Proceedings of the Royal Society of Edinburgh, **97B**, ix–xvii, *1991*

Foreword

This volume records the invited lectures given at *Acidic Deposition: its Nature and Impacts* an international conference arranged by the Royal Society of Edinburgh in association with CEP Consultants Ltd. It was held in Glasgow from 16 to 21 September 1990. It was the fourth conference in a loosely co-ordinated series that started in Columbus, Ohio, USA in 1975 (subsequent conferences have been held at intervals of five years):

1975 (12–15 May): Columbus, Ohio, U.S.A.
Acid Precipitation and the Forest Ecosystem
1980 (11–14 March): Sandefjord, Norway
Ecological Impact of Acid Precipitation
1985 (15–20 September): Muskoka, Ontario, Canada
International Symposium on Acidic Precipitation
1990 (16–21 September): Glasgow, Scotland, U.K.
Acidic Deposition: Its Nature and Impacts

Each of the conferences has had its own individuality, understandably allied to the constantly changing foci of scientific interest as research and public and scientific awareness have gained momentum. Their individuality has reflected the inherent attitudes of the organising committees in the different host countries where aptitudes and concern for reductionist and holistic research, but not objectivity, differ greatly.

At Columbus there were three keynote papers: one was given by Professor Svante Odén, one of the founding fathers of modern atmospheric pollution research who sadly died in the interval between the Muskoka and Glasgow conferences. Professor Odén, like Mr Lennart Granat, Dr Henning Rodhe and Professor Carl Olof Tamm who all participated in *Acidic Deposition*, was one of the group of experts intimately involved with the preparation of *Air pollution across national boundaries. The impact on the environment of sulfur in air and precipitation* — Sweden's case study for the United Nations Conference in Stockholm (1972) concerned with the Human Environment – a document of profound importance in the history of air pollution.

The keynote papers at Columbus were "The Acidity Problem — an Outline of Concepts", "Acid Precipitation — Effects on Forest and Fish" (a presentation of the Norwegian project) and "The more things change". In their own way each of these contributions set the stage for the years ahead. While those made by Professor Odén (an Outline of Concepts) and Dr Lars Overrein (The Norwegian project) have remained to the fore, less has been heard of Professor Earl Murphy's contribution ("The more things change"). In it he referred to a paper by Carey *et al.* (1972) describing pre-1970 reactions of officialdom to pollution episodes

> Budgetary fluctuations and crash sampling efforts in response to crises ... [produce] a vast avalanche of data in varying states of order and disarray. Taken together these data do not add up to a congruent body of information ...

Happily times have changed with the development of many substantial, well co-ordinated and integrated national and international programmes of pollution research whose progress has been charted in the Proceedings Volumes of the Sandefjord and Muskoka conferences.

At Columbus the contributed papers were arranged in four groups —"Atmospheric transport, chemistry and precipitation", "Acid precipitation and aquatic ecosystems", "Acid precipitation and forest soils" and "Acid precipitation and forest vegetation". By the Sandefjord conference, five years later, the volume of research results warranted 12 invited papers with the separation of atmospheric transport from the chemistry and deposition of acidic pollutants and the division of aquatic studies into separate sections dealing with water chemistry and the biology of aquatic biota. Within some of the sessions of contributed papers there were signs of the fruitfulness of co-ordinated national projects of which the SNSF project (Sur Nedbørs virkning på Skog og Fisk: Acid Precipitation Effects on Forest and Fish) in Norway was a prime example.

In contrast to the organisation of the two preceding conferences, the plenary sessions at Muskoka in 1985 were arranged to highlight the fields of interest of most concern in different parts of the northern hemisphere. Thus, in western N. America interest centred on pollution studies in remote areas and effects on peatlands and aquatic ecosystems whereas, in eastern N. America, effects of pollutants on forests were of greater concern. As indicated by Martin (1986) "the perception of a link between air pollution and forest health has changed from passive interest to grave concern", an assessment echoing the warnings given by Professor Bernard Ulrich at Sandefjord. In Nordic Europe effects on freshwater ecosystems tended to hold centre-stage, whereas in non-Nordic Europe (the home of the non-nords!) forest decline was hotly debated. But, throughout, there was a clear and ever-increasing awareness of interdependence; the need to understand source/receptor relationships, to consider the involvement of acidic gases (sulphur dioxide and oxides of nitrogen) at the same time as that of acid rain *sensu stricto*, to take cognisance of the indirect effects of pollutants on soil properties in addition to the direct effects of gases and *vice-versa* when assessing effects of pollutants on plant growth, to consider the effects of deposited pollutants on soils while studying the acidification of freshwaters and so on. With an awareness of the interplay between different components of terrestrial and freshwater ecosystems, and of potentially interacting influences of atmospheric pollutants, the concept of modelling was to prove of inestimable value. Were source/receptor relationships adequately understood? Had the key issues and processes really been identified? Did we have sufficient knowledge of the responses to atmospheric and deposited pollutants of cells, whole plants and animals, soil, freshwater and terrestrial and freshwater ecosystems? Was sufficient knowledge available to develop mechanistic models without invoking too many black boxes in which to hide our ignorance of detail?

To an extent this was the background when steps were taken to organise *Acidic Deposition: its Nature and Impacts*. But evidence was additionally appearing of (i) the reversibility of freshwater acidification where atmospheric loads of pollutants were decreasing, (ii) the increasing importance of nitrogen pollutants emanating from vehicles (oxides of nitrogen) and the intensive management of domestic animals (ammonia), (iii) the enhanced acidity of cloud (aerosol) droplets vis à vis raindrops (which are larger) and, perhaps most profoundly, (iv) the role of other stress factors,

for example, unseasonable frosts and droughts, on plant responses to pollutants. At the same time, it was known that a number of major national and international programmes of pollution research were to be terminated or reviewed in 1989/90, for instance:

DEFORPA (Dépérissement des forêts attribué a la pollution atmosphérique) in France.
HAPRO (Happamoitumistutkimusuprojekti: Acidification Research Programme) in Finland.
NAPAP (U.S. National Acid Precipitation Assessment Program)
PEF (Projekt Europäisches Forschungszentzum für Masshahmen zur Luftreinhaltung) in the Western part of Germany
SWAP (Surface Water Acidification Programme), involving scientists in Norway, Sweden and the U.K.

These programmes were concerned with topics that have become traditional to the series of international conferences, but should *Acidic Deposition* become involved with the renewed interest in (a) medical aspects of air pollution and (b) collaborative work on buildings and materials? In Europe the latter, like effects studies on terrestrial and freshwater studies, owes a great deal to the encouragement of the Directorate General for Science, Research and Development, Commission of the European Communities and the UNECE International Cooperative Programme on Effects of Air Pollution on Materials including Historical and Cultural Monuments.

To arrange *Acidic Deposition: its Nature and Impacts*, for which HRH the Duke of Edinburgh graciously agreed to be Patron, two Committees were appointed — the Steering Committee (Appendix A), chaired by Professor George Holmes and concerned with overall development, and the Scientific Committee (Appendix B) chaired by Professor Fred Last. The latter committee was of two parts, the executive of 11 members, who were able to attend meetings in Scotland at fairly regular intervals, and the group of more than 70 corresponding members, drawn from 21 countries and international organisations, who had the opportunity to comment on plans as they evolved. At an early stage it was decided to have a series of plenary lectures and concurrent sessions related to nine fields of interest, one being allocated to each of nine executive members of the Scientific Committee. Before doing so it was agreed that "Effects of Pollutants, indoors and outdoors, on materials and buildings" should be included as a field of interest, more particularly because of the substantial and extensive programmes of investigation that had been established. While it was considered that medical investigators might gain from sessions concerned with (a) the chemistry of atmospheric pollutants (some of which are generated indoors) and (b) processes controlling the deposition of pollutants, it was decided not to include medical aspects, primarily because their inclusion might divert attention unduly from discussions of terrestrial and aquatic ecosystems. However, with increasing knowledge of the health effects of air pollutants it is likely that this topic could be an important feature of the next conference in the series, to be held in 1995.

The nine fields of interest (1,2,3...) were advertised along with a series of themes (1.1,1.2,1.3...) within each field of interest, and as a result of the response, including more than 600 offered contributions, the following programme of concurrent sessions

was adopted. (The names in parentheses refer to designated executive members of the Scientific Committee.)

1. *Chemistry of atmospheric pollutants* (Dr J. N. Cape)
   - 1.1 Pollution climates (joint with 9.1)
   - 1.2 Photochemical oxidants and precursors
   - 1.3 Cloud and fog chemistry (joint with 2.3)
   - 1.4 Cloud deposition (joint with 2.4)
   - 1.5 Pollutant transport and modelling (joint with 2.5)
   - 1.6 Throughfall and stemflow measurement
   - 1.7 Throughfall and stemflow experiments (joint with 2.7)
   - 1.8 Catchment budgets (joint with 2.8)

2. *Processes controlling the deposition of pollutants* (Dr D. Fowler)
   - 2.1 Ammonia deposition
   - 2.2 Dry deposition
   - 2.3 Cloud and fog chemistry (joint with 1.3)
   - 2.4 Cloud deposition
   - 2.5 Pollutant transport and modelling (joint with 1.5)
   - 2.6 Wet deposition processes
   - 2.7 Throughfall and stemflow experiments (joint with 1.7)
   - 2.8 Catchment budgets (joint with 1.8)

3. *Effects of pollutants on soils* (Professors H. G. Miller and M. Cresser)
   - 3.1 Soil acidification (× 2)
   - 3.2 Aluminium sources and mobilisation processes (joint with 7.3)
   - 3.3 Effects of pollutants on soil organisms (joint with 6.4)
   - 3.4 Critical loads (joint with 7.5)
   - 3.5 Retention of sulphate and nitrate in soils
   - 3.6 Acidification and soil processes (i) soil chemistry
   - 3.7 Acidification and soil processes (ii) flux of elements

4. *Physiology of plant responses to pollutants* (Professor T. A. Mansfield)
   - 4.1 Mechanisms controlling the fluxes of pollutants into plants
   - 4.2 Injury at the cellular level particularly to membrane based functions (× 2)
   - 4.3 Effects on photosynthesis, nitrogen metabolism and assimilate partitioning
   - 4.4 Physiological effects of disturbances in soil and atmosphere
   - 4.5 Detoxification processes
   - 4.6 Physiological changes during periods of stress and their effects on the nature of responses to pollutants (× 2)

5. *Effects of pollutants in agricultural and natural/semi natural ecosystems* (Dr T. M. Roberts)
   - 5.1 Effects of air pollutants on crop growth (× 2)
   - 5.2 Impacts on semi-natural ecosystems (× 3)
   - 5.3 Direct effects of pollutants on trees (joint with 6.6)
   - 5.4 Interactions between air pollutants and other factors (× 2) (joint with 6.8)

6. *Atmospheric pollutants and forests* (Dr P. H. Freer-Smith)
   - 6.1 Surveys of forest decline and regional studies

6.2 Symptomatology and diagnosis of forest decline
6.3 Techniques for measuring effects of pollutants on growth of young and mature trees
6.4 Effects of pollutants on soil organisms (joint with 3.3)
6.5 International and national forest research programmes
6.6 Direct effects of pollutants on trees (joint with 5.3)
6.7 Direct and indirect effects of pollutants (notably nitrogen) on tree nutrition and growth
6.8 Interactions between air pollutants and other factors (joint with 5.4)

7. *Effects of pollutants on the chemistry of freshwater streams and lakes* (Mr R. Harriman)
   7.1 Role of strong and weak acid anions in determining the extent of surface water acidification
   7.2 Acidity and trace metal mobility
   7.3 Aluminium sources and mobilisation processes (joint with 3.2)
   7.4 Influence of afforestation and deforestation on surface water acidification
   7.5 Critical loads (joint with 3.4)
   7.6 Long term changes in the chemistry of acidified waters: comparison of techniques and results
   7.7 Chemical and hydrological models: applicability and sensitivity (× 2)

8. *Effects of pollutants on freshwater plants and animals* (Mr B. Morrison)
   8.1 Physiological effects of acidity on aquatic animals
   8.2 Hydrochemical episodes and their effects on fish populations
   8.3 Effects of acidity on freshwater animal communities (× 3)
   8.4 Changes in water acidity and their influence on aquatic plants
   8.5 Amelioration of the acid freshwater environment (× 2)

9. *Effects of pollutants, indoors and outdoors, on materials and buildings* (Mr R. B. Wilson)
   9.1 Pollution climates (joint with 1.1)
   9.2 Urban pollution-climate and buildings (× 2)
   9.3 Effects of air pollutants on metals
   9.4 Effects of air pollutants on stone (× 2)
   9.5 Socio-economic aspects

During 1991, refereed contributions to many of the concurrent sessions will be published in special volumes of specialist journals

Field of Interest	*Specialist Journal*	*Title of Special Volume*
Chemistry of atmospheric pollutants Processes controlling the deposition of pollutants	*Environmental Pollution*	Physics and Chemistry of Acid Deposition
Effects of pollutants on soils	*Agriculture, Ecosystems and Environment*	Acidification of Soils
Effects of pollutants in agricultural and natural/semi-natural ecosystems	*Agriculture, Ecosystems and Environment*	Impacts of Air Pollutants on Crops

Physiology of plant responses to pollutants	*Agriculture, Ecosystems and Environment*	Physiology of Plant Responses to Pollutants
Atmospheric pollutants and forests	*Forest Ecology and Management*	Atmospheric Pollutants and Forests
Effects of pollutants on the chemistry of freshwater streams and lakes Effects of pollutants on freshwater plants and animals	*Environmental Pollution*	Freshwater Biology and Chemistry
Effects of pollutants, indoors and outdoors, on materials and building	*Atmospheric Environment (Part B) Urban Atmosphere*	Special issue

While it was decided that the specialist contributions to concurrent sessions should be published in specialist journals, it was agreed that the invited contributions, which were intended to be of wider appeal, should be produced in this volume (97B) of the *Proceedings of the Royal Society of Edinburgh, Section B (Biological Sciences)*. The 12 invited contributions include the introductory talk written by Dr Tom Brydges and Mr Bob Wilson.

Acid rain since 1985. Times are changing

By inviting Dr Tom Brydges of Canada, the organisers of *Acidic Deposition* aimed to ensure continuity with the 1985 conference in Muskoka where he was much involved: they were not disappointed. When approached, the plenary lecturers, chosen for their erudition and specialist knowledge, were given a free rein. They could attempt to produce either wide-ranging or relatively narrow presentations, with or without co-authors in the same or different countries, the choice of approach being based on their assessments of the needs of their subjects. In other words, this Proceedings Volume is not a compendium; instead it focusses on key issues in different facets of research related to atmospherically-dispersed pollutants, mostly derived directly or indirectly from the combustion of fossil fuels or smelting of sulphide ores — sulphur oxides and oxides of nitrogen, sulphuric and nitric acids with a significant involvement of ozone, also of ammonia, locally produced in considerable amounts during the intensive management of domestic animals.

During the conference, the different fields of interest were monitored by a system of rapporteurs which provided a series of technical résumés/critiques that were presented after Dr Tony Schneider of the Netherlands had opened the penultimate session of the conference devoted to an assessment of technical knowledge. The contents of this and the final session, concerned with policy, have been used as the basis of the thirteenth, and final, contribution to this volume. In the final session individuals, some holding official positions, from the U.K., Sweden, European Parliament, U.S.A., Canada and Czechoslovakia showed, without exception, how attitudes to atmospheric pollution have developed. These presentations demonstrated that it is no longer a matter of "should something be done?", but "how much and on what timescale?", recognising that the problem of sulphur and nitrogen pollution is likely to switch, in years to come, to the developing world and should not, in any circumstances, be divorced from that of climate change.

Acidic Deposition owed a great deal to a very large number of people and organisations, including Mr Walter Giles, Dr Hans Martin and Dr Floyd Elder, the organisers of the Muskoka conference in 1985, and the staff of CEP Consultants and the Royal Society of Edinburgh. On the day however, the success of the conference depended upon the participants themselves (the total of over 700 including a gratifying proportion of youngsters). The Steering and Scientific Committees wish to acknowledge the commitment of the plenary lecturers and chairmen, in particular Professor Eville Gorham, Dr Gene Likens and Professor Carl Olaf Tamm, who have been to the fore from the start of this series of conferences, also the chairmen and rapporteurs of concurrent sessions. But, without the support, moral and financial, of a generous group of sponsors the conference wouldn't have taken place. Their names are listed at the end of this Foreword. Accepting that it may be invidious, the organisers nonetheless would like to single out (a) the unswerving support of the City of Glasgow, the Scottish Office and the Department of Environment — it was an honour to welcome the Lord Chancellor, the Rt. Hon. Lord Mackay of Clashfern, the then Secretary of State for Scotland, the Rt. Hon. Malcolm Rifkind Q.C., M.P. and the Minister of State for Environment and Countryside David Trippier J.P., M.P. – (b) the willingness of the New Phytologist Trust, the Caledonian Research Foundation and the Royal Society of London to facilitate the participation of young research workers and (c) the spontaneous generosity, characteristic of colleagues in the U.S.A., notably the Electric Power Research Institute and the U.S. Department of Agriculture Forest Service.

The Steering and Scientific Committees wish their colleagues in Sweden every success with the next conference, tentatively fixed for 1995 and being planned with colleagues in Czechoslovakia. They trust that their endeavours will be strongly supported and rewarded.

References

Carey, G. W., Zobler, L., Greenberg, M. R. & Hordon, R. M. 1972. *Urbanization: water pollution and public policy, New Brunswick*. Centre for Urban Policy Research, Rutgers University, U.S.A.

Martin, H. C. 1986. Introduction. *Water, Air and Soil Pollution* **30,** 1–3.

Appendix A — Steering Committee

G. D. Holmes — Chairman
Formerly Director General, GB Forestry Commission
W. Duncan
Executive Secretary, Royal Society of Edinburgh
D. Hammerton
Director, Clyde River Purification Board, Glasgow
R. Hurley
Director, CEP Consultants Ltd, Edinburgh
C. Kemball
President, Royal Society of Edinburgh

F. T. Last
Department of Forestry and National Resources, Edinburgh University; Faculty of Agriculture, Newcastle University
F. W. Robertson
Programme Convenor, Royal Society of Edinburgh
W. D. P. Stewart
Secretary and Deputy Chairman, Agricultural and Food Research Council, Swindon (until 30.9.90)
C. D. Waterston
General Secretary, Royal Society of Edinburgh

Appendix B — Scientific Committee

F. T. Last — Chairman
J. N. Cape
Institute of Terrestrial Ecology, Edinburgh
D. Fowler
Institute of Terrestrial Ecology, Edinburgh
P. H. Freer-Smith
GB Forestry Commission
R. Harriman
Department of Agriculture and Fisheries for Scotland, Pitlochry
R. Hurley
Director, CEP Consultants Ltd, Edinburgh
T. A. Mansfield
University of Lancaster
H. G. Miller
University of Aberdeen
B. Morrison
Department of Agriculture and Fisheries for Scotland, Pitlochry
T. M. Roberts
Institute of Terrestrial Ecology, Monks Wood
R. B. Wilson
Department of the Environment, London

In addition, and very importantly, there were 70 corresponding members from 21 countries and international organisations.

Appendix C — Acknowledgements

The Royal Society of Edinburgh is grateful for support from the following organisations, without which the Conference would not have been possible.

- Agriculture and Food Research Council
- Babcock Energy
- Bank of Scotland
- British Gas plc (Scotland)
- Caledonian Research Foundation

- Coal Research Establishment of British Coal
- Department of the Environment
- Dulverton Trust
- Electric Power Research Institute, USA
- Glasgow District Council
- GB Forestry Commission
- National Power
- Natural Environment Research Council
- New Phytologist Trust (Tansley Fund)
- North of Scotland Hydro-Electric Board
- Orkney Island Council
- Royal Society of London
- Scottish Brewers Ltd
- Scottish Development Agency
- Scottish Office Environment Department
- Scottish Office Education Department
- Scottish Post Office Board
- Scottish Power
- Shell UK Ltd
- Strathclyde Regional Council
- United Distillers
- United Nations Development Programme
- United States Department of Agriculture Forest Service
- University of Glasgow
- University of Strathclyde