

ACID DEPOSITION and the ENVIRONMENT

**The Annual 'Grey Literature'
Environmental Reference Collection**

**Containing material up to
and including 1988**

**An agency, author and thematic
index, compiled by Jo Mullins**

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Environmental Reference Collection
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PUBLISHER'S NOTE

Research Publications have pleasure in launching a new Primary Social Series (PSS) microfiche series, focusing on environmental issues of immediate global concern. Part One, Acid Deposition And the Environment, deals with one such problem, the international awareness of which has spread significantly and encouragingly over the past decade. It is to be hoped that by making previously inaccessible information more readily available, this programme will help to augment people's knowledge of acid deposition, and to raise the profile of many organisations involved in work and research into this field of enquiry.

This is to be an annual collection. Updates will comprise all material issued by the participating organisations since the publication date of the previous edition, in addition to any material received too late to be included in the former filming schedule. Every attempt has been made to present a representative selection of those organisations working in this field. As such, this introductory package features a total of 35 groups, organisations and government organisations from 11 countries. Much of this information has previously been unavailable to both researchers and the general public. The publications are presented in a variety of formats, including reports, journals, leaflets and newsheets. Much of this material is retrospective, and this information combined with a wealth of current literature creates an indepth and wide-ranging picture of the acid deposition 'story'. Each new edition will feature updated findings as they become available. It is envisaged that many other organisations will be encouraged to include their publications in future issues.

As this is a publication of international coverage, a number of items are written in languages other than English. Publications in French, German, Polish, Swedish and Danish are also included.

For the convenience of the user, a bibliographical guide to Acid Deposition and the Environment accompanies the collection. The documents have been arranged, listed and filmed in a way which enables the user to locate any item very easily and quickly. The filming sequence is alphabetical by group name with corresponding publications arranged chronologically. Every item is numbered clearly in the top right hand corner of the front cover. Each organisation begins a fresh numerical sequence. The Guide

incorporates a series of helpful indexes and listings. A thematic index subdivides the groups into pertinent categories; and an author index provides a further mode of identification. The detailed listing of all material issued by each group identifies a particular item, the publication title, the date of issue and the number of the fiche on which the publications may be located. An alphabetical list of groups with brief biographical details is also included as a source of reference.

This collection seeks to close a major gap in the coverage of acid deposition documentation. It is the first reference scheme to make available on microfiche a body of information designed solely to illuminate this important environmental issue. It will be of interest to researchers and the general public alike.

Acknowledgements

Research Publications are grateful for the support of all groups, organisations and departments featured in the collection. A sincere and special thank you must go to the consultant editor, Dr. James Longhurst, Director of the Acid Rain Information Centre at Manchester Polytechnic. His expertise, unstinting assistance and unbounded enthusiasm have proved invaluable during the lengthy process of obtaining and assembling material into a comprehensive and informative package. Research Publications are indebted to Dr. Longhurst and his staff for the successful launch of this series.

ACKNOWLEDGEMENTS

The Editor gratefully acknowledges the assistance and encouragement of his colleagues at the Acid Rain Information Centre - Sue Green, David Lee, David Raper, Tim Jenkins and Bridget Heath - and Sharon Levy and Jo Mullins of Research Publications in the preparation of this collection.

HOW TO USE THE INDEX

The Guide to Acid Deposition and the Environment is arranged with a detailed index system, such that any item can be found quickly and easily.

The three main indexes are divided into an Agencies and Authors index, an Author index and a detailed Thematic index. This enables the reader to locate any author, the organisation for whom he or she has written and the topic under discussion.

The Agencies and Authors index is an alphabetical listing of each organisation participating in the collection, and all ascribing authors. The publications are arranged chronologically, and feature material up to and including June 1988.

The Author index lists alphabetically every author contributing to the collection. In many cases several authors contribute to a single item or article. When this occurs, items are listed under the first author in their entirety, but also under the secondary authors in abbreviated form. Thus, each author is listed both in his or her own right, and the items can easily be located by cross-reference, as shown below.

Longhurst, JWS; Lee, DS and Green, SE. Temporal and Spatial Variations of Acidic Deposition over Greater Manchester. A presentation of data from June 1986. Acid Rain Information Centre. September 1986, 32pp. Item 2. (Card 4)

Lee, DS. Temporal and Spatial Variations of Acidic Deposition over Greater Manchester. A presentation of data from 1986. See Longhurst, JWS.

Green, SE. Temporal and Spatial Variation over Greater Manchester. See Longhurst, JWS.

The Thematic index aims to give a detailed breakdown of the most important themes in Acid Deposition and the Environment.

The index is divided into five main areas: General Works; Emission, Transport and Deposition Processes; Environmental Effects; Social, Economic and Political Aspects and Control and Mitigation Measures. The latter two categories contain much material and are therefore further divided into sub-sections.

In many instances, a degree of overlap occurs, whereby items cover more than one thematic area. The items are then included in all relevant sections. For instance, the Report by the Panel on Acidic Deposition in New Jersey appears in four of the five main thematic areas.

In each index, a card number appears against the entries. This indicates the microfiche on which the item can be found.

JM.

ACID DEPOSITION AND THE ENVIRONMENT

A MULTIDISCIPLINARY PRIMER

Edited by Dr James W S Longhurst

Director

Acid Rain Information Centre

Department of Environmental and Geographical Studies

Manchester Polytechnic

For my father Leonard James Longhurst DFC & Bar
1919 - 1987

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ACID DEPOSITION AND THE ENVIRONMENT
A MULTIDISCIPLINARY PRIMER

An Introduction to the Collection and Guide

The material presented in this collection is intended to meet the needs of students, researchers and others studying the complex subject of acid deposition and the environment.

It is first and foremost an introduction to the 'grey literature' on acid deposition, that large body of information which lies, for whatever reason, outside the domain of the scientific journals and mainstream book publishers. This literature covers a wide range of providers: local (eg State of New York, Ministère de l'Environnement, Quebec); national (eg Herausgegeben vom Bundesamt für Umweltschutz, Switzerland) and international (eg Nordic Council); encompassing publications of government (eg Norwegian Ministry of Environment); national agencies (eg Forestry Commission, GB); specialist research centres (eg Environmental and Energy Study Institute); commercial company publications (eg Davy McKee Ltd); and environmental pressure groups (eg Canadian Coalition on Acid Rain).

The collection is also a primer for researchers, students and teachers wishing to obtain a grounding in the subject or seeking to improve their understanding of the causes, processes and implications of environmental acidification. Individual workers will also find the collection useful in establishing first contact, or to expand their range of contacts, with practitioners in this multidisciplinary area.

As the first edition of an annual series of microfiche publications relating to acid deposition, this edition is in part a consolidation collection drawing together important 'grey literature' from the preceding decade.

Acid deposition knows no boundaries and likewise this collection is deliberately international in perspective. Materials from 35 organisations in 10 countries are included and reflecting this international perspective the collection is multilingual with publications in French, Swedish, German, Danish and English, although the latter

is the dominant language. Publications from Switzerland are included in both French and German and those from Quebec in French with some English translations.

The guide is arranged in five parts:

1. Introduction to Acid Deposition and the Environment.
2. Alphabetical listing of participating agencies including short biographical description
3. Alphabetical list of agencies with all authors ascribed to their agency
4. Alphabetical listing by author
5. Thematic listing in five subject areas

Thematic listing

Five subject areas comprise the thematic listing as follows:

- i General Works
- ii Emission, Transport and Deposition Processes
- iii Environmental Effects:
 - aquatic
 - terrestrial
 - human health
 - materials and cultural artefacts
 - effects monitoring
- iv Economic, Political and Social Aspects:
 - policy and regulation
 - education
 - pressure groups
- v Control and Mitigation Measures

Whilst a degree of overlap between categories exists, those materials categorised as General Works will include overview publications addressing more than one thematic area and material of a non specific nature.

Emissions, Transport and Deposition materials include emission data, meteorology, atmospheric chemistry, physics and transport, deposition processes, deposition monitoring, chemical analysis of deposition and modelling.

Environmental Effects - aquatic deals with materials on freshwater chemistry, biogeochemistry, aquatic flora and fauna; that headed terrestrial is concerned with soils, forests, crops, animals and acidified ecosystems; effects monitoring is concerned with surveys and inventories of damage.

Economic, Political and Social Aspects holds materials classified as laws and regulation, government policies and initiatives, educational initiatives and relating to the activities and publications of pressure groups.

The Control and Mitigation Measures section holds materials on emission reduction technologies, demand side management initiatives and chemical amelioration techniques such as liming.

AN INTRODUCTORY PERSPECTIVE

by

Dr James W S Longhurst

The purpose of this introduction is to provide a framework in which the essential elements of the phenomena of acid deposition can be understood and appreciated, particularly with respect to areas of uncertainty and doubt. A summary of this nature, in a subject as vast as this, crossing many traditional academic boundaries cannot hope to give full coverage to the many important contributions made by individuals and institutions, it can only touch the important issues and gloss over many valuable ideas contributions and arguments. This is regrettable but inevitable.

This introduction seeks to exemplify the issues raised by acid deposition through a review of the situation in the United Kingdom and its relationship with Norway and Sweden. Apologies are offered to non European readers for this Eurocentric perspective but the importance of this region to both history and the future of acid deposition cannot be overstated. North American readers will recognise shared experiences and parallel developments. The most significant similarity is the presence of a region of major atmospheric pollution upwind of a nation comprising in part of very sensitive geology such that the environment is predisposed to acidification.

An Introductory Perspective

With Particular Reference to the United Kingdom,

Norway and Sweden

The situation in the UK and the relationship between the UK and its European neighbours with regard to acid deposition exemplifies many of the important issues in an understanding of the cause, effect, and control of acidifying air pollutants.

The environmental implications of acid deposition and acidification are the subject of extensive international and national research programmes addressed at the local, regional and global sources and effects of sulphur dioxide, nitrogen oxides and hydrocarbons. The complete relationship between cause and effect is not yet fully understood as there are complicated interactions between pollutants, within soils and water leading to direct and indirect effects. However, the relationship between sulphur and nitrogen emissions and environmental change is understood well enough to enable local, national and supra-national control policies to be formulated. For example in the UK, the Government has authorised the Central Electricity Generating Board to retrofit flue gas desulphurisation equipment to 3 large power stations (DOE 1986b), to modify the boilers of the 12 largest power stations to reduce nitrogen oxide production (CEGB 1987) and to require such control technology to be installed on all new coal fired power stations, 2 of which have been announced, and a further 2 are expected for completion by the turn of the century (CEGB 1986).

Acid deposition is not a new environmental problem. It was first described and named in 1852 by R A Smith working in the city of Manchester (Smith 1852). At this time, sulphur was clearly the main pollutant and the effects of acid deposition were clearly an urban and near urban phenomenon. Environmental effects described and quantified by Smith included damage to building materials, metalwork and textiles. Vegetation effects were also described (Smith 1872). The southern Pennines of England received acid precipitation as a direct consequence of acid emissions in Manchester and other cities (Press et al 1983). The combination of dry and wet deposition of sulphur compounds profoundly affected the sphagnum moss communities, leading to species reduction, habitat change, moorland drying and subsequent erosion (Woodin et al 1987).

The distribution of pollutants from industrial and urban areas was generally no more than regional in scale although longer range transport of pollutants to Norway from the U.K. is considered to have occurred as early as 1881 (Brogger 1881). Regional acidification of south west Scotland, the English Lake District and the Southern Pennines is considered to have begun at the onset of the industrial revolution.

In the U.K. the Clean Air Act of 1956 significantly reduced urban sulphur pollution. The combination of the closure of small urban power stations, the improvement in combustion technology, changing energy use, industrial restructuring and the building of power stations remote from urban areas in the U.K., all contributed to an improved urban pollution situation.

The consequence, however, has been a spreading of acid emissions further afield by the U.K. through the use of tall chimney stacks at power stations, at a time when European sulphur and nitrogen emissions were starting to rise steeply. This is a pattern replicated in other industrial nations.

Sources of emission and pollutant distribution. The latest available European figures are for 1983. The U.K. emitted 3,690,000 tonnes of sulphur dioxide out of a total 44,889,000 tonnes (DOE 1987) some 44% of this sulphur is deposited in the U.K., 34% at sea and 22% abroad. By 1985 the U.K. SO₂ emission had fallen to 3,580,000 tonnes, of which 71% is estimated to arise from power stations, 15% from industrial sources, 6% from the domestic sector, 4% from refineries, 3% from the commercial sector and 1% from road transport (DOE 1986a).

Nitrogen oxide emissions are more difficult to quantify; the U.K. is estimated to have emitted 1,837,000 tonnes in 1985, 40% from road transport, 40% from power stations, 10% from other industrial sources and the remainder from a variety of sources (DOE 1986a), the estimates of European NO_x emissions is 17,977,000 tonnes. U.K. emissions of hydrocarbons are estimated at 2,059,000 tonnes, 48% from industrial processes, 26% from road transport and 20% from gas leakage (DOE 1986a).

Sulphur and nitrogen have clearly defined natural cycles but in the industrialised northern hemisphere, covering less than 10% of the earth's surface, more than 90% of sulphur in the atmosphere is of anthropogenic origin. Thus on the regional scale, man-made emissions dominate (Beilke 1982).

After emission the sulphur and nitrogen gases undergo chemical and physical processes of transport and conversion within the atmosphere, until they or their reaction products are removed. Removal is by two main routes, wet and dry deposition with occult deposition a third removal mechanism, particularly im-

portant in upland areas for the transfer of cloud/mist/fog water to vegetation and ground surfaces. Photochemically stimulated atmospheric reactions of nitrogen oxides and hydrocarbons are important for the production of ozone, itself important both in the reaction chemistry of sulphur dioxide and as a potentially phytotoxic pollutant.

Dry deposition predominates as a removal mechanism for gases closer to emission sources (300km of emission) (Beilke 1982). Wet deposition occurs after chemical transformation, dependent upon the presence and concentration of ozone, hydroxyl radicals and sunlight. The resulting acid products, sulphate, nitrate and hydrogen ions may reach the earths surface via wet deposition or dry deposition. The surfaces upon which wet and dry depositions fall are subject to chemical change as a consequence.

In 1984, the U.K. is estimated by the European Monitoring and Evaluation Programme (E.M.E.P.) to have deposited 644,000 tonnes of sulphur to other countries by these processes (Eliassen, 1987)). Approximately 10% of the sulphur deposited in southern Sweden has its origin in the U.K. (Eliassen, 1987). A further 28% of such deposition cannot be attributed to any one nation but it can be assumed that a percentage of this originates in the U.K., as well as from natural sources, other European nations and North America. In Norway and Sweden, 92% and 82% of sulphur deposition respectively is considered to be received from other countries (Eliassen, 1987).

E.M.E.P. has calculated the distribution of pH across Europe based upon data supplied by participating nations for the period 1978-1982 (NILU 1984). This indicates that the majority of the U.K. (excluding Northern Ireland, north west Scotland and south west Cornwall), southern Scandinavia, northern France, northern Austria, Switzerland and north eastern Europe are bound by the pH 4.5 isoline, the most acidic precipitation occurring in central Europe bound by the pH 4.1 isoline, encompassing northern Belgium, the Federal Republic of Germany, the D.D.R., eastern Czechoslovakia and Poland.

Natural unpolluted rainfall is considered to have a pH of 5.6, the pH of carbon dioxide dissolved in rainwater (RGAR 1983). Some workers consider that natural fluctuations in the sulphur cycle can depress the pH of rain to 5.0 (Charlson et al 1982).

Monitoring of acid deposition on a systematic regular basis only began in the U.K. at the beginning of 1986 (RGAR 1986). Data from the first years operation of the monitoring

networks, established by Warren Spring Laboratory on behalf of the DOE, is not yet available in full form, but that which confirms previous observations at a smaller number of monitoring stations (RGAR 1983, 1987). Namely that:-

- i) the concentration of H⁺ ion increases from west to east with a maximum between the Humber and the Wash
- ii) maximum concentrations of non marine sulphate, nitrate and ammonium occurred in the east, particularly south of the Wash
- iii) greatest deposition occurred in areas of highest rainfall, particularly parts of Highland Scotland, north Wales, Cumbria and the Pennines, where acid deposition is comparable to areas of southern Scandinavia
- iv) largest concentrations of non marine sulphate occur in low rainfall easterly air flows
- v) highest deposition occurs in high rainfall westerly air flow

The importance of reliable, quality assured monitoring data such as provided by the U.K. acid precipitation monitoring networks can not be over emphasised. It is vital in defining patterns and trends, in providing data for model validation and of course in providing data from which potential and actual environmental effects can be assessed. A great wealth of such data now exists and the Research Publications collection presents monitoring data from a number of nations, collected at the local, national and international level. These include: European Monitoring and Evaluation Program data from Denmark; National Atmospheric Deposition Program data from the U.S.A.; national monitoring in Switzerland; U.S. State and Canadian Province monitoring data from Wisconsin, New Jersey, Wyoming, Minnesota, and Quebec ; from Nordrhein - Westfalen in FRG and urban data from Greater Manchester, U.K.

Environmental Effects

Forestry. Trees have always been under stress; harsh climate, poor nutrition and pathogens have all taken their toll. However, since the 1970's an unprecedented decline of forest ecosystems has occurred in Central Europe. Species affected include silver fir, Norway spruce, beech, Scot's pine, larch and oak (Longhurst et al 1987). Symptoms of decline include growth reduction and growth alteration. Forest decline is particularly severe in coniferous trees in Switzerland, Netherlands, Czechoslovakia and the Federal Republic of Germany. In the latter more than 50% of the forest area is affected by the decline. Numerous hypotheses have been proposed to account for the decline. Most include air pollution as a predisposing and/or inciting factor for decline. Six main categories of explanation may be identified:

- i) classical SO₂ damage as seen in the U.K. pre 1956 (see for example Lines 1984, Farrar et al 1977)
- ii) Ozone/acid mists (see for example Krause et al 1986)
- iii) soil acidification (see for example Ulrich 1983)
- iv) excess nitrogen (see for example Nihlgard 1985)
- v) epidemics of pathogens (see for example Krause et al 1986)
- vi) stress (including elements of other hypotheses and climatic factors) (see for example Schutt and Cowling 1985).

As the decline has occurred over a wide area in many species at approximately the same time, it suggests a common link; air pollution, with a triggering factor of perhaps climate, either drought or sudden temperature decline. Debate continues as to whether the decline is 'top down' or 'bottom up', i.e. direct effects of acid air pollutants and ozone on trees or indirect effects through soil acidification.

Surveys of forest health conducted in the U.K. by the Forestry Commission do not reveal identical symptoms of damage to those seen in Central Europe (Binns et al 1985a, b). However, using uniform, internationally agreed survey methods, U.K. forests have more trees categorised as slightly and moderately damaged than in the Federal Republic of Germany.

Whilst the climate of the U.K. is maritime and thus experiences a different pollution climate to most of Europe some have suggested that a progressive decline in forest health is occurring in the U.K.. The Forestry Commission cautions against ascribing the decline in health of British trees to the effect of air pollution (Innes 1987). They contend that U.K. forests show no signs of decline that can

not be explained by other natural factors. They do, however, concede that air pollution is involved in the decline in the Federal Republic of Germany, taking the view that multiple stress from air pollutants predisposes trees to damage by other factors.

The status of forest health and the role of acidifying air pollutants is particularly assessed in materials presented for the Research Publications collection by forestry authorities and government agencies from France, Switzerland, Canada, the U.K. and Sweden.

Surface and Groundwater Acidification. The occurrence of freshwater acidification has been documented in, amongst others, Norway, Sweden, Canada, the U.S.A. and the U.K.. Documentary evidence of freshwater acidification in these countries is presented in this collection.

Water acidification arises from natural processes in soils, atmospheric deposition and land use practices, interacting in complex ways.

Factors influencing the chemical change to rainfall in a catchment include soil buffering capacity, alkalinity production, volume of run off, size of catchment and water transfer time (AWRG 1986). Storage of pollutants in snow packs also has a profound influence on water quality. The physical and chemical consequences of water acidification include:

- a) decreased calcium availability
- b) mobilisation of aluminium and heavy metals
- c) loss of base cations from soils
- d) low phosphate and selenium availability.

The relationship between acid deposition water acidification is thus complicated by the interaction of soils, geology, vegetation and land use. For example, reservoirs receiving drainage from Pennine peat moorlands, have elevated levels of acidity due to organic acids produced in the peat (Diamond et al 1987). In the U.K. uplands elevated levels of acidity are also thought to have arisen as a result of the cessation of the farming subsidy for lime, thus reducing the amount applied and consequently, calcium levels in watercourses (Crawshaw 1986). This particularly illustrates the cultural dimension to acidification.

Acid lakes and streams are usually found in catchments with poor thin soils and naturally acid bedrock, dominated by moorland or coniferous vegetation with variable hydrological characteristics (AWRG) 1986). Ecological effects are

documented for many water courses where damage arises from a changing acidity - alkalinity balance and speciation of toxic metals. In such areas, effects on plankton, invertebrates, benthic fauna, fish and aquatic plants have all been described and quantified where possible.

In areas of high sulphate deposition and low calcium content, surface waters are likely to be acid with high aluminium levels. Sulphate ions mobilise aluminium and other ions through the soil into watercourses. Acidity is fatal at different levels to different fish; at pH 4 no fish will be found. If aluminium concentrations are $100 \mu\text{g l}^{-1}$ and calcium levels $300 \mu\text{g l}^{-1}$, then pH 5 can be fatal to fish (AWRG 1986).

Acid pulses following snow melt and associated with elevated aluminium levels are particularly hazardous to fish.

The Norwegian Ministry of Environment, the US Fish and Wildlife Service, the UK Freshwater Biological Association, the Province of Quebec and the States of New Jersey, Wisconsin and Minnesota present data on regional and national freshwater acidification in this collection.

Agricultural crops Sulphur dioxide in laboratory experiments is toxic to crops at levels of $100 \mu\text{g m}^{-3}$ and in mixtures of pollutants at $50 \mu\text{g m}^{-3}$, levels of this nature can be found in eastern Europe and in the south east of the Federal Republic of Germany (Shell 1986). There is no evidence of direct effects of acid deposition on crops but indirect effects through soil acidification represents a potential risk. Whole plant harvesting reduces the input of nutrients and acid neutralising substance to the soil, with no countermeasures, such as liming and the application of fertilisers such as ammonium sulphate, soil acidification may result.

Some experimental work indicates that agricultural crops are affected by ozone concentrations of $100 \mu\text{g m}^{-3}$ causing growth reductions and yield losses. A combination of SO_2 , NO_x and ozone may affect net photosynthesis of crops and hence depress crop yields.

Agricultural implications of acid deposition are addressed in this collection by the material presented by NAPAP, and at the State level by New Jersey, Minnesota and Wisconsin.

Soil acidification

Soil susceptibility to acidification is related to natural acidity, soil particle size, soil depth, soil moisture, alkalinity production, bedrock geology and local terrain (Cresser and Edwards 1987).

Soil acidification can arise from either natural or anthropogenic activities either singularly or in combination. These include: land uses such as agriculture and forestry, natural processes such as microbial respiration, nitrification and decomposition processes and atmospheric desposition of acidifying materials.

Soil acidification decreases the reserves of exchangeable cations, liberates aluminium and heavy metals, disrupts soil decomposition processes, binds phosphate reducing its availability to plants and reduces the diversity of soil microorganisms. Atmospheric deposition also enriches the nitrogen store in soils leading to saturation. Some plants with low nitrogen requirements may be eliminated and for surviving plants other nutrients may become limiting factors in plant growth (Nihlgård 1985).

Materials and cultural property Buildings, materials and cultural property are subject to decay under the action of climatic factors. This is a natural process which acts even in the absence of human involvement.

Atmospheric pollutants and their transformation products affects materials in two ways (Kucera 1987):

- i. atmospheric corrosion, a direct effect mainly at the local level
- ii. corrosion in water/soil systems, an indirect effect experienced at the regional level

Atmospheric corrosion is mainly due to dry deposition of pollutants, particularly SO_2 , but also in combination with NO_x . A range of important technical materials and cultural and historical monuments are at risk such as sandstone, limestone, marble, metals such as zinc and steel, and painted surfaces (Kucera 1987).

Corrosion resulting from soil and water acidification is a threat to technical and economically valuable materials on a regional scale. Structures such as water pipes, cables and culverts are at risk from water and soil acidification. Water acidification represents a health risk due to increased corrosivity of water.

This collection presents a review of the situation in Denmark with regard to cultural artefacts undertaken by the Danish National Agency for Environmental Protection and the work of Kucera, cited above, in the proceedings of the Nordic Council's International Conference on Air Pollution.

Potential health effects A framework for the assessment of acid deposition health risks is provided by the statement of Goyer (1985) that acid deposition is an environmental phenomena not a toxic substance per se but that it can be the *raison d'etre* for increased human exposure to air pollutants and toxic metals. Thus health effects arising from acid deposition can be divided into direct effects of precursors (air pollutants) and indirect effects such as mobilisation of, and increased risk of exposure to, heavy metals in drinking water.

Direct effects have been extensively studied and reviewed by international and national organisations. Concentrations at which SO₂ and NO_x affect human health have been established and guidelines produced to ensure that such concentrations are not exceeded (WHO 1977, 1979). Direct effects occur through inhalation of acid gases and particles, individually or in combination. Indirect effects of acid deposition occur as a result of ingestion of contaminated foodstuffs or drinking water (WHO 1986). Mobilisation of heavy metals by acidified water increases the risk of exposure to contaminated food stuffs such as freshwater fish (WHO 1986)

Acidified waters that are untreated and used as a drinking water supply, eg a groundwater well, may corrode copper, lead and cadmium from plumbing systems. In parts of southern Sweden more than 50% of the drinking water supply comes from wells where 400,000 people and 650,000 recreation houses are dependent upon such sources of supply.

Within the Research Publications collection the proceedings from a workshop chaired by Goyer and organised by the US National Institute for Environmental Health Sciences and others are presented as are Environmental Health Criteria documents produced by the World Health Organisation.

Ecological Effects in the UK and Scandinavia. Selected examples drawn from the UK and Scandinavia are used to exemplify the ecological impacts associated with acid deposition and air pollution. Both have a historical dimension and effects can be ascribed to both nationally derived acidifying pollutants and to long range transport of pollutants.

Ecological effects of acidification in the UK. Field, laboratory and anecdotal evidence suggests that environmental effects of acid deposition may be present in the UK in both terrestrial and freshwater ecosystems. Such effects may be considered as historical where the cause has been past exposure to high concentrations of gaseous pollutants and recent where new effects are being recorded.

Historical damage by SO₂ has included a failure of tree plantings in the S. Pennines (Lines 1984), decline of lichen species in polluted urban areas (Hawksworth and Rose 1976) and the extinction of sphagnum moss species in moorlands of the southern Pennines (Woodin et al 1987). Such damage can be described as historical, occurring up to the implementation of the Clean Air Act of 1956.

Recent Woodin et al (1987) have suggested that the increasing deposition of nitrogen compounds onto the English southern Pennines has been responsible for the inability of transplanted sphagnum species to recolonise the moorlands where the moorlands have historically been exposed to both gaseous sulphur dioxide and rainwater solutions of sulphur oxidation products since the onset of the industrial revolution.

As urban SO₂ levels have fallen in response to pollution control initiatives, sulphur dioxide intolerant lichen species have begun to recolonise the cities. Anecdotal evidence suggests that acid tolerant species, rather than those common prior to the industrial revolution, are establishing themselves.

The impact and importance of acid deposition and precursor gases on the health of UK forest resources is an area of dispute between the Forestry Commission and the environmental groups who argue that the relatively large percentage of UK trees assessed as being damaged to one degree or another has parallels in the development of the forest decline syndrome in Central Europe.

Freshwater acidification has been recorded in geologically sensitive areas of the UK. The North West Water Authority (NWWA) has reported freshwater acidification in streams in the Lake District draining into ~~the rivers~~ Duddon and Esk fish deaths following 'acid surges' have been experienced (Diamond et al 1987, Crawshaw 1986). Impoverished fauna communities are present which have also been observed by the Freshwater Biological Association in tarns and other water courses (Sutcliffe 1983). The Welsh Water Authority has identified reductions in plant and animal species diversity in acid waters in Wales (Stoner et al 1984), and a decline in mayfly populations in acid streams in Scotland has been observed by Harriman and Morrison (1982).

A significant decline in fish stocks has been observed in geologically sensitive areas of the UK, such as Galloway in Scotland, where as many as 40 lochs may now be acidified and in danger of losing their fish stocks. The onset of acidification has been determined by sediment analysis to be the latter part of the 19th century, with the rate accelerating this century (Batterbee and Flower 1985). Salmon and trout stocks are also thought to have undergone a significant reduction in certain Welsh rivers as a result of freshwater acidity, elevated aluminium levels and depressed calcium levels (Gee and Stoner 1985).

Changes to fish populations and to general freshwater chemistry affects other parts of the aquatic food chains including amphibians, birds and plants, directly by changing habitat and indirectly by reduced food stuff availability. It has been suggested that dipper populations in Wales have declined due to the reduction in food stuff availability (Ormerod et al 1985).

Within this collection views on the ecological effects of acid deposition and air pollution in the UK are presented by the Forestry Commission, Northern Ireland Dept. of Agriculture, the Freshwater Biological Investigation Unit and the Freshwater Biological Association.

Ecological effects in Scandinavia - a brief summary (after Rosseland et al 1986 and Anderson 1986)

Aquatic effects The decline of fish populations due to acidic water in Norway started as early as the 1920's but the most rapid losses occurred during the decade 1960-1970 (Rosseland et al 1986). By 1978 the population of Atlantic salmon had disappeared from southern Norway (Rosseland et al 1986). In the same area more than half of the brown trout populations had disappeared by 1985. Fishery inventories conducted by local fish authorities show that lakes known to have fish populations in the late 1970's had experienced a 30% loss of brown trout and a 12% loss of perch between 1978 and 1983. Although initially based on interview survey data, this trend was subsequently confirmed by test fishing in lakes where there were good time series data on fish catches (Sevaldrud et al 1986) and this is despite a reduction in acid deposition falling in southern Norway.

Episodic fish kills due to rapid changes in water quality as a result of 'acid surges' have severely affected salmon rivers on the west coast of Norway. Most severely affected have been smolts of Atlantic salmon and spawning migrating salmon on returning to acidified home waters (Rosseland et al (1986).

A continuing and increasing acidification of lake waters is being experienced in both central Sweden and in high mountainous areas with fish and invertebrate populations affected. An increase in acidic deposition during the last decades has also been experienced in Finland which has led to acidification in the most sensitive freshwater systems.

Aquatic status. Southern Norway contains 33,000 km² of acidified freshwater systems which are unable to support a normal ecological community. It is estimated by the Norwegian Government that to restore water quality to lakes and rivers in this area, to that in which fish could survive, would cost 250,000,000 N.K. per annum (Delegation of Norway 1986). In Sweden, the National Environment Protection Board estimates that 18,000 lakes and 90,000 km of running water have pH values where damage to freshwater organisms can be expected. As much as 90% of this damage is attributed to the deposition of sulphur.

Terrestrial effects. Forest decline has been observed and surveys conducted in Norway and Sweden. No effects of forest decline were reported until 1980. Inventories of forest

health have been conducted in all of Sweden and parts of Norway, assessing needle loss, crown density and tree growth rates (Andersson 1986). Norway spruce is particularly affected, with needle loss increasing with tree age. In southern Sweden a decrease in crown density and tree growth has also been recorded. Needle loss does not only occur as a result of air pollution, it is a non specific signal of stress. It is unlikely that direct effects of sulphur dioxide could cause such needle loss but high episodic levels of ozone have been measured at a level that may lead to chronic injury (Andersson 1986). Increased soil acidity is reported from forests in southern Scandinavia with a possible cause being a combination of natural biogeochemical processes and acidic deposition. Mobilisation of aluminium and heavy metals from the soil, loss of basic cations and reduced availability of phosphorus are all consequences of soil acidification. Reduced phosphorus availability may become a limiting factor on forest growth (Andersson 1986). In southern Scandinavia air pollution stress and soil acidification stress are superimposed upon climatic and meteorological stress (Andersson 1986) thus providing both predisposing and inciting factors in forest decline.

Terrestrial status. In the 1986 Forest Damage Survey of Europe, conducted on behalf of the United Nations Economic Commission for Europe, 17.7% of the Swedish and 28.9% of the Norwegian coniferous trees are classified as having greater than 20% defoliation (needle loss). Up to 10% defoliation does not constitute forest damage in this survey.

Within this collection further evidence of the status of acidification in Scandinavia is presented by the Norwegian Ministry of Environment, including the final report of the S.N.S.F. project (Overrein et al 1980), Skoggsstyrelsen, the Norwegian Stop Acid Rain Campaign and the Swedish N.G.O. Secretariat on Acid Rain.

Acidification control programmes in Scandinavia The Norwegian Government aims by 1994 to have reduced national sulphur emissions by 50% based on 1980 levels, and Sweden 65% by 1995. However acid deposition in Scandinavia occurs primarily as a result of long range transport from Europe. Consequently, the action of national governments is severely constrained if operating alone. International agreement on emission reductions is recognised in Scandinavia as the only route by which acidification can be halted and then reversed. In particular through such bodies as the Nordic Council and the United Nations Economic Commission for Europe (UNECE), the latter being a particularly important forum offering the opportunity for significant international agreement on emission reductions. The UNECE Convention on Long Range Transboundary Air Pollution was adopted in 1979 and entered into force in 1983 as the first multilateral treaty to protect the atmospheric environment (UNECE 1987). Thirty two parties have ratified this convention which lays down principles and provides a framework for co-operation. Two protocols to the convention provide the instruments by which emission reductions can be achieved and base line monitoring carried out. These are:

- a) The protocol on the reduction of sulphur emissions or their transboundary fluxes by at least 30% adopted in Helsinki, July 1985
- b) The protocol on the long term financing of the co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe.

The 30% protocol has been ratified by 16 nations and entered into force in September 1987. This protocol, the so called '30% club', aims for a 30% reduction in 1980 S emissions by 1993 (UNECE 1987). Already 10 parties to the protocol have reduced emissions by 30%, 11 parties have announced a reduction of 50% and 4 parties 65% reductions. A protocol to control NO_x is under discussion and may be adopted by the end of the decade.

Such emission reductions are essentially political agreements relying upon social and economic acceptance of the reduction rather than the capacity of environmental systems to receive deposition. However this latter approach has been adopted by Scandinavian scientists working on behalf of the Nordic Council who have defined critical loads for deposition to sensitive ecosystems, such that deposition loads will not cause chemical change and long term effects to sensitive systems (Nilsson 1986). This concept has been translated into ecologically derived emission reductions, equal to 90% of European sulphur emissions and 75% of nitrogen emissions

(Elsworth and Ågren 1987). There is pressure from Scandinavia for these ecological target reductions to supplant the politically derived figures of the 30% protocol. This pressure will intensify as European environmental groups at a meeting at Lida, Stockholm in 1986, set a timescale of 1993 for the S and 1995 for N emissions reduction, based upon 1983 emissions (Elsworth and Agren 1987)

In the period whilst such international agreements are being implemented Sweden has developed an impressive range of counter measures to combat both the emission and effect of acid deposition. These actions include:

- i) reduction in sulphur emissions by 65% between 1980 and 1995
- ii) nitrogen dioxide emission reduction of 30% by 1995, including adoption of US '83 standard for emission from petrol engined vehicles
- iii) countermeasures against forest soil acidification
- iv) improved agricultural practices to reduce use of acidifying fertilisers and limit ammonia emissions
- v) improved research and monitoring programmes
- vi) reductions in hydrocarbon emissions
- vii) measures to reduce traffic growth
- viii) more liming of forests, soils, watercourses and groundwater supplies
- ix) measures to protect the cultural heritage

These actions will significantly reduce Sweden's own contributions to acidification but will not achieve the target set by the critical load calculations. This will require concerted international action.

Action in the UK to reduce acid precursor emissions. The UK has not signed the protocol to the UNECE convention calling for a 30% reduction in SO₂ emissions between 1980 and 1993, but acknowledges that acid deposition is an area of major international concern (DOE 1987). UK SO₂ emissions have been reduced by 40% from their peak emission of 1970 and the government aim to ensure a reduction of 30% of the 1980 figure by the end of the century. However, the most recent emissions figures for the UK (1986) indicate that thanks to

a reviving economy and a strong and growing demand for electricity the national sulphur dioxide emission has risen by 200,000 tonnes on 1985 levels.

To achieve the governments stated intention of a 30% reduction by 1999 two measures were announced in September 1986:

- i. the retrofitting of three 2000MW coal fired power stations with flue gas desulphurisation (FGD) equipment over the next ten years
- ii. a future policy of equipping new coal fired power stations with FGD.

In May 1987, the government authorised the Central Electricity Generating Board to begin a 10 year programme to reduce NOx emissions at the 12 largest power stations through the use of low NOx burners.

Together these measures will significantly reduce sulphur and nitrogen emissions from coal fired stations, and should achieve the government's aim of a 30% reduction by 1999, based on 1980 figures.

The European Community (EC), also affects the UK in respect of emission policies, for both large combustion plant and motor vehicles.

Broad agreement on a framework for new vehicle emission standards for the EC, as a whole has been reached. This will involve both the use of catalysts to reduce emissions from vehicles and encourage the development of fuel efficient lean burn engines. However, pressure from certain EC members for still tougher standards will be maintained.

An EC proposal for a Council Directive on the limitations of emissions of pollutants into the air from large combustion plant (COM [83] 704 Final) called for a reduction of 60% in SO₂ emissions from large plant (i.e. greater than 50MW) and a 40% reduction in NOx emission. The base year again being 1980 with the reduction to be achieved by 1995. After much dispute agreement has finally been reached on this draft directive which sets a longer time scale for implementation than first suggested and introduces phased reduction levels. For the UK this translates as fixed reductions on 1980 sulphur dioxide emission levels to 1993, 1998 reaching an emission 60% down on the 1980 figure by 2003. To achieve this target would require FGD to be fitted to perhaps a further 3 or 4 fossil fueled power stations.

In common with most western nations the UK mounts a major research programme aimed at improving knowledge of the fundamental chemistry of acid deposition, the distribution and transport of pollutants, their environmental effects and control technologies (Apling 1986). The purpose of the programme is to examine areas of continuing uncertainty and thus assist in the refinement and development of our understanding of the ways in which acidification occurs. However there is clear acknowledgement of the overwhelming role of sulphur and nitrogen oxides in the cause of acidification in the implementation of a multi-million pound abatement programme in the United Kingdom.

Within this collection materials on abatement technology are presented by Davy McKee Ltd and the OECD. Environmental issues raised by the operation of FGD plants in the UK are described by material from the Acid Rain Information Centre.

Prognosis for the Future

Clearly much has been learnt in the intensive study of acid deposition since the 1971 Stockholm Conference on the Human Environment introduced the subject onto the political agenda of the world but much still remains to be scientifically demonstrated. Whilst some early guesses and perceptions mistated and only partially explained important concepts and processes quite obviously many of the first conclusions are still as valid today. Throughout the last 17 years new problems have emerged particularly the importance of nitrogen compounds, the role and importance of hydrocarbons and photochemical pollutants. Work has clarified the timescales of acidification and the importance of land use factors in explaining the occurrence of observed effects. Timescales are now clearly dated to the onset of industrialisation although rates of acidification are obviously related to periods of intense air pollution emission. Soil mediation in explaining environmental effects is now recognised, particularly pathways through soil in explaining the chemical status of freshwater bodies through mobilisation of aluminium and depression of calcium levels. Replacement of base cations to both soils and watercourses is recognised as a requirement if effects are to be ameliorated. Reversibility of acidification has become an important issue with original time estimates of decades now looking exaggerated as new evidence points towards much faster rates of recovery, to a point where normal freshwater life becomes tenable, once deposition loadings are reduced.

Even though the role of acidifying air pollutants in forest decline is far from clear with numerous hypotheses to explain its occurrence few now dispute the requirement to reduce emissions of acidifying air pollutants. The debate now concerns the rate at which emission reductions must take place and whether politically acceptable emission reduction targets are to be superseded by ecologically derived targets. As this debate continues and agreements are reached attention will begin to turn towards the legislative process as the means by which emission reduction agreements can be translated into reality. In the United States legal action has already been instigated by, amongst others, the States of New York, Minnesota and Wyoming in an attempt to protect sensitive environments. Materials presented in this collection by these States provide some guidance to the future development of legal controls on acid deposition.

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PARTICIPATING AGENCIES

ACID RAIN CO-ORDINATING COMMITTEE

Committee co-ordinating the initiatives of Wyoming in response to the problems of acid deposition.

Department of Environmental Quality
Herschler Building
122 W 25th Street,
Cheyenne,
Wyoming 82002
U.S.A.

ACID RAIN INFORMATION CENTRE

Research, education and information centre funded by Association of Greater Manchester Authorities and the UK Department of the Environment.

Department of Environmental and Geographical Studies
Manchester Polytechnic
Chester Street
Manchester
U.K.

AMIES DE LA TERRE

Friends of the Earth, France. Environmental pressure group campaigning to reduce the environmental impact of acid deposition.

15 Rue Gambey
75011
Paris
France

BOKSKOGEN OCH MILJÖFÖRBUNDET

Publisher (Bokskogen) and Environmental Federation in Sweden. Miljöförbundet is a member of the Swedish NGO Secretariat on Acid Rain.

BOKSKOGEN OCH MILJÖFORBUNDET (Continued)

Box 33031
S40033
Göteborg
Sweden

BUNDESAMT FÜR UMWELTSCHUTZ

(Incorporating L'Office Federal de la Protection de
l'Environment, Departement Federal de l'Interieur, Eidg.)
Dept. des Innern.

Swiss Federal Office of Environmental Protection
CH3003
Berne
Switzerland

CALIFORNIA AIR RESOURCES BOARD

Body responsible for the State of California Acid Deposition
Research and Monitoring program. A comprehensive program
investigating cause and effects of, and strategies to reduce
acid deposition in California.

1800-15th Street
Sacramento
California
U.S.A.

CANADIAN COALITION ON ACID RAIN

Established in 1980, the Canadian Coalition on Acid Rain is a
national coalition of 52 business, environmental, tourism
and public interest groups with a total membership of
approaching 2 million Canadians. The Coalition's objective is
a substantial reduction in the emission of sulphur and
nitrogen oxides in Canada and the United States.

1121 St Clair Avenue, West Suite 401
Toronto
Ontario M4V 2Y3
Canada

DAVY MCKEE (LONDON) LTD

Commercial company, manufacturing the Wellman Lord flue gas desulphurisation system and other air pollution control equipment.

250 Euston Road
London NW1 2PG
England.

DEPARTMENT FEDERAL DE L'INTERIEUR

(See Bundesamt für Umweltschutz)

DEPARTMENT OF AGRICULTURE, FRESHWATER BIOLOGICAL
INVESTIGATION UNIT

Statutory body responsible for all aspects of agriculture in Northern Ireland. Undertakes research into the chemical quality of precipitation and now operates one primary and three secondary monitoring sites on behalf of the UK acid precipitation monitoring networks.

Greenmount Road
Muckamore
Antrim
BT41 4PX
Northern Ireland

EIDG DEPARTEMENT DES INNERN

(See Bundesamt für Umweltschutz)

EIDG. FORSCHUNGSANSTALT FÜR AGRIKULTURCHEMIE UND
UMWELTHYGIENE/STATION FEDERALE DE RECHERCHES EN CHIMIE
AGRICOLE ET SUR L'HYGIENE DE L'ENVIRONNEMENT.

Federal research station for agricultural chemistry and environmental hygiene.

Schwarzenburgstrasse 155
CH-3097
Liebefeld
Bern
Switzerland

ENVIRONMENTAL AND ENERGY STUDY INSTITUTE

Institute studying the relationship of energy and the environment.

122 C Street, NW
Suite 700
Washington DC
20001
U.S.A.

FISH AND WILDLIFE SERVICE (U.S. Dept. of the Interior)

Fish and Wildlife service, Dept. of the Interior. Responsible for the wise use and management of fish and wildlife resources.

U.S. Department of the Interior
Office of Information
Aylesworth Hall
Fort Collins
Co. 80523,
U.S.A.

FORESTRY COMMISSION

Body responsible for the management of British forest health and assessment of any adverse effect of air pollution and acid rain.

Research Division
Alice Holt Lodge
Wrecclesham
Farnham,
Surrey
SU10 FLH
U.K.

FRESHWATER BIOLOGICAL ASSOCIATION

UK association for the study and promotion of research in freshwater biology.

Windermere Laboratory
The Ferry House
Far Sawrey
Ambleside
Cumbria
U.K.

PARTICIPATING AGENCIES

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LANDESANSTALT FÜR IMMISSIONSSCHUTZ DES LANDES NORDRHEIN-
WESTFALEN

Body responsible for pollution control in the state of
North Rhine Westphalia.

Wallneyer Strasse 6
D4300
Fissen 1
Federal Republic of Germany

MINISTÈRE DE L'ENVIRONNEMENT, FRANCE

Body responsible for the monitoring and assessment of air
pollutants and the implementation of counter measures
necessary to protect the environment.

Service de la Recherche des Etudes et du Traitement d'
Information sur l'Environnement
14 Bd du General le Clerc
92524 Neuilly-sur-Seine
Cedex
France

MINISTÈRE DE L'ENVIRONNEMENT, QUEBEC

Responsible for the assessment of emissions of air
pollutants, their effects and control within the province
of Québec.

Gouvernement Du Québec
Directrice Générale des Inventaires et de la Recherche
3900 Rue Marly
Sainte-Foy
Québec
Canada G1X 4E4

MINISTRY OF ENVIRONMENT, NORWAY

National Ministry of the Environment, concerned with the
causes, effects and counter measures to acidic deposition.

Box 80103
Dep. N-0030
Oslo 1
Norway

NATIONAL ACID PRECIPITATION ASSESSMENT PROGRAM

Federally supported 10 year research program established in 1980. Goals include assessment of precursor emissions, chemical transformation, deposition patterns, environmental effects and counter-measures.

722 Jackson Place, NW
Washington DC
20503
U.S.A.

NATIONAL AGENCY FOR ENVIRONMENTAL PROTECTION

National agency responsible for environmental protection in Denmark.

Air Pollution Laboratory
Risø National Laboratory
DK-400 Roskilde
Denmark

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM

Multi member program for the monitoring and assessment of atmospheric deposition in the U.S.A. Originally consisting of the Association of State Agricultural Experiment Stations, but now considerably extended and incorporating the National Trends Network.

National Resources Ecology Laboratory
Colorado State University
Fort Collins
CO 80523
U.S.A.

NATIONAL INSTITUTE FOR ENVIRONMENTAL HEALTH SCIENCES

Concerned with the health implications of acid deposition.

Research Triangle Park
North Carolina 27709
U.S.A.

PARTICIPATING AGENCIES

51

NOAH'S FORLAG

A Danish environmental pressure group, the publishing arm of which is Noah's Forlag (Press)

Klostergade 33
DK-8000 Aarhus C
Denmark

NORDIC COUNCIL

The Nordic Council is the official body for co-operation between parliaments and government in Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and the Åland Islands. It organises conferences, and publishes information on air pollution and acidification in member states.

Box 19506
S-104 32
Stockholm
Sweden

L'OFFICE FEDERAL DE LA PROTECTION

(See Bundesamt für Umweltschutz)

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Twenty four member organisation, promoting economic and social welfare throughout the OECD area.

2 Rue André-Pascal
75 775
Paris
CEDEX 16
France

PANEL ON ACID DEPOSITION IN NEW JERSEY

Expert panel appointed by Governor's Science Advisory Committee to report on acid deposition in New Jersey, with particular reference to water, wildlife, marine life, vegetation, property, recreation and agriculture.

PANEL ON ACID DEPOSITION IN NEW JERSEY (cont.)

Governor's Science Advisory Committee
Department of Environmental Protection
35 W Hanover Street
CN 230
Trenton
New Jersey 08625
U. S . A.

POLISH ECOLOGICAL CLUB

An independent pressure group operating in Poland

Malopaska Branch - Krakow
Rynek G1 27
Palac Pad Baranami
31 010 Krakow
Poland

SHELL INTERNATIONAL PETROLEUM CO. LTD

Shell is a major oil company, and its briefing service provides an industrial perspective on air pollution.

Briefing Service
Shell Mex House
Strand
London WC2R ODX
U. K.

SKOGSTYRELSEN

The Swedish National Board of Forestry

S- 551 83
Jönköping
Sweden

STATE OF MINNESOTA POLLUTION CONTROL AGENCY

Agency responsible for the Acid Precipitation Program in Minnesota. Required by State legislation, passed in 1982, to identify sensitive areas, set standards and establish a control plan to be complied with by 1990.

STATE OF MINNESOTA POLLUTION CONTROL AGENCY (cont.)

520 Layfayette Road
St Paul
Minnesota 55155
U.S.A.

STATE OF NEW YORK

Since 1980, the State of New York Department of Law has been forcefully advocating Federal acid rain controls in Congress, in the courts and in agency proceedings. The Attorney General has led a coalition of north eastern States in a series of legal actions designed to force the Environmental Protection Agency to reduce emissions of acidifying air pollution.

Department of Law
Albany NY 12224
New York
U.S.A.

STATE OF WISCONSIN, DEPARTMENT OF NATURAL RESOURCES

The Department of Natural Resources is responsible for the 10 year Wisconsin Acid Deposition Monitoring Program. The goals of this Program include quantification of the threat posed by acid rain to air, water, wildlife, and recreational resources, public health and welfare, and property in Wisconsin.

Acid Deposition Section
Box 7921
Madison
Wisconsin 53703
U.S.A.

STOP ACID RAIN CAMPAIGN

Campaign to provide information on the effects of acid rain and to press for the reduction of acidifying pollutants. Campaign organised by Nature and Youth, Norwegian Association of Anglers and Hunters, Norwegian Forestry Society, World Wildlife Fund - Norway, Norwegian Society for Conservation of Nature and the Norwegian Mountain Touring Association.

STOP ACID RAIN CAMPAIGN (cont.)

Det Norske Skogelskop
Wergelandsveien 23B
N-0167 Oslo 1
Norway

SWEDISH NGO SECRETARIAT ON ACID RAIN

Secretariat supported by the Environmental Federation, the Swedish Anglers National Association, the Swedish Society for the Conservation of Nature and the Swedish Youth Association for Environmental Studies and Conservation with the objective of reducing emissions of acidifying air pollutants.

Miljövard
Box 33031
S 400 33
Göteborg
Sweden

WORLD HEALTH ORGANISATION

UN agency with the objective of promoting the attainment by all peoples of the highest possible health standards.

Avenue Appia
1211 Geneva 27
Switzerland

ACID DEPOSITION AND THE ENVIRONMENT

The Annual 'Grey Literature'
Environmental Reference Collection

Containing material up to
and including 1988

An Agency, Author and
Thematic Index

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AGENCIES AND AUTHORS

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3. Longhurst, JWS; Lee, DS and Green, SE. Temporal and Spatial Variation of Acidic Deposition over Greater Manchester. A presentation of data from July 1986. November 1986, 33pp. (Cards 4-5)
4. Longhurst, JWS; Lee, DS and Green, SE. Temporal and Spatial Variation of Acidic Deposition over Greater Manchester. A presentation of data from August 1986. February 1987, 31pp. (Card 5)
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