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ORNL FOREIGN TRIP REPORT

ORNL/FTR-3791

DATE: October 18, 1990

SUBJECT: Joint Report of Foreign Travel of R. B. Cook (Research Staff Member, Environmental Sciences Division), P. F. Ryan (Subcontractor, Science Applications International Corporation), and R. S. Turner (Research Staff Member, Environmental Sciences Division)

TO: Alvin W. Trivelpiece

FROM: Robert B. Cook, Patrick F. Ryan, and Robert S. Turner

PURPOSE: To participate in the Fourth International Conference on Acidic Deposition: Its Nature and Impacts, September 16-21, 1990

SITES VISITED:

9/16-21/90	Fourth International Conference	Glasgow, United Kingdom	F. T. Last, Chairman, Scientific Committee

ABSTRACT: The travelers presented papers on various aspects of modeling performed as part of the U.S. National Acidic Precipitation Assessment Program (NAPAP) at the Fourth International Conference on Acidic Deposition: Its Nature and Impacts. The meeting was sponsored by the Royal Society of Edinburgh and was attended by over 800 scientists, primarily from Europe and North America. The conference focused on nine aspects of the nature and impacts of atmospheric pollutants, including ozone: (1) chemistry of atmospheric pollutants; (2) processes controlling the deposition of pollutants; (3) effects of pollutants on soils; (4) physiology of plant responses to pollutants; (5) effects of pollutants in agricultural and natural or seminatural ecosystems; (6) atmospheric pollutants and forests; (7) effects of pollutants on the chemistry of freshwater streams and lakes; (8) effects of pollutants on freshwater plants and animals; and (9) effects of pollutants, indoors and outdoors, on materials and buildings.

Discussions with scientists, particularly international delegates, were important in increasing the visibility of research performed by the travelers, in learning of recent research not yet published in the international literature, and in identifying key areas requiring future research. The travelers participated in a postconference field trip to an experimental watershed that had been limed to mitigate the effects of acidic deposition. The foreign research and related policy implications are of value to the travelers and the U.S. Department of Energy (DOE) in finalizing the NAPAP Integrated Assessment, in evaluating critical loads for sulfur and nitrogen in the eastern United States, and in modeling and assessing the fate of energy-related contaminants and global change.

INTRODUCTION

The purpose of the trip was to attend an international conference, "Acidic Deposition: Its Nature and Impacts," in Glasgow, United Kingdom. The conference, which was attended by approximately 800 scientists, with 600 oral and poster presentations, was the fourth in a series devoted to the effects of acidic deposition on terrestrial and aquatic ecosystems. The conference was structured around a series of plenary and concurrent sessions, the latter being used for the presentation of papers, the examination of posters, and structured debates. Progress was monitored throughout the conference by rapporteurs who presented a synthesis of the main conclusions on the final day, when policy implications were considered. The foreign research and policy implications are of great value to the travelers and the U.S. Department of Energy in finalizing the Integrated Assessment of the National Acid Precipitation Assessment Program (NAPAP), in conducting ongoing research evaluating critical loads of sulfur and nitrogen for terrestrial and aquatic ecosystems in the eastern United States, and in developing enhanced approaches to modeling and assessing energy-related contaminants and global change.

SUMMARY OF KEY TOPICS

AFFORESTATION

Several papers described measurable effects of afforestation on watershed chemistry. J. W. Hornbeck (U.S. Department of Agriculture Forest Service, United States) argued that effects of afforestation were variable, so site-by-site nutrient budgets were necessary to assess effects. He found that clear-cutting increased mineral weathering rates. Separate work by P. A. Stevens (University College of North Wales, United Kingdom) and R. Harriman (Freshwater Fisheries Laboratory, United States) performed in Scotland showed that increased deposition scavenging was the major effect of afforestation. This conclusion is based on a strong positive correlation between both sulfate and chloride and percent of forested catchment. This result is consistent with observed decreases in sulfate concentration in water draining clear-cut sites.

REVERSIBILITY OF ACIDIFICATION

Evidence concerning the reversibility of acidification in surface waters indicated that recovery may be slow for several reasons. (1) Depleted base saturation will take a long time to be replenished (R. F. Wright, Norwegian Institute for Water Research, Norway). (2) Nitrification, which neutralizes acidity, is inhibited by low pH levels (D. W. Schindler, Freshwater Institute, Canada). (3) Oxidation of reduced sulfur compounds can continue to produce acidity (P. J. Dillon, Ontario Ministry of the Environment, Canada). (4) Low calcium-to-hydrogen ion ratios may make conditions for fish worse before these conditions improve (R. A. Skeffington, National Power, United Kingdom). Sulfur oxidation and nitrification will have large effects on acid-neutralizing capacity in only a limited number of systems. Cation supply, which is the more universally important process, is not yet fully understood.

Reduced base cation supply is simulated differently by various models. For example, reduced supply is caused by the depletion of the cation exchange complex in the MAGIC model (R. F. Wright) and a variable weathering rate in the PROFILE model (H. U. Sverdrup, Lund Institute of Technology, Sweden). The PROFILE model includes an innovative method for estimating weathering rates based on soil mineralogy, texture, moisture, and temperature. Measurements of changes in soil base saturation (D. W. Johnson, Desert Research Institute, United States) revealed far larger changes on shorter time scales than previously predicted. The mechanism of base cation supply has different effects on the predicted steady-state concentrations and therefore is important in determining critical deposition loads. If changes in base saturation neutralize incoming acidic deposition without changes in weathering rates (as modeled in MAGIC), the question is one of the timing of changes in surface water chemistry with no effect on the ultimate critical load. If weathering rates change, critical loads are affected.

HEAVY METAL CONTAMINATION

Several papers concerned with heavy metals in the environment may point to research that would be useful in evaluating on- and off-site contamination problems on the Oak Ridge Reservation. R. Mosello (C. N. R. Istituto Italiano di Idrobiologia, Italy) reported on plans to lime Lake Orta, which has received plating discharges high in metals such as copper, chromium, nickel, and zinc. P. L. Brezonik (University of Minnesota, United States) reported that iron and manganese increased more than aluminum and cadmium in an experimentally acidified lake. J. Mannio (National Board of Waters and the Environment, Finland) found that elevated concentrations of heavy metals were found in both surface waters and terrestrial mosses, indicating an atmospheric source. Peter Dillon indicated that mercury levels in fish in some lakes in Ontario exceed levels considered safe for human consumption (0.5-1.0 μg/g). The source of mercury to the lakes appears to be atmospheric deposition, although geologic sources are implicated for several sites. More research is needed on why bioaccumulation of mercury is higher at some sites than at others. A paper by Haines et al. indicated that mercury content of fish was higher in acidic than in alkaline lakes in the U.S.S.R. This research could help place contamination at DOE facilities in a more global perspective.

DISSOLVED ORGANIC CARBON

In a session on the weak acid/strong acid contribution to surface water acidity, C. T. Driscoll (Syracuse University, United States) described his excellent technique for characterizing the acid-base chemistry of dissolved organic carbon (DOC). This technique enables both the acid dissociation constant and the acid content of DOC to be determined. For lakes in the Adirondack Mountains of New York State, Driscoll found that (1) DOC has some strong acid anion character and (2) the contribution of DOC to acid-base chemistry was small compared to that of HCO_3^-. Driscoll observed an inverse relationship on a regional basis between DOC and SO_4^{2-}. One of the travelers (R. B. Cook) has observed a similar regional relationship between DOC and SO_4^{2-} in eastern Canada. However, in another paper presented later in the week, P. Dillon showed that within a watershed, DOC decreased as SO_4^{2-} decreased. Driscoll stressed that the interaction between acidic deposition and DOC is not known and requires further field research to evaluate.

NITROGEN DYNAMICS AND NITRATE

John Rudd (Freshwater Institute, Winnipeg, Canada) and Carol Kelly (University of Manitoba, Canada) presented results from a whole-lake experiment that showed that NO_3^- is nearly as efficient as SO_4^{2-} in acidifying. This observation is in contrast to earlier findings, which suggested that SO_4^{2-} was the key acid anion that caused acidification, because NO_3^- is effectively taken up during vegetation growth and also during denitrification. Kelly and Rudd observed that as NO_3^- concentrations in lakes and streams increase, the biogeochemical removal of NO_3^- from surface water (by algal uptake and denitrification) decreases markedly.

A. Newell and J. Stoddard (NSI Technology Services, Inc., United States) and J. Wigington (U.S. Environmental Protection Agency, United States) found that spring NO_3^- peaks and summer NO_3^- concentrations appear to be increasing in streams in the northeastern United States. According to work done by Newell, Stoddard, and Wigington, NO_3^- is an important contributor to episodic acidification in the northeastern United States. All these workers advocated establishment of research programs to understand how biogeochemical NO_3^- cycling in terrestrial and aquatic systems responds to increasing levels of NO_3^- deposition. Because nearly all emission-reduction scenarios focus on reducing sulfur emissions, acidification due to NO_3^- may become even more important in future years.

CHANGES IN SOIL CHEMISTRY

Until recently there has been little field evidence for long-term changes in soil aluminum chemistry and nutrient status. In the past several years, more and more such changes have been demonstrated. In a plenary session E. D. Schulze (Universitaet Bayreuth, Germany) discussed evidence for reduction in soil base saturation; changes in soil solution calcium-to-aluminum ratios; magnesium deficiency; changes in the form of nitrogen uptake by plants; changes in root distribution in the soil; and changes in forest structure, especially the understory. D. W. Johnson discussed mechanisms of soil chemistry change and highlighted numerous recent studies of change. These apparent, fairly rapid changes in soil chemistry are a surprise to many soil scientists who thought soils represented stable, well-buffered systems. It remains to be shown how widespread or typical such changes are, however.

CRITICAL LOADS

The Europeans are devoting a great deal of effort to establishing critical loads of sulfur and nitrogen as a first step to setting target loads and legislating emissions levels. One conference session was dedicated to the critical loads issue, and many posters and papers in other sessions reported on approaches being used. An attempt is being made across Europe to use common modeling methods and levels of data, but it is clear from the presentations that a wide range of modeling sophistication and data quality is being used. A critical load is, by definition, a single number, but there was little said explicitly about uncertainty in these numbers or reporting of comparisons of different data aggregation or modeling approaches used in arriving at the numbers. J. P. Hettelingh (National Institute for Public Health and Environmental Protection, The Netherlands) suggested that a statistical approach showing a range of change in critical chemical parameters should be used rather than single values for critical loads, but the point drew little attention. H. Sverdrup presented a critical loads map for Maryland streams, based on his Profile soil weathering model. S. J. Langan (Institute of Terrestrial Ecology, United Kingdom) showed critical loads for soils in the United Kingdom but pointed out that there currently is no suitably quantified link between soil chemical change and biological effect, a problem with which the U.S. NAPAP and critical loads program has also wrestled. The European attitude (expressed by H. Sverdrup in individual discussion) toward inconsistencies in approach and inadequacies in models and data seems to be to ignore the problems for the first pass, produce numbers that can be used as best/rough estimates, and then go back and refine the models and data later.

LIMING

During the Loch Fleet field trip, we observed the results of a six-year project designed to reduce the acidity in the lake through addition of lime to the watershed, so that a self-sustaining brown trout population could be restored in the lake. The results of this project suggest that practical and economic liming treatments can be designed even for difficult terrain and that fisheries can be restored at a reasonable and acceptable cost. During our field trip we were shown that the effects of the treatments on moorland vegetation and soils have been slight.

ACIDIC DEPOSITION IN DEVELOPING NATIONS

J. N. Galloway (University of Virginia, United States) presented a plenary paper in which a major point was that burning of coal is projected to increase dramatically in areas of South America, Africa, and especially Southeast Asia. The implications for sulfur and carbon emissions are enormous. There is an opportunity now to assess potential effects and implement necessary controls and efficiency measures as the plants are built to avoid effects or damage such as has occurred in Europe and North America.

POLICY

In one of the better presentations in the closing session on policy, A. Persson (Chalmers University, Gothenburg, Sweden) described the approach to establishing policy in Sweden. The threefold approach includes (1) development of a research program that will establish critical loads and levels based on the tolerance of ecosystems to acidic deposition, (2) reduction of emissions to appropriate levels, and (3) addition of lime to the most sensitive watersheds and aquatic systems to prevent the further deterioration of ecosystems while emissions are reduced. This combination of emission reduction and liming is novel and should aid in rapid amelioration of acidified ecosystems.

Papers and discussions at the conference included areas of concern to Oak Ridge National Laboratory besides the direct concern about acidic deposition. Dr. T. Brydges (Environment Canada) mentioned nuclear power as a potential answer to the acid rain problem in his introductory lecture on the history of the acid rain problem. He did not, however, say whether he favored it.

SUMMARY EVALUATION

Although research related to acidic deposition in the United States has all but ceased, attendance at this conference and the fact that another in the series is planned for Sweden in 1995 indicate that acidic deposition research is going strong in Europe, focusing increasingly on critical loads. The critical loads process is providing for Europe the integration that NAPAP attempted in its Integrated Assessment, but the critical loads process promises to pay more attention to establishing target loads and optimizing emissions reductions–a more integrated and far-reaching assessment than NAPAP could muster by 1990. The United States has learned much in the NAPAP process that should be shared with the Europeans. The United States also stands to gain much from the continuing European research by participating in the critical loads process and by continuing watershed process research in this country. Research developments on effects of afforestation, dissolved organics, nitrogen dynamics, changes in soil chemistry and weathering, liming, and modeling approaches could influence future U.S. policy on sulfur, nitrogen, and carbon emissions; these were all areas of great uncertainty in NAPAP's assessment. At this conference the travelers profited from presentations and discussions of research findings and policy implications that are helpful to them in finalizing the NAPAP Integrated Assessment, in evaluating critical loads of sulfur and nitrogen in the United States, in evaluating and assessing the movement of water and contaminants through watersheds, and in developing enhanced approaches to modeling biogeochemical processes affecting transport and fate of energy-related contaminants. Much has been learned from acidic deposition research that is relevant to other contaminant problems as well. Many unknowns remain, however, and a U.S. plan for continued policy-relevant process research on the watershed-to-regional scale is needed to build on the impressive strides made over the past ten years.

APPENDIX A

ITINERARY

September 14	Travel from Oak Ridge, Tennessee, to Glasgow, United Kingdom
September 15	Arrival in Glasgow, United Kingdom; informal discussions
September 16	Conference registration; informal discussions
September 17-21	Fourth International Conference on Acidic Deposition: Its Nature and Impacts
September 22	Field trip to Loch Fleet, southwestern Scotland
September 23	Travel from Glasgow, United Kingdom, to Oak Ridge, Tennessee

APPENDIX B

PERSONS CONTACTED TO A SIGNIFICANT EXTENT

P. Brezonik, Civil and Mineral Engineering Department, University of Minnesota, Minneapolis, Minnesota

D. J. A. Brown, National Power, United Kingdom

B. J. Cosby, Duke University, Durham, North Carolina

P. J. Dillon, Limnology Section, Ontario Ministry of the Environment, Dorset, Ontario, Canada

R. Harriman, Freshwater Fisheries Laboratory, Pitlochry, United Kingdom

H. Hemond, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts

A. Jenkins, Institute of Hydrology, Wallingford, Oxon, United Kingdom

A. H. Johnson, Department of Geology, University of Pennsylvania, Philadelphia, Pennsylvania

P. Kauppi, Finnish Acid Research Project, Finland

C. Kelly, Department of Microbiology, University of Manitoba, Winnipeg, Manitoba, Canada

B. Lazerte, Limnology Section, Ontario Ministry of the Environment, Dorset, Ontario, Canada

J. Mannio, National Board of Waters and the Environment, Helsinki, Finland

J. O. Reuss, U.S. Forest Service, Fort Collins, Colorado

J. Rudd, Freshwater Institute, 501 University Crescent, Winnipeg, Manitoba, Canada

D. Schindler, Biological Sciences, University of Alberta, Edmonton, Alberta, Canada

H. U. Sverdrup, Lund Institute of Technology, Sweden

P. Warfvinge, Lund Institute of Technology, Sweden

P. J. Wigington, U.S. Environmental Protection Agency, Corvallis, Oregon

R. F. Wright, Norwegian Institute for Water Research, Oslo, Norway

APPENDIX C

LITERATURE ACQUIRED

Anonymous. 1989. Acidification in Scotland. Proceedings of a Symposium Organized by the Scottish Development Department, Edinburgh, United Kingdom.

International Conference on Acidic Deposition: Its Nature and Impacts, Glasgow, United Kingdom, September 16-21, 1990. Conference Abstracts. Royal Society of Edinburgh. 620 pp.

Kros, J., W. de Vries, P. H. M. Janssen, and C. I. Bak. The uncertainty in forecasting regional trends of forest soil acidification. Preprint.

Sverdrup, H., and P. Warfvinge. Calculating field weathering rates from soil mineralogy, texture, and temperature. Preprint.

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