as it passes through the different soil layers and as it flows into and out of the lake.

Lime is spread on New York State lakes in attempt to neutralize acid rain effects. Less accessible lakes are reached by helicopter.

J. Goerg/N.Y.S. Dept. of Envir. Con.

Unique to the Adirondacks project is a study of the little-understood area of soil chemistry. Under the leadership of Dartmouth's Cronan, lysimeters have been placed throughout each watershed at two depths in the soil. (A lysimeter is an open-topped basin with a drain that allows the study of water as it passes through soil.) Cronan plans to study the role of naturally occurring organic acids in releasing metals and providing nutrients in the soil and how that role is changed by acid rain. Such studies, he explains, may help predict how a given soil will respond to acid rain.

Other projects have been developed with an eye to acid rain's long-lived nature. The National Atmospheric Deposition Program, for example, collects and analyzes precipitation across the country (SN: 6/24/78, p. 407). Probably the most complete monitoring network, the nearly $700,000 project has about 50 stations operating now, says coordinator Jim Gibson at Colorado State University, and plans to have 80 stations nationwide by next summer. In contrast, the National Oceanic and Atmospheric Administration is setting up a monitoring system in remote areas in order to determine the relative roles of transport of pollutants and natural sources in the formation of acid rain. Sites are already established north of Fairbanks, Alaska and on Amsterdam Island in the Indian Ocean, according to NOAA's John Miller, and stations are planned for South America and Australia.

A major challenge for researchers is that of deciding exactly how resilient the environment is to acid rain. The question becomes particularly important in deciding whether or not to impose pollution controls and what level of control is necessary. It is possible, for example, that the Adirondack lakes represent an extremely fragile system that would be upset by any environmental disturbance, suggests Orie Loucks of the Institute of Ecology. "It's quite possible that for some reason, the class of watershed the next step less sensitive won't go," he says. EPRI's Adirondacks project, and particularly Cronan's work, is designed with that concept in mind, he notes.

A study of the Boundary Waters Canoe Area along the Minnesota-Canada border will also deal with that issue. As coordinator Gary Glass of the EPA in Duluth puts it, "We are looking at a healthy system before it gets ruined," though he adds that some lakes in the region teeter on the brink of acidity. Also taking a whole-ecosystem approach, Glass has begun choosing 10 lakes in the BWCA, as well as in Michigan and Wisconsin, for intensive study. Like someone racing against time, Glass says he is trying to gather enough quantitative data to provide some idea of the control necessary to protect the Minnesota wilderness. "We don't have to have dead lakes in Minnesota to prove the point [that acid rain has effects]."

Still other studies are designed to batten down the scientific hatches. Studies of lake sediments in New England, for example, may answer many of API's questions about the supposed trend of increasing acidity. Using core samples from 25 remote lakes, University of Maine's Steve Norton can read a 300- to 400-year record of chemistry and biology. He finds that the cores show a simultaneous increase in acidity at about 1900. This is one of the strongest bits of evidence for an atmospheric cause of acid rain, he says.

An EPA study at an experimental farm in Corvallis, Ore., is designed to nail down the effects of acid rain on crop yield. Under the direction of Norman Glass, 28 major field crops—with a $50 billion agricultural value — have been enclosed in a shelter and exposed to simulated sulfuric acid rain at levels of acidity similar to that found in the midwestern and eastern United States. Studies of the effects of nitric acid rain as well as field studies are necessary, Glass stresses, but preliminary evidence shows about "50 percent [of the crops] are somewhat inhibited, and 50 percent are somewhat enhanced." Leafy crops such as chard and lettuce are particularly blemished by acid rain, he says, and radishes are dramatically reduced in size.

One of the biggest gaps in acid rain knowledge is atmospheric chemistry. Most researchers are convinced of the link between acid rain and air pollution, but the actual mechanism eludes them. To close that gap, researchers from the National Center for Atmospheric Research in Boulder, Colo., are analyzing storm systems using a specially equipped airplane. According to project director Al Lazarus, samples are taken within and beneath a cloud system and on the ground in an attempt to relate the acidity at each step to

Model forest ecosystems give researchers a controlled look at acid rain effects.

the concentration of sulfate particulates, nitric acid aerosols and other acid precursors.

Other work focuses on remedies. Carl Schofield of Cornell University has found that certain strains of brook trout can tolerate acidified waters. After selecting those with the highest tolerance, he has restocked about six Adirondack lakes that have been rendered fishless or where previous attempts at restocking failed. Schofield has also found that certain fish seem to adapt to their acid environment. Some fish, for example, no longer spawn in the acidified lake but lay their eggs in a tributary where hatchlings will not be exposed to damaging levels of acidity.

On one end of the acid rain production line, attempts are being made to find a way of controlling the emissions of sulfur and nitrogen oxides. Current methods include physical washing of the coal and in-stack scrubbers, but these do not remove much nitrogen oxide and produce an unwieldy sludge. Promising techniques include producing briquets of limestone and coal that neutralize acid precursors and rearranging burners to control nitrogen oxide emissions. But according to EPA's Lowell Smith, most of these methods are years down the road.

On the receiving end of the line, groups such as the New York State Department of Environmental Conservation have been liming some acidified lakes in order to neutralize them. Because of the expense and difficulty, usually only lakes on the brink of acidity or those that harbor unique wildlife are treated. The technique costs about $10 to $20 per pound of trout and may last only half a season to several years, depending on the lake, says Brookhaven Laboratory's George Hendry.

But all these efforts will be just so much paperwork if they are not translated into policy. The EPA has been accused of not taking leadership in attempts to control sulfur and nitrogen oxide emissions. Part of the difficulty is that the existing legislative tool — the Clean Air Act — did not anticipate a problem like acid rain. Even so, many environmentalists claim some sections of the act can handle acid rain's idiosyncracies.

For example, long-range transport of air pollutants — the phenomenon that gives sulfur and nitrogen oxides time to change to acids and carries them thousands of miles from their source — is not specifically addressed in the act. But, says Betsy Agle of Friends of the Earth, there is a section on interstate pollution that could be interpreted and enforced to handle the problem.

Similarly, current air quality standards are set to protect human health, which is not directly affected by acid rain. The Clean Air Act has some requirements for other standards aimed at protecting the environment, but no timetable exists for their creation or enforcement. Agle and others would have the EPA beef up those standards that, though indirectly, could be used to control acid rain. Paul Stolpman, EPA's director of the office of policy analysis, counters that "the things that can be done under the existing act are so indirect or convoluted that they are ineffective. We want to go directly ... head on to get the kind of program to deal with this."

Environmentalists view this position with skepticism. Recent EPA moves—such as lowering emission standards for two plants in Cleveland and granting Ohio a different and much relaxed air quality plan —cause Robert Rauch of the Environmental Defense Fund to say, "There is an enormous chasm between the [EPA's] rhetoric on acid rain and reality." Sources at EPA confirm Rauch's stand; they say EPA is caught between conflicting pressures with a problem they don't quite know how to handle. "It is important that they feel so much pressure that they will have to move [on some controls]," says one source.

That pressure may come within the next year as the Clean Air Act comes up for re-authorization. Environmentalists fear that industry may use the opportunity to push for weakening revisions under the guise of dealing with acid rain. Agle and Rauch hope to push for a technology-based standard that would place sulfur and nitrogen oxide emission controls on old coal and oil-fired power plants and would require the best available control technology for new plants. Industry and some factions at EPA, however, take the stand that controls may not be warranted until the data are in. But as EPA's David Hawkins told a recent meeting, "When a truck is bearing down on you, you don't stop to calculate the mass and velocity. You move." □