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Environmental Protection
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Office of Research and Development

EPA

Research Summary

Acid Rain

Acid rain may be one of the most significant environmental problems of the coming decade. It poses new challenges to the full development of our forest, agricultural, and aquatic resources; and to the use of fossil fuels as an energy source. The objective of our research program is to develop information which will assure that the Nation's energy needs are met without sacrificing environmental quality.

The recently promulgated New Source Performance Standards for fossil fuel power plants will control sulfur oxide emissions from future power plants, and after 1995, begin to effect regional reductions of sulfur oxides and hence acid rain. This program, however, does not address continued emissions from existing plants over the next two decades. The possible alterations for existing plants range from low cost coal cleaning to retrofitting with stack gas scrubbers. Because coal can be burned cleanly, the solutions to our acid rain problems need not conflict with national energy priorities. Pollution control may be expensive, but the costs of environmental protection *are far less than the costs of environmental neglect.*

I expect the future results from our research program and those of other agencies to be the basis for a new dialogue between many interested parties. This Research Summary is the first of several documents designed to insure an informed public debate on this important national issue.

Stephen J. Gage
Assistant Administrator
for Research and Development

This brochure is one of a series providing a brief description of major areas of the Environmental Protection Agency's research and development program. Additional copies may be obtained by writing to:

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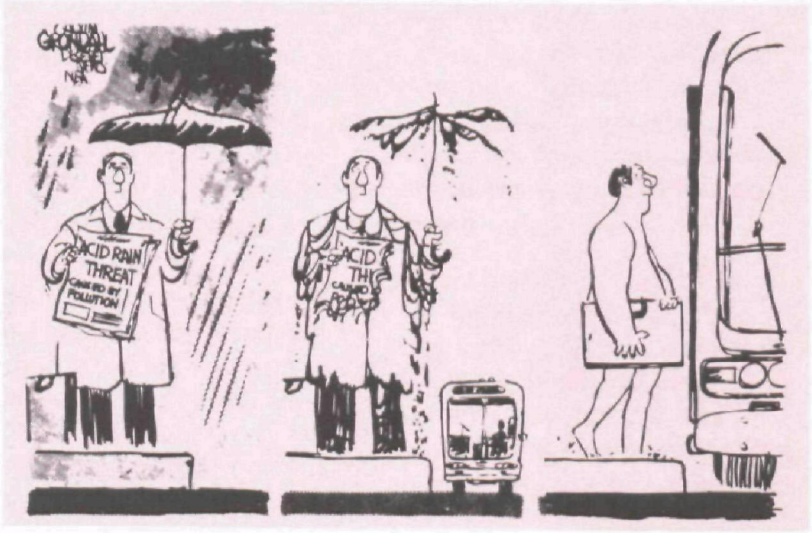
Cover Photo by David Natella

As a result of the combustion of tremendous quantities of fossil fuels such as coal and oil, the United States annually discharges approximately 50 million metric tons of sulfur and nitrogen oxides into the atmosphere. Through a series of complex chemical reactions these pollutants can be converted into acids, which may return to earth as components of either rain or snow. This acid precipitation, more commonly known as acid rain, may have severe ecological impacts on widespread areas of the environment.

Hundreds of lakes in North America and Scandanavia have become so acidic that they can no longer support fish life. More than 90 lakes in the Adirondack mountains in New York State are fishless because acidic conditions have inhibited reproduction. Recent data indicate that other areas of the United States, such as northern Minnesota and Wisconsin, may be vulnerable to similar adverse impacts.

While many of the aquatic effects of acid precipitation have been well documented, data related to possible terrestrial impacts are just beginning to be developed. Preliminary research indicates that the yield from agricultural crops can be reduced as a result of both the direct effects of acids on foliage, and the indirect effects resulting from the leaching of minerals from soils. The productivity of forests may be affected in a similar manner.



Courtesy of Calvin Grondahl, Deseret News

In addition, acid deposition is contributing to the destruction of stone monuments and statuary throughout the world. The 2500 year old Parthenon and other classical buildings on the Acropolis in Athens, Greece, have shown much more rapid decay in this century as a result of the city's high air pollution levels. Research is underway to clarify the role of acid rain in the destruction.

President's Environmental Message

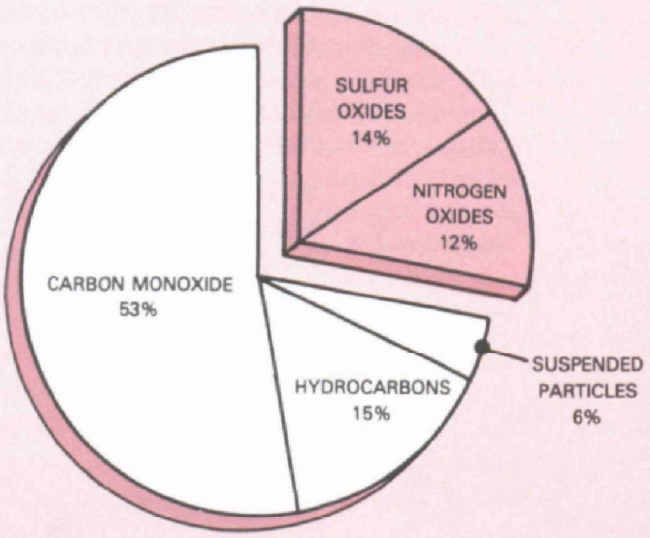
In recognition of the potential seriousness of the acid rain problem, the President's Second Environmental Message to Congress in August of 1979 called for a minimum $10 million per year research program to be conducted over the next ten years. The Environmental Protection Agency and the Department of Agriculture co-chair the Acid Rain Coordination

Committee established to plan and coordinate the Federal interagency program which is presently being developed.

Source of the Problem

In 1977, sulfur oxides accounted for 14 percent (27.4 million metric tons) of the total air pollution in the United States, while nitrogen oxides accounted for 12 percent (23 million metric tons). Although other pollutants also act as precursors to acid rain, it is believed that these two oxides are the major contributors to the problem.

Air Pollution Emissions



Source: National Air Quality, Monitoring, and Emission Trends Report, 1977, US EPA, December 1978.

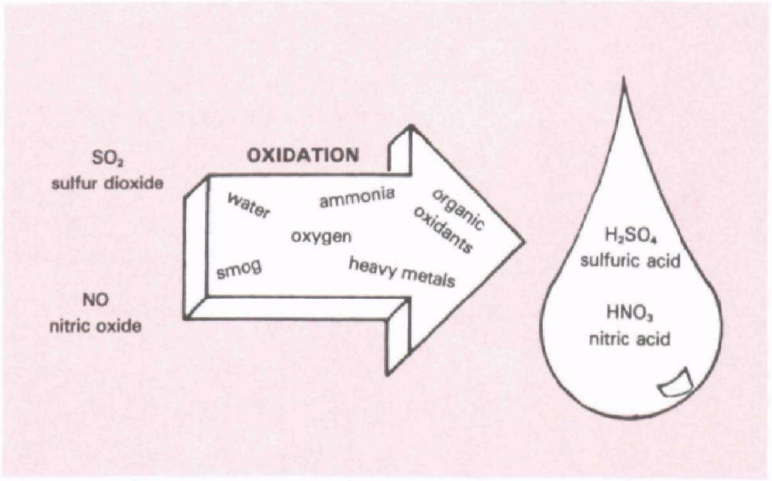
Sulfur oxides (SO_X) are primarily emitted from stationary sources such as utility and industrial boilers burning coal as a fuel. However, nitrogen oxides (NO_X) are emitted from both stationary and transportation-related sources such as cars and trucks. Approximately 56 percent of the NO_X discharged into the atmosphere in 1977 resulted from the combustion of fossil fuels by stationary sources, while 40 percent originated from transportation-related sources. Over the next twenty years the combustion of fossil fuels is expected to increase significantly. In particular, emissions of nitrogen oxides from stationary sources are likely to increase rapidly during this period.

Fundamental Chemistry

The most common sulfur and nitrogen oxides are sulfur dioxide (SO_2) and nitric oxide (NO). After being discharged into the atmosphere, these pollutants can be chemically converted into sulfuric (H_2SO_4) and nitric (HNO_3) acid through a process known as oxidation. There are several complicated pathways or mechanisms by which oxidation can occur. Which path is actually taken is dependent upon numerous factors such as the concentration of heavy metals, the intensity of sunlight, and the amount of ammonia present.

Again, one should keep in mind that other acids contribute to the acid rain problem. Hydrochloric acid (HCl), for example, may be emitted directly from coal-fired power plants and

frequently is found relatively short distances downwind from the source.



Dry Deposition

The process by which acids are deposited through rain or snow is frequently called wet deposition. However, another atmospheric process known as dry deposition may also occur. Dry deposition is the process by which particles such as fly ash, or gases such as sulfur dioxide (SO_2) or nitric oxide (NO), are deposited, or absorbed, onto surfaces. While these particles or gases are normally not in the acidic state prior to deposition, it is believed that they are converted into acids after contacting water in the form of rain, dew, fog, or mist following deposition. The precise mechanisms by which dry deposition takes place, and its effects on soils, forests, crops, and buildings, are not adequately understood. Much research will be undertaken in the coming years to clarify its contribution to the overall acid deposition problem.

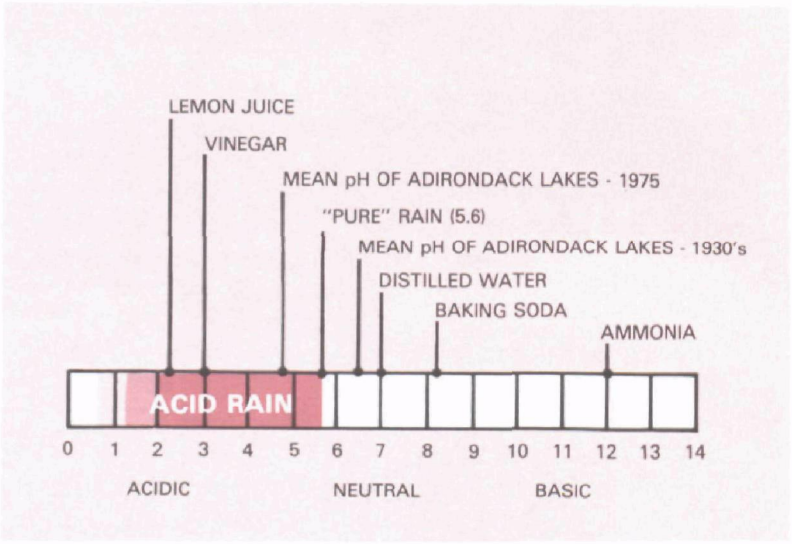
Long Distance Transport

Various sulfur compounds which may act as precursors to sulfuric acid are known to travel as far as several hundred kilometers per day while in the atmosphere. During transport these pollutants may easily cross geographical and political boundaries. This situation creates numerous national and international regulatory problems in that the air pollution standards of one state or country can have an indirect impact on the natural resources of another.

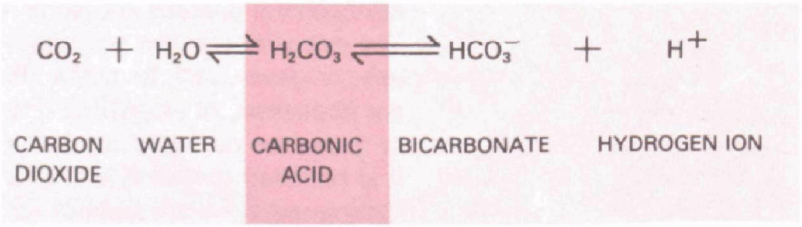
It is believed that other nitrogen-containing pollutants may be transported in a similar manner. Research is underway to clarify the transport processes associated with the major pollutants contributing to the acid deposition problem.

pH Scale

The pH, a numerical value used to describe the strength of an acid, is determined by a mathematical formula based on a solution's concentration of hydrogen ions (H+). The pH scale ranges from a numerical value of 0 to 14. A value of pH 1 is very acid (battery acid), pH 7 is neutral, and pH 13 is very alkaline (lye). Because of the logarithmic nature of the scale, pH 4 is 10 times more acidic than pH 5, and 100 times more acidic than pH 6, and so on. Precipitation is defined as being acidic if the pH is less than 5.6, the pH of normal, unpolluted

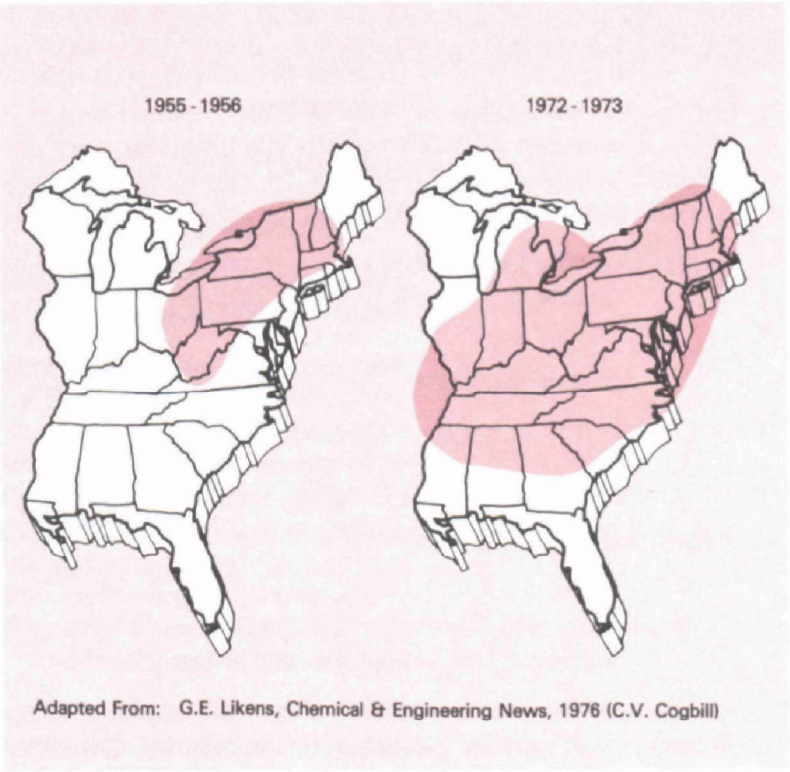


rain. The slight natural acidity of normal rain is due to the presence of carbonic acid (H_2CO_3), which is formed by the reaction of atmospheric carbon dioxide (CO_2) with water.



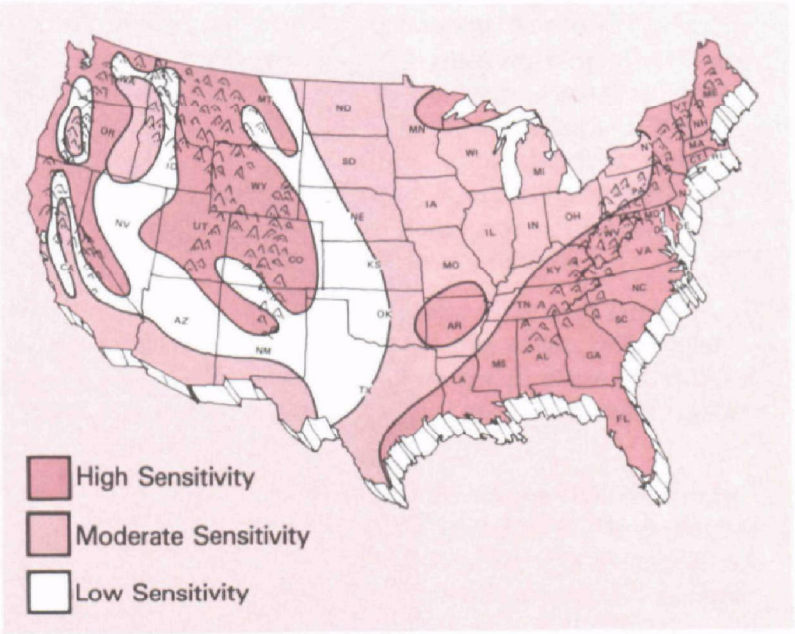
As was pointed out earlier, fish populations are especially sensitive to changes in the pH of their surroundings. A recent study of several hundred Norwegian lakes showed that of the lakes having a pH between 5.5 and 6.0, less than 10 percent contained no fish. At pH's of less than 4.5, more than 70 percent of the lakes were fishless. Acidic lake water not only affects fish directly. Low pH water frequently promotes the release of potentially toxic metals from the lake bed. Aluminum, for example, is frequently found in high concentrations in fishless lakes, and is released from soils at approximately pH 4.5. Rainfall runoff may carry aluminum from nearby soils into lakes, or into streams which empty into lakes and thus magnify the problem.

The average annual rainfall pH is presently less than 4.5 over most of the eastern United States. Lakes that lack a buffering capacity, or ability to chemically neutralize this acidity, face serious ecological harm. The following figure indicates the trend in the acidity of rain in the eastern United States. The colored area represents a pH of less than 4.5.



Adapted From: G.E. Likens, Chemical & Engineering News, 1976 (C.V. Cogbill)

The map below indicates those areas of the continental United States that are believed to be sensitive to acid deposition. This map was constructed by examining such factors as chemical composition of soils, climatic patterns, and types of vegetation within a given geographical area. This, and other maps, will be improved and updated as additional information becomes available through research projects that are presently underway.



EPA's Program

The Environmental Protection Agency's program for investigating the acid deposition problem and building a data base for possible future regulatory action consists of three major categories of effort:

- environmental effects
- monitoring
- atmospheric processes

This program is the responsibility of the EPA's Office of Research and Development (ORD).

Because of the complex and diverse manifestations of the acid precipitation problem, it is necessary to involve a broad-based, interdisciplinary team of researchers composed of atmospheric chemists, meteorologists, aquatic and terrestrial biologists, forest scientists, geologists, and economists to mention a few. The EPA's program is being conducted in-house and through grants, interagency agreements and contracts with universities and other institutions. Scientists from more than 10 government labs and 30 universities are presently contributing to the effort.

Much of the data developed through the EPA acid rain research program will ultimately be incorporated into criteria documents prepared by the Environmental Criteria and Assessment Office in Research Triangle Park, North Carolina. Criteria documents provide the technical scientific foundation upon which the EPA develops congressionally mandated standards and regulations, and are used by the Office of Research and Development to identify future avenues of research.

Larry J. Heinis

ENVIRONMENTAL EFFECTS

The environmental effects of acid deposition are diverse and widespread and are being documented by research throughout the world—especially in Scandanavia and the eastern United States. Some of the reported effects are:

- acidification of lakes, rivers and groundwaters resulting in damage to fish and other components of aquatic ecosystems
- acidification and release of metals from soils
- possible reductions in forest productivity
- possible damage to agricultural crops
- deterioration of man-made materials such as buildings, statuary, metal structures, and paint
- possible contamination of drinking water supplies by metals being released from soils and pipelines

EPA Research

The Environmental Protection Agency's acid deposition environmental effects research is coordinated at the Environmental Research Laboratory (ERL) in Corvallis, Oregon. Research is also being performed at the Environmental Research Laboratory in Duluth, Minnesota, and through interagency agreements with the Department of Energy's national laboratories, and the Tennessee Valley Authority. In addition, the EPA is cooperating with NATO's Committee on the Challenges of Modern Society (CCMS) in a worldwide effort to study adverse environmental effects of acid deposition on historic and artistic stone monuments.

The EPA environmental effects research program is designed to answer several broad questions about the present and future effects of acid deposition on the environment such as: What are its effects on the nation's lakes and streams? Will agricultural productivity be significantly affected, and if so, what crops will be most susceptible to damage? To what extent will terrestrial ecosystems be adversely affected? Can we prevent or reduce any potential damages or reverse any effects that have already manifested themselves?

An understanding of the environmental effects of specific quantities and concentrations of acid deposition on various resources is essential if policy-makers are to make informed decisions about the future use of coal and other fossil fuels as sources of energy.

Aquatic Effects

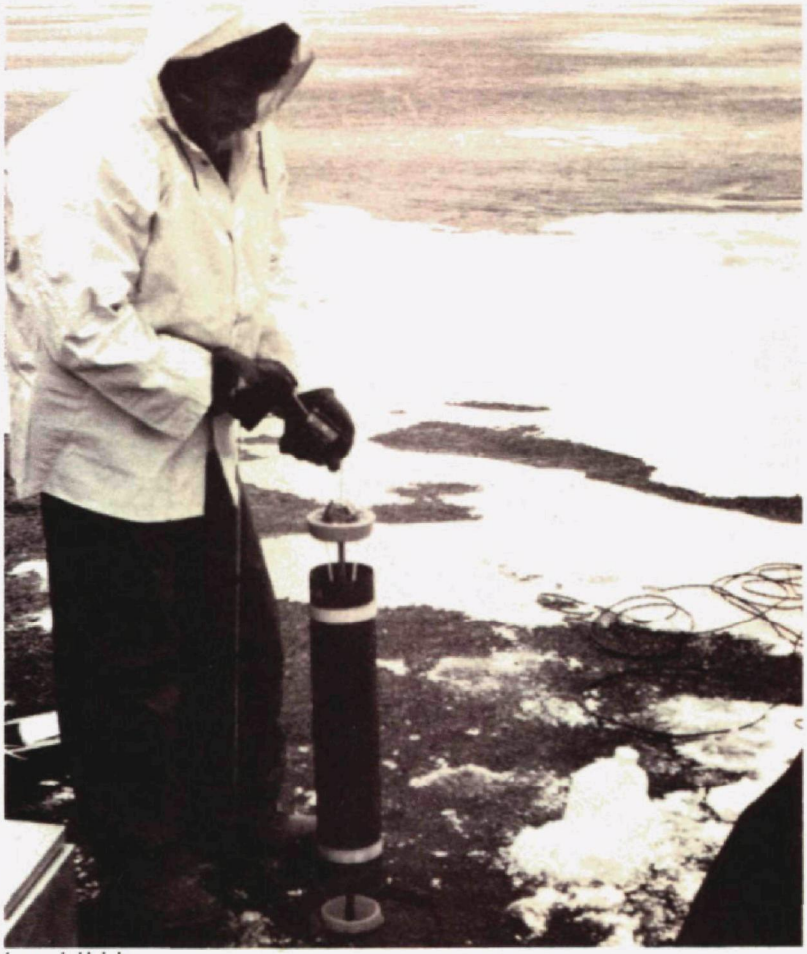
Research is underway at the EPA's Environmental Research Laboratory in Corvallis to identify those lakes in the eastern and western United States that are sensitive to acid deposition. Suitable lakes for long-term study are being selected in order to assist in the determination of the factors that influence lake acidification such as buffering capacity, precipitation quantity, and chemical composition of acids entering lakes. In addition, researchers are developing physical and chemical models of aquatic ecosystems designed to link ecological effects with

specific levels of acidity. Information of this nature will be used to forecast the impacts of acid deposition on lakes throughout the United States.

Researchers at the Environmental Research Laboratory in Duluth, Minnesota, and its Monticello Ecology Research Station are studying the release of toxic elements from soils and sediments and the resulting impacts on aquatic ecosystems. Field studies in natural watersheds and artificial channels are used to determine specific quantities of acid precipitation causing adverse impacts. These studies are designed to provide insight into the response of aquatic ecosystems to various levels of acidity, and to provide data for any future regulations required to protect important aquatic resources.

Northern Minnesota

A recent study was undertaken by the Duluth Environmental Research Laboratory concerning possible impacts of a power plant being built in Atikokan, Ontario, near northern Minnesota. Results from this study showed that current atmospheric deposition concentrations might already be causing damage to the sensitive wilderness of the Boundary Waters Canoe Area and Voyageurs National Park of northern Minnesota. The planned increase in siting of coal-fired power plants in this region presents a serious potential problem in light of this data. ERL-Duluth is expanding its research to accurately define the current sources and concentrations of pollutants, and to determine the susceptibility of the forests, agricultural lands, and some 20,000 lakes of the region to increases in pollution.



Larry J. Heinis

Initial research indicates that large areas of Minnesota, Wisconsin, and upper Michigan may be as susceptible to acid precipitation as the Adirondack lakes region in New York. Mercury levels in fish, that increase as lakes become acidic, are already high in some lakes in this area. Many fish species, valuable to both commercial and sport fishing, are similar to those that have been reduced or eliminated by acid precipitation elsewhere in the United States and Canada.

In terms of terrestrial impacts, the largest and most long-lived species of trees in the Boundary Waters Canoe Area and Voyageurs National Park of northern Minnesota, the white pine *(Pinus strobus)*, is being threatened due to its sensitivity to gaseous emissions from coal-fired power plants and high ozone concentrations from industrial and municipal emissions. The quaking aspen *(Populus tremuloides)* has shown a similar sensitivity.

Geological Sensitivity

The effects of acidification of fresh waters within geologically sensitive regions of the United States are being examined through an interagency agreement between the EPA and Brookhaven National Laboratory in Upton, New York. Those areas lacking bedrock materials with sufficient buffering capacity are being looked at in light of existing data on acid deposition. This information is then compared with historical data on water quality in order to make determinations as to the rate of water deterioration in a given area.

Terrestrial Effects

The effects of acid deposition on the leaching of nutrients from various soils are being documented by the Corvallis Environmental Research Laboratory. A soil water chemistry computer simulation model is being used to evaluate nutrient leaching from soils varying in chemical composition, organic content, alkalinity and acidity. Data developed from this project will be integrated with that from similar soil experiments designed to measure changes in litter decomposition rates, effects on microbial populations, and other factors. These data will then be used to make crude predictions regarding the long-term effects of acid precipitation on soil fertility.

Model Forest Ecosystems

Other experiments have been undertaken to estimate the effects of acid precipitation on forest productivity and the cycling and use of nutrients. Model forest ecosystems containing reconstructed forest soil and litter layers, sugar maples, red alder seedlings, and other ecosystem components, have been exposed to simulated acid rain at varying pH's. Biological processes such as tree growth, leaf production, nutrient uptake,

and litter decomposition are being monitored to document adverse effects. These data will be used to estimate the loss of nutrients from the forest soil, and the transport of minerals to ground and surface waters.

Future research is being planned to document the effects of acid rain on ecosystems representative of the northeastern United States, to study the historical and potential adverse impacts of various types of soils and to develop models to be used to forecast the ecological effects of acid deposition. Possible consequences of various management strategies to counteract the adverse effects of acid rain will also be examined.

The Oak Ridge National Laboratory in Tennessee is examining the effects of acid rain, sulfur dioxide, and ozone on agricultural and forest ecosystems. Laboratory, greenhouse, and field studies are being performed to relate pollutant concentrations to responses of individual plants and plant ecosystems. With regards to forest ecosystems, the effects of acid rain and individual atmospheric pollutants on such trees as the yellow poplar, the white and black oak, and the black cherry, are being documented. A forest growth simulation model is being used to examine the responses of forest ecosystems exposed to air pollution over long periods of time.

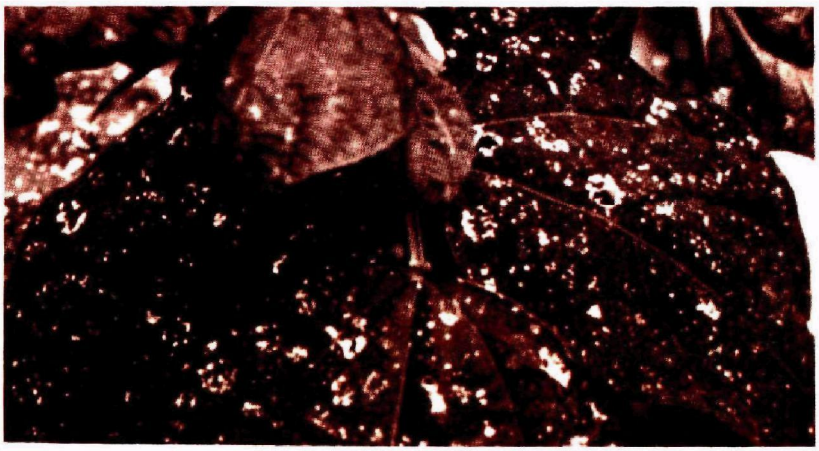
Effects on Crops

Researchers at the Brookhaven National Laboratory in New York are examining the effects of simulated acid precipitation on various terrestrial ecosystems. The threshold limits for injury or biological change to crops and organisms within the soil are being documented through the exposure of plants and various soil types to artificial acid precipitation in laboratory chambers and in the field. Models of forest and plant growth are being used to assist in the analysis of data related to both the extent of injury and relationships of injury to growth.

A crop survey is being performed at the EPA's experimental farm facility in Corvallis to determine the sensitivity of numerous field crops to various quantities of sulfuric acid. Future studies will look at the effects of nitric acid and the interactive effects of two or more acids on crops.

A research project designed to identify the effects of simulated acid rain on the bush bean *Phasesolus vulgaris* has recently been completed. Visual leaf injury was observed on plants exposed to precipitation less than pH 3. Microscopic cross sections of injured areas of leaves exposed to acid rain showed extensive damage to chloroplasts, the centers for photosynthesis, and surrounding cells.

The photo below shows the spotting or necrosis of leaves that takes place at low pH levels.



Future research at the Corvallis Environmental Research Laboratory will center on the determination of the impact of acid deposition on growth, yield, and quality of economically important crops taking into account possible future acid rain concentrations. Several research sites near current deposition monitoring stations are planned to be established in order to assess the impacts of known quantities and chemical compositions of acid precipitation. Data from these experiments will augment that data being developed through field, laboratory, and exposure chamber studies using simulated acid rain.

EPA Documerica

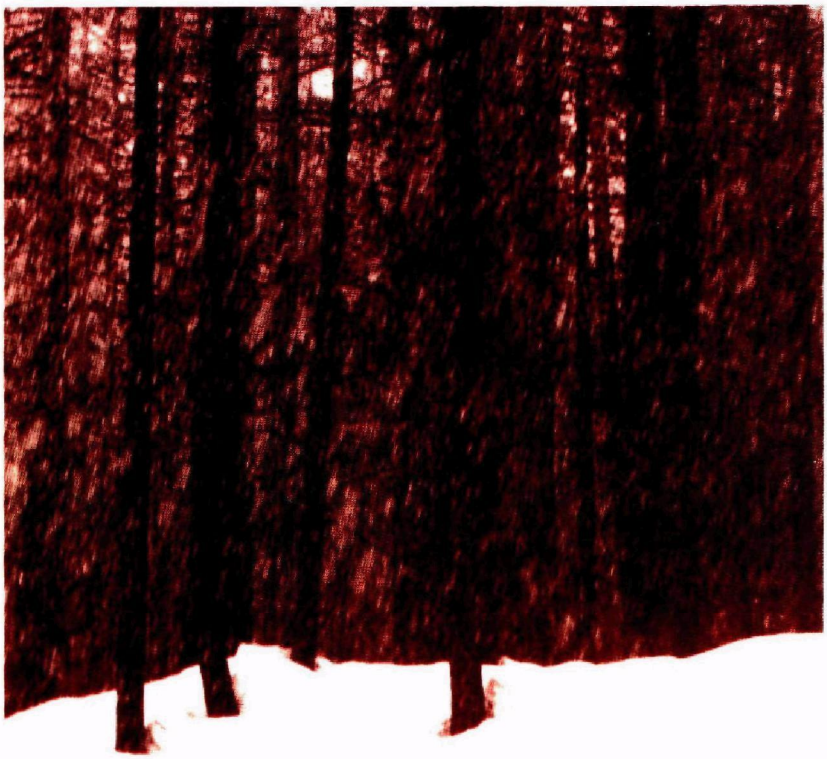
Integrated Watersheds

Through an interagency agreement with the Tennessee Valley Authority, the impacts of coal-fired power plant emissions on a small experimental watershed are being documented. The Cross Creek watershed in southern Tennessee has been subjected to sulfur and nitrogen emissions from the Widow's Creek Power Plant in northern Alabama for about thirty years, and therefore serves as an excellent location for studying the numerous effects of both wet and dry atmospheric deposition. Data on the transport, fate, and effects of pollutants throughout the forest ecosystem are being compared with similar data from a relatively remote forest ecosystem in central Tennessee. A comparative study of the two sites will enable the construction of models to be used to predict the ecological effects of man's activities on a given area. These models may then assist scientists and legislators in the development of atmospheric emission standards.

Effects on Stone

The Office of Research and Development is participating in an interagency and international study of the effects of acid precipitation on stone monuments and statuary, and ways to protect against such damage. Because of the many variables associated with material damage to stone, the evaluation of field data and its correlation with atmospheric pollutant levels is very difficult. The ideal subjects for analysis should be uniform materials produced under controlled conditions, placed in a variety of climates and environments over a continuous period of time, and accompanied by accessible, high quality documentation. All of these conditions are met by the marble headstones and markers placed nationwide under the direction of the Veterans Administration (VA). Since an 1875 Act of Congress, the VA has provided over 2.5 million tombstones to various National Cemeteries. These tombstones have been relatively standardized, being of just a few basic shapes, and are made from stone taken from only three quarries. These nearly ideal conditions offer researchers an excellent opportunity to document the effects of acid precipitation on stone. Approximately one dozen National Cemeteries have been selected in three climate zones for initial study: appalachian, far west, and northeast. Tombstones will be examined for such effects as measurable loss of detail, rounding of edges, and surface erosion to develop quantitative estimates of damage. This damage will then be correlated with data on the stone's history from Veterans Administration records and data on air pollution and meteorological patterns from the National Weather Service.

The Environmental Sciences Research Laboratory (ESRL) in Research Triangle Park, North Carolina, and the Department of Energy's Battelle Pacific Northwest Laboratory in Richland, Washington, have lead responsibility for the atmospheric processes and modeling portion of EPA's acid rain program. Research is presently directed towards understanding the transport of atmospheric acids, the wet deposition of acids through rain and snow, and dry deposition. In addition, regional models are being developed that will enable the prediction of the deposition of both wet and dry acids.



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Researchers are answering such questions as: Will acid rain increase with increased coal utilization, and if so, by how much and where? How does dry deposition vary with terrain, temperature, particle size, etc.? Are there differences between SO_2 transport in the northern and southern hemispheres?

Transformation-Transport Theory

The adverse effects of sulfate on human health and the environment that were documented by the Environmental Protection Agency in the early 1970's led to the mandatory control of sulfur dioxide emissions. This mandatory control forced the utilization of low sulfur fossil fuels, and resulted in lower sulfur dioxide emissions. However, reductions in urban sulfur dioxide levels did not result in proportional decreases in urban sulfate. Several theories have been set forth to explain this unexpected phenomenon. One explanation, the transformation-transport theory, holds that reductions in urban SO_2 emissions were accompanied by increases in *rural* SO_2 emissions from new power plants located outside cities. SO_2 from these power plants could have been transformed in the atmosphere to sulfate and transported over long distances to urban areas.

Project MISTT

ORD's recently completed Project MISTT (Midwest Interstate Sulfur Transformation and Transport) was initiated in the summer of 1973 to investigate the transformation-transport theory and to provide data on the mechanism and rate of conversion of SO_2 to sulfate. Results from the project proved that the SO_2/sulfate conversion did indeed take place at appreciable rates (a previously disputed assumption), and that the sulfate aerosols could be transported hundreds of kilometers from the initial SO_2 source. This validation of the transformation-transport theory reinforces data indicating that the acidity of lakes in New York's Adirondack Mountains, for example, may be due to the acidic components of deposition originating from such distant sources as midwest coal-fired power plants.

Project STATE

The Environmental Sciences Research Laboratory is undertaking various research projects designed to provide data for the development of regional atmospheric deposition models. The STATE Program, "Sulfur Transport and Transformation in the Environment," was initiated in 1978 primarily to quantify the impact of various regional air pollution sources on air quality.

The first major STATE field effort was conducted in August 1978, and focused on the Tennessee Valley Authority's (TVA) Cumberland power plant in north-central Tennessee. EPA funding supported participation in this project by the TVA and the National Oceanic and Atmospheric Administration. Numerous aircraft and surface sampling vehicles were used to obtain measurements of plume dispersion and chemical transformations over a range of atmospheric conditions. The basic design of each experiment involved injecting an inert tracer gas into the pollution source's effluent, and following this labelled portion of the plume downwind to sample the dispersion rate and chemical constituents for as long as possible.

The next major effort of the STATE program is planned for the summer of 1980. The focal area of the study will be the Ohio River Basin because of its high density of emissions from industrial and utility sources. However, individual experiments will involve sampling over most of the northeastern United States. The core experiment of this effort will consist of repeated sampling of labelled air masses for periods of several days to determine the accumulation of pollutants as air masses move over source areas, and to determine subsequent changes in pollutant chemical composition.

In addition to the two intensive field studies described, ongoing work in related areas continues to receive support under the STATE program. Techniques are being developed to better characterize the chemical and physical forms of sulfates and their precursors. Results from these experiments indicate that sulfates of more recent origin tend to be more acidic than "older" sulfate. In addition, researchers have found that the amount of ammonia (NH_3) available in the atmosphere appears to determine the extent to which sulfuric acid and nitric acid can be chemically neutralized.

Great Lakes

Through two interagency agreements underway at Argonne National Laboratory in Illinois, the effects of wet and dry deposition of atmospheric pollutants in the Great Lakes are being evaluated with special emphasis on pollutant transport processes. Pollutant levels are being monitored at various locations in and around the lakes, including the water surface and bottom sediments, to determine how and where various pollutants are transported.

Modeling

Numerous modeling activities are underway through the Multistate Atmospheric Power Production Pollution Study (MAP3S) being performed at several of the Department of Energy national laboratories. The MAP3S study was initiated in 1975 by the Energy Research and Development Administration (ERDA) to document pollutant concentration, atmospheric behavior, and precipitation chemistry resulting from air pollution from large scale power production processes, primarily coal combustion. Recently, funding and management responsibilities for this study were transferred from the DOE to the EPA's Office of Environmental Processes and Effects Research. The program is now being modified to focus more strongly on the acid deposition problem.

Data for the various modeling activities being undertaken through this study are provided by the MAP3S monitoring network as well as various other monitoring networks which are described later in this Summary. The overall goals of the MAP3S study are to elucidate the sources, processes, and mechanisms of the acid rain problem.

The Environmental Sciences Research Laboratory is presently adapting the European Regional Model of Air Pollution (EURMAP) to the eastern United States. This model, originally developed under the sponsorship of the Federal Republic of Germany, is being modified to predict monthly and seasonal wet and dry deposition of sulfur dioxide and sulfate. Through the use of the model, a series of emissions patterns based on future projections of energy use in the eastern U.S. are being examined to determine possible impacts on sulfur dioxide and sulfate levels.

The EPA is supporting the development of other models which enable researchers to calculate the concentrations of sulfur dioxide (SO_2) and sulfates (SO_4) both along lines of transport and at specific locations. Through the use of these models, researchers at Colorado State University recently found that sulfur dioxide normally resides in the atmosphere for between 15 and 30 hours in the cold season, and between 15 and 40 hours in the warm season. The residence time of sulfate, however, was found to be about ten times that of sulfur dioxide: between 150 and 450 hours for the cold season, and between 200 and 500 hours for the warm season. This information will be very useful in making predictions about the seasonal impacts of acid rain.

MONITORING

The EPA's acid deposition monitoring program is primarily the responsibility of the Environmental and Monitoring and Systems Laboratory in Research Triangle Park, North Carolina. The major objectives of the program are to:

- determine the scope of the present problem
- establish long-term trends resulting from atmospheric acid deposition
- help meet the research data requirements necessary to gain a better understanding of the atmospheric processes involved in the production of acid rain
- provide data necessary for the development of acid deposition-related models

The major shortcomings of many past and present precipitation monitoring networks have been a lack of adequate regional coverage, limited chemical analysis of samples, and a lack of practical application of quality control procedures. The EPA monitoring program is being developed with these past shortcomings in mind.

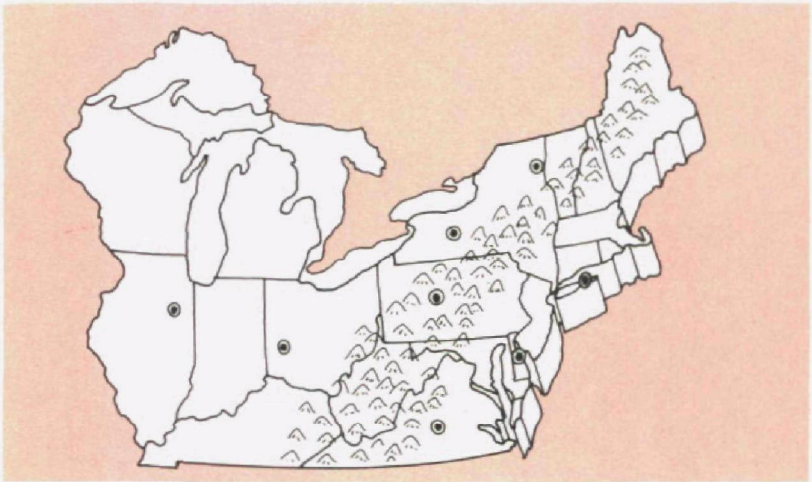
A prototype strategy for building a coordinated Federal monitoring program has been recently developed to support the President's acid rain research initiative. This proposed strategy involves a three-tiered system of monitoring networks.

In addition to this tiered strategy, the EPA plans to continue to encourage the operation of other precipitation chemistry networks by EPA regional offices, other Federal agencies, state governments, universities, and private institutions.

The EPA is presently either solely or partially supporting a number of monitoring networks.

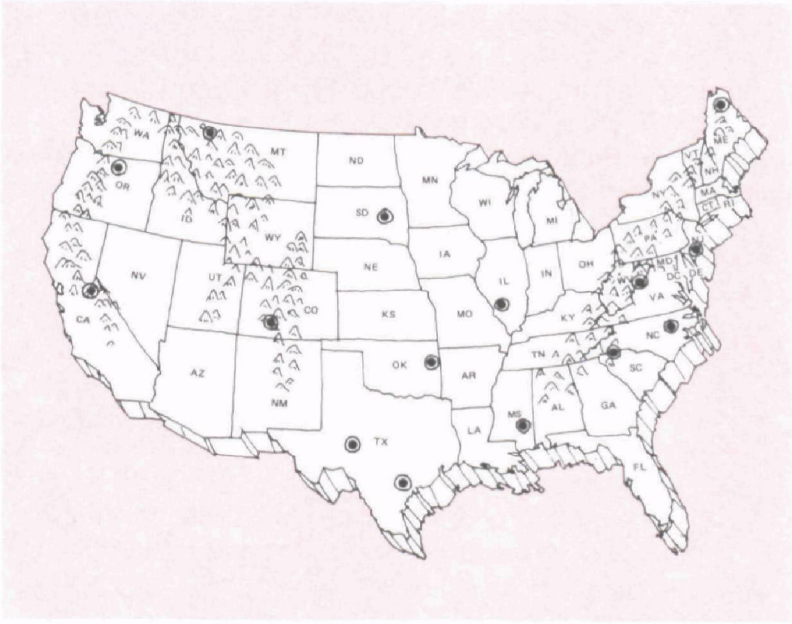
MAP3S

The Multistate Atmospheric Power Production Pollution Study (MAP3S) monitoring network was originally established to document sulfur dioxide emissions. However, this eight station network is now monitoring for more than a dozen constituents of acid deposition in the eastern United States.



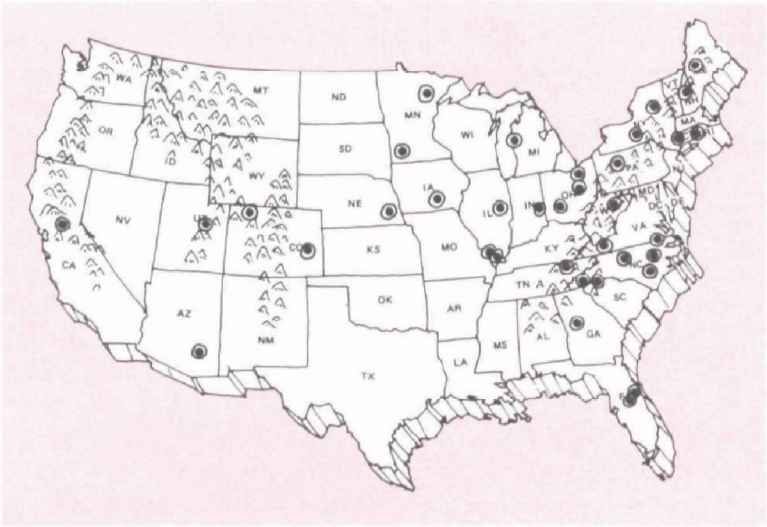
EPA/NOAA/WMO

A major global monitoring network has been established by the World Meteorological Organization (WMO) to help elucidate long-term global acid precipitation trends. The U.S. contribution to the 15 station WMO network is being coordinated by the EPA and the National Oceanic and Atmospheric Administration (NOAA). Precipitation samples collected on a monthly basis are sent to EPA's Environmental Monitoring and Systems Laboratory in Research Triangle Park, North Carolina and analyzed for pH, and inorganic and organic constituents. The data are published annually in conjunction with the National Oceanic and Atmospheric Administration's National Climatic Center in Ashville, North Carolina.



NADP

The National Atmospheric Deposition Project Network (NADP) is a major monitoring network involving a cooperative effort among numerous Federal, state, and private research agencies. The network is designed to provide data on atmospheric deposition and its effects on agriculture, forest lands, and surface waters. The NADP network will eventually include more than 50 monitoring stations nationwide, utilizing instrumentation capable of collecting both wet and dry deposition. Analyses of samples are performed by the Illinois State Water Survey's Laboratory, and results are sent to the Environmental Monitoring and Systems Laboratory in Research Triangle Park, North Carolina, for storage with other acid rain data. The EPA and other Federal agencies support the NADP network.



Atmospheric Pollutants Loading Study

The EPA's regional office in Chicago, Illinois, is sponsoring a 37 station precipitation chemistry monitoring network in the upper Great Lakes area.

In addition, the EPA is cooperating with private institutions, particularly the Electric Power Research Institute (EPRI), which have acid deposition monitoring networks underway.

Data Management

The systematic storage of data from all precipitation monitoring networks has long been a goal of researchers involved with the major Federal networks. An integrated national data system will soon be a reality. The Environmental Monitoring and Systems Laboratory in Research Triangle Park, is now managing much of the atmospheric deposition data developed by the various monitoring programs under operation nationwide.The lab is serving as a focal point for the reception, storage, and retrieval of data on acidity and chemical constituents of acid rain. This system will result in more effective analysis of acid precipitation data by assuring that accurate and timely information is readily available to researchers.

INDIVIDUAL RESEARCH PROJECTS

Selected acid rain-related research projects being performed by or through the various ORD laboratories or offices are listed below. Additional information about any of these projects may be obtained by writing to:

ORD Information System
Office of Research and Development, RD-674
US EPA
Washington, DC 20460

Environmental Research Laboratory — Corvallis, Oregon

- Potential Impact of Acidified Precipitation on Element Cycling and Production in Southern Appalachian Deciduous Forests
- Investigation of the Effects of Coal-Fired Power Plant Emissions on the Tissue Structure of Selected Bird Species
- Monitoring Plant Community Changes Due to Fossil Fuel Power Plants in Eastern Montana
- Aerosol Characterization Research — Colstrip, Montana (through interagency agreement with U.S. Department of Energy)
- Development of Protocol to Assess the Effects of Western Coal Conversion Activities in a Terrestrial Ecosystem — Colstrip
- Assessment of the Acid Precipitation Monitoring Needs in the Northeastern United States
- Impact of Acid Precipitation on Yield of Crops
- Response of Model Forest Ecosystems to Acid Rain
- Short-term Acid Precipitation Program to Assess the Extent of Sensitive Aquatic and Terrestrial Systems in the Eastern U.S. and the Present Extent of Damage

Environmental Research Laboratory — Duluth, Minnesota

- Impacts of Air Pollutants (Acid Rain) on Wilderness Areas of Northern Minnesota
- Mobilization and Transformation of Soil and Sediment Components into Pollutants by Acid Precipitation and Related Factors
- Acid Effects to Flathead Minnows, Community Functions and Macro-invertebrates in Outdoor Experimental Channels (through Monticello Ecological Research Station, Monticello, Minnesota)
- Human and Environmental Exposure and Impacts from Air and Water Pollutants: Coal-Fired Power Plants
- Susceptibility of Aquatic and Terrestrial Resources of Minnesota and Wisconsin to Damage from Atmospheric Pollutant Deposition and Loading

Office of Environmental Processes and Effects Research — Washington, D.C.
(via Interagency Energy/ Environment R&D Program)

- Effects of Acid Precipitation on Terrestrial Ecosystems (U.S. Department of Energy — Brookhaven National Laboratory)
- Effects of Chronic SO_2 Exposure on Midwestern Crops (U.S. Department of Energy — Argonne National Laboratory)
- Ecological Effects of Coal Combustion: Response of Vegetation to SO_2, Ozone, and Acid Precipitation (U.S. Department of Energy — Oak Ridge National Laboratory)
- Great Lakes — Pollutant Transformation and Fate (U.S. Department of Energy — Argonne National Laboratory)
- Great Lakes — Pollutant Transport Processes (U.S. Department of Energy — Argonne National Laboratory)
- Support to the NADP Precipitation Monitoring Network (coordinated by the U.S. Department of Agriculture)
- Camp Branch and Cross Creek Experimental Watershed Projects (Tennessee Valley Authority)

Environmental Sciences Research Laboratory — Research Triangle Park, North Carolina

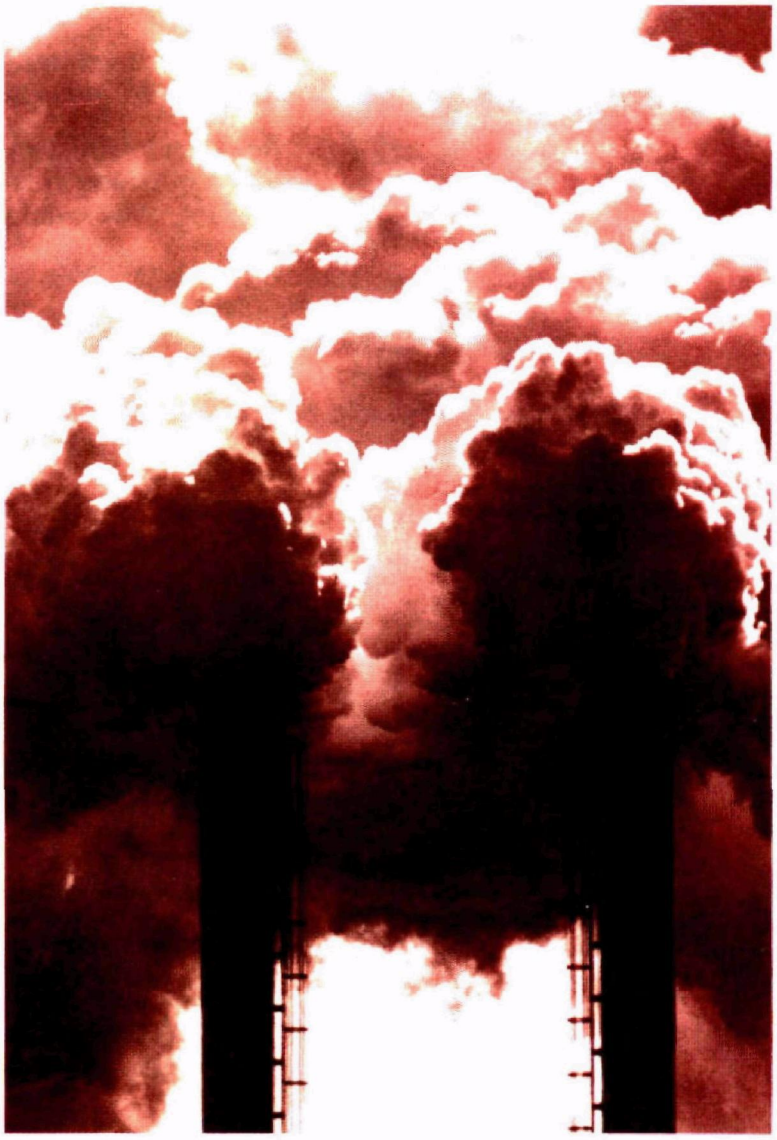
- Development and Evaluation of a Prototype Device to Analyze Ambient Sulfuric Acid
- Aircraft Measurement in Support of Sulfur Transformation and Transport Studies
- Atmospheric Transport and Transformation from Coal-Fired Power Plants
- Analytical Support for Determining the Character and Origin of Aerosols
- Sulfur Dioxide and Sulfates Materials Damage Study
- Long Range Transport Modeling
- Dry Deposition of Gaseous Pollutants
- Adaptation and Application of the EURMAP Model to the Eastern United States
- Experimental Study of Aerosol Formation Mechanisms in a Controlled Atmosphere
- Kinetics and Mechanisms of Nitrate Formation in Photochemical Smog
- Long-Range Transport and Transformation of Sulfur Dioxide and Sulfate
- Scavenging of Gases and Aerosol Particles by Clouds and Precipitation in the Atmosphere
- Experimental Determination of Dry Deposition Rates
- Formation of Atmospheric Aerosols
- Aerosol Deposition Rates
- Engineering and Development of Dichotomous Sampler
- Characterization of Primary Sulfate Emissions from Industrial/Residential Sources
- Development of Analytical Techniques for the Measurement of Nitric Acid

Environmental Monitoring and Systems Laboratory — Research Triangle Park, North Carolina

- Standards For and Methods of Analysis of Rainwater for Acidity
- WMO Collaborating Center on Background Air Pollution Data
- Quality Assurance for Environmental Pollutant Monitoring
- Improvement and Evaluation of Methods for Sulfate Analysis
- Standardization and Quality Assurance of Stationary Source Emission Methodology
- Ambient Air Monitoring Reference and Equivalent Methods Program
- Quality Assurance in Support of Energy-Related Monitoring Activities in the Western USA

Office of the Assistant Administrator — Washington, D.C.

- Development of a Strategy for Acid Rain Monitoring
- Development of an Integrated Five-Year Plan (FY 80-84) for the EPA's Atmospheric Acid Deposition Program
- Correlation of Existing Acid Deposition Exposure Sites with Air Pollution Records
- Determination of the Effects of Individual Pollutants on Materials and Development of a Damage Function Model (Jointly Funded with the National Bureau of Standards)



FOR FURTHER INFORMATION

- Decision Series: Acid Rain. December 1979. EPA-600/9-79-036.

  An in-depth discussion of the global acid rain problem focusing on the latest environmental effects data being developed in North America and Scandanavia. Intended for those seeking a good overview of the issue.

- EPA Research Outlook. February 1979. EPA-600/9-79-005. 140 Pages.

  A concise description of the EPA's plans for future environmental research.

- EPA Research Highlights. December 1978. EPA-600/9-78-040. 70 Pages.

  Highlights of the EPA research program accomplishments of 1978.

Information on the availability of these publications may be obtained by writing to:

Research Information, RD-674
Office of Research and Development
US EPA, Washington, DC 20460

or by calling (202) 755-0648

Technical Reports

- Sulfates in the Atmosphere: A Progress Report on Project MISTT. March 1977. EPA-600/7-77-021. 29 Pages. (PB 268 361, $4.00)

- Environmental Effects of Increased Coal Utilization: Ecological Effects of Gaseous Emissions From Coal Combustion. June 1978. EPA-600/7-78-108. 49 Pages. (PB 285 440. $5.25)

- Simulation of Nutrient Loss From Soils Due to Rainfall Acidity. May 1978. EPA-600/3-78-053. 44 Pages. (PB 285 174, $6.00)

Technical reports can be obtained by writing to:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

or by calling (703) 557-4650

Questions or Comments

The office of Research and Development invites you to address any questions or comments regarding the EPA acid rain research program to the appropriate individuals listed below:

Topic	Contact
Environmental Effects	Dr. Norman Glass Environmental Research Laboratory 200 SW 35th Street Corvallis, OR 97330
Environmental Effects (especially Minnesota, Wisconsin, Michigan region)	Dr. Gary Glass Environmental Research Laboratory 6201 Congdon Blvd. Duluth, MN 55804
Atmospheric Chemistry	Dr. Paul Altshuller Environmental Sciences Research Laboratory, MD-59 Research Triangle Park, NC 27711
Monitoring	Mr. Franz Burmann Environmental Monitoring and Systems Laboratory, MD-75 Research Triangle Park, NC 27711
Interagency Agreements	Mr. Clinton Hall Office of Research and Development, RD-682 US EPA Washington, D.C. 20460
Program Management	Mr. Dennis Tirpak Office of Research and Development, RD-676 US EPA Washington, D.C. 20460