LETTERS

Sulfur Dioxide Emissions

M. Oppenheimer *et al.* (Letters, 8 Mar. p. 1154) take issue with Philip H. Abelson's conclusions (Editorial, 14 Dec., p. 1263) that action to reduce pollution in the United States would be premature, and they characterize Abelson's position as "both unconvincing and puzzling." The writers contend that "surface water acidification cannot be avoided if sulfur dioxide emissions are not reduced by one-half or more." However, Abelson's position seems entirely reasonable in light of the weight of the evidence now available and the conflicting interpretations expressed by participants in the emissions reduction issue.

The 1983 report of a National Academy of Sciences (NAS) committee (*1*), noted that decreasing sulfur dioxide emissions may not significantly affect the acidity of precipitation. In Environmental Protection Agency (EPA) Region 1 (New England), SO_2 emissions fell by 38 percent from 1965 to 1978, with no significant long-term trend in the acidity of precipitation at Hubbard Brook, New Hampshire. Similarly, in EPA Region 2 (New York and New Jersey), SO_2 emissions fell by 40 percent over the same period, again with no significant long-term trend in acidity (*2*).

Others (*3*) have analyzed the precipitation chemistry data for three sites from the mid-1950's and the mid-1970's. In Virginia, acidity increased by 74 percent, while SO_4^{2-} fell by 3 percent. In Pennsylvania, acidity increased by 216 percent, while SO_4^{2-} fell by 23 percent. In Illinois, acidity increased by 27,000 percent, while SO_4^{2-} increased by 22 percent.

The relation between SO_2 emissions and sulfate deposition is also equivocal. In EPA Region 1, while SO_2 emissions fell by 38 percent, sulfate concentrations at Hubbard Brook, New Hampshire, fell by 33 percent (*1*). In New York, a drop of 40 percent in sulfate concentrations (*1*) was accompanied by an annual average drop of 2 percent in sulfate (*4*), which amounts to a reduction of about 25 percent over the 13-year span.

In a letter about the apparent inconsistency in opinions about the linearity of the SO_2-sulfate relation, the executive director of the National Acid Precipitation Assessment Program has reported (*5*) the explanation agreed upon by the NAS committee and the National Laboratory Consortium (NLC). Emission-deposition relationships were said to be "nearly [linear] (i.e., proportionately

1:1) when *averaged* over at least a year and *averaged* spatially over a large half-continent sized area." He also commented that "this is a valid hypothesis based on current information which will be tested as new research yields better information. However, both parties [NAS and NLC] agreed that for smaller spatial scales and shorter time scales, the relationship may not be directly proportional. . . . In other words, linearity may apply to average deposition and yet not hold true for each receptor site of concern."

The sites of concern are largely forested mountain areas, specifically the trees, lakes, and streams in forested watersheds. The evidence increasingly points to the decaying organic layer of forest litter as the primary source of acidity (*6*).

Concern about the acidification phenomenon is appropriate, but if benefits for sensitive ecosystems are to be achieved, the mechanisms that operate must be clarified and quantified. The hard data now available do not support the hypothesis that major reductions of emissions will benefit the ecosystems of major concern. As successive research findings emerge, Abelson's position becomes ever more convincing and appropriate.

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References

1. National Research Council, *Acid Deposition: Atmospheric Processes in Eastern North America* (National Academy Press, Washington, D.C., 1983).
2. N.E. Peters, R. A. Schroeder, D. E. Troutman, *Temporal Trends in the Acidity of Precipitation and Surface Waters of New York* (U.S. Geological Survey Water-Supply Paper 2188, Government Printing Office, Washington, D.C., 1982).
3. *The Acidic Deposition Phenomenon and its Effects: Critical Assessment Review Papers*, vol. 1, *Atmospheric Sciences* (Environmental Protection Agency, Washington, D.C., 1984); G. J. Stensland and R. G. Semonin, *Bull. Am. Meteorol. Soc.* **63**, 1277 (1982).
4. *Acid Rain: Sources and Effects in Connecticut. Report of the Acid Rain Task Force* (Bulletin 809, Connecticut Agricultural Experiment Station, New Haven, 1983).
5. C. Bernabo, letter to the Committee on Energy and Commerce, U.S. House of Representatives, 22 February 1984.
6. *Acid Rain and Transported Air Pollutants—Implications for Public Policy* (Office of Technology Assessment, Washington, D.C., 1984); *The Integrated Lake-Watershed Acidification Study*, vol. 4, *Summary of Major Results* (Electric Power Research Institute, Palo Alto, Calif., 1984).

High-Technology Agriculture

I liked Jean Mayer's editorial "Preventing famine" (15 Feb., p. 708). He makes everything sound so simple. American and Canadian experts, like the White Knight in Alice in Wonderland,