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Acid Rain. Part 2. Public Issues and Proposed Solutions

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In Part 1 of this essay,[1] I defined the problem of acid rain and briefly reviewed some of the voluminous scientific literature on the subject. In this part, I will examine the worldwide nature of the acid-rain problem, public perceptions of it, and some possible solutions.

Many of the studies to date have indicated that acid rain is rapidly becoming a worldwide problem. The portrayal of the problem in the American press might lead people to believe that the issue is one chiefly between Canada and the northeastern US on the one hand and the midwestern US on the other. As I noted in Part 1, much of the early research into acid rain was done by Europeans.[1] Indeed, many of the current research projects are being conducted outside of North America. Much attention is now focusing on acid-rain damage in European forests. For some time, evidence has been gathered on acid-rain damage to fisheries in Scandinavia.[2-5] But concern is not limited to areas near the great industrial centers of the Western world. Arne Jernelöv, Swedish Environmental Research Institute, Stockholm, has reported on acid-rain problems as far afield as the People's Republic of China.[6] Dispersion of acid emissions, such as those from very tall smokestacks, means that areas far from the emission sources can feel the effects of acid rain.

With the possibility that acid rain is such a widespread problem, we might wonder what the general public around the world knows about the issue. An indicator of public knowledge is the volume of information and opinion appearing in the popular press. Whereas most of the information in Part 1 of this essay came from scientific publications, many of the articles cited here are from newspapers, magazines, and books aimed at the general public. In fact, the volume of relevant items in these publications is so great that only a small fraction can be mentioned here. It would seem, therefore, that the popular press is providing considerable coverage of the issue. Whether the public is absorbing the discussion is another question. According to Stephen Clarkson, professor of political economics, University of Toronto, Canadian demonstrations against acid rain prompted many Americans to phone radio and television stations, asking what acid rain was.[7] (p. 183)

As awareness of the acid-rain problem increases, the emphasis must inevitably shift from "is it a problem?" to "what do we do about it?" Various methods for reducing or eliminating the undesirable effects of acid rain have been proposed. They fall into two general categories: those measures taken at the site of acid deposition and those taken to prevent or reduce the emission of acid precursors into the atmosphere. The former include measures such as liming of sensitive lakes. Of course, these methods do not prevent acid rain, but they do attempt to limit its adverse effects. Liming of lakes is currently in use in Canada, the US, and Sweden, but this is only possible in accessible areas.[8] (p. 20)

Reducing or eliminating acid emissions can be done in two ways. The installation of devices such as smokestack

scrubbers reduces sulfur dioxide (SO_2) emissions by removing most of the harmful substances from the effluent before they are released into the atmosphere. The second approach involves the use of low-sulfur fossil fuels, alternative energy sources, or improved methods of combustion of fossil fuels.[8] (p. 6)

Preventive measures aimed at power plants and other large industrial facilities are the most important, since these installations are the greatest source of man-made emissions. Using low-sulfur coal can reduce the emissions that would otherwise be produced by burning high-sulfur coal.[8] (p. 6) One new, promising method is pressurized fluid-bed combustion. In this technique, coal is burned while suspended in a column of air along with pieces of limestone. The limestone reacts with the sulfur emissions to produce calcium sulfate, or gypsum, an inert material that can be disposed of easily. However, the technology for commercial use of this method has not yet been developed. Moreover, this method is probably not suited to existing plants, as pointed out by Fred Pearce, news editor, *New Scientist*.[9]

In addition to power plants and industries, automobiles contribute to acid rain, so it might seem logical to undertake efforts to further reduce auto emissions. George R. Hendrey, Terrestrial and Aquatic Ecology Division, Department of Energy and Environment, Brookhaven National Laboratory, Associated Universities, Inc., Upton, New York, believes that such measures would not have much of an effect. He notes that all forms of transportation combined contribute only about 3 percent of the sulfur emissions and less than 14 percent of total strong-acid-anion emissions in the US. Hendrey's data come from emission figures for 1980, that is, after the introduction of emission controls on motor vehicles.[10]

Each of the proposed control methods, developed or undeveloped, has its proponents, and research continues to develop better alternatives. But a general review of the literature indicates that no control is perfect, and each carries an economic cost for someone.

While much debate exists in the scientific community about the best technology for controlling acid rain, even greater controversy has been generated by questions of public policy on the issue. Some indication of the variety of opinions on the subject was provided in two issues of *Current Controversy* that presented the views of a broad spectrum of authors in many different publications. One article summarized the debate over the costs of controlling acid rain,[11] while the other addressed the question of whether controls are really necessary.[12]

Many articles in newspapers and other publications have addressed the scientific and political controversy. There are far too many of these to cover here, but the discussions have included research scientists, government officials, and representatives of environmental groups, as reported in publications ranging from scientific and trade journals to daily newspapers.

The question of how to control acid rain involves important political and social issues, as well as purely technological questions. As Myron Magnet, contributing editor, *Fortune* magazine, notes, all of the proposed control methods cost money.[13] Questions therefore arise about whether the cost of such controls is justified by the countervailing economic and social costs of not controlling acid rain. If controls are deemed justified, someone must then decide who will pay for them. Adoption of a particular type of control often means that the jobs of certain classes of workers (e.g., coal miners) will be threatened. Whole regions may be affected by the loss of jobs. If the burden of control measures is placed on power utilities, consumers and industry may be saddled with much higher electric bills.[13] These considerations have made control of acid rain an important political issue.

Acid rain has captured the attention of politicians around the world, but especially those in Canada and Europe. I have already mentioned some research

projects in Part 1 of this essay.[1] The Canadian government has taken unilateral actions to address the issue, while attempting to negotiate a cooperative effort with the US. The state of US-Canadian relations at various times on the acid-rain issue has been described in detail by John E. Carroll, associate professor of environmental conservation, University of New Hampshire, Durham,[14] and Clarkson.[7] (p. 181-203)

Norway and Sweden have for some time been calling for controls on sulfur dioxide emissions. They have cited damage to fisheries, an important part of the Scandinavian economy. Dermot A. O'Sullivan, reporting on acid rain in *Chemical & Engineering News*, notes that other European nations did not join the Scandinavians in their concern until relatively recently, when evidence of severe damage to European forests began to mount.[15]

The Federal Republic of Germany has recently become a leader in the movement to develop a common strategy for combatting acid rain among the nations of the European Economic Community. The impetus for the move stems from the fears of the German people that their forests, particularly the Black Forest, are being destroyed by acid rain. The Germans, supported by the Swiss and Danes, want to reduce sulfur emissions 30 percent by 1990. They also want to establish monitoring programs and research into emission-control technology.[16]

In 1983, the West German government imposed new standards for controlling acid emissions by power plants and industries. These standards called for a reduction of annual SO_2 emissions by 25 percent, from 3.2 to 2.4 million tons.[16]

While they have served as a model for other nations, however, the West German regulations pointed up a major problem with such governmental efforts in many countries. Loopholes in the regulations allowed many producers of emissions to avoid both the obligation and the expense of control measures. In the Federal Republic of Germany, as many as 90 percent of the nation's power plants would not have had to meet the 1983 standards. As news writers R. Zell and M. Cross point out, exemptions based on remaining plant life-expectancy were allowed in the law for power plants, and the maximum allowed level of sulfur in the coal used by the plants was raised.[17]

More recently, the West Germans have pushed for greater reductions in sulfur emissions, and a number of nations in both eastern and western Europe have formed the so-called 30-Percent Club. The Club comprises nations that have committed themselves to reduce their sulfur emissions by 30 percent below 1980 base levels.[15]

Recently, Britain's House of Lords called for the installation of equipment to remove sulfur oxides (SO_x) from the emissions of at least two British power plants. In issuing the call, a subcommittee of the Lords said, "The magnitude of damage [due to air pollution] makes it necessary to implement a preventive programme now despite the 'scientific uncertainties.' " The subcommittee said that failure to act would be "foolish and dangerous." While the subcommittee report calls for installation of some desulfurization equipment, the Lords believe that the best long-term method for reducing sulfur emissions is to develop pressurized fluid-bed combusters. They feel this is cheaper and more energy-efficient than desulfurization of flue gas.[9]

In another development in Britain, a five-year study is under way by the Royal Society. The project, which is being conducted with the cooperation of the Norwegian Academy of Science and Letters and the Royal Swedish Academy, will provide an independent evaluation of the effects of acid rain. What is unusual about the study is that it is funded by two agencies that could be subject to a substantial economic burden if British emissions are found to cause damage in Scandinavia. These agencies are the Central Electricity Generating Board and the National Coal Board.[18]

Acid rain is clearly an important issue to many Europeans. The British publication *Nature*, in summarizing the situation, acknowledged the public clamor for action. At the same time, however, the journal urged that the problem be more clearly defined and understood, so that governments do not take rash and ill-considered actions.[19]

In 1983, an interagency task force of the US government released a report concluding that most acid rain is produced by human activities and that action should be taken to reduce it. Previously, government officials, including Ann Burford, then director, Environmental Protection Agency (EPA), maintained that the scientific evidence was not strong enough to justify new clean-air regulations.[20]

Exactly what action, if any, will be taken in the US remains unclear at this time. It may be significant that the EPA recently turned down a petition by New York and other states to reduce emissions from sources in the Midwest. The EPA cited a lack of proof of harm from the sources in question. Commenting on the EPA decision, the *New York Times* noted that the current administration in Washington has taken stands on other issues, such as alleged Soviet use of "yellow rain," on the basis of evidence much more tenuous than that available on acid rain. The *Times* also noted that an acid-rain reduction program, if initiated now, would take 7 to 10 years to produce a significant effect. The newspaper argued that further delay for additional studies will only waste time and allow the problem to get worse.[21]

Some sort of acid-rain legislation will probably be passed by about 1986, according to Michael Oppenheimer, Environmental Defense Fund, a non-profit organization that favors a reduction in sulfur emissions. Oppenheimer predicts that the impetus for the legislation will come from Congress, rather than from the executive branch.[22]

Many of the political and economic issues affecting acid-rain control in other countries can be illustrated by what has happened in the US. Bruce A. Ackerman, professor of law and philosophy, Columbia University, and William T. Hassler, his student when he was at Yale, wrote a highly readable account of the political maneuvering in the US on the issue of regulating the burning of coal by new plants. They detail how measures that were intended to produce cleaner air and less acid rain have been manipulated to protect the interests of particular political constituencies. The result has been a requirement for expensive equipment that has not been effective and a failure to achieve the desired reduction in acid-forming emissions.[23]

Magnet analyzed how proposed regulations on acid emissions might affect electric power companies. He found estimates of the total cost of control to be in the range of $6.2 to $35 billion, with $2.2 to $12 billion of this to be added to the power companies' operating costs. Under a "mild" proposal, companies in 31 states of the eastern US could be saddled with costs ranging from $49 to $818 million per company each year. These companies might pass on additional costs of $39 to $442 per year to each of their residential customers.[13]

Proposals under consideration by the US Congress vary in the way that the costs of controls would be distributed among emission producers, electric rate-payers, and taxpayers. One proposal before the US Congress would impose a nationwide tax on electricity to pay for emission controls on power plants. The bill's sponsors claim that the tax would distribute the burden fairly and would avoid severe economic penalties on the midwestern states that would have to undertake the controls. The tax would be levied on electricity not produced by nuclear power.[24]

Senator George J. Mitchell of Maine is a leader in the emission-controls fight. He believes that power companies in the midwestern US are a prime target for emission reductions. Mitchell cites a report by the Office of Technology Assessment. It predicts, for example, that a 50 percent reduction in emissions by

companies in Indiana alone would reduce US sulfur emissions by 700,000 tons, at a cost of an 8 percent rise in utility rates.[25] The Interagency Task Force on Acid Precipitation's *1983 Annual Report to the President and Congress* put total annual sulfur emissions in the US at 27.6 million tons.[26] (p. 26)

Regional politics play a part not only with respect to emission sources, but also with respect to the sources of the fuels that produce the emissions. It is significant that coal from the western US tends to be low in sulfur, while eastern US coal tends to be high in sulfur. A shift to the use of low-sulfur coal would therefore benefit western coal miners at the expense of eastern coal miners.[27] (p. 92)

One political organization in the US that has attempted to deal with acid rain is the National Governors' Association (NGA). Governor John H. Sununu of New Hampshire, former chairman of the NGA's Acid Rain Task Force and current chairman of the Energy and Environment Committee, has described the importance of regional politics in attempting to form a government policy on acid rain.[28] He notes that the acid-rain issue has created new political alliances. Of particular interest is the difference in the balance of political power between the US Senate, where senators from the Northeast and West hold key committee posts, and the House of Representatives, where midwestern lawmakers who might oppose certain controls have considerable power. Governor Sununu attributes much of the difficulty in passing federal acid-rain legislation to this difference between the legislative houses and the need to reconcile the interests of different regions.

Opponents of measures to control emissions have argued that some measures may not produce the expected benefits. They argue that acid rain is not necessarily produced in a linear fashion—that is, in proportion to the quantity of sulfur oxides released into the air. This view has been expressed by representatives of public utilities and the coal industry.[29]

Contradictory findings came to light at the 1983 International Colloquium on Acid Precipitation, held in Lindau, Federal Republic of Germany. The colloquium heard a report by the National Research Council (NRC) in the US. Led by Jack G. Calvert, Ohio State University, Columbus, the NRC team found that conversion of SO_2 to sulfuric acid does indeed occur as a linear phenomenon.[30] (p. 139) Their report concluded that a reduction of sulfur and nitrogen emissions by 50 percent would bring about an approximate 50 percent reduction in acid rain in downwind areas. This conclusion lends support to claims that the cost of controlling emissions would produce a substantial economic gain because damage would be averted. The NRC, however, could not say with certainty *where* specific reductions in acid rain would occur. The NRC said that the computer-modeling methods used in their calculations were not accurate enough to allow specific predictions.[30] (p. 139-41)

A number of organizations around the world have directed their attention to the problem of acid rain and, in some instances, to the broader problems of air pollution and the environment in general. A representative sampling of these organizations is shown in Table 1.

The Acid Rain Foundation, Inc., based in St. Paul, Minnesota, is dedicated to promoting public awareness of, education about, and research into acid rain. The Foundation's president is Ellis B. Cowling, North Carolina State University, Raleigh, whose work was cited in Part 1 of this essay. The Environmental Defense Fund, headquartered in New York, is a 50,000-member public-interest group dedicated to the responsible reform of public policy on matters affecting the environment. The Fund has offices in Boulder, Colorado; Berkeley, California; Richmond, Virginia; and Washington, DC. Another organization concerned with acid rain is the Natural Resources Defense Council, Inc. (NRDC), also headquartered in New York. According to Debbie Sheiman of

Table 1: A selected list of organizations that are concerned with acid rain.

Acid Rain Foundation, Inc.
1630 Blackhawk Hills Road
St. Paul, MN 55122

Acid Rain Information Clearinghouse (ARIC)
Center for Environmental Information, Inc.
33 S. Washington Street
Rochester, NY 14608

Association for the Prevention of Air Pollution
(Association pour la Prévention de la Pollution Atmosphérique—APPA)
62 Rue de Courcelles
F-75008 Paris, France

Canadian Coalition on Acid Rain
112 St. Clair Avenue West
Suite 504
Toronto, Ontario M4V 2Y3
Canada

Environmental Defense Fund (EDF)
444 Park Avenue, S.
New York, NY 10016

German Federation for Environmental Protection
(Deutscher Naturschutzring e.V., Bundesverband für Umweltschutz—DNR)
Kalkuhlstrasse 24
Postf. 320210
D-5300 Bonn 3
FRG

Hellenic Association on Environmental Pollution (ERYEA)
Xenofontos 14
Athens 118
Greece

Izaak Walton League of America, Inc. (IWLA)
1701 N. Fort Myer Drive
Suite 1100
Arlington, VA 22209

National Clean Air Coalition
530 7th Street, SE
Washington, DC 20003

National Wildlife Federation
Dept. AR
1412 16th Street, NW
Washington, DC 20036

Natural Resources Defense Council, Inc. (NRDC)
122 E. 42nd Street
New York, NY 10168

Sierra Club
530 Bush Street
San Francisco, CA 94108

Soil Conservation Society of America
7515 NE Ankeny Road
Ankeny, IA 50021

Swedish Water and Air Pollution Research Institute
Sten Sturegatan 42
S-402 24 Gothenburg
Sweden

NRDC's acid-rain project, the NRDC is a nonprofit public-interest law firm with 46,000 members from various disciplines, who seek to promote public understanding, conduct research, and provide legal advice and services on matters related to the environment.[31] We described the NRDC in more detail previously.[32]

The Izaak Walton League of America, Inc., is a conservation group with 50,000 members that also promotes public awareness of environmental issues. The League is particularly active in encouraging citizen involvement in efforts to protect the environment. The Canadian Coalition on Acid Rain, formed in 1980, comprises businessmen, environmentalists, conservationists, and recreation groups with the common goal of reducing emissions of sulfur and nitrogen oxides and the speedy conclusion of an air-quality agreement between the US and Canada. Further information about the groups may be obtained by writing to the addresses given in the table. For those interested in locating more information, EIC/Intelligence, Inc., has started a new database dedicated entirely to acid rain. The database includes sources of information on the causes, effects, and possible solutions to the acid-rain problem, dating from 1984 onward.

Bibliographic information on acid rain can also be obtained from ISI®'s own *SCISEARCH®*, a database introduced in 1976 that provides comprehensive information on articles listed in *Current Contents®* and the *Science Citation Index®* (*SCI®*) since 1974. The *SCI* and *SCISEARCH* include coverage of all important journals related to environmental research.[33] The social aspects of the problem may be researched in *Social SCISEARCH®*, the online version of the *Social Sciences Citation Index®*.[34]

It is clear from the available evidence that acid rain is a serious problem. Unfortunately, it is also evident that, in many instances, the precise effects of acid rain and the extent of environmental damage are not yet known. We still have much to learn about the problem,

and future political developments are unclear. Moreover, simply learning more about acid rain will not solve the problem.

Governments have not yet developed a common policy for action, and they may not, as long as the scientific picture remains controversial.

Governments and societies will have to make hard decisions, balancing the need for a healthy environment against legitimate economic and social needs of large numbers of people.

* * * * *

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21. Acid procrastination. *NY Times* 2 September 1984. p. 14 E.
22. **Oppenheimer M.** Personal communication. 13 February 1985.
23. **Ackerman B A & Hassler W T.** *Clean coal/dirty air.* New Haven, CT: Yale University Press, 1981. 193 p.
24. House gets bill to curb acid rain. *Phila. Inquirer* 15 May 1984. p. C-11.
25. **Mitchell G J.** To decrease acid rain, cut smokestack emissions. *Christian Sci. Monit.* 11 October 1983. p. 30.
26. **Interagency Task Force on Acid Precipitation.** *National Acid Precipitation Assessment Program. 1983 Annual Report to the President and Congress.* Washington, DC: GPO, 1983. 72 p.
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31. **Sheiman D.** Personal communication. 12 February 1985.
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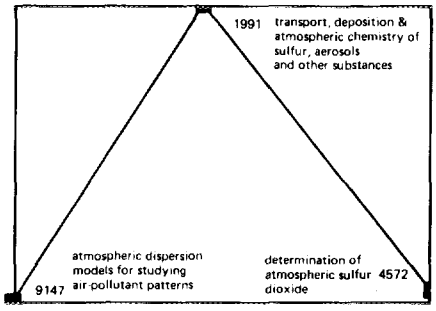
33. ----------. If you think you're ready to search online, here's how to use *SciSearch. Current Contents* (4):3-9, 28 January 1985.
34. ----------. How to use the *Social Sciences Citation Index (SSCI). Current Contents* (27):3-13, 2 July 1984.

A Note on Cluster Maps for Acid Rain

In Part 1 of the essay on acid rain,[1] we included a multidimensional scaling map, or C-1 level cluster map, showing the co-citation relationships among the 14 papers that were core to the 1983 research front #83-1991, "Transport, deposition and atmospheric chemistry of sulfur, aerosols and other substances." Another 1983 research front (#83-1341) that was discussed in Part 1, but not mapped, was "Effects of acid rain on pollen germination and stomatal changes in plants exposed to sulfur dioxide."

Figure 1: C-2 level map for cluster 718, "Atmospheric transport of sulfur compounds."



Our procedures for identifying research fronts have been discussed in detail in previous essays.[2] Not only can we identify research fronts through clustering, but we can also create "clusters of clusters"—hierarchies of research fronts and groups of research fronts that show the citation links between various areas of research, and even between whole disciplines. For acid-rain research, we have reproduced below some of the higher-level maps. Research front #83-1991 is one of three closely linked research fronts shown in the C-2 level map in Figure 1; these three fronts, in turn, are represented by the single point 718, "Atmospheric transport of sulfur compounds," on the C-3 level map of "Atmospheric processes" in Figure 2. Similarly, the relationship between research front #83-1341 and a research front entitled "Pollination barriers, self-incompatibility and pollen-tube growth" is shown in the C-2 level map in Figure 3. These two research fronts are both encompassed within the point labeled 533, "Plant pollination barriers," on the C-3 level map of "Plant ecology and botany" in Figure 4.

Figure 2: C-3 level map for cluster 64, "Atmospheric processes."

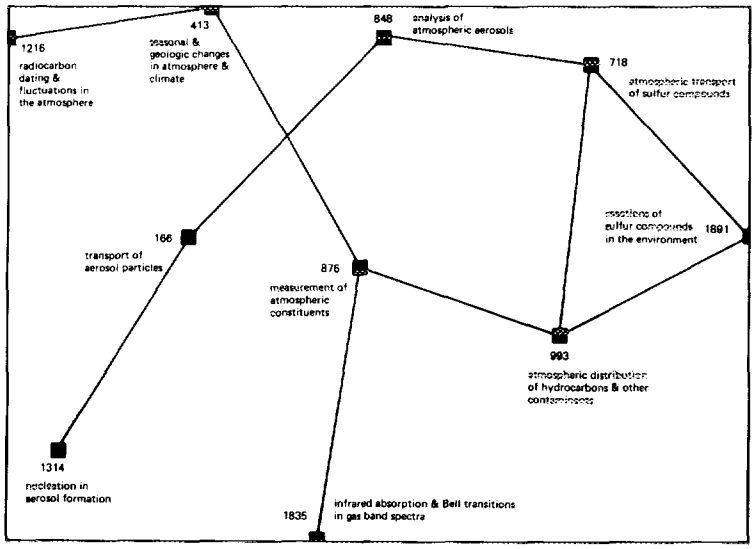
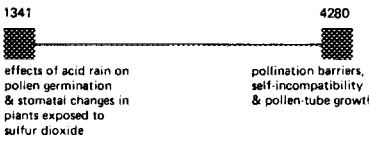
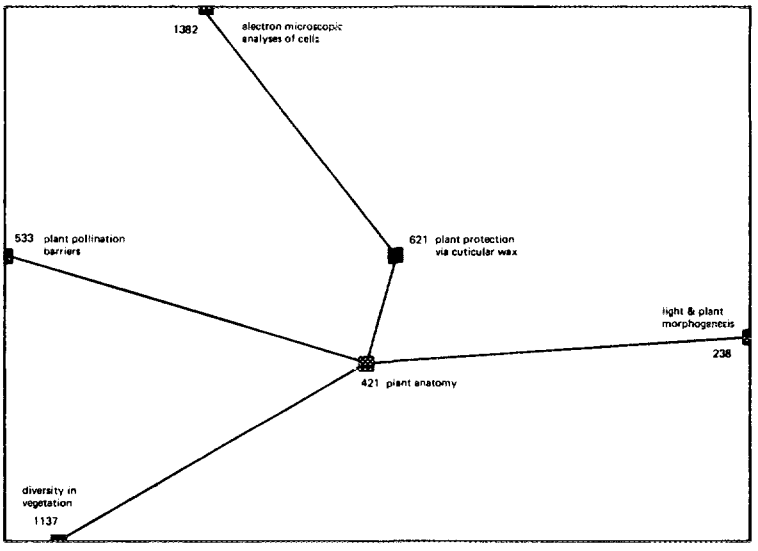


Figure 3: C-2 level map for cluster 533, "Plant pollination barriers."



In creating these higher-level maps, we move from the more specific to the more generic. At the C-1 level, you can observe the "connections" between individual core papers. At the C-2 level, various C-1 research fronts are linked. At the C-3 level, you can observe links between the various C-2 maps. In this way, the interdisciplinary and multidisciplinary nature of the scientific enterprise can be concretely illustrated. In this instance, we see that acid rain "falls" within the earth sciences and the biological sciences.

Figure 4: C-3 level map for cluster 84, "Plant ecology and botany."



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