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Project Summary

Atmospheric Deposition to Mountain Forest Systems: Workshop Proceedings April 1984

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The Atmospheric Sciences Research Center of the State University of New York at Albany has organized and hosted a workshop which specifically addressed the need, design and implementation of research, development and monitoring with advanced techniques for these purposes:

- **to identify the contribution of acidic and non-acidic pollutant deposition to damage of forests on mountain peaks, and**
- **to monitor air and cloud chemical quality in regional transport winds for possible source-receptor model evaluation.**

This report presents the results of the workshop which was held in Albany, New York, on April 5-7, 1984, with over 40 invited participants from universities, state and federal government and the private sector.

The international aspect of this workshop involved Canadian and European scientists and institutions. The workshop participants recommended the establishment of a research and monitoring network extending from the Smoky Mountains to the Laurentian Mountains where forest and atmospheric scientists can study and test in detail the major hypotheses that have been developed in attempts to explain the current decline of forests.

Recommendations for atmospheric research and monitoring are detailed in this report. They include atmospheric related measurements, deposition related measurements, required meteorological measurements, analytical procedures, and a management structure for coordinating these above activities at the various field sites.

A cost estimate for the recommended study on atmospheric deposition and its impact on high elevation forest systems is also included.

This Project Summary was developed by EPA's Environmental Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

The EPA/NSF workshop on high elevation forest systems was organized to bring together leading representatives of various scientific disciplines for the purpose of developing jointly a comprehensive research plan that would enable an assessment as to what degree atmospheric depositions are responsible for the observed forest changes The higher frequency of occurrence of forest damage in high elevation versus low elevation forest systems and the higher deposition of pollution related material in eastern North America versus the western parts of the U.S. and Canada suggest that the initial research efforts should focus at this time on the impact of cloud/precipitation elements and certain air pollutants on the forests of the northern and southern Appalachian Mountains extending from the Laurentian to the Smoky Mountains. The

participation of Canadian and German scientists in this workshop provides a unique opportunity for adopting a common research and implementation strategy in all three countries.

Climate changes (i.e., drought) alone cannot adequately explain the observed damages to North American and Central European forests. Manmade causes are thus prime suspects. The wet and dry depositions of acidic or acidifying substances, organic and inorganic oxidants, heavy metals, etc., from the atmosphere onto the forest canopy and their subsequent movements into the ecosystem are considered by most scientists as a major process by which forest damage can occur. High elevation mountain ecosystems can experience higher deposition fluxes of pollution related material because of (1) their frequent exposure to clouds, fog, dew, or related special deposition processes, and (2) the high wind speeds aloft causing higher collection efficiencies by the canopy.

Four major hypotheses have been developed in attempts to explain the current decline of forests:

- The acidification-aluminum toxicity hypothesis. Increased acidity in the soil leads to increased concentrations of soluble aluminum ions in the soil solution which, in turn, results in accelerated morbidity and/or decreased synthesus of fine feeder roots.

- The general stress hypothesis. "Air pollution" had led to a decrease in net photosynthesis and associated diversion of photosynthesis from mobile carbohydrates to relatively less mobile and toxic secondary metabolites.

- The magnesium deficiency hypothesis. The decline symptoms often occur in combination with extreme magnesium deficiency in trees with plentiful supplies of nitrogen and phosphorous. According to this hypothesis, acid deposition from the atmosphere contributes to the following growth disturbances: it adds nitrogen to the ecosystem but may leach out magnesium and calcium from needles and soils. The leaching from the foliage is presumably accelerated by episodic ozone exposure or frost damage to cuticles and cell membranes.

- The dry deposition air-canopy hypothesis. Ozone and other oxidants (hydrogen peroxide, organic peroxides, nitrogen dioxide, peroxyacetylnitrate (PAN)), nitric acid vapor, and sulfur dioxide interact directly with the cuticles and cell membranes of the foliage. During periods of drought, characterized by a high pressure system and air stagnation, the levels of secondary air pollutants (oxidants and acids)can reach episodic levels. Particles containing acids, heavy metals, etc., are also known to cause direct or indirect damage to foliage. The postulated damage could be significantly larger if cloud droplets are intermittently deposited on the leaves or needles, moistening the surface without causing an appreciable "runoff."

The protocols of measurements recommended at this time are intended to help resolve basic research questions, and allow for enough flexibility to both guide and respond to the developments in our understanding of the relationship between depositions and forest response.

The workshop recommends these tasks be carried out by atmospheric scientists to test the multiple working hypotheses outlined above:

- Characterize the variability in wet and dry deposition to the forest canopy.

- Determine the variability of the microclimate.

- Determine loss rates of dominant ions from a watershed.

Atmospheric deposition inputs occur from all three phases (gas, liquid and solid) and actual rates cannot be directly monitored at this time in any of them. Throughfall and steamflow measurements are only relative measures and require knowledge of the ambient, time dependent concentrations of cloud and precipitation water before reactions on the vegetation surface either destroy, create or otherwise modify the species of interest.

The workshop recommends these tasks:

- Monitor cloud water for dominant ions, trace metals and strong oxidants.

- Determine ambient concentrations of selected gases at representative sites--ozone, sulfur dioxide, oxides of nitrogen and, eventually, hydrogen peroxide, ammonia, nitric acid and peroxyacetyl nitrate.

- Determine average chemical composition of aerosol with special emphasis on measuring the ionic concentration of sulfate, nitrate, hydrogen, ammonium and heavy metals.

The measurement efforts toward quantifying atmospheric depositions (cloud and precipitation elements, reactive gases and aerosols) to high elevation forest systems yield an additional benefit. From these measurements it is possible to obtain a representative cloud chemistry data base for the purpose of establishing long term trends, if any, in the ionic composition of cloud water.

The collection and analysis of cloud water--either before or after interception by the forest canopy--at several field sites in eastern North America requires rigorous procedures that must be adhered to by all site operators. To minimize the overall uncertainty of the chemical measurements it is necessary to establish a central facility for analysis of the primary ions contributing to the chemical quality of cloud water. Ideally, this would be the same laboratory that currently is responsible for the NADP/NTN analyses so that interlaboratory bias is eliminated. The use of the Central Analytical Laboratory (CAL) of the NADP/NTN will ensure analysis and quality assurance compatibility between the cloud water and the precipitation chemistry elements of the National Acid Precipitation Assessment Plan.

The Research and Monitoring plan, as described in this workshop report provides the opportunity to conduct highly multidisciplinary research. A great deal of meteorological, air quality, cloud and precipitation quality, forest related and ecological data will be needed to help assess the impact of atmospheric deposition on forest productivity.

Without proper attention to the associated data management issues, the science that could be done would be compromised. Attention, therefore, will be devoted to: (1) information system planning, (2) timely delivery of documented data, (3) standardization and cataloguing, (4) appropriate software practices and, (5) advice from the science community. The best quality science data are produced when the science community is intimately involved in the activity.

The data base management team will provide for:

- Project analysis and reporting by the Project Manager
- Providing comparisons and relationship among data from different project disciplines
- Transfer of the data to a national data base

While existing instruments and methods are adequate to make a useful beginning in measurement of atmospheric deposition into forests, there are some serious limitations in sensitivities for certain species in one or more phases.

Technology limited types of measurement include, for example, gas-phase concentrations of H_2O_2, NH_3 and organic radicals in clouds or cloud-free air, collection devices for automatically collecting supercooled cloud/fog droplets, and devices for measuring both dry and wet deposition directly to foliage.

A Center for instrument technology is recommended to focus on instrument development and standardization and calibration. The needs for such services are by and large not unique to this program, but common to main-stream problems of atmospheric chemistry, and acid deposition research, so that the work of the Center will be of benefit to, and be cooperative with, that of other groups concerned with atmospheric sampling.

Several regions in eastern North America show evidence of forest species decline. Sites in or near these areas have been selected as appropriate locations to be integrated into a high elevation atmospheric deposition network.

The interactions of the atmospheric-terrestrial system is extremely complicated. Some measurements and commitments of personnel can become fairly expensive. For this reason, it is suggested that sites having primarily one of two slightly different missions be established.

1) monitoring sites to be established for the purpose of providing the data required to test some or all of the hypothesis being considered (at least three such monitoring sites are recommended); and

2) research sites which would additionally provide the facilities and personnel to develop or improve methods for sampling and analysis which will guide the network evolution from a research to a monitoring focus. Three such research sites are recommended for eastern North America.

The recommended field sites are: Mt. Morency, Laurentian Mts.; Mt. Washington, White Mts.; Hubbard Brook, White Mts.; Camels Hump, Green Mts.; Whiteface Mt., Adirondack Mts.; Mohonk Mt., Shawangunk Mts.; Shenandoah Mt. (three sites); Mt. Mitchell, S. Appalachian Mts.; Look Rock, Smoky Mts. Site descriptions have been obtained from personnel responsible for each site.

Most important to the successful operation of any site is the availability of local resources of both technical and professional staff. Their commitment to research in the fields of deposition and/or forest ecology must be evident and their work, as judged by their peers, to be of outstanding quality.

Efficiency of operation for a dispersed and sophisticated sampling network of the type recommended here requires an equally efficient and well-integrated communication, decision-making and management system. The recommended research program will include a Management and Assessment Center with a single scientific and technical manager having both the responsibility and authority to carry out this research and monitoring program. It would be responsible only for the U.S. efforts.

The various offices and/or components reporting to the Management and Assessment Center include:

- Cloud Chemistry Research and Monitoring Sites
  a. research sites (total of three are recommended at this time)
  b. monitoring sites (at least three are recommended at this time)
- Meteorological and Climatological Documentation Office for all sites
- Analytical Measurement Laboratory (one centralized facility for all sites)
- Data Management and Quality Control Office (one office for all sites)
- Data Documentation and Distribution Office (one office for all sites)
- Academic Exchange and Minority Program Office (one office coordinating the activities for all sites)
- Center for Advanced Instrumentation Technology (one central facility serving all sites)
- Advisory Committee

The Management and Assessment Center will rely on an advisement committee which will consist of representatives of sponsoring agencies, the site directors, and recognized scientific leaders working in related fields. It will communicate directly with the site directors, who in turn will have full accountability and authority to oversee all activities of the program at their site, in accordance with the management plan worked out in consultation with the advisory committee.

As both government and university policies encourage interaction with small business at appropriate times, cooperation with the small businesses offers this program the opportunity to interact with a wider range of scientists and technicians. Three areas of this program seem appropriate for such interaction: 1) meteorology/climatology, 2) data base management, and 3) instrumentation. Traditionally, these areas have been well developed in the private sector and could offer substantial support to this research effort.

The workshop developed a budget for the recommended activities and a timetable for implementation which includes a phase-in approach. It is anticipated that the proposed research program can be in full operation within three years.

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***Jack L. Durham** is the EPA Project Officer (see below).*
The complete report, entitled "Atmospheric Deposition to Mountain Forest Systems: Workshop Proceedings, April 1984," (Order No. PB 84-246 412; Cost: $10.00, subject to change) will be available only from:

National Technical Information Service
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