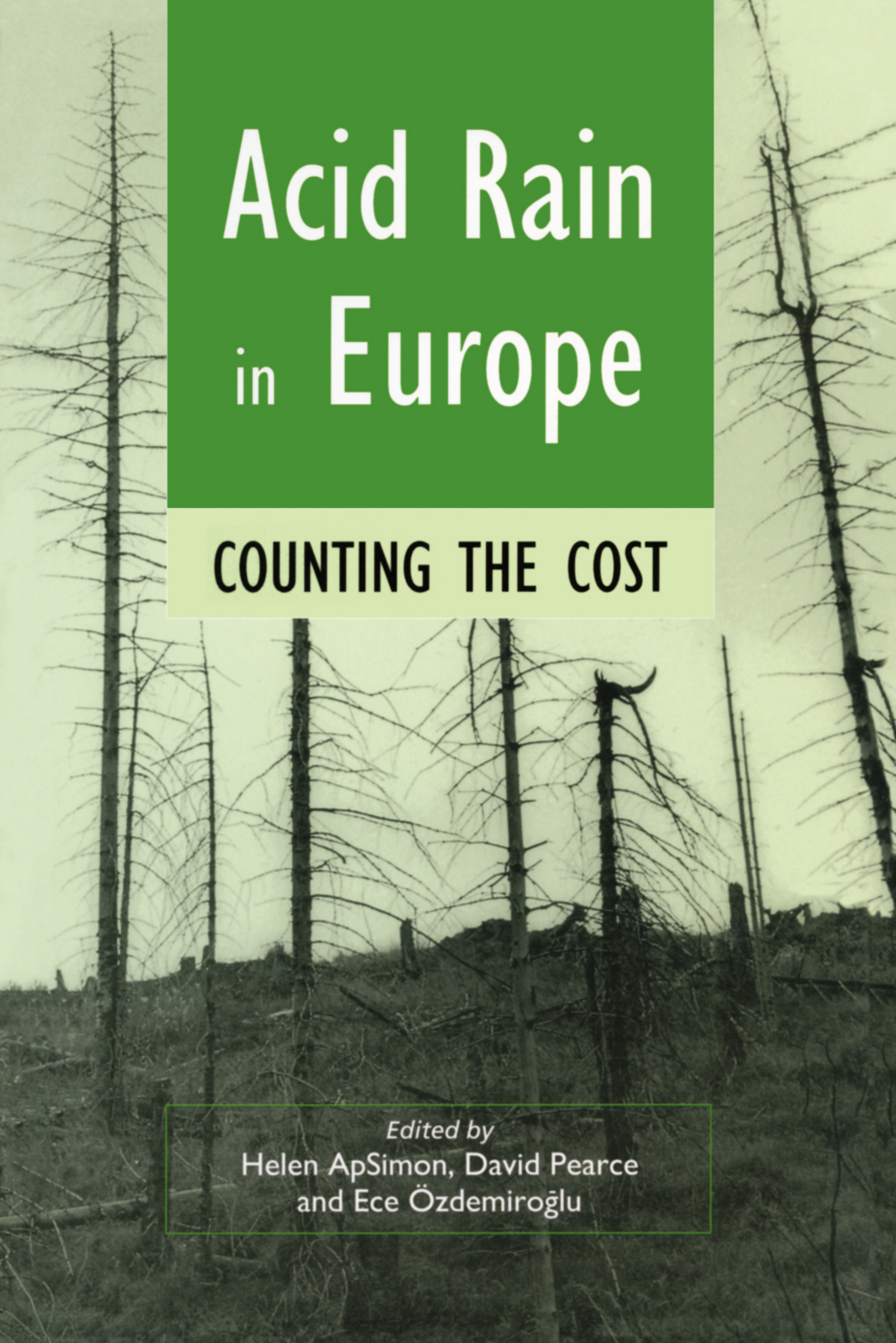

Acid Rain in Europe

COUNTING THE COST

Edited by
Helen ApSimon, David Pearce
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Acronyms and Abbreviations

ANC	Acid Neutralising Capacity
ASAM	Abatement Strategies Assessment Model
ATLAS	Aggregate Timberland Assessment System
BERG	Building Effects Review Group
BV	Bequest Value
CAP	Common Agricultural Policy
CASM	Coordinated Abatement Strategy Model
CEC	Cation Exchange Capacity
CEC	Commission of the European Community
CLRTAP	Convention on Long-Range Transboundary Air Pollution
COPD	Chronic Obstructive Pulmonary Disease
CORINAIR	Coordination of Information of Emissions into Air
CORINE	Coordination of Information of Emissions
CSERGE	Centre for Social and Economic Research on the Global Environment
CV	Contingent Valuation
DRF	Dose-Response Function
DUV	Direct Use Value
EDF	Economic Damage Function
EFTEC	Economics for the Environment Consultancy Ltd
EIFAC	European Inland Fisheries Advisory Commission
EMEP	Cooperative Programme for Monitoring and Evaluation of Long-Range Transboundary Air Pollution
EOTCP	European Open-Top Chamber Programme
ETS	Effective Temperature Sum
FEV	Forced Expiratory Volume
FGD	Flue Gas Desulphurization
FVC	Forced Vital Capacity
GHG	Greenhouse Gases
GNP	Gross National Product
HAZOP	Hazard and Operability Techniques
ICCET	Imperial College Centre for Environmental Technology
ICP	Integrated Crop Programme
ICPAMARL	International Cooperative Programme on Assessment and Monitoring of Acidification in Lakes and Rivers
IHD	Inflammatory Heart Disease
IIASA	International Institute for Applied Systems Analysis
ILWAS	Integrated Lake-Watershed Acidification Study
IPCC	Intergovernmental Panel on Climate Change

IPC/IM	International Cooperative Programme/Integrated Monitoring
IUV	Indirect Use Value
IVM	Institute of Environmental Studies
JNC	Just Noticeable Change
MAGIC	Model of Acidification of Groundwater in Catchments
MWTP	Marginal Willingness to Pay
MWTS	Marginal Willingness to Supply
NAPAP	National Acid Precipitation Assessment Panel
NCLAN	National Crop Loss Assessment Network
NOAA	National Oceanic and Atmospheric Administration
NOEL	No Observed Effect Levels
NUV	Non Use Value
OECD	Organisation for Economic Co-operation and Development
OR	Odds Ratio
OV	Option Value
PAN	Peroxy-Acetyl-Nitrate
PEC	Particulate Elemental Carbon
PM10	Particulate Matter (10μmdia)
PSD	Pine Stand Decline
QALY	Quality Adjusted Life Year
RAD	Restricted Activity Day
RAINS	Regional Air Pollution Information and Simulation
RCHM	Royal Commission on Historic Monuments
RIVM	Rijksinstituut voor Volksgezondheid en Milieuhygiene (National Institute of Public Health and Environment) (The Netherlands)
SAV	Submerged Aquatic Vegetation
SEI	Stockholm Environmental Institute
SMART	Simulation Model for Acidification's Regional Trends
SSP	Second Sulphur Protocol
SSSI	Site of Special Scientific Interest
TAMM	Timber Assessment Market Model
TCM	Travel Cost Model
TEV	Total Economic Value
TFIAM	Task Force on Integrated Assessment Modelling
TSP	Total Suspended Particulates
UN/ECE	United Nations Economic Commission for Europe
USEPA	United States Environmental Protection Agency
UV	Use Value
VOC	Volatile Organic Compound
VSL	Value of a Statistical Life
WHO	World Health Organization
WTA	Willingness to Accept
WTP	Willingness to Pay
XV	Existence Value

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August 1997

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FOREWORD

The phenomenon of acid rain remains high on the political and environmental agendas some decades after it was first implicated in Scandinavian water ecosystem damage and, allegedly, in forest damage. Action on the policy front has combined scientific, economic and modelling research in a unique way. Data on the long-range transport of the relevant pollutants have been generated. The concept of a critical load, ie the deposition of pollution below which no damage is done, has provided a benchmark for the assessment of damage. Control costs and cost-minimising models have been developed. One result has been the 1994 Second Sulphur Protocol which is perhaps unique among international agreements for its foundations in these 'integrated assessment' approaches to policy. But much remains to be done. Control costs based on available technologies such as flue gas desulphurisation certainly overstate the true costs of compliance. Other activities such as energy conservation and fuel switching are cheaper. Critical loads represent a major scientific breakthrough but they tell us little or nothing about the behaviour of pollution damage once the loads are exceeded. This book has its rationale in the requirement for further work and research. It focuses on what is known about acid rain damages and their economic costs. Understanding more about damages has to be an essential ingredient in the next stage of integrated assessment modelling.

David Pearce
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PART I

METHODOLOGY

1

Background to the Acid Rain Problem

The consequences of transboundary transport of acidifying pollutants from the increasing combustion of fossil fuels became apparent in Europe in the 1960s. Large numbers of lakes and streams in Scandinavia showed a marked change in pH, and rain was observed to be significantly more acid over large parts of Europe. Deterioration in the state of forests was also linked to exposure to acid substances and associated changes in soils, in addition to other causes such as drought and frost.

National and international concern led to the establishment of scientific research to investigate the causes of the observed changes and how they could be controlled and reversed. In particular this included the Cooperative Programme for Monitoring and Evaluation of Long-Range Transboundary Air Pollution (EMEP), initiated under the Organisation for Economic Co-operation and Development (OECD) and now an important part of the overall structure under the UN Economic Commission for Europe (UN/ECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP). At first the emphasis was on sulphur dioxide (SO_2) as the main pollutant causing damage, but subsequently the significant contribution from nitrogen species was also recognised; these include both oxides of nitrogen (NO_x), generated by the transport sector and stationary sources of combustion, and reduced nitrogen originating as ammonia (NH_3), mainly from agriculture.

In the 1970s models were developed at the Norwegian Meteorological Institute to simulate the transport of SO_2 and other acidic species across Europe, and the contributions of different countries to the overall pattern of deposition. This became the EMEP Centre West, with a sister EMEP Centre East established in Moscow with similar objectives, both covering the whole of Europe. Simultaneously a monitoring programme was established with a number of 'EMEP stations' making comparable measurements of the concentrations of the same range of species in air and precipitation.

The clear trends in acidification and increasing concern about the effects on fish and forests resulted in agreement on the need to reduce SO_2 emissions, and the First Sulphur Protocol. This was the so-called '30-per-cent club', whereby signatory countries agreed to reduce their emissions of

SO_2 by 30 per cent relative to their emissions in 1980 by the end of 1993. A further protocol was set up to stabilize emissions of NO_x, which were also increasing steadily, especially with the growth of road transport.

However these steps were insufficient to combat increasing acidification in sensitive areas. Further measures were necessary, and the process of developing new international agreements to reduce acidification began under the auspices of the UN/ECE. Scientific questions arose as to just how low deposition of acidifying species needed to be to avoid further acidification. Furthermore, since some areas of Europe are more sensitive than others and are suffering from acidification far more severely, it was important to place more emphasis on reducing emissions which led to deposition in these areas. It was clear therefore that a further uniform reduction in emissions across all European countries would not be the most effective strategy for the next protocol on sulphur emissions to replace the '30-per-cent club' after 1993, but that it would be important to reduce emissions more in some countries than in others.

THE SECOND SULPHUR PROTOCOL

The Second Sulphur Protocol was signed in June 1994, with a schedule of agreed emission reductions to be achieved at specified times between the years 2000 and 2010 (Table 1.1). The development of this protocol represents a major step forward in recognising scientific criteria for setting environmental standards, as represented by critical loads. Critical loads represent levels at, or below, which annual deposition is expected to have no adverse effects on natural ecosystems. They have been derived across Europe according to objective methods agreed by the UN/ECE Working Group on Effects, and though necessarily simplified, distinguish the relative sensitivity of different regions of Europe in terms of soils and surface waters.

To investigate cost-effective strategies for emission reductions a special Task Force on Integrated Assessment Modelling (TFIAM) was established, which assessed different scenarios for emission reduction. Integrated assessment models were used to combine data on emissions, atmospheric transport between source and receptor regions, critical loads or target loads as an intermediate step towards them, and abatement options and costs. The aim of such modelling studies was to derive tables of emission reductions for each country which provided cost-effective strategies for reducing acidification.

Because of the cost, it was not possible to reduce emissions sufficiently to attain critical loads. Hence the TFIAM investigated a large number of scenarios setting less stringent target loads. Eventually the one adopted as the basis for the protocol was the '60-per-cent gap-closure scenario' whereby deposition in excess of the critical loads is to be reduced by at least 60 per cent relative to 1990. Thus critical loads will still be exceeded in some areas after the new protocol is implemented. This raises questions about the environmental effects that will result, and to what degree loads will be reduced by the year 2010.