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COVER SHEET
FOR TRIP REPORTS SUBMITTED TO THE OFFICE OF ENERGY RESEARCH

Destination(s) and Dates for Which Trip Report Being Submitted:

C. T. Garten, Glasgow, United Kingdom, 9/15-22/90
S. E. Lindberg, Glasgow, United Kingdom, 9/15-17/90
Amsterdam, The Netherlands, 9/18-19/90
Glasgow, United Kingdom, 9/20-22/90
H. Van Miegroet, Glasgow, United Kingdom, 9/14-27/90

Name of Traveler: C. T. Garten, S. E. Lindberg, and H. Van Miegroet

Joint Trip Report ☑ **Yes**
☐ **No**

Name of Other Traveler(s):

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ORNL

FOREIGN TRIP REPORT

ORNL/FTR-3787

DATE: October 24, 1990

SUBJECT: Report of Foreign Travel by Steven E. Lindberg (Senior Research Staff Member), Helga Van Miegroet (Research Associate), and Charles T. Garten, Jr. (Research Staff Member), Environmental Sciences Division

TO: Alvin W. Trivelpiece

FROM: S. E. Lindberg, C. T. Garten, Jr., and Helga Van Miegroet

PURPOSE: To attend the Fourth International Conference on Acidic Deposition and present several papers in the areas of atmospheric chemistry, throughfall methods, nitrogen cycling, and soil solution chemistry. In addition, one traveler (S. E. Lindberg) was invited to chair a conference session on throughfall experiments and to present a plenary lecture on Metal Cycling and Global Change at an environmental symposium in honor of the 110th Anniversary Celebration of the Free University of Amsterdam.

SITES VISITED:

9/16-21/90 (Garten, Van Miegroet)	Glasgow, United Kingdom	Fourth International Conference on Acidic Deposition	F. T. Last, Chairman, Scientific Committee
9/16-17/90 (Lindberg)	Glasgow, United Kingdom	Fourth International Conference on Acidic Deposition	F. T. Last
9/18-19/90 (Lindberg)	Amsterdam, The Netherlands	Environmental Symposium at the Free University	J. Rozema
9/20-21/90 (Lindberg)	Glasgow, United Kingdom	Fourth International Conference on Acidic Deposition	F. T. Last

ABSTRACT: The travelers presented several papers at the Fourth International Conference on Acidic Deposition. These covered the following topics: atmospheric chemistry and deposition of airborne nitrogen compounds, soil solution chemistry in high-elevation spruce forests, and forest throughfall measurements for estimating total sulfur deposition to ecosystems. In addition, S. E. Lindberg was invited (1) to organize and chair a conference session on Throughfall and Stemflow Experiments, and (2) to present an invited lecture on "Atmospheric Deposition and Canopy Interactions of Metals and Nitrogen in Forest Ecosystems: The Influence of Global Change" at the 110th Anniversary Celebration of the Free University of Amsterdam.

SUMMARY OF ACTIVITIES

The International Conference on Acidic Deposition was organized to provide a forum for exchange of data and ideas from the North American and European scientific communities relating to research on acidic precipitation and air pollution conducted over the past ten years. The conference was organized by nine major themes, and results were presented during parallel sessions in the form of invited plenary lectures, oral presentations, and poster sessions. These themes included (1) chemistry of atmospheric pollutants, (2) processes controlling the deposition of pollutants, (3) effects of pollutants on soil, (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 on materials and buildings.

Several important research projects were highlighted during the conference by multiple presentations. The Integrated Forest Study (IFS), which was designed and managed by scientists at Oak Ridge National Laboratory (ORNL) for the Electric Power Research Institute, was an important component of the conference. The IFS was highlighted in eight different presentations, posters, and plenary lectures by several of the participating researchers. These presentations covered a wide range of topics including atmospheric deposition, air/surface exchange, ozone effects, soil changes, and nutrient cycling. The U.S. Forest Service Spruce-Fir Cooperative Research Program, in which several scientists at ORNL have participated, also received high visibility. The program was represented by several oral and poster presentations that highlighted the physiological, soil chemical, and nutritional conditions of high-elevation forests in the eastern United States.

Among the more interesting topics covered at the conference were the issues of sulfur and nitrogen interactions with forest canopies, the sources of elements in throughfall, the processes influencing nitrogen saturation in forest soils, and critical loads of sulfur and nitrogen to

terrestrial and aquatic systems. With respect to the last topic, it was found that the behavior of sulfur in soils is fairly well understood and can be predicted with some degree of certainty, whereas the lack of predictability concerning nitrogen dynamics in forest soils makes critical load assessments extremely uncertain. Consequently, most critical load presentations focused primarily on the impact of atmospheric sulfur deposition. Numerous presentations documented various degrees of nitrogen saturation (i.e., incomplete retention of atmospheric nitrogen) in forest ecosystems and the effect of excess nitrogen on nutrient deficiencies and aluminum toxicity in trees, as well as the effect on drainage water quality.

It was interesting to note the strong emphasis on nitrogen in the "post-acid deposition" research in Europe, both through modeling efforts and field experimentation. The NITREX project, sponsored by the Commission of European Communities (CEC), stands prominently among those efforts. The program establishes a network of sites in Norway, Sweden, The Netherlands, Denmark, Germany, and the United Kingdom, spanning a gradient from low to high atmospheric nitrogen deposition. It aims at experimentally altering the nitrogen input to entire catchments and/or large forest stands to determine whether increased nitrogen deposition will lead to nitrogen saturation, the effect of nitrogen saturation on biogeochemical fluxes, and the extent to which this condition can be reversed under proposed lower nitrogen deposition scenarios. Some of the same sites and institutions are also cooperating under the CLIMEX program, which will focus on the ecosystem response (particularly plant-soil-water linkages and processes) to climate change.

Several papers at the conference sessions dealt with analysis of throughfall and its potential use in deposition studies. British scientists reported new results of ^{35}S studies originally performed at ORNL and recently repeated in Europe. Results were similar, with the authors concluding that labeled internal sulfur contributed a small percentage to the summer flux of sulfate in throughfall at the Devilla Forest in Scotland. This finding confirms that sulfate in throughfall is largely deposited from the atmosphere. The authors improved on the ORNL studies by adding the ^{35}S to the soil system but still felt that further improvements could be made and that the possibility of non-steady-state behavior of ^{35}S in forest systems must be considered in interpreting the data. Whole-catchment manipulation studies are planned in Sweden to study the behavior of applied ^{35}S in throughfall and stream export and to determine their utility in deposition estimates. Recent catchment studies indicated excellent agreement between long-term estimates of sulfate fluxes in throughfall and stream export. These studies indicate substantially higher deposition rates of sulfur to forests than do several deposition models, thereby creating considerable disagreement between the meteorological and modeling communities and researchers in biogeochemical cycling who have applied throughfall methods. Several different studies using a variety of methods (exclusion chambers, fumigations with SO_2 and NO_x, and plot and catchment manipulations with sulfate salts and elemental sulfur) all confirmed minimal internal leaching of foliar sulfur and the dominant role of deposition in throughfall sulfate. Results of studies on nitrogen compounds are still contradictory but suggest important foliar

uptake of some nitrogen compounds deposited to foliage (notably NH_4^+ and NO_2).

Three general observations from the technical presentations at this meeting included (1) a continuing debate between the British and the Americans regarding the validity of throughfall measurements for estimating total sulfur and nitrogen deposition to forest ecosystems, (2) the rising attention to research on nitrogen deposition and cycling in ecosystems and a declining attention to research on sulfur, and (3) the increasing use of stable isotopes (particularly nitrogen) to address questions related to the fate and cycling of pollutant nitrogen in ecosystems.

Research on sulfur deposition and cycling in ecosystems is presently being supplanted by research on nitrogen. The consensus of opinion at this meeting was that researchers know sulfur chemistry in the environment better than nitrogen chemistry. This lack of knowledge about nitrogen deposition was particularly evident in those technical presentations on "critical loads" of nitrogen to ecosystems. It was clear from policy statements delivered on the last day of this meeting that the governments of the United Kingdom and Sweden are investing considerable effort into the mapping of critical nitrogen loads in their countries for the purpose of setting regional emission standards. In this regard, Sweden has demonstrated an excellent integration of science and policy-making that would appear to serve as a model for much of the rest of Europe. However, there is considerable uncertainty in the scientific community about two parameters used to define critical loads: (1) how well we can quantify nitrogen deposition to terrestrial ecosystems and (2) the origin of nitrate leaching from ecosystems in groundwaters.

Many researchers are preparing for future studies with stable isotopes (^{15}N) to resolve uncertainties surrounding the critical load concept. For example, the NITREX project that is being sponsored by the CEC will employ ^{15}N studies to trace the fate of experimental nitrogen additions to forest stands. It is increasingly evident from the formal presentations and informal discussions at this meeting that studies with stable isotopes (particularly $^{15}N/^{14}N$) are becoming a routine part of the methods used by ecologists working on acidic deposition. However, one danger is that interpretations of these tracer experiments could be fraught with misinterpretation and debate because the nitrogen cycle is complicated by many pathways for nitrogen transformation, and the isotope fractionations that accompany such transformations are sometimes counterintuitive.

The Free University of Amsterdam is celebrating its 110th anniversary in October 1990. The celebration was highlighted by a one-day special symposium entitled "Environment, Policy, and Science" (see program in Appendix D). The theme of the symposium was the need for interdisciplinary research in order to understand environmental problems. The program consisted of six lectures on a range of "hot" issues in The Netherlands environmental community. These included the following: (1) a description of a new national study by scientists at the Free University on Environment, Policy, and Science by the Chairman of the Board of Regents of the Free University; (2) "Perspectives on Dutch Environmental

Policy," by the Dutch Minister of Environmental Affairs; (3) "Climate Change," by H. Lamb, East Anglia University and British Meteorological Office; (4) "Metal/Nitrogen Interactions in Forest Biogeochemical Cycles," by the traveler (S. E. Lindberg); (5) "Sea Level Change in Past and Future," by O. van de Plassche, Free University; and (6) "Management and Quality of Freshwater and Marine Coastal Ecosystems," by the Secretary-General of the Ministry of Public Works of The Netherlands. These presentations highlighted past, present, and future problems faced by northwestern Europe, and The Netherlands in particular, notably groundwater pollution with nitrate and metals, loss of wetlands, seawater intrusion, and forest damage.

SUMMARY EVALUATION AND RECOMMENDATIONS FOR FUTURE CONTACTS

All of the contacts made at the conference and during the lecture at the Free University were very useful for information exchange. The IFS project, which is directed by ORNL for the Electric Power Research Institute, was described in several presentations and generated considerable interest in methodology and data evaluation in deposition and nutrient cycling studies. The application of throughfall methods to deposition studies remains a controversial issue in Great Britain despite recognition of the utility of the method in the United States, Sweden, The Netherlands, and Germany. To continue critical evaluation of the methods, D. Fowler of the United Kingdom and S. E. Lindberg are planning a special session at the 1991 Conference on Air/Surface Exchange Processes on Comparisons of Throughfall and Modeling Data. Various discussions linked findings from research conducted at ORNL with those from high-deposition areas in Europe regarding the pivotal role of nitrogen dynamics on soil chemical processes, forest nutrition, and general forest health.

The European research community is putting increased focus on the role of nitrogen dynamics in forest ecosystems both from the standpoint of atmospheric deposition effects and critical loads and potential changes due to global climate changes. From the formal presentations and informal discussions at the conference, it has become clear that the critical loads issue cannot adequately be addressed without considering internal nitrogen source-sink relationships. Consequently, more effort (modeling and/or experimental) is needed in the area of soil nitrogen transformation processes, as well as an increased flow of information between the European and American research communities on appropriate methodologies to assess these processes. Efforts to that effect will be made by ORNL personnel.

The Dutch are experiencing significant problems due to deposition of metals and nitrogen compounds at rates significantly higher than any measured in ORNL studies. In addition, sea-level rise as a result of global climate change is a very serious concern. ORNL is urged to maintain contacts with researchers in The Netherlands as work continues on various aspects of global change and critical loads. S. E. Lindberg will continue to interact with students at the University of Utrecht, where he is currently on the Ph.D. committee of W. Ivens.

APPENDIX A

ITINERARY

Charles T. Garten, Jr.

9/15-16/90	Travel from Oak Ridge, Tennessee, to Glasgow, United Kingdom
9/16/90	Arrival in Glasgow, United Kingdom
9/16-21/90	International Conference on Acidic Deposition: Its Nature and Impacts
9/22/90	Travel from Glasgow, United Kingdom, to Oak Ridge, Tennessee

S. E. Lindberg

9/15-16/90	Travel from Oak Ridge, Tennessee, to Glasgow, United Kingdom
9/16/90	Arrival in Glasgow, United Kingdom
9/16-17/90	International Conference on Acidic Deposition: Its Nature and Impacts
9/18-19/90	Travel to Amsterdam, The Netherlands; lecture at the Free University, Amsterdam, The Netherlands; and return to Glasgow
9/20-21/90	International Conference on Acidic Deposition: Its Nature and Impacts
9/22/90	Travel from Glasgow, United Kingdom, to Oak Ridge, Tennessee

Helga Van Miegroet

9/14/90	Travel from Oak Ridge, Tennessee, to Raleigh, North Carolina
9/15-16/90	Travel from Raleigh, North Carolina, to Glasgow, United Kingdom
9/16/90	Arrival in Glasgow, United Kingdom
9/16-21/90	International Conference on Acidic Deposition: Its Nature and Impacts

9/22-23/90	Weekend
9/24-25/90	Vacation
9/26/90	Travel from Glasgow, United Kingdom, to Raleigh, North Carolina
9/27/90	Travel from Raleigh, North Carolina, to Knoxville, Tennessee

APPENDIX B

PERSONS CONTACTED TO A SIGNIFICANT EXTENT

G. Abrahamsen, Agricultural University of Norway, Department of Soil Sciences, Aas, Norway

J. N. Cape, Institute of Terrestrial Ecology, Edinburgh, United Kingdom

E. Cowling, North Carolina State University, Raleigh, North Carolina

E. Dambrine, INRA-CRF, France

W. Ernst and H. J. Rozema, Free University of Amsterdam, The Netherlands

D. Fowler, Institute of Terrestrial Ecology, Edinburgh, Scotland

J. Galloway, University of Virginia, Charlottesville, Virginia

D. Gatz, Illinois State Water Survey, Champaign, Illinois

G. Gobran, Swedish University of Agricultural Science, Uppsala, Sweden

L. Granat, University of Stockholm, Sweden

P. Grennfelt, Swedish Environmental Research Institute, Goteborg, Sweden

W. Ivens, University of Utrecht, The Netherlands

R. Jandl, Universitat fur Bodenkultur, Vienna, Austria

D. Johnson, Desert Research Institute, Reno, Nevada

K. Katzensteiner, Universitat fur Bodenkultur, Vienna, Austria

J. Kjonaas, Norwegian Forest Research Institute, Aas, Norway

G. Krause, State Agency for Pollution Control, Essen, Germany

D. Laflamme, Min. de l'Energie et des Resources, Quebec, Canada

G. Likens, New York Botanical Garden, New York

G. M. Lovett, Institute for Ecosystem Studies, The New York Botanical Garden, Millbrook, New York

R. Olson, Agricultural University of Norway, Department of Biotechnological Sciences, Aas, Norway

W. Robarge, North Carolina State University, Raleigh, North Carolina

D. A. Schaefer, Syracuse University, New York

C. L. Simmons, Natural Resource Ecology Laboratory, Colorado State University, Fort Collins, Colorado

A. Stuanes, Norwegian Forest Research Institute, Aas, Norway

G. E. Taylor, Jr., Desert Research Institute, Reno, Nevada

F. M. Thomas, Universitat Göttingen, Federal Republic of Germany

B. Tveite, Norwegian Forest Research Institute, Aas, Norway

APPENDIX C

PUBLICATIONS RECEIVED

Acid Deposition Register of Research in Scotland. 1989. Scottish Development Department, Environmental Protection Agency, Edinburgh.

Anderson, B. R. Phosphorus fluxes through a Norway spruce stand in Denmark. Poster summary.

Anonymous. 1989. Acidification in Scotland, Proceedings of a Symposium Held in Edinburgh, November 8, 1988. Scottish Development Department, Edinburgh, United Kingdom.

Beier, C., P. Gundersen, and K. Hansen. Spatial and seasonal variability of throughfall fluxes in a spruce stand. Poster summary.

Berggren, D. 1989. Speciation of aluminum, cadmium, copper, and lead in humic soil solutions: A comparison of the ion exchange column procedure and equilibrium dialysis. Int. J. Environ. Chem. 35: 1-15.

Clarke, N., L. G. Danielson, and A. Sparen. 1990. The determination of "free" aluminum in natural waters by kinetic discrimination in a flow system. Full text of poster presented at the International Conference on Acidic Deposition: Its Nature and Impacts.

Hansen, K. Concentration variations in rain and throughfall collected sequentially during individual events. Poster summary.

Hendriksen, A., L. Lien, and T. S. Traaen. 1990. Critical loads for surface waters: Chemical criteria for inputs of strong acids. Norwegian Institute for Water Research (NIVA) Report 22/1990.

Jacobson, J. S., L. Heller, F. Greenwood, J. Gold, and S. Aidid. Volatilization of nitric acid and removal of sulfate, nitrate, and hydrogen ions from acidic solutions by shoots of red spruce (Picea rubens Sarg.). Poster summary.

Kamari, J., M. Forsius, and M. Posch. 1990. Mapping critical loads for Finnish lakes by static methods. Summary of poster presented at the International Conference on Acidic Deposition: Its Nature and Impacts.

Kelly, C. A., J. W. M. Rudd, and D. W. Schindler. 1990. Acidification by nitric acid: Future considerations. Water Air Soil Pollut. 50: 49-61.

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

Lamb, H. 1990. Climatic changes: The development of knowledge, problems of assessing trends, causes, and human impact. Presented at 110th Anniversary Celebration of the Free University of Amsterdam.

NADP/NTN Ad Hoc Committee on New Initiatives. 1990. The Future Role of the NADP/NTN in Environmental Research. Position paper.

Olsen, A. R.,, E. C. Voldner, D. S. Bigelow, W. H. Chan, T. L. Clark, M. A. Lusis, P. K. Misra, and R. J. Vet. 1990. Unified wet deposition data summaries for North America: Data summary procedures and results for 1980-86. Atmos. Environ. 24: 661-672.

Rasmussen, L., C. Beier, P. de Visser, N. van Breemen, K. Kreutzer, R. Schierl, E. Matzner, and E. P. Farrell. EXMAN: Experimental MANipulations of forest ecosystems in Europe. Poster summary.

Schmid, S., W. Koerdel, H. Kloeppel, and W. Klein. 1989. Differentiation of Al^{3+} and Al species in environmental samples by isotachophoresis. J. Chromatogr. 470: 289-297.

Simmons, C. L. Geographic patterns in precipitation chemistry in the USA in 1989: Results from the National Atmospheric Deposition Program/National Trends Network. Poster summary.

APPENDIX D

DEFINITIEF PROGRAMMA VAN HET SYMPOSIUM MILIEU BELEID EN WETENSCHAP

13.00
Opening van het symposium door Dr.Ir.A.W. de Jager, lid van het College van Bestuur van de Vrije Universiteit.

13.15
Officiële start van de studierichting ***milieuwetenschappen*** aan de Vrije Universiteit door minister J.G.M. Alders, ministerie van Volksgezondheid, Ruimtelijke Ordening en Milieubeheer. Daarop volgend een lezing over ***de perspectieven van het Milieubeleid.***

14.00
Lezing door Dr. S.E. Lindberg (Oak Ridge National Laboratory, Oak Ridge Tennessee, USA) over ***effekten van zware metaalverontreiniging op bos-ecosystemen.***

14.45
Pauze, met gelegenheid om presentatieborden van milieuonderzoek van de beide faculteiten te bekijken.

15.15
Lezing door Dr. H.H. Lamb (East Anglia University, England) over ***klimaatsverandering.***

16.00
Lezing door Dr. O. van de Plassche (Faculteit der Aardwetenschappen, Vrije Universiteit) over ***Zeespiegel-veranderingen in verleden en toekomst.***

16.45
Lezing door Dr. G.M. Janssen (Rijkswaterstaat, dienst getijdewateren) over ***het beleid van rijkswaterstaat inzake het kustmilieu en de kustwateren.***

17.30
Receptie !

END

DATE FILMED

11/21/90