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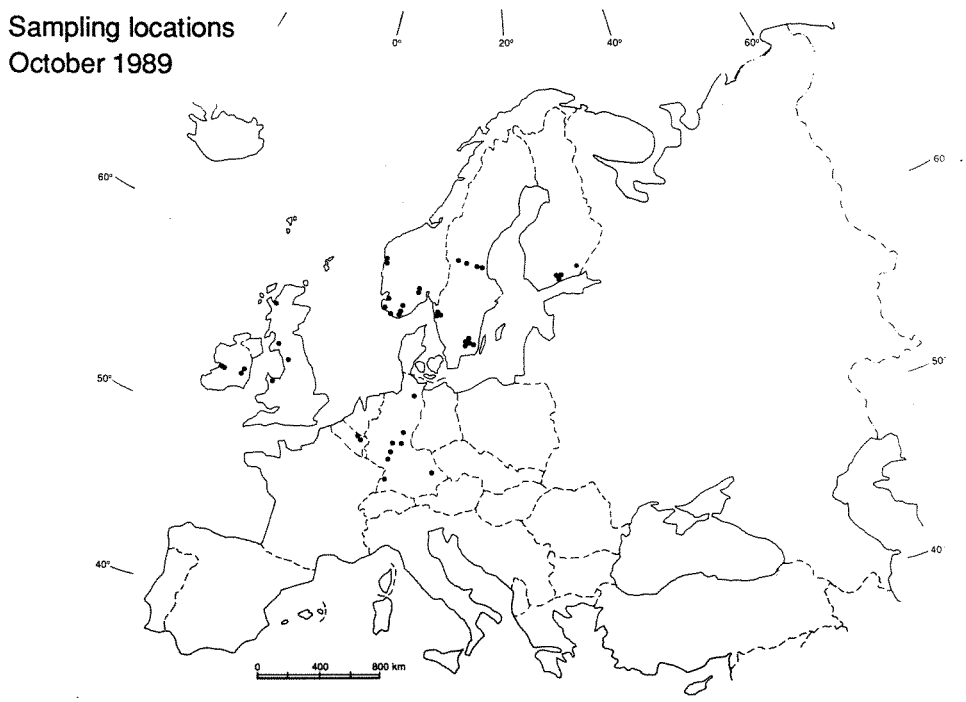
Acid Rain Research

REPORT 20/1990

Overview of areas sensitive to acidification: Europe



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Abstract:

We present here an overview of the geographical extent of areas in Europe sensitive to acidification due to acid deposition. Information on water sensitivity comes from a variety of detailed national maps of water chemistry, soil type and bedrock geology. The resulting sensitivity map serves as a basis for the choice of catchments in the International Co-operative Programme on Assessment and Monitoring of Acidification in Rivers and Lakes.

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OVERVIEW OF AREAS SENSITIVE TO ACIDIFICATION: EUROPE

United Nations Economic Commission for Europe (UN/ECE)

International Co-operative Programme for
Assessment and Monitoring of Acidification of Rivers and Lakes

March 1990

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CONTENTS

1. PREFACE

In 1986 the International Co-operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes was established under the auspices of the United Nations Economic Commission for Europe (UN/ECE). The Programme Centre is at the Norwegian Institute for Water Research (NIVA), Oslo. The primary objective of the programme is to define long-term trends and variations in the chemistry and biota of aquatic systems due to atmospheric pollution, focussing on acid deposition.

At the Fourth Meeting of the Programme Task Force, held 3-5 October 1988 in Helsinki, Finland, the Programme Centre agreed to prepare an overview of the geographical extent of areas in Europe sensitive to acidification due to acid deposition. A report in draft form was presented for discussion at the Fifth Task Force Meeting 17-19 October 1989 in Freiburg, BRD.

This report is a revised version of the draft report presented at the meeting. The revisions result from comments by the participants at the meeting and new national publications on the subject.

This report on sensitive areas in Europe was prepared at NIVA by Brit Lisa Skjelkvåle and Richard F. Wright. The work was supported in part by the Norwegian State Pollution Control Authority and the Norwegian Ministry of Environment. We thank Merte Johannessen for helpful discussions.

2. INTRODUCTION

The growing awareness of acid deposition and its effects on aquatic ecosystems has led to investigations of acidified

freshwaters and damage to fish and other aquatic organisms from an increasing number of areas in Europe. What was long viewed as a problem largely limited to Norway and Sweden has emerged as a phenomenon affecting nearly every country in Europe.

Two factors appear necessary and sufficient to explain the regional acidification of freshwaters: (1) acid deposition, and (2) sensitive water. Sensitive waters are those with low ionic strength and low buffer capacity.

In general poorly-buffered, low ionic strength waters are located in environments dominated by carbonate-free highly siliceous overburden and soils. Under such conditions rates of chemical weathering are low and concentrations of bicarbonate and base cations in surface and groundwaters are thus low. Such environments are found under three sets of circumstances (Wright 1983): (1) glaciated areas on granitic, gneissic or other highly-siliceous bedrock with thin and patchy overburden and soils derived from material of similar lithology, (2) areas with overburden of siliceous sands, and (3) areas with relatively old, highly-weathered and leached soils. In Europe all three types are present. Most of the thousands of lakes dotting the glaciated Precambrian Fenno-Scandian shield are of the first type. The lakes and shallow groundwaters in sandy areas of Denmark and the Netherlands are of the second category, and the streams in several upland areas of Germany are of the third category.

The state of acidification of a given lake or river depends on both the acid deposition and the inherent sensitivity. Acidic waters can be defined as those which have alkalinity < 0 (pH < 5.3); although in some waters adverse biological effects may begin to occur already at higher levels. Extremely sensitive waters will be acidic with relatively modest acid loadings, whereas less-sensitive waters will first be acidified when acid deposition is higher.

Maps of areas in which waters are sensitive to acid deposition are best prepared from extensive water chemistry data. Alkalinity maps or alternatively maps of non-marine base cations in surface waters can provide information of water sensitivity. In many regions, however, water chemistry data sufficient to prepare such maps are lacking. Thus information on bedrock geology and soil type are often used to estimate water sensitivity. There is a general correspondence between bedrock geology, soil type and surface water chemical composition.

Maps of sensitive waters have previously been prepared on a European scale (Wright, 1983, Merilheto et al., 1988, Posch et al., 1985) and at the national level for several European countries such as Norway (Wright and Henriksen, 1978, Henriksen et al., 1988), Sweden (Sverdrup and Warfinge, 1988), Finland (Kämäri, 1986), the Netherlands (Leuven et al., 1986), Federal Republic of Germany (Wieting, 1986), Ireland (Bowman, 1986) and the United Kingdom (Anon.,1986). These maps are based on geology and/or soils maps using various criteria for definition of sensitivity.

In this report we attempt to combine the detailed national maps into a map of water sensitivity for Europe. Further we show the location of the UN/ECE water monitoring stations with respect to the two factors sensitivity and acid deposition, and finally summarize the present state of water acidification as reported in Europe.

3. AREAS IN EUROPE SENSITIVE TO SURFACE WATER ACIDIFICATION

Our sensitivity map is based partly on detailed information on a national level. Information from bedrock geology and soil maps are used for those countries where no other information exists.

Several countries have prepared national maps of areas sensitive to surface water acidification, or such areas are described in the literature (Merilehto et al. 1988). Here we briefly summarize the information regarding areas sensitive to surface water acidification from each country in Europe.

Austria

According to Psenner et al.(1989), high altitude lakes in crystalline areas (North and East Tyrol) are sensitive to acid deposition. Most of Austria shows good buffering capacities and is not sensitive.

Belgium

According to Vangenechten (1983) the northern part of Belgium, known as the Campain region, has soil composed of mineral-poor siliceous sand. Small lakes in this area have low neutralizing capacity and are vulnerable to acid precipitation.

Czechoslovakia

Fott et al.(1987) reports sensitive lake areas in the Sumava Mountains, Giant Mountains and the high Tatra mountains.

Denmark

Softwater lakes constitute only a minor part of the total number of Danish lakes, as most of the soil in Denmark is derived from glacial moraine with a high content of calcium carbonate. There are certain areas with sandy soil poor in lime in parts of the Jutland peninsula. Lakes situated in this areas are slightly alkaline and vulnerable to acidification (Rebsdorf, 1983).

Finland

Finland is sensitive to effects of acid deposition due to the siliceous bedrock and thin, podsolic soils (Kenttämies, 1987). Kämäri (1986) has presented a map of Finland showing geographical areas in which surface waters are susceptible to acid deposition.

France

Clear evidence of surface water acidification in France is very recent. Only one lake in the Vosges massife is reported to be acid sensitive (Massabuau et al., 1987).

The Federal Republic of Germany

The location of acidified or acid sensitive surface water is strongly differentiated in the country as geology, soil properties and land utilization are extremely varied. Maps of areas which are potentially dangered by acidification are prepared based on soil and rock conditions and land use (Hamm et al., 1986). Wieting (1986) presents a map of areas potentially inclined to water acidification.

Hungary

Generally, the natural buffering capacity of surface water in Hungary is high, owing to high bicarbonate concentrations (Licskò and Zotter, 1985).

Iceland

No lakes are known to be affected by airborn acidification, and almost all lakes have a pH value of 7.0 or above (Merilehto et al., 1988). From this we conclude that Iceland is not sensitive to surface water acidification.

Ireland

A map of areas in Ireland sensitive to acid deposition is presented in Bowman (1986). This map is based on bedrock geology.

Italy

The studies carried out on the acidification of surface waters in Italy have at present primarily covered the subalpine lakes of northern Italy and high altitude alpine lakes. The western and central zones of the Italian Alps have geology characterized by crystalline rocks sensitive to acidification of surface waters (Mosello, 1984, 1986).

The Netherlands

Areas sensitive to surface water acidification are mainly situated in areas with soils poor in lime. Moorland pools are the most widespread acidified surface waters in the Netherlands and at least 1000 water bodies are sensitive including a number of dune pools. (Leuven et al., 1986). A map of acid sensitive areas in the Netherlands is given by Higler (1984).

Norway

Norway is particulary suceptible to inputs of acid precipitation. Areas sensitive to surface water acidification are presented in a map based on bedrock geology and water chemistry data from over 1000 lakes (Henriksen et al., 1988).

Poland

Many rivers streams and lakes in Poland are reported to contain large amounts of calcium and magnesium and have a low sensitivty to acidification. Lakes in Tatra, Sudety and Swietokrzyski Mountains show the highest sensitivity to acidification (Plaza, 1985).

Sweden

Much of Sweden is sensitive to acidification due to siliceous bedrock and soils (Monitor, 1986). The lake waters are generally of low ionic strength and low alkalinty. Of the total 85,000 lakes in Sweden, 35,000 are reported to be sensitive to acidification, and 5000 lakes acid (Monitor, 1986).

Switzerland

Acid and acid sensitive surface waters are reported only from the southern Alps in regions of granitic bedrock at high altitudes, generally above the timberline (Schnoor and Stumm 1985).

The United Kingdom of Great Britain and Northern Ireland

The full extent of acidified surface waters in the United Kingdom is not yet known. Highly acid waters have been reported in many areas of the UK. These are generally located in areas in which slow-weathering bedrock coincides with high acid deposition (Battarbee et al., 1988).

Yugoslavia

Acidification of lake and river waters is practically nonexistant due to the natural insensitivity of soils and water. Surface and groundwaters to have very large buffer capacities due to their high bicarbonate contents (Tuhtar, 1985).

For the countries Bulgaria, Byelorussian SSR, German

Democratic Republic, Greece, Holy See, Lichtenstein, Luxemburg, Portugal, Romania, San Marino, Spain, Turkey, Ukrainan SSR and USSR we have at the present time no detailed information regarding the sensitivity of waters to acidification or to the occurrence of water acidification. For some of these areas we have estimated sensitivity from bedrock geology maps (von Gaertner et al. 1972) and soil maps (FAO-UNESCO, 1974).

Bedrock geology: Areas with granitic or other highly-siliceous bedrock with overburden and soils derived from material of similarlithology gives poorly-bufferd, low ionic strength softwaters highly sensitive to acidification. From the International Geological Map of Europe (von Gaertner et al. 1972) (scale 1:5,000,000) we have picked out areas with Precambrian gneisses and acid granitic intrusions and defined them as areas highly sensitive to surface water acidification. In glaciated regions and areas with thin soils, the location of sensitive freshwaters can generally be made on the basis of bedrock geology. This is the case for most of the Nordic countries, northwestern USSR and northern Great Britain as well as for mountainous areas elsewhere in Europe.

Soil type: The soil map of Europe (FAO-UNESCO, 1981) (scale 1:5,000,000) gives information on soil types in Europe with characteristic soil analyses. This makes it possible to classify the soil into two types; sensitive and non-sensitive.

The resulting map of areas in Europe sensitive to surface water acidification is shown in fig.1. As detailed information from other countries becomes available, this map must be revised.

4. PRESENT DAY ACID DEPOSITION SITUATION FOR EUROPE

The Chemical Co-ordinating Centre (CCC) of Co-Operative Programme for Monitoring and Evaluation of the Long Range Air Pollutants in Europe (EMEP), located at the Norwegian Institute for Air Research (NILU), reports chemistry of precipitation in Europe. The latest summary report from the third phase of EMEP (Schaug et al. 1987) shows the 1985 situation for pH in precipitation (fig.2). The EMEP Meteorological Synthesizing Centre-West (MSC-W) at the Norwegian Meteorological Institute models transport and deposition of sulphur and nitrogen based on emission data and meteorology (Iversen et al., 1989). The results of model runs for total deposition of sulphur and nitrogen from all sources for the year of 1985 is shown in fig. 3 and 4.

5. AREAS WITH DOCUMENTES SURFACE WATER ACIDIFICATION

The Finnish Ministry of the Environment and the National Board of Waters and the Environment carried out a survey of the present day extent of acidification in surface waters in the ECE region (Merilehto et al., 1988). The study is based mainly on two sources: (1.) the response to a questionaire sent to each Parties of the Convention about statistics of lakes and streams affected by acidification and 2. a literature review. The results of this study were presented at the Fourth Task Force Meeting of the International Co-operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes and published in Merilehto et al. (1988).

Acidification of surface waters has been reported in many parts of the world during recent years. In Europe, the southern parts of Finland, Norway and Sweden are well known to be affected. Investigations in Austria, Belgium, Canada, Czechoslovakia, Denmark, France, the German Democratic

Republic, the Federal Republic of Germany, Italy, the Netherlands, Poland, Switzerland, the Union of Soviet Socialist Republics, and the United Kingdom of Great Brtain and Northern Ireland suggests that these areas also have environmental problems due to surface water acidification.

In Iceland and Yugoslavia no lakes or streams show decline in pH or alkalinity. Fig. 5 shows the currant geographical extent of acidification in aquatic ecosystems in the countries of the ECE region (from Merilehto et al., 1988).

6. LOCATION OF CATCHMENTS IN THE INTERNATIONAL CO-OPERATIVE PROGRAMME FOR ASSESSMENT AND MONITORING OF ACIDIFICATION OF RIVERS AND LAKES

As of October 1989, 7 European countries have sent information on their monitoring catchment studies to the Program senter in Oslo. The location of the catchments are shown in fig.6. At the moment the database includes catchments of different buffering capacities situated in areas of different acid load, and with different degrees of acidification. As expected, acid and low buffered catchments are often found in the database.

7. RECOMMENDATIONS

The map of areas in Europe sensitive to surface water acidification is at the same level of detail for the various countries. For some countries we have information from detailed maps at the national level and for other countries we have used general information from geological maps and soil maps to indicate the grade of sensitivity. The map would be greatly improved if each country could provide a national sensitivity map using the same criteria. A detailed sensitivity map for Europe would improve the possibilities

to chose locations for new catchments so that the range of catchment types could be increased. A wide range in catchment types is of importance for the programme.

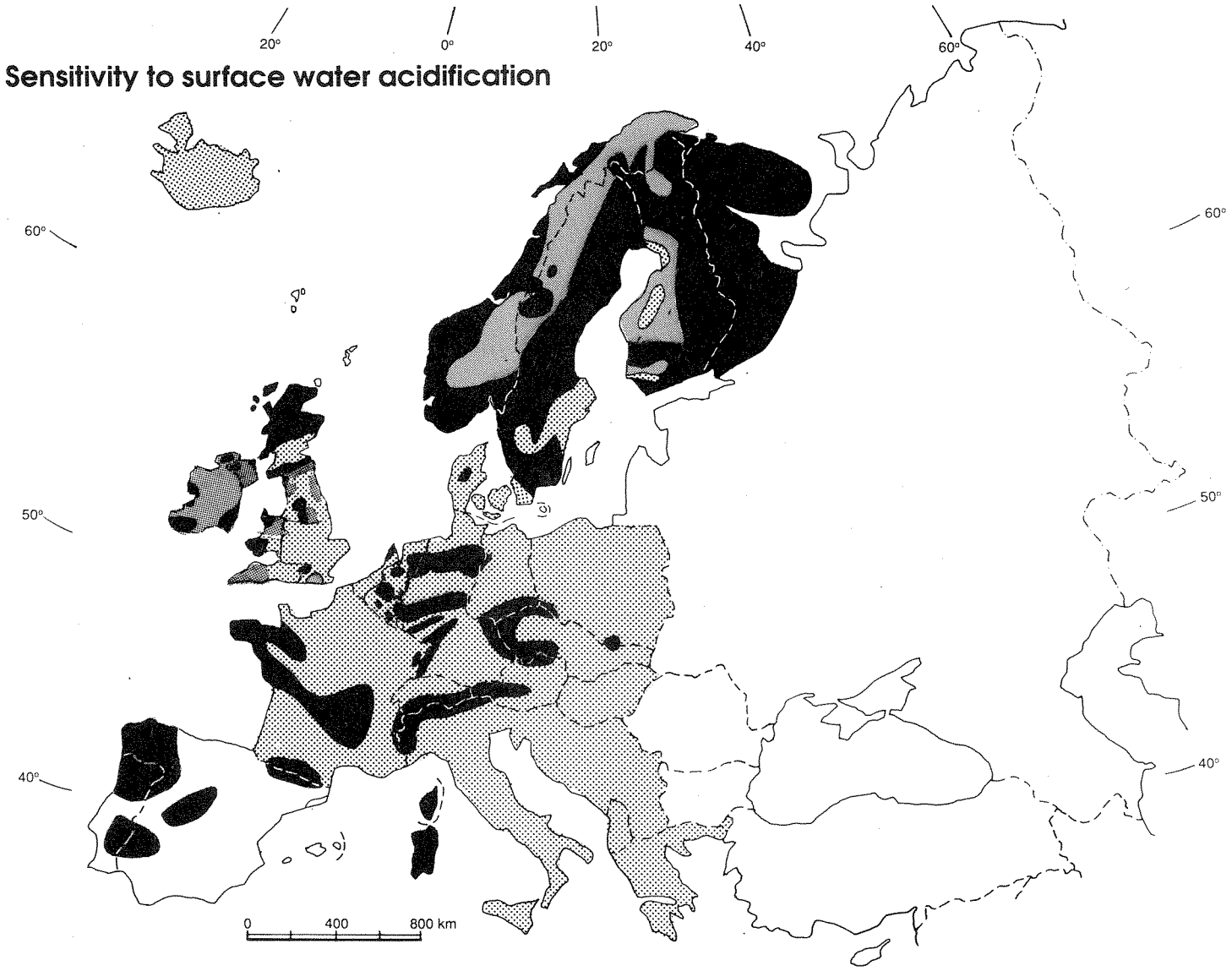

Figure 1.
Areas in Europe sensitive to surface water acidification.
Black : High sensitivty
Grey : Moderate sensitivity
Dotted: Low sensitivity
White : Areas with inadequate or no information about the sensitivity.

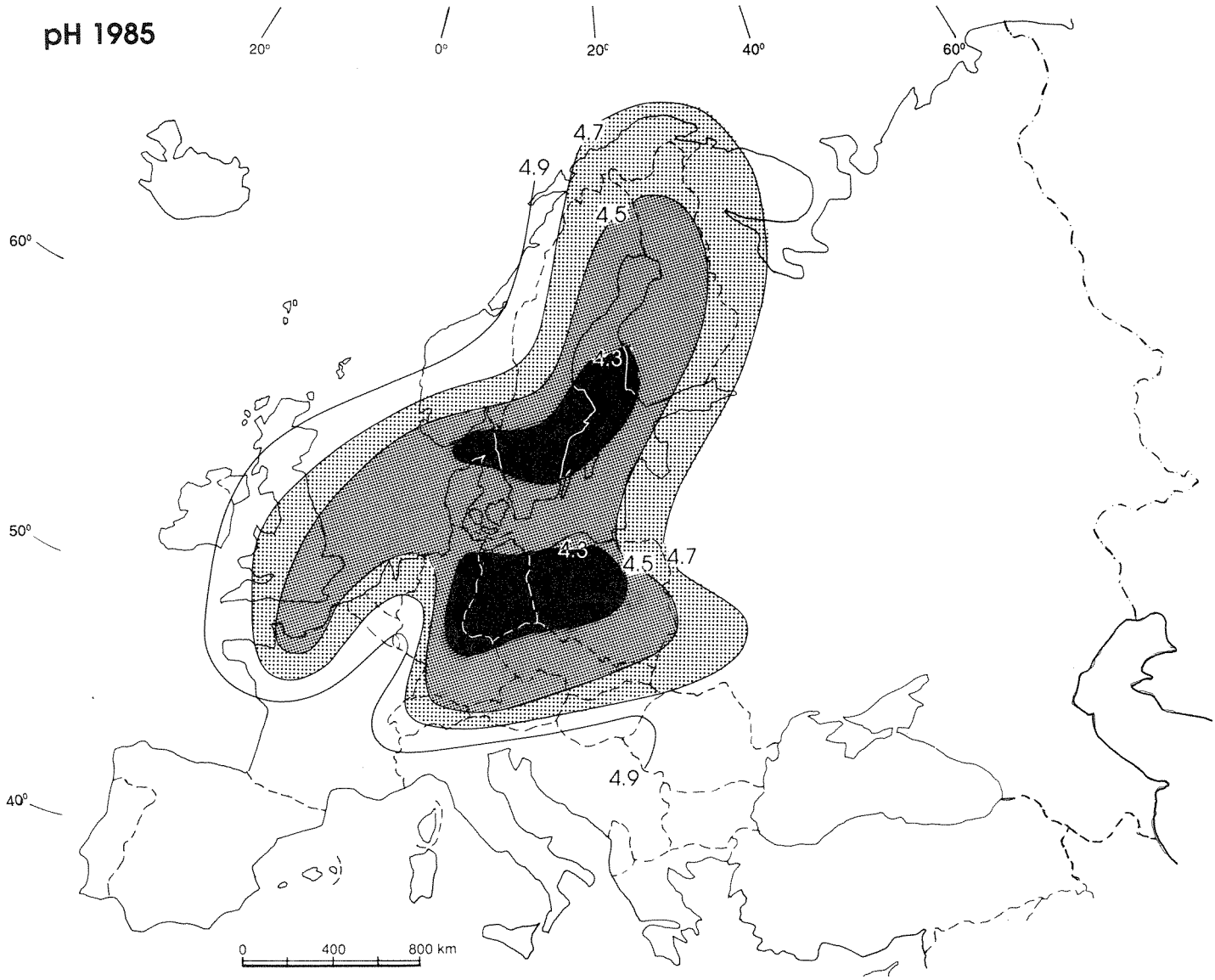

Figure 2.
1985 measured annual pH in precipitation (Schaug et al., 1987)

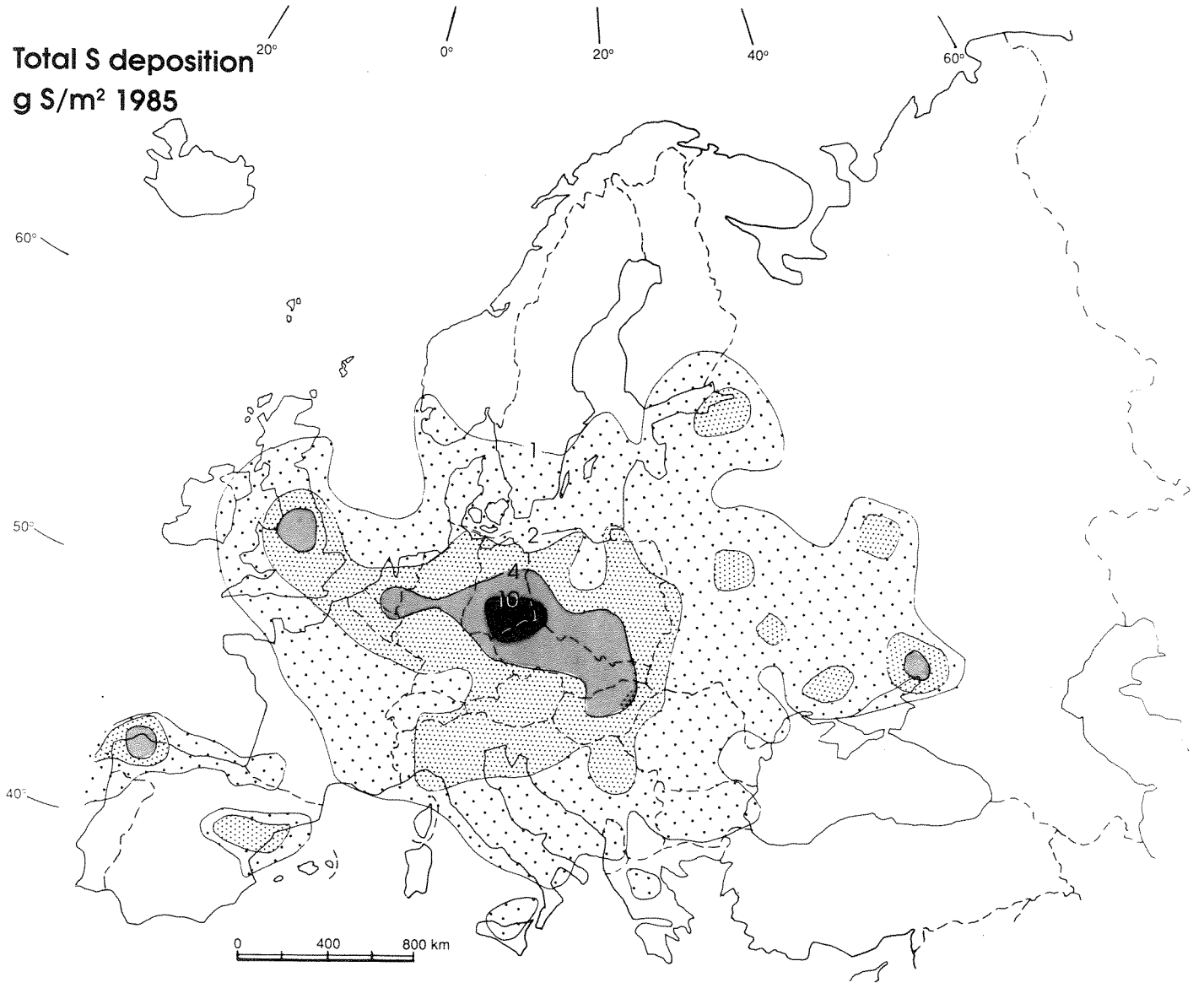

Figure 3.
Calculated 1985 annual total (wet and dry) deposition of sulphur from all sources. The results are from EMEP model runs based on emission data and meteorology (from Iversen et al.,1989).

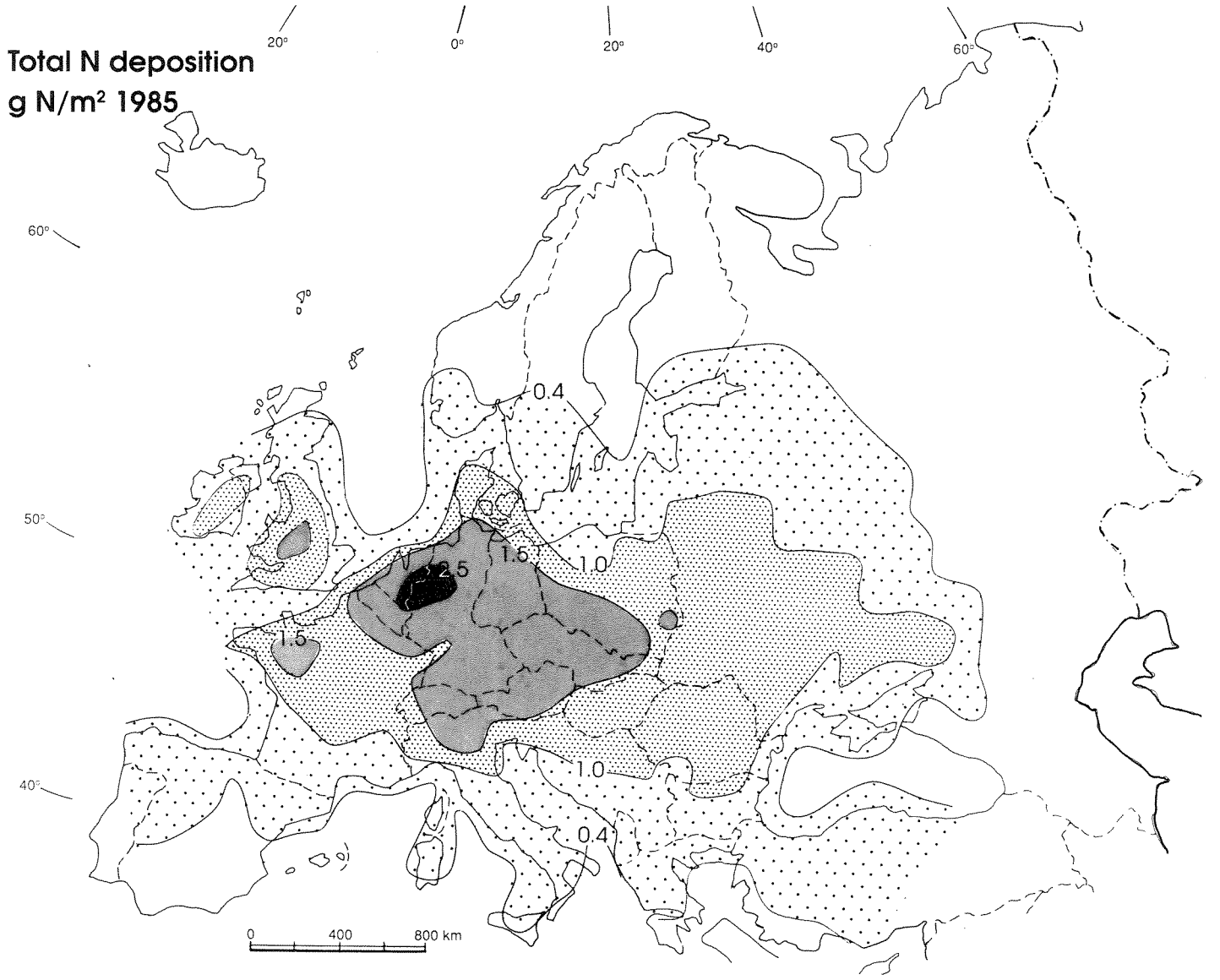

Figure 4.
Calculated 1985 annual total (wet and dry) deposition of nitrogen from all sources. The results are from EMEP model runs based on emission data and meteorology (from Iversen et al.,1989).

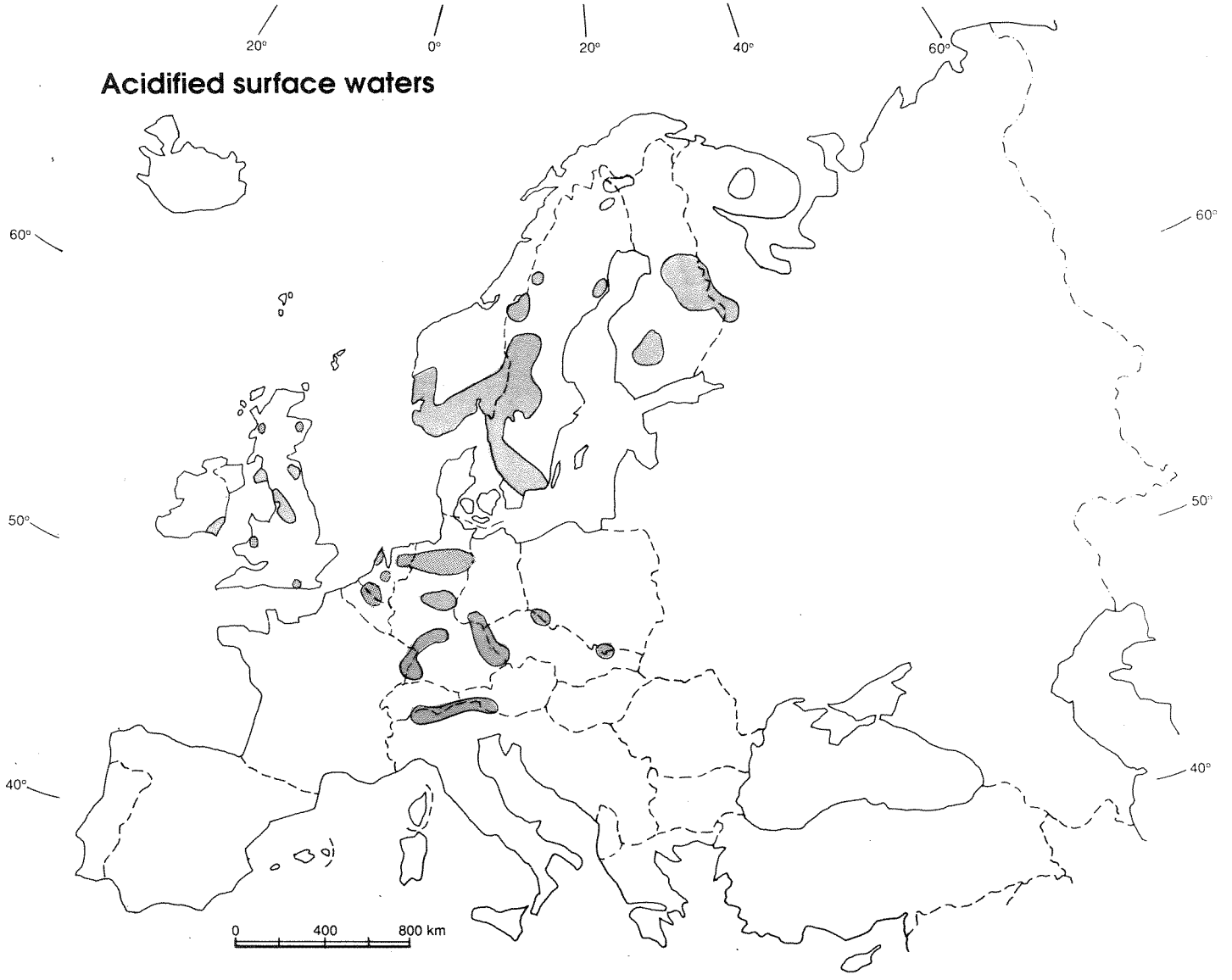

Figure 5.
Areas with acidified surface waters in Europe based mainly on Merilehto et al. (1988) with some revisions.

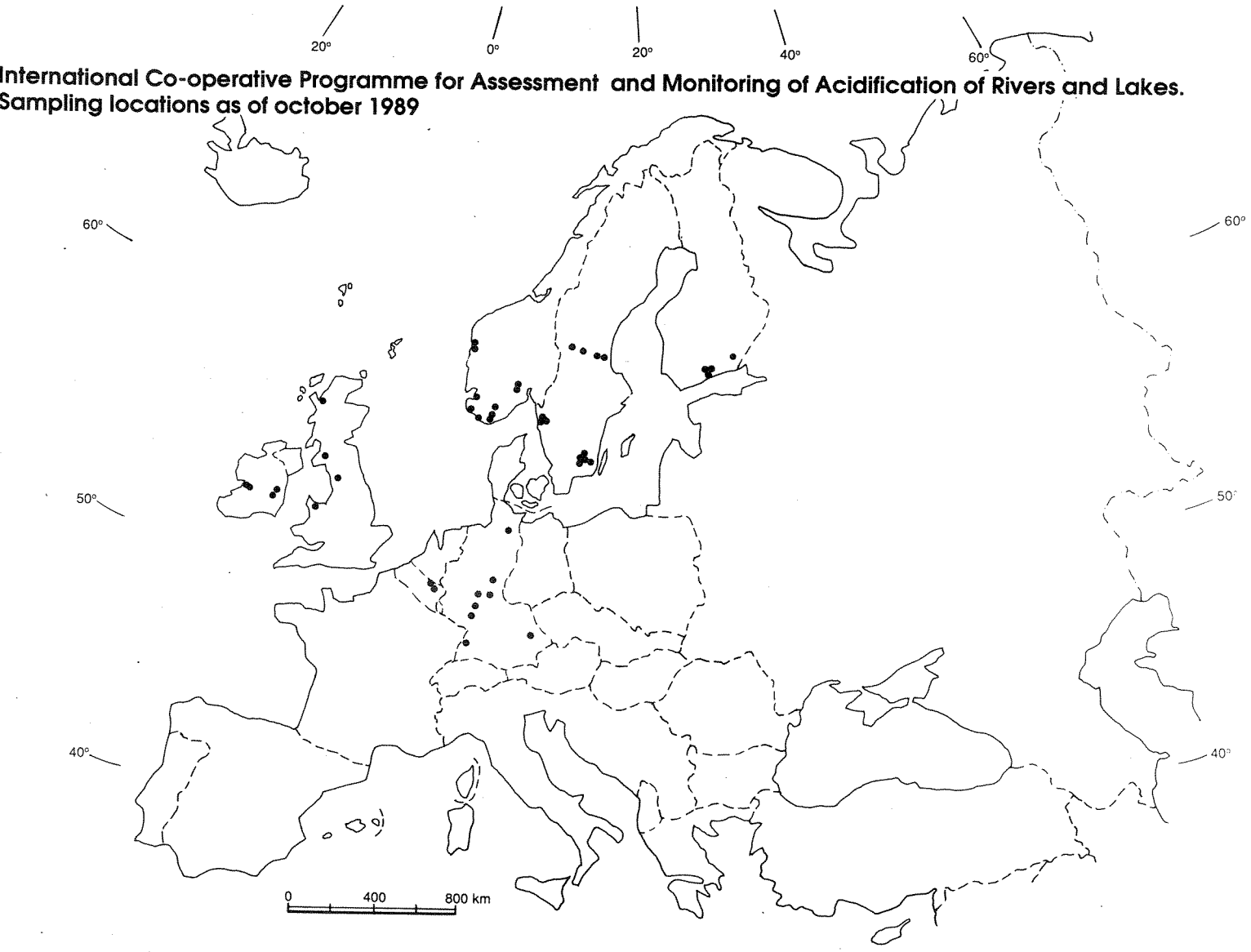

Figure 6.
The UN/ECE International Co-operative Programme for Assessment and Monitoring of Acidification of Rivers and Lakes sampling locations as of October 1989.

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