

Human Ecology: Acid Rain and Public Policy

Rodger W. Bybee



Rodger W. Bybee (who also served as guest editor for this special focus issue) is Associate Professor of Education and Chairman of the Education Department at Carleton College, Northfield, MN 55057. He holds a Ph.D. in science education from New York University and B.A. and M.A. degrees from the University of Northern Colorado. Bybee has taught at the elementary, high school, and college levels and has written three books on science teaching, including, most recently, *Violence Values and Justice in the Schools*, (Allyn and Bacon, 1982) and *Piaget for Educators* (Charles E. Merrill, 1982). He was a coauthor of *New Directions in Biology Teaching* (NABT, 1982). He has been a frequent contributor to *ABT* and served as guest editor for the September 1982 convention preview issue.

Human beings are in part biological, but they are also social and cultural.

A connection between science and society can be seen in the human and ecological dimensions of one contemporary problem—acid rain. My intention in this article is to introduce a human ecological theme and relationships between acid rain and public policy.

Human ecology studies the relationships between the environment and the human community. Study of the environment is clear to most individuals. But many environmental problems, such as acid rain, can only be studied and resolved by entering the arena where science, technology, and society interact. Human beings are in part biological, but they are also social and cultural. Human ecology attempts to integrate scientific fields with social, political, economic, and ethical domains as these influence relationships of humans with their environment (Miller 1982; Ophuls 1977). Public policy should be formulated based on human ecological concerns.

Scientific Understanding and Public Awareness

Scientists in the United States and Canada became aware of the acid rain problem in the late 1960s. Records of precipitation in the eastern United States were used to identify changes in the average pH of rain for the 1950s, 1960s, and early 1970s. In the early 1950s, rain with a pH below 5.6 was falling in many areas of the northeastern United States. Over the decades acid deposition spread and intensified. By 1976 most precipitation in the area east of the Mississippi was ten times more acidic than natural rain, i.e., the pH was 4.6. Some areas, Pennsylvania, New York, and New England report annual precipitation averages of pH 4.1 to 3.8 (Cogbill and Likens 1974; Likens, *et al.* 1979).

In the United States, the first articles about acid rain were published by scientists (Likens 1972; Gorham 1976). Soon the topic was being discussed in popular science and environmental journals (see, e.g., Dumanoski 1980; Hendrey 1981; Speth 1980; West 1980 a,b). Recently, discussions of acid rain have extended beyond the confines of scientific and environmental journals. Public awareness and opinions are being informed by articles in publications such as *National Geographic* (LaBastille 1981) and *Sports Illustrated* (Boyle 1981). Two recent books, both titled *Acid Rain* and both authored primarily by journalists, have also been published (Ostmann 1982; Howard and Perley 1982). Acid rain presents an interesting case study of the relationship between scientific understanding and public awareness in both the European and North American context (see, e.g., Cowling 1981, 1982).

Scientific Research and Public Policy

In July 1975, the U.S. Congress heard testimony on the inadequacy of research on acid rain and its biological consequences. There was neither a stable monitoring system nor a coordinated program on the ecological effects of acid precipitation. Soon after this, a project that became the National Atmospheric Deposition Program (NADP) was established. In the fall of 1977, the Council on Environmental Quality contracted with NADP to draft a national program assessing atmospheric deposition. The resulting publication (Galloway, *et al.* 1978) was the basis for President Carter's initiative to study acid rain. The proposal was announced in his Second Environmental Message (Carter 1979) in August 1979. President Carter proposed a ten-year study funded at \$10 million a year to investigate the causes and consequences of acid rain. Shortly after the President's initiative, Congress passed a similar proposal titled the "Acid Precipitation Act of 1980" (Title VII of PL 96-294). I quote from Section 702 the statement of findings and purpose because this is a public law and as such is the basis for public policy.

Sec. 702 (a) The Congress finds and declares that acid precipitation resulting from other than natural sources—

(1) could contribute to the increasing pollution of natural and man-made water systems;

(2) could adversely affect agricultural and forest crops;

(3) could adversely affect fish and wildlife and natural ecosystems generally;

(4) could contribute to corrosion of metals, wood, paint, and masonry used in construction and ornamentation of buildings and public monuments;

(5) could adversely affect public health and welfare; and

(6) could affect areas distant from sources and thus involve issues of national and international policy.

(b) The Congress declares that it is the purpose of this subtitle—



(1) to identify the causes and sources of acid precipitation;

(2) to evaluate the environmental, social, and economic effects of acid precipitation; and

(3) based on the results of the research program established by this subtitle and to the extent consistent with existing law, to take action to the extent necessary and practicable (A) to limit or eliminate the identified emissions which are sources of acid precipitation, and (B) to remedy or otherwise ameliorate the harmful effects which may result from acid precipitation.

(c) For purposes of this subtitle the term "acid precipitation" means the wet or dry deposition from the atmosphere of acid chemical compounds.

These two initiatives resulted in a federal interagency program to develop and implement a national assessment of acid precipitation. The research efforts have been summarized by Ellis Cowling (1981, 1982). Continued scientific research is clearly supported by public policy. Resolving the problems of acid rain is another matter.

National Politics and Acid Rain

Sulfur dioxides from smelters and utility plants and nitrogen oxides from automobile emissions and industrial combustion are the main sources of sulfur and nitrogen oxides. Two tables from a 1979 Environmental Protection Agency (EPA) report tell the story. Table 1 shows total emissions of the five most pervasive pollutants. The figures are reported in metric tons (a metric ton is 1,000 kilograms, about 2,200 pounds). Note that in 1977 about 27 million tons of sulfur oxides and 23 million tons of nitrogen oxides were spewed into the atmosphere. Table 2 clearly indicates that power plants, industrial processes, and transportation are the major sources of sulfur and nitrogen oxides.

Industry in the Midwest, particularly the Ohio River Valley, is one of the primary sources of sulfur dioxide. For example, the 21 major power plants in Ohio represent the largest single source of sulfur pollution in this country. And many plants in the Ohio River Valley do not comply with present standards of the Clean Air Act. The problems of politics are exemplified in the following example described by Dianne Dumanoski (1982).

In 1979 the Environmental Protection Agency (EPA) made efforts to reduce sulfur emissions of two plants belonging to Cleveland Electric Illuminating (CEI). Specifically, the EPA wanted CEI to comply with existing emission standards. CEI proposed to do so by switching from high- to low-sulfur coal and, by so doing, switching from Ohio coal to coal from Kentucky and West Virginia. The tradeoff was a loss of thousands of jobs for Ohio coal miners. A special provision of the Clean Air Act holds that the President, a governor, or EPA administrator can allow a utility to burn local (high-sulfur) coal if switching coal sources would result in significant unemployment or economic

Minnesota's Boundary Waters Canoe Area. (Photograph courtesy of the Canadian Embassy.)

problems. But, the utility has to meet emission standards by other methods such as smokestack scrubbers. The EPA decided that CEI did not have to switch sources of coal. Immediately, Ohio utilities began a campaign suggesting that scrubbers were ineffective and unreliable and would result in increased utility bills. They were incorrect in the first assertion and correct in the second.

The Carter administration was in the midst of a losing battle for reelection. The President finally relaxed emission limits for the two plants. Permitting pollution was easier than convincing labor, industry, and citizens that environmental consequences outweighed economic benefits. Paradoxically, this was the same President who initiated the ten-year and \$10 million study of acid rain.

The 1980s witnessed intense political debates over the acid rain problem. In two days of hearings before a subcommittee of the U.S. House of Representatives (1980) and later before a Senate Subcommittee on Environmental Pollution (1980), all the information and issues were neatly laid before the Congress. As Robert Ostmann points out in *Acid Rain* (1982) this was the first real test of the American political will on the issue of acid rain. In the end, the results were inconclusive, though the debates have continued. It seems evident that acid rain is another example of the Sisyphus syndrome (named after the legendary king of Corinth condemned to roll a heavy rock up a hill in Hades only to have it roll down again as it nears the top), and it will be a time before the public and their representatives realize their responsibility (Speth 1980).

Sulfur dioxide emissions from the Ohio River Valley are the primary sources of acid precipitation in the Northeast. There is a regional dispute developing among politicians. Industries in the Midwest benefit from the lower emission standards and the people of the Northeast pay the environmental, industrial (forest), and tourist costs. Central to the controversy is the question of the adequacy of information to appropriate blame. Senators (Stafford, R-Vt., Mitchell, D-Me) from the Northeast think there is adequate information and that the taxpayers in the Midwest should pay between \$2 and 4 billion annually to help solve the problem. The Mitchell Bill requires a 40% reduction of sulfur dioxide in 26 states east of the Mississippi. Senator Moynihan (D-NY) has also proposed a bill that calls for a 35% reduction of sulfur dioxide emissions by 1991 from 16 states east of the Mississippi. The first step in the Moynihan Bill is to enforce existing requirements to limit emissions. Emissions would then be further reduced by requiring scrubbers, washing, switching fuels, and encouraging conservation (*Science* 1981).

Industry and utilities have argued that action on these bills should be delayed until more information

is available (Katzenstein 1981; Poundstone 1980). This, too, is the position of the Reagan administration. In 1981 an administrator for the EPA told a Senate committee:

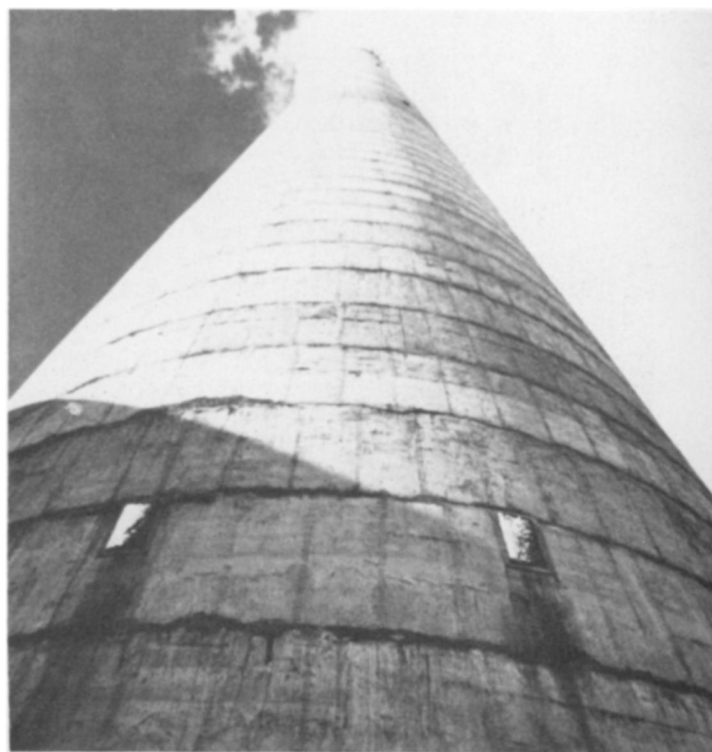
The American people have the right to expect that their government will not impose additional multibillion dollar programs without first determining with some assurance that the intended environmental benefit will be achieved. (*Science* 1981, p. 771)

This section has introduced several of the central themes in efforts to reduce the effects of acid rain. The themes are the cost of controls, jobs, efforts to repair a damaged environment, debates of sufficiency and insufficiency of information to set public policy.

International Issues and Acid Rain

Acid rain became a prominent issue in Scandinavia in the late 1960s, but an estimated 56% of acid precipitation falling in Sweden originated in West Germany and the United Kingdom. The damage to Sweden has been significant; about 10,000 Swedish lakes have a pH below 6.0 and 5,000 have a pH below 5.0 (Swedish Ministry of Agriculture 1982; Pearce 1982). Based on this information, what should be done? What kind of international negotiations and agreements should be developed? How would you approach the resolution of the international problem?

Similar international issues of acid rain exist between the United States and Canada. About half the sulfur deposited in Canada originates in the U.S. Only about 20% of the sulfur deposited in the northeastern United States originates in Canada. In 1980 President Carter and Prime Minister Trudeau signed a memorandum of intent in which the respective governments agreed to reduce air pollution. Since then the Canadian government has taken substantial action to reduce acid



The smelting complex of the International Nickel Company in Sudbury, Ontario is the continent's single greatest source of SO₂ emissions. Since 1969 it has reduced emissions by 70%. Here, INCO's superstack, reaching 1,200 feet into the air. (Photograph courtesy of Media Associates, Inc.)

TABLE 1. Estimated Pollutant Emissions in the United States
1970 Through 1977 (Millions of Metric Tons)

| Year | Suspended Particles | | Sulfur Oxides | | Nitrogen Oxides | | Hydrocarbons* | | Carbon Monoxide | | Total |
|------|---------------------|-----|---------------|-----|-----------------|-----|---------------|-----|-----------------|-----|-------|
| 1970 | 22.2 | 11% | 29.8 | 15% | 19.6 | 9% | 29.5 | 15% | 102.2 | 50% | 203.3 |
| 1971 | 20.9 | 10% | 28.3 | 14% | 20.2 | 10% | 29.1 | 15% | 102.5 | 51% | 201.0 |
| 1972 | 19.6 | 10% | 29.6 | 14% | 21.6 | 11% | 29.6 | 14% | 103.8 | 51% | 204.2 |
| 1973 | 19.2 | 10% | 30.2 | 14% | 22.3 | 11% | 29.7 | 14% | 103.5 | 51% | 204.9 |
| 1974 | 17.0 | 9% | 28.4 | 15% | 21.7 | 11% | 28.6 | 15% | 99.7 | 50% | 195.4 |
| 1975 | 13.7 | 7% | 26.1 | 14% | 21.0 | 11% | 26.9 | 15% | 96.9 | 53% | 184.6 |
| 1976 | 13.2 | 7% | 27.2 | 14% | 22.8 | 11% | 28.7 | 15% | 102.9 | 53% | 193.8 |
| 1977 | 12.4 | 6% | 27.4 | 14% | 23.1 | 12% | 28.3 | 15% | 102.7 | 53% | 193.9 |

*Volatile hydrocarbons only; methane and other nonreactive compounds omitted so far as possible.
National Air Quality, Monitoring, and Emission Trends Report, 1977, EPA, December 1978

rain (Ontario Ministry of the Environment 1980; Subcommittee on Acid Rain 1981; Ministry of Environment 1981; Canadian Embassy 1981). For example, Canada has required 40% cuts in emissions at two plants, one of which is Sudbury, Ontario, the largest single source of sulfur pollution in the world. And in February 1982, the Canadian government offered to reduce emissions further by 50% in eastern Canada if the Reagan administration would reciprocate. The offer was refused.

Thinking Globally, Acting Locally

“Thinking globally and acting locally” has been a suggested approach to resolution of contemporary issues. It seems appropriate to the topic of acid rain. Several global conferences have been held in attempts to begin reducing problems of food, population, and environment. The 1972 United Nations Conference on the Environment formulated a declaration from which this quotation is taken.

Principle 21

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

According to international law, it seems that countries do not have the right to cause damage to the environment of other countries. The next principle indicates that nations should cooperate to develop laws regarding liability and compensation for victims of pollution. Acid rain becomes a specific case for the application of those principles. But, there is a reality of law and scientific information that is sometimes not realized by politicians. That is, the facts of the matter and the reciprocal obligations of justice do not vary with changes in administration or the pragmatics of politics. This is a fundamental frailty in the human side

of human ecological equations.

Ten years after the U.N. Conference on the Environment there was another meeting, also held in Sweden: the 1982 Stockholm Conference on Acidification of the Environment. The conference began with a series of Expert Meetings in which scientific information on the ecological effects of acid deposition was summarized. Another Expert Meeting considered strategies to control emissions of sulfur and nitrogen oxides. Summaries of these meetings support the information presented in this article. The conference continued with presentations by individuals from various countries and international organizations. There was remarkable agreement among participants concerning the need to begin acting on the problem of acid rain. However, Kathleen Bennett of the United States Environmental Protection Agency left some discord with her conclusion that scientifically supportable evidence is not available to tell with sufficient regulatory precision where and when to reduce emissions, and by how much, in order to achieve a locally required result. She concluded by mentioning that the U.S. has a considerable research effort underway to solve these problems (Swedish Minister of Agriculture 1982).

So the official position of the United States government leaves the question open. Could the scientific evidence of the Expert Meetings and the political support from the global community support the EPA's position?

There is still the possibility of acting locally. Recent legislation in Minnesota serves as an example. In March 1982, Minnesota passed the Acid Deposition Control Act. This is the first legislation of its kind in the country. According to the legislation the Minnesota Pollution Control Agency (1982) is required to:

- Identify areas of Minnesota sensitive to acid rain.
- Develop an acid deposition standard to protect these areas.
- Adopt an acid deposition control plan to attain and

TABLE 2. Estimated Pollutant Emissions by Source
1977 (Millions of Metric Tons)

| Source | Suspended Particles | Sulfur Oxides | Nitrogen Oxides | Volatile Hydro- carbons | Carbon Monoxide |
|------------------------------------|------------------------|------------------|--------------------|-------------------------------|--------------------|
| Transportation (autos, trucks) | 1.1 9% | 0.8 3% | 9.2 40% | 11.5 41% | 85.7 83% |
| Combustion (power, heating) | 4.8 39% | 22.4 82% | 13.0 56% | 1.5 5% | 1.2 1% |
| Industrial processes | 5.4 43% | 4.2 15% | 0.7 4% | 10.1 36% | 8.3 8% |
| Solid Waste (incinerators) | 0.4 3% | | 0.1 | 0.7 2% | 2.6 3% |
| Miscellaneous (fires, solvents) | 0.7 6% | | 0.1 | 4.5 16% | 4.9 5% |
| Total | 12.4 | 27.4 | 23.1 | 28.3 | 102.7 |

National Air Quality, Monitoring, and Emissions Trends Report, 1977 EPA, December 1978.

maintain the acid deposition standard by addressing emission sources in Minnesota and outside of the state.

- Ensure that in-state emission sources are in compliance with the acid deposition plan.

Perhaps legislation such as this could become a model for other states. There is also the possibility that such statutes could serve as legal bases to argue that other states do not have the right to release excessive quantities of pollutants into the atmosphere.

Ethical Dimensions

At the interfaces of science, technology, and society one finds ethical issues. Acid rain serves as an excellent example of this fundamental, but often ignored, idea. Through our discussion of acid rain it is easy to identify areas of fact, conjecture, and opinion. In a word, what is the truth of the matter concerning acid rain? We also hear discussion of what is good—for the economy and for the environment. And, we are not without appeals to beauty. These are the ideas upon which we base our judgments. The discussion of acid rain progresses to other ideas—the ones involving final actions. Should industries in Ohio have the liberty to release pollutants harmful to New England environments? Debates about regional and international pollution bring us face to face with the realities of justice as decisions involve cost increases to many, employment to some, profits to few, and environmental damage that affects all of us either directly or indirectly. All of these issues must finally be balanced on the scales of justice. The ethical dimensions are very difficult. They are also essential for citizens to know and understand in the context of issues such as acid rain.

Conclusion

Acid rain ranks as one of the most pressing environmental problems. As scientists continue their research, the cause-and-effect relationship between the use of fossil fuels and acid rain will become clearer. Most scientists and others who have studied the accumulated evidence think it is sufficient to begin actions to reduce acid rain. The problem is not insufficient scientific information; it is one of political will, economic incentives, and ethical defensibility. Society faces a serious problem. Decisions to resolve the problem are not risk free. Indeed, there is the risk of intervening too early and inappropriately, or the risk of intervening too late and inadequately. The human and environmental costs and benefits of these decisions must be considered. Scientific research will inform decisions, but the public will ultimately decide and act to solve the problem of acid rain.

References

- BOYLE, R. 1981. An American tragedy. *Sports Illustrated* 55(13):68-82.
- CANADIAN EMBASSY. 1981. How many more lakes have to die? *Canada Today* 12(2).
- CARTER, J. 1979. *Second White House message on the environment*. August 2.
- COGBILL, C., and LIKENS, G. 1974. Acid precipitation in the northeastern United States. *Water Resources Research* 10(6).
- COWLING, E. 1981. A status report on acid precipitation and its ecological consequences as of April 1981. Summary document of the National Atmospheric Deposition Program. Raleigh, N.C.: North Carolina University.
- _____. 1982. Acid precipitation in historical perspective. *Environmental Science and Technology* 16(2).

- DUMANOSKI, D. 1982. Acid politics. *Technology Review* 85(7).
- _____. 1980. Acid rain. *Sierra*. May/June.
- ENVIRONMENTAL PROTECTION AGENCY. 1980. *The acid precipitation problem*. Corvallis, Ore.: Environmental Research Laboratory.
- _____. 1979. *Acid rain: Research summary*. Washington, D.C.: U.S. Government Printing Office.
- _____. 1979. *Cleaning the air*. Washington, D.C.: U.S. Government Printing Office.
- GALLOWAY, J.N., COWLING, E., GORHAM, E., and McFEE, W. 1978. *A national program for assessing the problem of atmospheric deposition (acid rain)*. National Atmospheric Deposition Program. Fort Collins, Col.: Natural Resource Laboratory.
- GORHAM, E. 1976. Acid precipitation and its influence upon aquatic ecosystems—an overview. *Water, Air and Soil Pollution* 6 457-481.
- HENDREY, G. 1981. Acid rain and gray snow. *Natural History* February.
- HOWARD, R., and PERLEY, M. 1982. *Acid rain: The devastating impact on North America*. New York: McGraw-Hill Book Company.
- LaBASTILLE, A. 1981. Acid rain: How great a menace? *National Geographic* 160(5).
- LIKENS, G., BORMANN, F., and JOHNSON, N. 1972. Acid rain. *Environment* 14 33-40.
- LIKENS, G., WRIGHT, J., GALLOWAY, J., and BUTLER, T. 1979. Acid rain. *Scientific American* 241(4).
- MILLER, G. 1982. *Living in the environment*. Belmont, Calif.: Wadsworth Publishing Company.
- MINISTER OF ENVIRONMENT. 1981. *Downwind: The acid rain story*. Ottawa, Ontario: Environment Canada.
- MINNESOTA POLLUTION CONTROL AGENCY and MINNESOTA DEPARTMENT OF NATURAL RESOURCES. 1982. *Acid rain: Minnesota's response*. St. Paul, Minn.: Minnesota Department of Natural Resources.
- ONTARIO MINISTRY OF THE ENVIRONMENT. 1980. *The case against acid rain*. Toronto, Ontario: Information Services Branch, Ministry of the Environment.
- OPHULS, W. 1977. *Ecology and the politics of scarcity*. San Francisco: W.H. Freeman and Company.
- OSTMANN, R. 1982. *Acid rain: A plague upon the waters*. Minneapolis: Dillon Press.
- PEARCE, F. 1982. The menace of acid rain. *New Scientist* 95(1318):419-424.
- SCIENCE. 1981. Acid rain bills reflect regional dispute. *Science* 214 November 13.
- SPETH, G. 1980. The Sisyphus syndrome: Acid rain and public responsibility. *National Parks and Conservation Magazine*.
- SUB-COMMITTEE ON ACID RAIN, STANDING COMMITTEE OF FISHERIES AND FORESTRY, HOUSE OF COMMONS, CANADA. 1981. *Stillwaters*. Ottawa, Canada: Minister of Supply and Services.
- SWEDISH MINISTRY OF AGRICULTURE. 1982. *Acidification today and tomorrow*. Stockholm: Swedish Ministry of Agriculture.
- WEST, S. 1980a. Acid from heaven. *Science News* 117(February 2).
- _____. 1980b. Acid solutions. *Science News* 117(February 16).



20% Minimum Discount

We are now offering a minimum 20% discount on all American Optical, Bausch & Lomb and Swift student microscopes.

We also provide microscope light bulbs and an expert repair service on all major brands.

Bystrom Instruments — your microscope sales and service specialist ready to focus in on your individual microscope needs.

Bystrom Instruments 2025 S. Nicklas Okla. City, OK 73128 (405) 682-0831