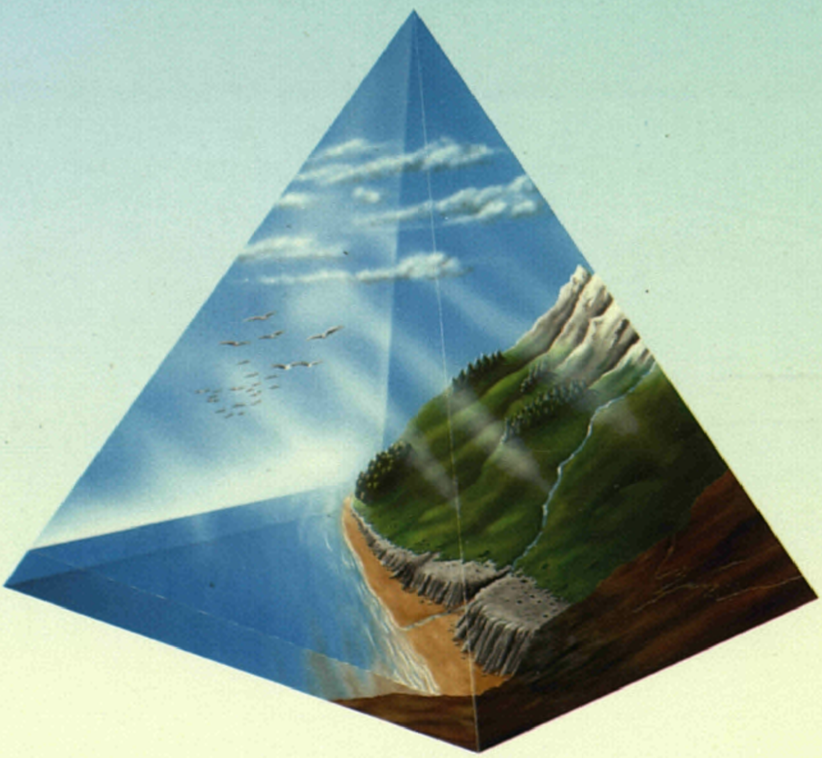
THE STATE OF THE ENVIRONMENT IN THE EUROPEAN COMMUNITY 1986



THE STATE OF THE ENVIRONMENT IN THE EUROPEAN COMMUNITY 1986

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Directorate-General
Environment, Consumer Protection and Nuclear Safety

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PREFACE

The European Community is fully committed to policies which reflect the concerns of its citizens for the environment, and has played an increasingly prominent role in seeking solutions to environmental problems, particularly in the years following the inauguration of the first Community environmental action programme in 1973. The Commission's proposals for a fourth environmental action programme, at present under consideration by the Council, would continue the work of the previous three programmes. In addition, and with the endorsement of Community heads of state and government, the proposed programme is directed towards new environmental problems and new fields of action, with a legal base strengthened by the treaty amendments of the Single European Act.

This development will give renewed impetus to the continuing requests of the European Parliament for periodic reports on the state of the environment within the Community. An essential precondition is, of course, that steps be taken to obtain information, on a comparable basis, on the state of the Community environment in order both to formulate and to effectively implement environmental policies.

In the absence of such information, reports previously published (in 1977 and 1979) inevitably gave greater emphasis to activities undertaken to implement policies, rather than to the quality of the environment itself.

The present report represents a substantial advance. It has benefited from a considerable increase in availability of data relating to the environment of member states and of the Community as a whole, representing the results of specific research programmes and of the preparation of national and regional reports on the state of the environment.

This third report on the state of the environment also has particular significance because it is published at the beginning of the European Year of the Environment. For all parties involved - policy makers, administrators and non-governmental organisations - it will therefore provide a basis for initiatives at all levels. The report will show the way for Community citizens to work for an improved environment and a better quality of life.

Notwithstanding the substantial successes of Community environmental policies, however, much remains to be done. Not all the problems of the past have been satisfactorily resolved. New problems - of greater complexity - have arisen or can be anticipated. To safeguard our previous achievements, and to overcome these new challenges, demands continuing vigilance. This in turn requires that we develop public awareness, to stimulate a demand for a better environment (and a willingness to bear the necessary costs). At the same time, we must promote recognition that environmental protection - apart from its intangible benefits - is justified in hard economic terms.

I am certain that the Community's citizens will not be slow to respond to these challenges. I commend the State of the Environment Report as a means to guide the way.

Stanley CLINTON DAVIS

Member of the Commission
of the European Communities

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A BRIEF OVERVIEW

Environment and Environmental Policies in the European Community

In an area as large and geographically diverse as the European Community, generalisations about the state of the environment are possible only to a limited extent. Environmental conditions and pressures differ between rural and urban areas, between northern and southern regions of the Community, between mountain zones and lowlands, and between inland and coastal regions. Thus, the Community has great ecological diversity, considerable variation in climate and topography, and marked differences in the absorptive capacity of the environmental media. There is, by the same token, a great variety of economic conditions in terms of both industrial structure and degree of development.

All this diversity leads to significant regional differences in the state of the environment: differences which are also reflected in and affected by the environmental policies which are adopted in the Community.

The relationship between environmental policies and the state of the environment is a matter of some complexity. Policy measures - even if appproporiately conceived and properly implemented - do not necessarily ensure environmental improvements; conversely environmental conditions may be ameliorated in some respects even in the absence of any new policy initiatives. For example, on the one hand stricter environmental regulations such as controls on emissions, controls on the use of environmentally damaging chemicals and practices, and legislation to protect threatened wildlife species and habitats have all played a part in securing environmental improvements in recent years. On the other hand, economic factors - notably the worldwide recession and the considerable industrial restructuring which has attended it - along with technological changes have undoubtedly had a major influence on environmental developments and consequently on the physical context in which environmental policies operate.

In recent years, environmental policies have also been strongly influenced by changing public perceptions of 'environmentalism' and 'green' politics. Environmental policies and pollution control legislation of the Community and member states have become progressively more rigorous. At the same time there has developed an increasingly international dimension to these policies as the Community and member states have collaborated in various international conventions on the environment. In addition, environmental concerns have greatly stimulated (and benefitted from) technical innovations in areas of pollution control and sewage treatment.

Although Community environmental policies have enjoyed important successes, they nevertheless face a number of new challenges which now require further policy initiatives. New pollutants (and potential pollutants) are being recognised, many of which can have multi-media effects. Other, existing problems are increasing in importance: most notably those associated with long-range or trans-frontier pollution. The pollution-induced effects of climatic change, for example, are commanding greater attention. Similarly, the Chernobyl nuclear accident emphasised the serious potential for damage which can be associated with cross-border pollution, and the need for international co-operation to minimise the dangers involved.

The Changing Economic Context

The impacts of economic change on environmental conditions in the Community have been clearly demonstrated in recent years. In the wake of worldwide economic recession, far-reaching changes have occurred in the structure of the economy and the pattern of industrial production: in consequence, new industrial and agricultural production methods have been introduced, while certain more traditional activities have declined. Economic activity has also been affected by the policies of the Community and member states, particularly in areas such as agriculture, energy and transport.

Amongst the many changes which have taken place, several developments in industry and agriculture may be given particular emphasis. There has been a significant decline in primary and manufacturing industries (with an associated increase in the activity of service industries). As a result, output from the metal manufacturing and chemical industries has fallen. Together with the effects of Community environmental policies, this in turn has led to a reduction in the use of certain environmentally important metals (e.g. cadmium) and chemicals (e.g. chlorofluorocarbons in aerosols). Patterns of energy production and consumption have changed, with a shift from coal to oil and nuclear power and a lessening of the substantial differences between per capita energy usage in the member states. In the field of transport, levels of car ownership and vehicle usage have increased progressively, and there has been a rapid expansion of air traffic.

The last few years have also seen a continuation of the trend towards agricultural intensification throughout the European Community. Farming has become more mechanised, although appreciable differences in the degree of agricultural mechanisation still persist in the member states. Especially in northern and western areas of the Community, the extent of agricultural drainage has increased; particularly in the more arid regions of southern Europe, irrigation has been extended. In almost all areas of the Community, rates of fertiliser application (most notably nitrates) have increased. Pesticide usage, too, has continued to rise, albeit with reductions in applications of non-specific, persistent compounds such as DDT, dieldrin and aldrin.

Environmental Trends

The evidence of this report shows grounds both for satisfaction with certain environmental improvements and, in other cases, for concern at inadequate progress or environmental deterioration. As a broad generalisation, while many of the 'traditional' pollution problems have become less serious, other problems - notably atmospheric acidification, nitrate pollution and loss of wildlife habitats - are becoming cause for greater disquiet. The available evidence is briefly summarised below, although, in considering these results, we should be aware of two fundamental qualifications:

- in many instances the available information constitutes a less than adequate basis for firm conclusions (a notable example is the lack of information on many aspects of land resources). As further (and more comprehensive) evidence becomes available, it is conceivable that perceptions will change and new problems will become apparent.

- identification of trends (towards improvement or deterioration) does not necessarily imply any priorities for future actions: better information is generally necessary to identify the scope and likely benefit of any environmental measures, so that resources can be deployed in the most effective manner.

The available information on air pollution suggests a mixed pattern. On the one hand, emissions of smoke and sulphur dioxide have declined in almost all areas, resulting in lower concentrations in the atmosphere; on the other hand, emissions of carbon dioxide, nitrogen oxides and hydrocarbons have tended to rise. Although the effects of long-range atmospheric pollution have become increasingly apparent, the problem of acid deposition appears to be more complex than previously thought.

Among the trends affecting land resources in recent years are a gradual but continuous loss of agricultural land to non-agricultural uses, and extensive problems of soil erosion and coastal erosion. Concern about soil acidification has also increased. Above all, however, there has developed a severe problem of forest dieback and damage to buildings and agricultural crops, to which acid deposition is undoubtedly a contributory factor. Whilst the effects of forest dieback remain most serious in Germany, it is becoming increasingly apparent that all these problems are of widespread importance throughout the Community.

Over recent years there have been a number of improvements in the quality of inland waters: levels of conductivity, chloride, ammonium, BOD5, COD, detergents and, to a lesser extent, phosphates have all tended to decline. Nevertheless, unacceptably high levels of dangerous substances and nutrients (especially nitrates) still occur in many rivers, lakes and groundwaters.

At the same time, information on the marine environment suggests cause for concern at increases in oil pollution in the North Sea and adjacent waters, and for satisfaction at the general decline in levels of heavy metals in the open sea. Nevertheless, marked concentrations of heavy metals and other pollutants are still found in the vicinity of input points.

Levels of radioactivity in the atmosphere, in the sea and in the soil have generally been declining over the last 10-15 years. Concentrations remain high, however, in the North Sea and close to fuel reprocessing plants. The long-term effects in the Community of the release of radioactivity following the Chernobyl accident still need to be ascertained.

Loss of, or disturbance to, habitats remains one of the main threats to wildlife; wetlands, ancient woodlands, natural grassland and coastal habitats appear to be under particular pressure from a wide variety of sources. Together with other factors such as the use of pesticides and deliberate and accidental killing, this has caused plant, mammal and bird species to be threatened. Especially in southern areas of the Community, significant threats also exist to invertebrate, amphibian and reptile species.

Prospects and Priorities

Notwithstanding the considerable extent of environmental improvement already achieved, environmental policies in the European Community still face great challenges. New problems are emerging, often requiring urgent action.

Old problems persist in some cases, and thus further environmental policy actions may be envisaged in a number of areas in which legislation is already in force, at Community or national level. In many instances, these policies may be undertaken on a regionalised basis. Environmental problems vary from one part of the Community to another, as does the availability of resources for environmental improvement. Thus is would be appropriate to increase the degree to which Community environment policies are tailored to the specific circumstances of regions to a greater degree.

Particular mention may be made of the following:

- transboundary pollution (especially from emissions to the atmosphere and discharges to international rivers);
- atmospheric pollution from hydrocarbon emissions;
- problems of marine pollution (especially in coastal areas where high concentrations of nutrients, land erosion and oil pollution occur);
- pollution of inland waters (most notably by nitrates and dangerous substances);
- threats to wildlife and sites of special environmental significance.

In addition, evidence presented in this report suggests possible areas of potential concern relating to economic activities and their environmental effects. These include:

- environmental implications of economic recovery - there might, for instance, be an increase in levels of heavy metal pollution as a result of increased industrial activity;
- an increase in afforestation and tourist development, possibly associated with a decline in the viability of farming in marginal areas, which would constitute a new threat to habitats;
- an increasing incidence of spillages involving hazardous chemicals due to ageing of existing plants and the centralisation of production;
- increasing pressures on water and other resources in Mediterranean regions as industry expands and as public demand rises.

Information Requirements for Environmental Policies

Environmental information is required for several purposes: to identify and analyse trends, to anticipate problems, to monitor the effects of environmental measures, and to inform policy makers and the public. It follows that, as the state of the environment changes over time, information must be continually updated.

The relationship between information and policy is interdependent and interactive: environmental concerns are both a reflection of existing information and a determinant of future priorities for data collection. As far as possible, policies should be anticipatory (on the principle that 'prevention is better than cure'), and this precept has increasingly characterised the policies of the Community as its environmental actions have developed. Nevertheless, it is important to recognise that this approach inevitably has its limitations, since existing data are generally inadequate.

This points to the need for an environmental information system which is both comprehensive and flexible. It must identify potential and developing sources of environmental deterioration, including those which initially may not be perceived as such, so that policies can be devised as soon as possible to counteract the problems before they become acute. At the same time, the policy response itself should normally include the precise formulation of requirements for information relevant to the problems in question.

In general, the ability to anticipate problems depends upon access to comprehensive and easy to use environmental information. Moreover, this access should be possible on a routine basis, as opposed to involving information collection for each specific problem as it arises and is perceived. Clearly, the more this facility is offered to decision makers and the public, the greater will be the benefit from improved policy formulation. Development of an information system for this purpose, however, would be justified only up to the point at which the additional benefit from the programme ceases to outweigh the extra cost involved. In present circumstances, with the Community information programme still at an early stage, it is likely that for the foreseeable future the balance of advantage will strongly favour further development of environmental information systems.

Recently, therefore, the Community has established, on an experimental basis, a co-ordinated information system on the state of the environment (CORINE). By 1987, the first results from this exercise will be available, covering data on soils, climate, water resources and important biotopes. Over the following two to three years, these data will be used and supplemented to provide more detailed information on a number of key issues, including land cover, atmospheric emissions, land quality and soil erosion. On completion of this experimental programme, consideration will be given to extending the programme on a routine basis, in co-operation with member states. In this process, a critical factor will be the contribution which such an extended programme might make to policy formulation.

Meeting the Challenges of Environmental Problems

Emphasis has been given in this report to trends which evolve over time, and to the process whereby policies are formulated to counter undesirable environmental developments. It is important to appreciate that the state of the environment is not a static concept, and that, even in the absence of any further policy measures, the nature of environmental problems is liable to change. Economic developments are of great significance in this context: the recession of the 1970s curtailed activity in some of the most heavily polluting industries, and the consequent changes in industrial structure have had far-reaching effects on the nature of environmental problems.

As the problems change, policies must also be modified and developed to meet the new challenges. It is increasingly recognised that any proposed measures should be subject to critical assessment to ensure that their benefits outweigh the costs which will be incurred - a need which underlies the recent enactment of a Community Directive requiring that certain major projects undergo a prior environmental impact assessment. It is also realised that further development is needed of assessment procedures which take full account of costs and benefits, including those (often very significant) factors which do not lend themselves to precise quantification. Moreover, appraisal of environmental policies must consider their broader effects within the wider economy; this should include the benefits associated with technological development prompted by clean technology programmes, and the stimulative effect on employment from environmental expenditures.

The importance of integrating environmental policies with other policy areas is taken into account in the Community's environmental action programmes. Thus, measures to stimulate employment, for example, should not be taken without reference to their environmental implications (and vice versa). Similarly, the increasing emphasis on preventive policies requires that the environmental implications, priorities and constraints must be considered as an integral part of policy development in all areas, including agriculture, energy and transport. A responsibility for environmental protection and improvement has already been noted by the recent Green Paper on the Community's agricultural policy: this needs to be extended to other areas of policy and put into practice in the actions which are adopted.

Whether or not they are explicitly environmental, therefore, the Community's policies need to take full account of the potential costs of environmental damage and deterioration - and hence of the benefits to be gained from avoiding these cost burdens. Examples include the costs of resource depletion (and the benefits of recycling); the costs of wasting resources, either by discarding them as wastes or losing them as a result of dereliction, pollution and misuse; and the costs, in both financial and social terms, of damage to human health and the environment as a result of pollution (and the attendant costs of repairing this damage). By incorporating these considerations, the Community policies will thus help to promote efficient management of resources.

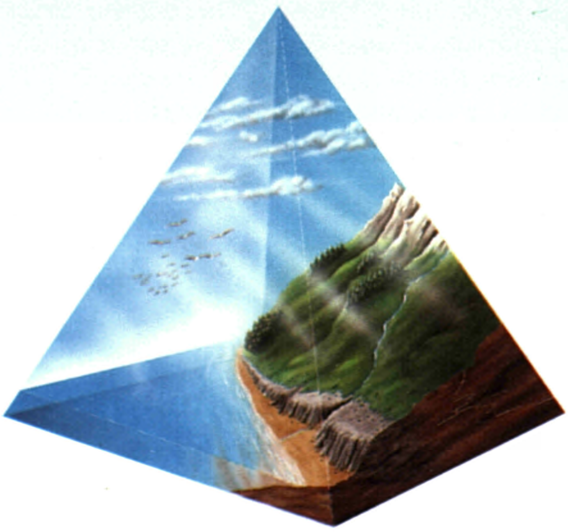
There are, nevertheless, several preconditions for the development of policies to maintain and safeguard the quality of life and to manage natural resources in an economically efficient manner. A fundamental requirement is for sufficient information. Significantly, the present report has identified many instances where available data are described as 'inadequate'. There is thus scope for additional data collection, the costs of which are likely to be outweighed by the benefits to be anticipated from better informed policy making.

At the same time, the present report has emphasised that the environment is a complex and interactive system: policy development must thus allow for the inter-relationships involved. In particular, data collection is a mutually enhancing process, in that the value of information relating to the environment is greatly increased by the availability of compatible information for other, related phenomena. For this reason, emphasis is given in the CORINE programme to the development of comprehensive and consistent data collection procedures. Similarly, there are interactions in the policy context between measures taken at local, regional, national and international levels. From these interactions arises the need for integration and co-ordination of environmental actions at all scales. Local development, for example, may threaten sites of national, Community or even global importance. National or Community policies may impinge upon resources, habitats or conditions which are important at a local level. Integration between all these levels is important, also, because otherwise action at one scale can be weakened or even negated by conflicting action (or inaction) at other levels. The problems in protecting migratory species of wildlife provide one crucial example; the difficulties in dealing with pollution of the Rhine and other major rivers are another.

The effectiveness of policies depends ultimately upon the manner of their implementation. This, too, is a matter of interaction and co-operation, both in the formal sense - Community directives are implemented by member states through national legislation - and less formally by the people and organisations affected. The success of environmental policies is in the end determined by the commitment of people from all walks of life - industrialists and farmers, scientists and planners, members of the general public - to understand their own responsibility to the environment. A major initiative to stimulate this environmental awareness in the Community is already being taken: the European Year of the Environment will cover the 12 months from 21 March 1987. This constitutes the beginning of a process of continuing development, whereby attitudes are influenced in favour of environmental protection as an essential means of safeguarding and improving the quality of life in the broadest sense. In this context, there is an increasing recognition of the need for education, research and communication to promote environmental consciousness. The present report seeks to contribute to this process - but also recognises that much more remains to be done.

PART ONE

BACKGROUND



PART ONE

BACKGROUND

CHAPTER 1.

INTRODUCTION

1.1 AIMS AND OBJECTIVES

For many centuries, mankind has tended to take for granted the environment in which he lived and on which he depended. That such an attitude is short- sighted has only become widely apparent over the latter part of the present century. Since then, the fragile relationship between man and the natural world has been broken on a number of instances, each at the cost of considerable human suffering and sometimes leaving a legacy of both economic and environmental damage for future generations. At sea there have been major shipping disasters, such as the *Amoco Cadiz* in 1978, resulting in large scale pollution of coastal waters and impacts on fish and marine birds. Over-fishing has similarly depleted stocks of several fish species, while land-based pollution has affected marine wildlife. On land, there has been the increasing evidence for the effects of pollution on wildlife, crops and human health. Accidental releases of hazardous substances have affected surrounding human populations (e.g. Chernobyl, Bhopal, Seveso). Pesticide residues have been shown to accumulate in soils, and stream and lake sediments, and to cause poisoning of bird and mammal populations. Atmospheric emissions of sulphur dioxide and particulates have been implicated in many respiratory diseases in urban areas and have, in several cases, been directly associated with large numbers of human deaths. Together with nitrogen oxides and other pollutants, sulphur dioxide is now known to contribute to atmospheric acidification, which in turn damages forests, lakes, crops and soil fertility (the so-called 'acid deposition' problem). Moreover, misuse of the land for agriculture has led to soil erosion, crop failure and, in some parts of the world, massive famine.

In the face of these problems, an awareness has grown throughout the world of the need to understand the environment, and to manage it in a sensitive yet also economically more rational manner. This cannot be achieved in a piecemeal fashion, however, for the environment is not composed of independent, discrete segments which operate in isolation. Instead, it is a complexly and intricately inter-related whole. Understanding consequently requires not only detailed knowledge of small parts of the environment, but a wider overview, in which these inter-relationships can be seen. Management, equally, is only likely to be effective if detailed management practices are embedded in more general policies which are designed to reflect the diverse and interwoven structure of the environment.

Over recent years, one approach to providing this essential overview has been the publication of reports on the state of the environment. These have several functions. They act as a means of reminding managers and scientists of the broader environmental framework within which they work. They also give both policy-makers and public a general picture of environmental conditions, and help to identify key issues or areas of concern. Similarly, they help to highlight gaps in our knowledge. In addition, they provide an opportunity for reviewing relevant policies and environmental actions, and for placing these in a wider context. Finally, they may show trends and patterns in economic or other activities which impinge on the environment, and thereby point to potential future problems and policy requirements.

Many countries and organisations now produce reports of this nature. Probably the most comprehensive is the report on Environmental Quality, published in the USA, but the OECD has also recently produced its second report on the state of the environment. The need for a similar report covering the European Community was recognised some years ago by the European Parliament, and the requirement to publish regular reviews of environmental conditions was specified in the Community's environmental action programmes. Nevertheless, in the past, the opportunity for compiling detailed reports on the state of the environment was limited, for data were scarce and many of the Community's own policies were in their infancy. As a result, the two previous reports published under that name by the Community (in 1977 and 1979) were not intended to summarise the state of the environment in any quantitative manner, but focused instead on the policies and actions being undertaken.

Since then, circumstances have changed considerably. Many member states of the Community now publish their own reports on the state of the environment, or at least regular statistical summaries of environmental conditions. In addition, the European Commission has undertaken a large number of studies, collecting data on specific aspects of the environment or particular areas. Thus, the quantity of data available has increased considerably.

At the same time, the need for environmental information has also become greater. New environmental problems are emerging, such as acid deposition, long range air pollution, nuclear wastes, groundwater pollution, forest damage and loss of habitats. Data are required to show where these occur in the Community, how serious they are and how they are changing over time, so that appropriate preventive policies can be taken. Meanwhile, new environmental policies are being adopted in response to these and other problems. Thus, data are also needed to ensure that these policies are correctly implemented and enforced, and to evaluate their real effects on the environment. Similarly, new structural policies are being introduced by the Community and its member states, especially in relation to regional plans and inter-regional programmes (e.g. the Integrated Mediterranean Programme). All these have potential environmental impacts. Data are consequently necessary to orientate the policies and monitor their effects on the environment.

In the years ahead, this need for data will be served to an increasing extent by Community instruments such as ECDIN and CORINE (see Inset, page 28). Until then, however, there is much that can be achieved by considering the broad range of existing - but as yet largely unco-ordinated and disparate - data on the environment available either in the member states or from previous Community studies. It is the aim of this report to bring together these data in as consistent a manner as possible. As such, it will present an overview of environmental conditions in the Community which can be an element in public and political discussion both about existing problems and actions, and about future issues of concern and policy requirements.

More specifically, the aim of the report is as follows:

i. to present data relevant to the state of the environment in the European Community in as consistent and complete a form as possible.

ii. to show on the basis of these data patterns and trends in human activities affecting the environment, and thus to identify pressures acting on the environment.

iii. to show, similarly, current patterns and trends in the state of the Community environment, and to relate these as far as possible to the human activities and policies affecting them.

iv. to illustrate actions to protect and improve the state of the environment taken at Community level.

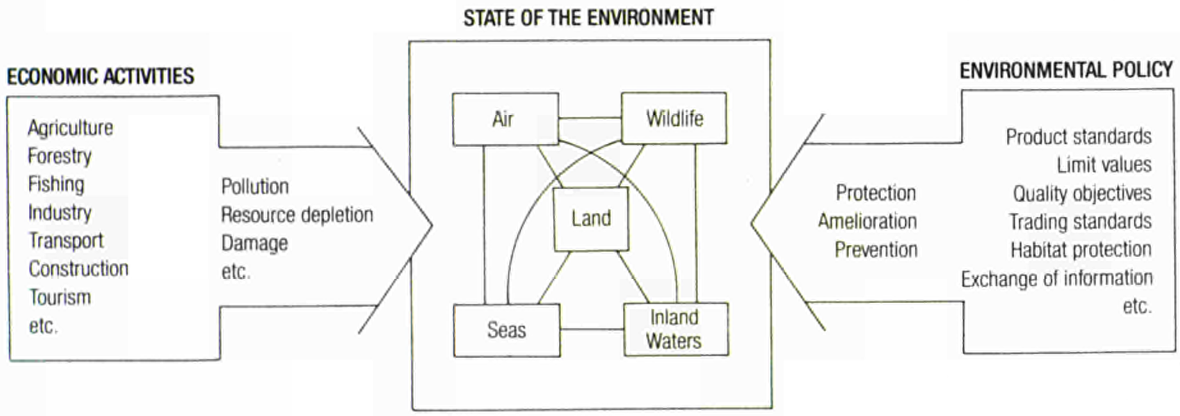
v. to indicate where possible pressures and problems of future concern in the Community might occur.

vi. to discuss the economic aspects of environmental problems and policies in the Community.

vii. to indicate as far as possible gaps in our present knowledge of the environment and needs for new data collection.

viii. overall, to provide a sound and objective basis for public, scientific and political discussion of the state of the environment in the European Community, and thus to improve the implementation, enforcement and orientation of Community policies.

Figure 1.1 **The environment and its relationships.**



1.2 STRUCTURE AND CONTENT OF THE REPORT

In order to achieve the objectives outlined previously, this report must reflect as closely as possible the structure and workings of the environment. If not, the picture it paints, and the issues and solutions it points to, may be misleading and inappropriate.

Today, the broad structure of the environment and its relationship to human activities are clearly recognised. The environment is seen as a system, comprising a number of distinct but related components - the air, land, inland waters, seas and wildlife. These components are linked by complex flows of energy and matter which pass through the environment in a range of forms. In the process these flows modify the various components and affect the overall state of the environment. Many of the inputs of energy and matter are derived from human activities: from industry, agriculture, residential activities, tourism etc. Moreover, these activities have a more direct impact upon the state of the environment through their effects on the basic structure of the environment - for example, by actions such as construction, cultivation and reclamation. As a consequence, the state of the environment depends to a great extent both upon the human activities and upon the environmental and other policies which influence or control them (Figure 1.1).

The problem is how to represent this complex system within a report such as this. It is not an easy task. Unlike a written report, the environment does not flow linearly from its beginning to its end; it has no title page and no final entry in the index. Whatever approach is taken, therefore, inevitably simplifies reality and emphasises some aspects of the system at the expense of others. The traditional sectoral approach, for example, in which each component of the environment is considered in isolation, stresses the cumulative effects of human activities on individual sectors but tends to ignore the character of the flows between them. Conversely, to follow individual substances or effects from their source through the environment demonstrates clearly the nature of the inter-relationships between the components, but disguises the impacts of the various substances in combination at any point.

The approach adopted here is as follows. The environment and its external influences are considered separately. First, in Part II of the report, attention is given to the policies and economic activities which affect the environment. Then, in Part III, the state of the environment within each sector is examined in the light of these effects (Figure 1.2). In order to emphasise the links between the different sectors, however, certain 'key themes' are followed through each of them (insofar as data availability permits). Thus cadmium is considered in terms of its production and use (Chapter 3), its occurrence as a soil pollutant (Chapter 6), and as a pollutant in seawater (Chapter 8). Radioactivity is followed from one of its main sources in the nuclear energy industry (Chapter 3), to its occurrence in the air (Chapter 5), soils (Chapter 6) and the sea (Chapter 8). Similarly, nitrates and phosphates are examined from their sources in sewage (Chapter 3) and fertilisers and manures (Chapter 4), to their occurrence as pollutants in streams and groundwaters (Chapter 7) and seas (Chapter 8). Thus:

Chapter 2 outlines the principles and evolution of the Community's environmental policy and stresses the new directions which are now being followed (e.g. regarding policy implementation, the need to take better account of regional variations, a multi-media approach and the role of economic aspects of environmental policy).

Chapters 3 and 4 describe the main human activities affecting the environment, and the pressures which they exert. Particular attention is given to the regional pattern of these activities and to recent trends.

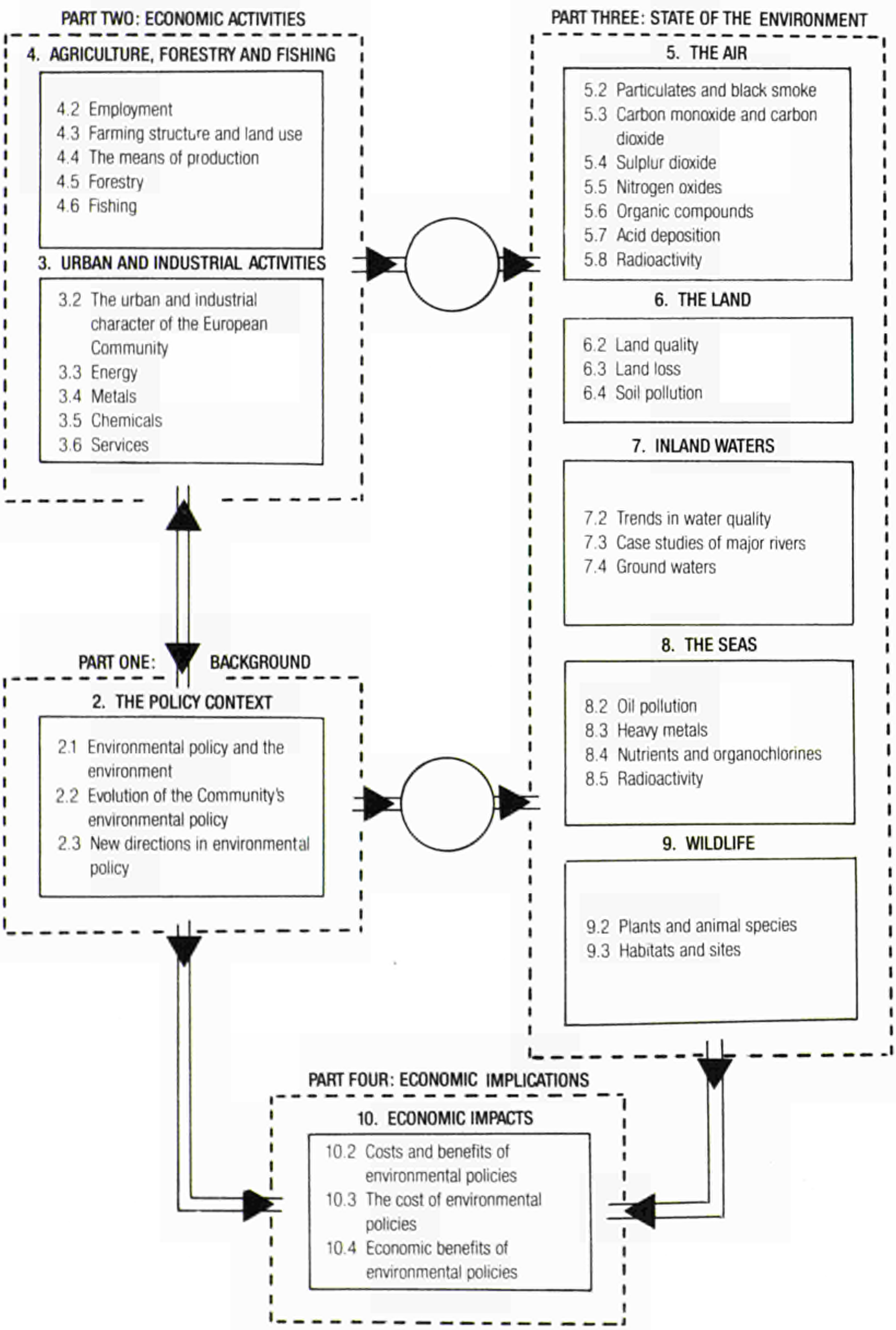
Chapters 5 to 9 assess the state of the environment in the European Community. In this section, the logical pathway is followed from the Air (Chapter 5), to the Land (Chapter 6), to Inland Waters (Chapter 7), the Seas (Chapter 8) and Wildlife (Chapter 9). This reflects the general route followed by a number of pollutants through the environment. It is important to remember, however, that these sectors are themselves closely interlinked, so both within the individual chapters and between them examples are used as insets, demonstrating the interactions.

Chapter 10 considers the economic implications of environmental problems and policies in the European Community and highlights the cost-benefit effects of environmentally-sensitive economic policies.

A number of additional aspects should, however, be noted. First, when work on this report was started, the Community consisted of ten member states: Spain and Portugal had not yet joined. In the time, and with the data available, it has not been possible to extend the report to cover these states, though where possible data for these countries are included for comparison.

Second, while it is accepted that the Community plays a vital role in environmental policies and impacts on a global scale, these issues have not been considered to any extent here.

Figure 1.2 **The structure of the report.**



This is because the recently published OECD report discusses these matters in full and places the Community in its wider context.

Third, given inevitable limitations of space, this report is admittedly selective. As far as possible, selection of which topics to include and which to omit was based upon judgements of their relative importance to the Community as a whole or to the Community's environmental policies. But, in addition, factors such as the availability of data, the need for some sort of geographic balance, and the need to illustrate the wide range of problems and conditions in the Community were also taken into account. The availability of data was, in many circumstances, a crucial factor, and several important topics (e.g. odours, the occupational environment) were excluded largely because of the lack of suitable data.

Finally, it should be stressed that this report is not intended to duplicate or replace either national studies or those of international organisations such as the OECD. Rather, it will complement these by bringing together data at a scale, and for an area, appropriate to the Community as an individual entity. It will also form a starting point for future, more detailed reports. These will draw both on the data provided by the CORINE programme and on information supplied by member states as part of their duty under Community legislation to report on the progress of policy implementation.

1.3 THE EUROPEAN COMMUNITY

1.3.1 The Physical Framework

Since the accession of Spain and Portugal, in January 1986, the European Community consists of twelve member states with a total land area of 2.25 million square kilometres and a population of 320 million (Figure 1.3). (The previous ten member states covered 1.6 million square kilometres, with a population of 271 million.)

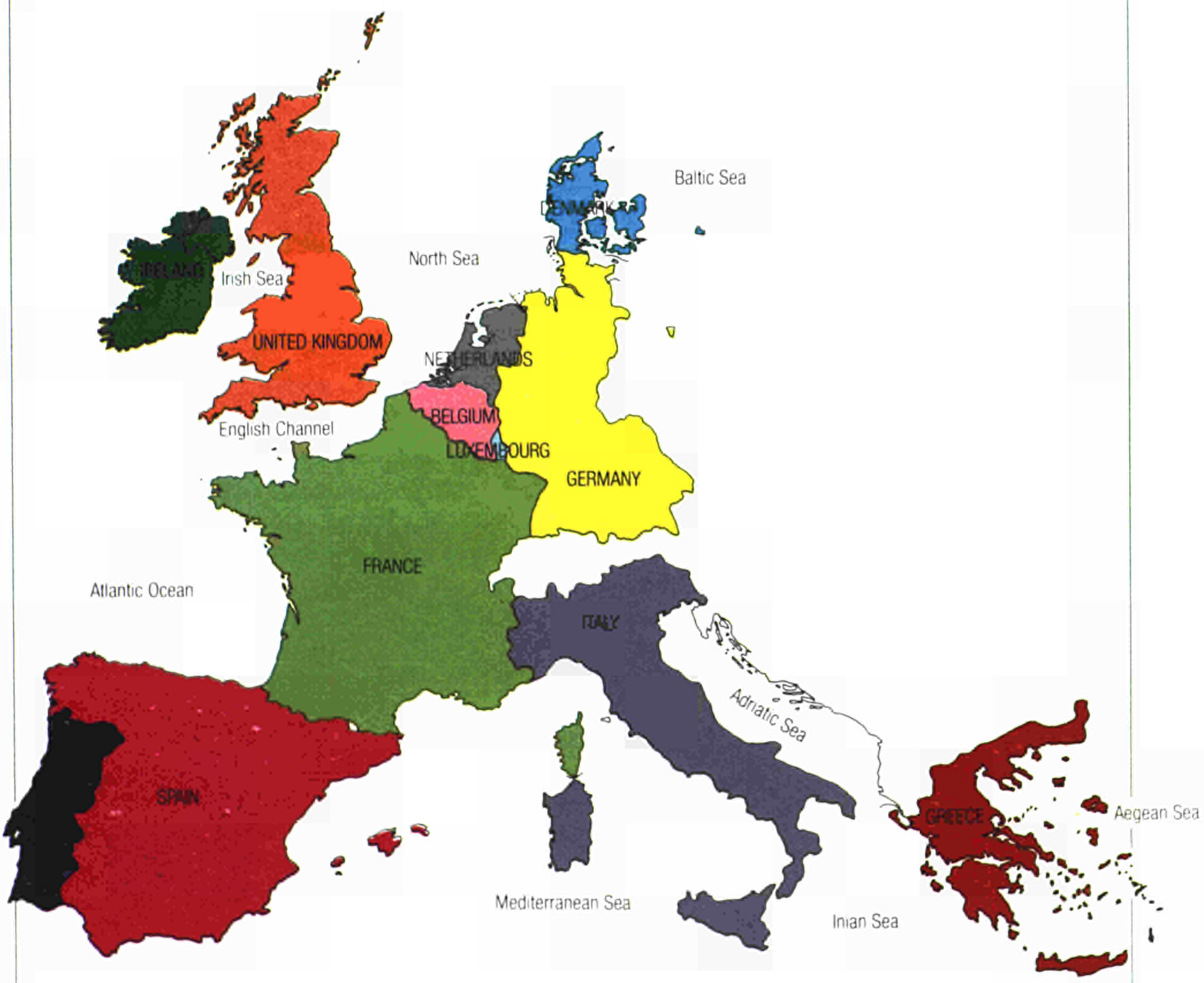
It is an area of immense geographical range and diversity. It stretches from 61°N in the Shetland Isles to 35°N in southern Crete, and from 11°W in western Ireland to 28°E in eastern Greece. Enclosed within or bordering this territory is a sea area including most of the North Sea, the Irish Sea, the eastern Atlantic and the northern Mediterranean (Figure 1.3). Topographically, the land area ranges from the high mountains of the Alps to the broad lowlands of northern Germany, and from the fjords and cliffs of Scotland to the coastal lagoons of the Italian east coast (Figure 1.4; Plates 1.1-1.4). Climatically, it varies between the cool, moist maritime region of the north-west and the relatively dry and warm Mediterranean zone in the south (Figures 1.5-1.7). The soils are equally diverse. They include deep, silty loessial soils over much of the northern lowlands and shallow, stony lithosols in the glaciated mountains and inland areas of Italy and Greece; they range from podsols and raw, acid peats in the wet moorlands of Ireland and western Britain to weathered luvisols in the coastal areas of the Mediterranean.

Within its borders, the European Community contains an immensely wide range of environmental conditions, which are expressed in the great diversity of landscapes. Here we see just four examples: coastal sand-dunes on the Atlantic coast of south western Ireland, densely forested mountains in the French Vosges, irrigated lowlands in Crete and the flat, glaciated plainlands of northern Germany and Denmark.

In principle the natural vegetation would show a related pattern. In practice, however, the relationship is often relatively weak for the long history of land use and human interference means that nowhere in the Community is the vegetation totally natural, and over wide areas even semi-natural vegetation is scattered and scarce. Moreover, local variations in soils, topography,

Figure 1.3 **The European territories of the Community.**

Member State	Area (× 1000 km²)	Population (million)	Member State	Area (× 1000 km²)	Population (million)
Belgium	30.6	9.9	Luxembourg	2.6	0.4
Denmark	43.1	5.1	Netherlands	41.2	14.3
France	544.0	54.2	Portugal	92.0	10.1
Germany	248.6	61.6	Spain	504.8	37.8
Greece	132.0	9.8	United Kingdom	244.1	56.0
Ireland	70.3	3.5			
Italy	301.3	56.6	EC 12	2254.4	319.3



Plates 1.1-1.4 **The landscapes of the European Community.**
Plate 1.1 **Banna Strand, County Kerry Ireland with the Dingle Peninsula in the background.**
Plate 1.2 **The Vosges, near Molsheim.**

Photo: D. J. Briggs

Photo: D. J. Briggs

Plate 1.3 **Crete.**
Plate 1.4 **Glaciated lowlands, Denmark.**

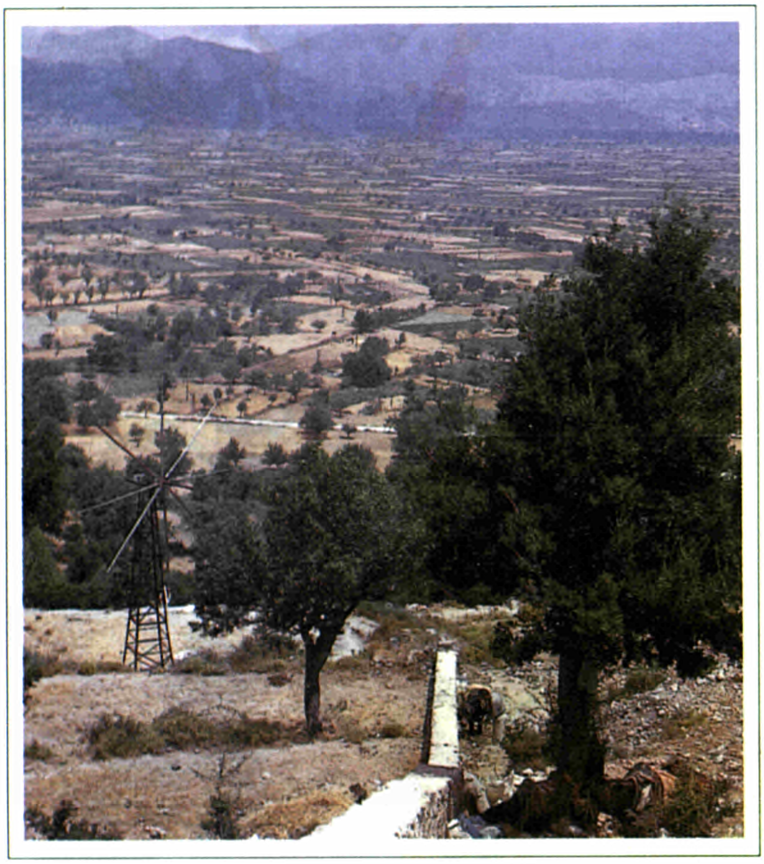
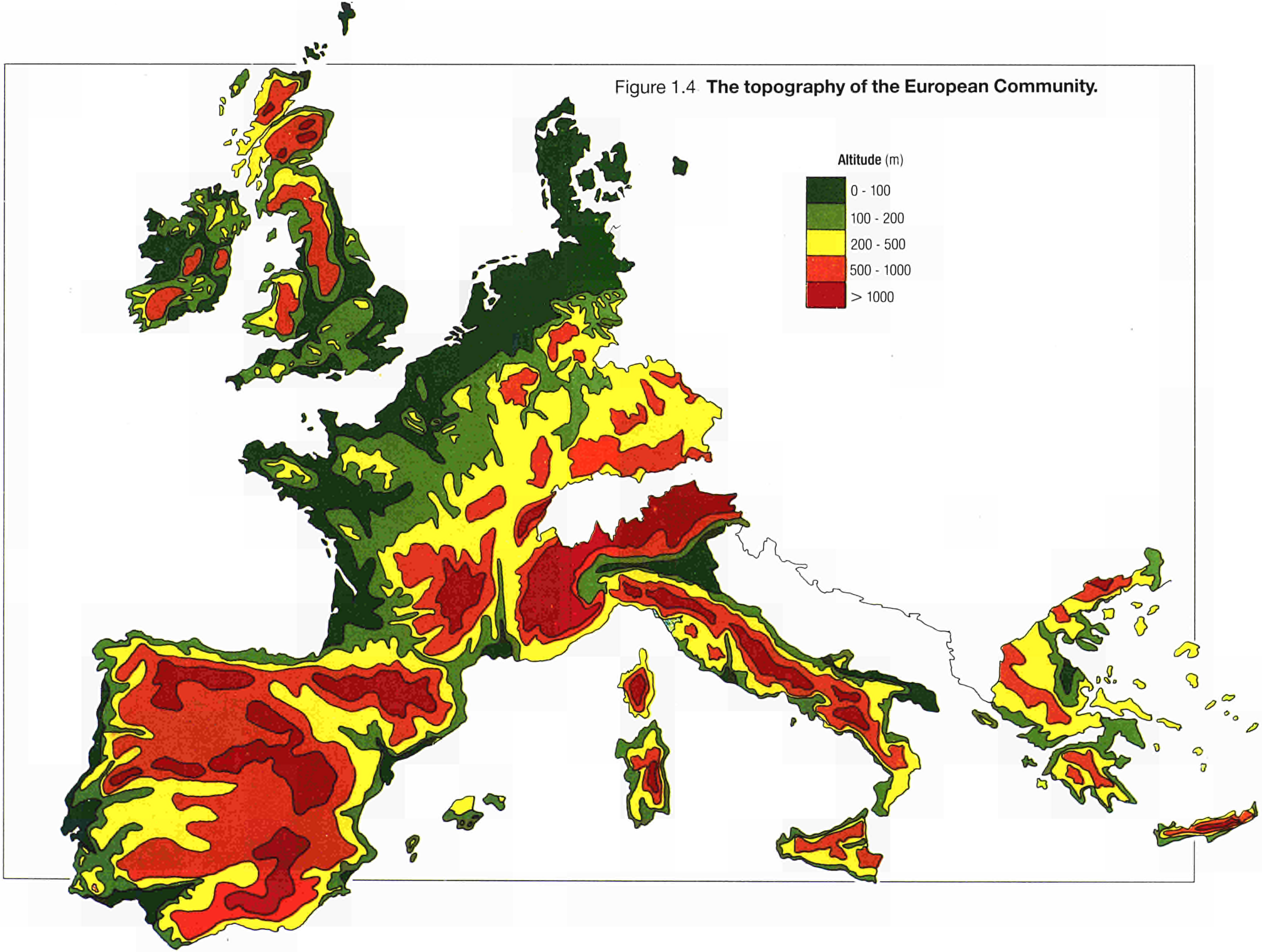


Photo: H. R. Singleton

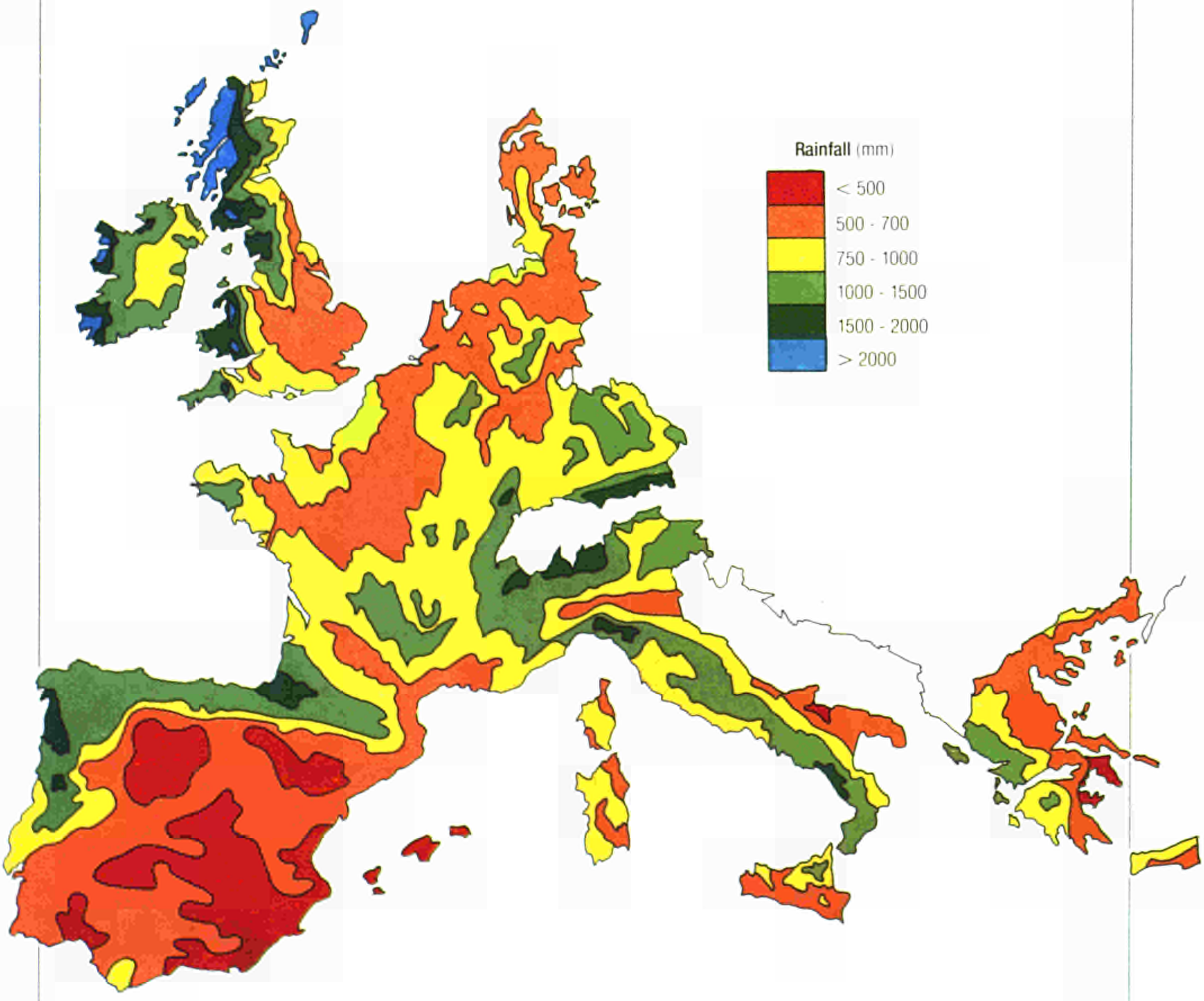
Photo: anon

Figure 1.4 **The topography of the European Community.**



hydrology and climate result in marked differences in vegetation composition over short distances. Because of this, and because of the complex history of climatic change, the territory of the Community provides habitats for a large number of species. Exact figures are impossible to give because of the problems of defining resident species and limited knowledge of many groups of plants and animals, but the previous ten members of the European Community contain some 6,000 plant species, 100,000 invertebrate species, almost 600 bird species, about 130 mammal species (including bats) and 60 species of freshwater fish.

Figure 1.5 **The climate of the European Community: annual rainfall.**



Source: data from Thran and Broekhuizen 1965

Figure 1.6 **The climate of the European Community: January temperature.**

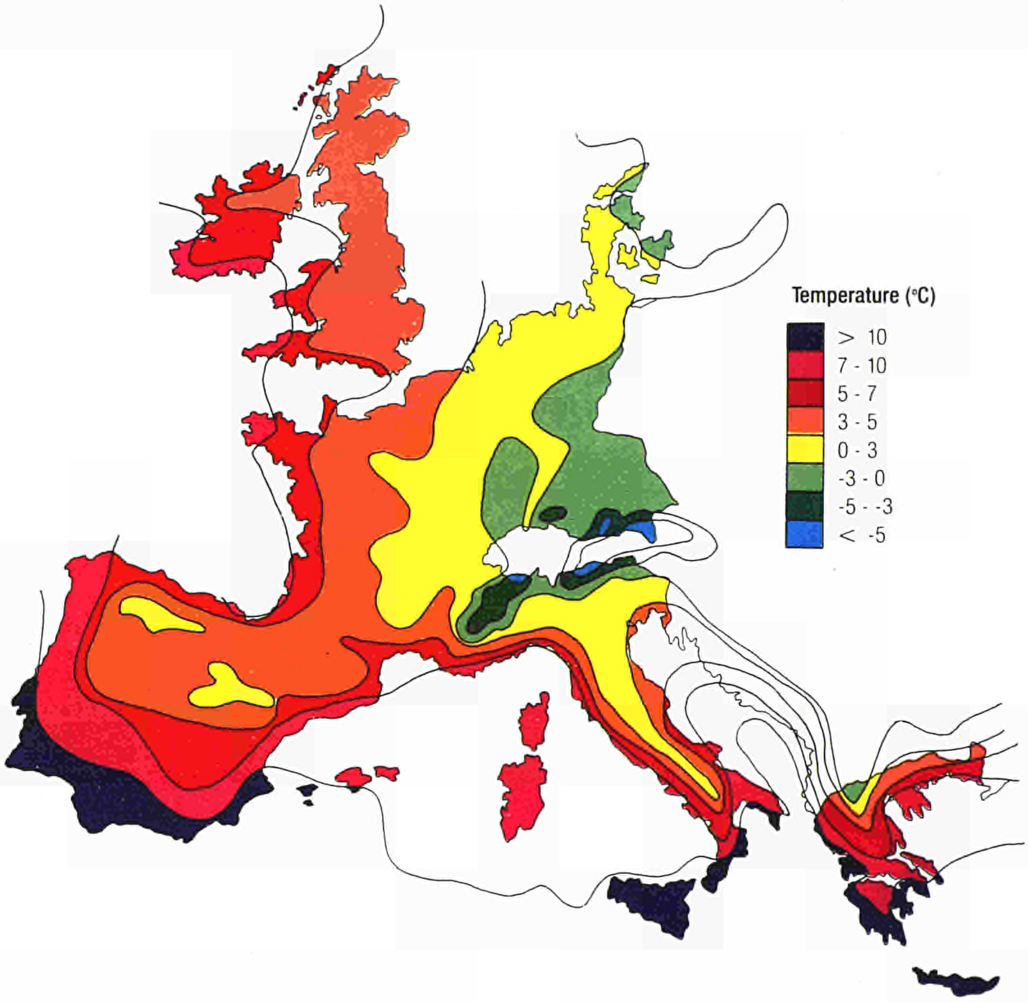
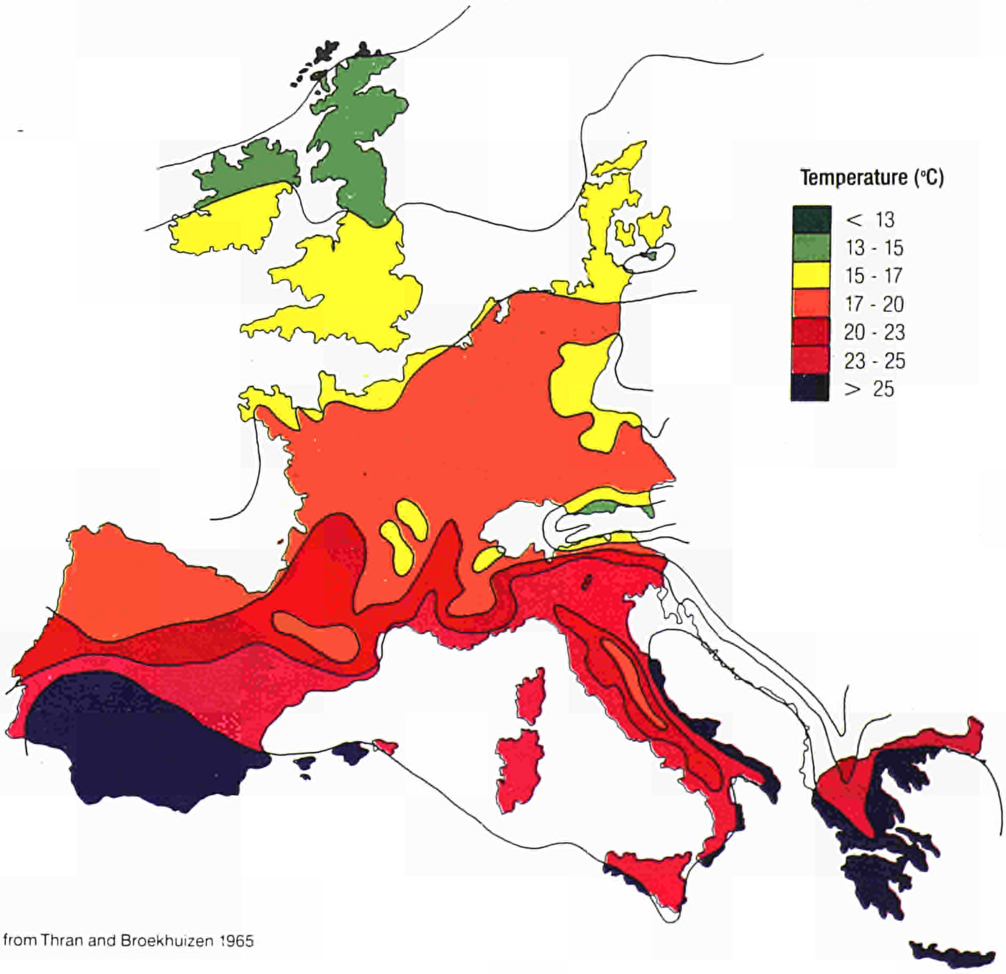
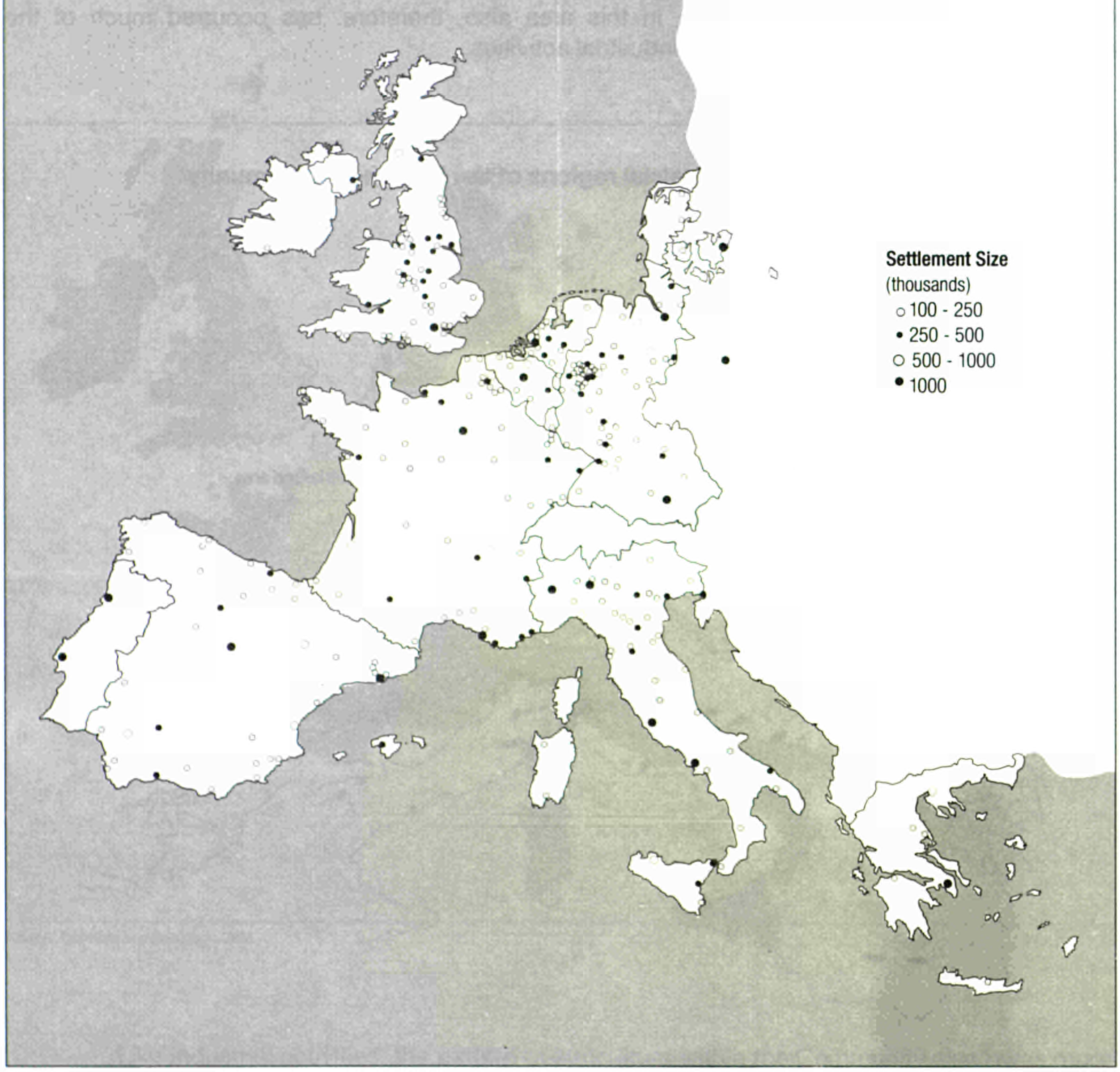


Figure 1.7 **The climate of the European Community: July temperature.**



Source: data from Thran and Broekhuizen 1965

Figure 1.8 **Major towns and cities of the European Community.**



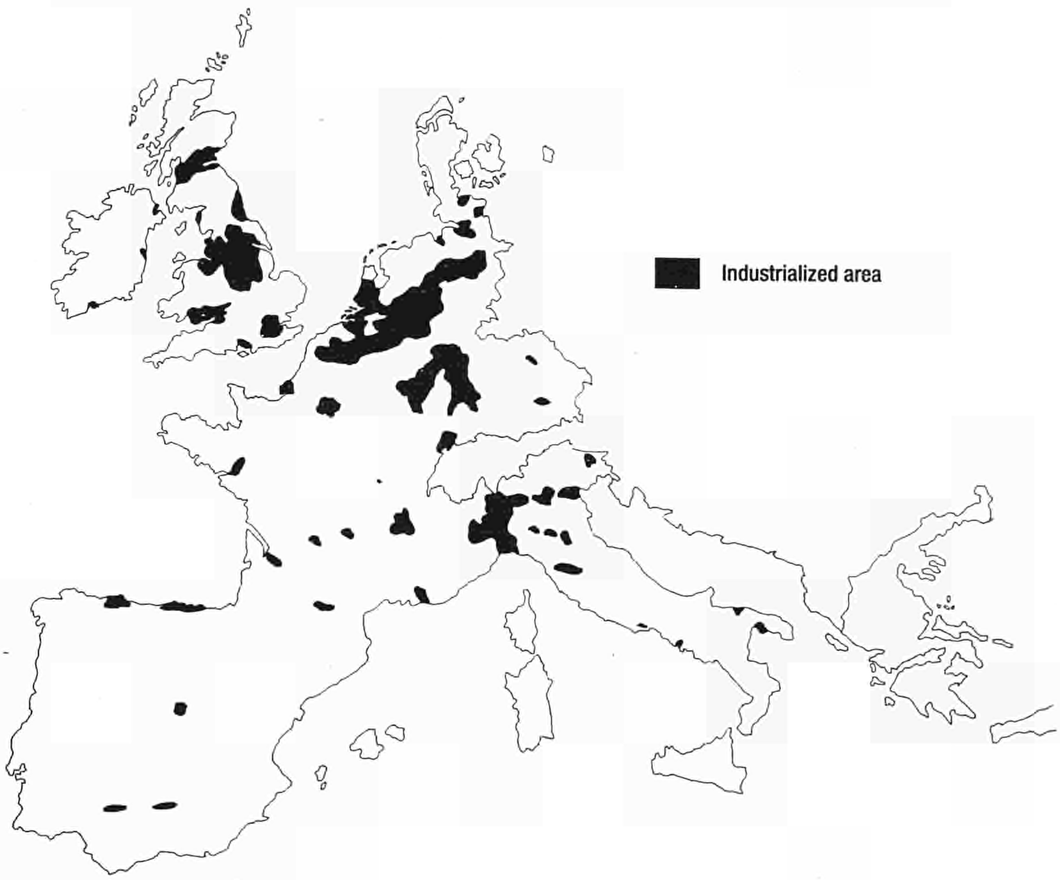
Source: data from Paxton 1984

1.3.2 The Social and Economic Framework

To a large extent, the physical diversity of the Community is reflected by its economic and social activities. The pattern of these activities will be considered in more detail in the next section (Chapters 3 and 4), but it is readily apparent that marked differences occur in the level of urbanisation and industrialisation across the Community. The distribution of major towns and cities, for example, is shown in Figure 1.8. As can be seen, these are clustered in northern and western regions, especially in north-west Germany, Belgium, the Netherlands and southern and central England.

In much the same way, industrial activity in the Community is concentrated in a broad zone running from central and north-western England through Belgium and northern France, thence along the Rhine valley and its tributaries and into north Italy (Figure 1.9). Within this zone, a more narrowly defined heartland can be identified, forming a triangle bounded by the Ruhr and Lorraine rivers and the Nord-Pas de Calais region. In this area is focused the preponderance of the Community's heavy industrial output. In this area also, therefore, has occurred much of the environmental damage from traditional industrial activities.

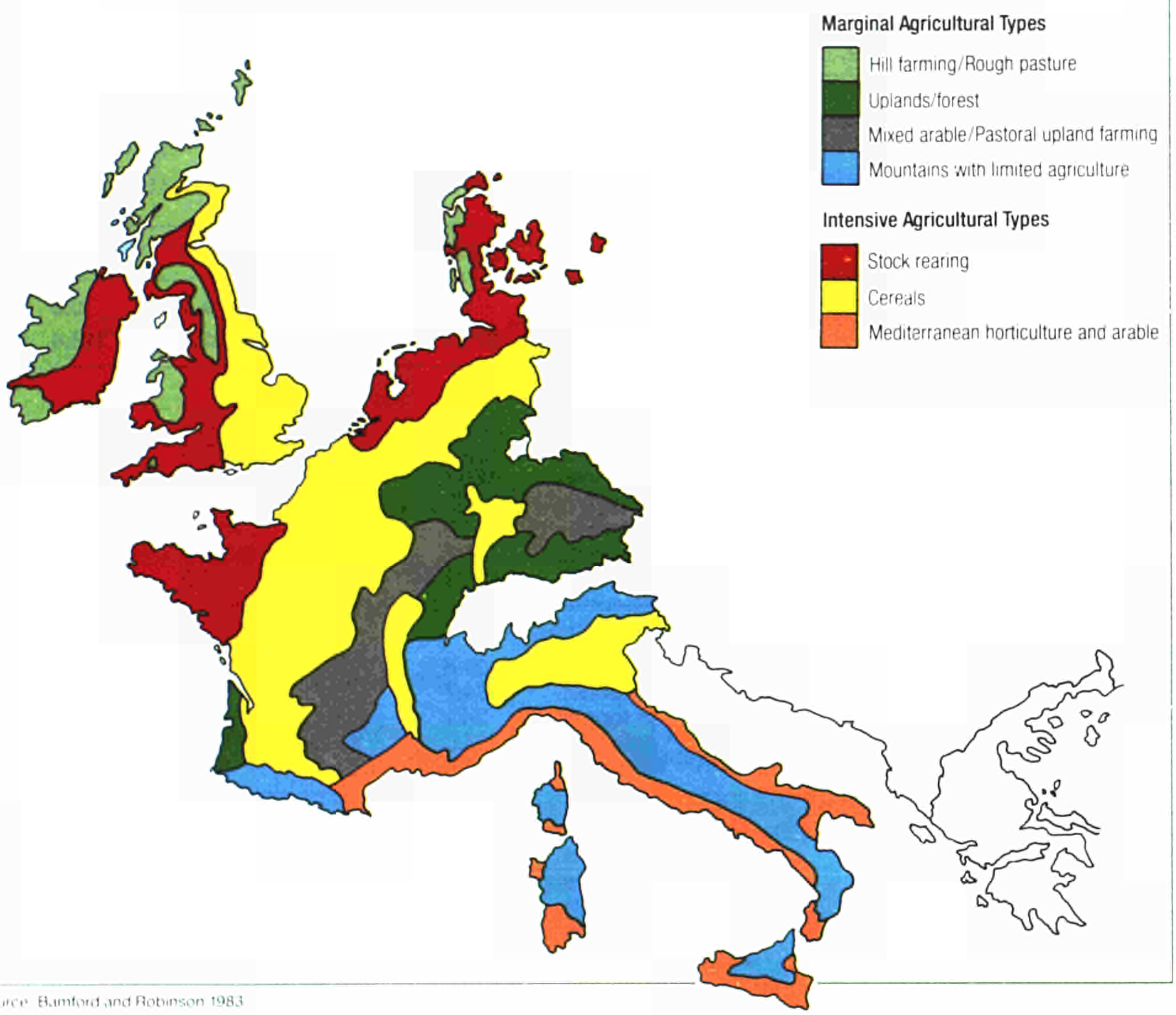
Figure 1.9 **Major industrial regions of the European Community.**



Source: Bamford and Robinson 1983

The position of this industrial corridor owes much to the interaction of resource location and historical factors - most notably the distribution of coal and iron ore deposits which played a major role in the industrial development during the nineteenth and early twentieth century. Although, today, steel production is on the decline and coal is no longer the foundation of industry which it was previously, the legacy of this historical location remains. Nevertheless, it is a legacy which is gradually diminishing. In recent years, a number of industries - especially iron and steel and power - have tended to move towards coastal sites. In addition, the effects of economic recession have been most acute in the heavy, traditional industries and have therefore hit the older industrial areas most severely. Conversely, new industries have been far more independent of either raw material locations or associated manufacturing activities, and have consequently responded to other factors such as market location, transport infrastructure, and the push or pull of industrial policies.

Figure 1.10 **Major agricultural regions of the European Community.**



Source: Bamford and Robinson 1983

Like industrial activities, the pattern of agriculture within the Community also owes much to environmental, political and historical factors. Any generalisations about agriculture must be treated with caution because of the great diversity of farming which occurs. Nevertheless, it is possible to identify several broad agricultural zones in the European Community (Figure 1.10). In the north and west, for example, a form of hill farming can be recognised, based primarily upon the rearing of sheep on upland, rough pasture. On the lower lands of the north-west, more intensive stock-rearing for milk and beef occurs, while over much of northern and central France, cereal cultivation predominates. In the Mediterranean region, arable-horticulture systems occur in coastal areas, but in the mountains agriculture is limited.

A major determinant of this distribution is climate (Figures 1.5-1.7). This operates both directly, by influencing the length of the growing season and the quantities of water and energy available for plant growth, and more indirectly through its control on factors such as the incidence of disease and trafficability of the land. Additionally, however, variations in topography, soil conditions, and the history of land tenure and use play important roles. These are expressed not only in the type of crop or livestock, but also in aspects such as farm size, rotation system and details of management practice - all of which in turn affect the state of the environment.

1.3.3 The European Community in a World Context

The large and varied industrial and agricultural foundations of the European Community make it one of the major economic forces in the world. Though much smaller in size than either the USA or USSR, for example, it ranks with both in the production of many basic commodities, and is outranked only by Japan in the manufacture of motor vehicles (Table 1.1). It is also a major importer of many resources, and one of the world's main markets for manufactured goods.

Table 1.1. **The European Community in a world context**

	Date	Units	EC10	USSR	USA	Japan
Area	**1982**	**million km²**	**1.7**	**22.4**	**9.4**	**0.4**
Population	**1982**	**millions**	**271.4**	**275.0**	**232.1**	**118.4**
Industrial production:						
Hard coal	1981	m tonnes	245.6	491.5	698.1	17.1
Crude oil	1981	m tonnes	98.5	609.0	478.4	0.5
Crude steel	1981	m tonnes	126.1	148.5	111.3	101.7
Aluminium	1980	m tonnes	2.2	2.4	4.5	0.7
Refined copper	1980	m tonnes	1.0	1.5	2.0	1.1
Refined lead	1980	m tonnes	1.2	0.8	1.1	0.3
Motor vehicles	1981	millions	10.3	2.2	7.9	11.2
Agricultural production:						
Cereals	1979-81	m tonnes	121.8	172.4	295.3	1.0
Potatoes	1979-81	m tonnes	34.7	76.7	14.8	3.4
Total meat	1982	m tonnes	24.1	15.4	25.0	3.0
Milk	1981	m tonnes	117.3	88.5	60.2	6.6
Sugar beet	1979-81	m tonnes	91.0	72.1	22.0	3.4
Imports:						
Food etc	1982	m ECUs	72,123	16,291	18,185	14,877
Fuel products	1982	m ECUs	146,547	752	66,765	67,095
Raw materials	1982	m ECUs	43,088	3,436	9,181	18,894
Machinery	1982	m ECUs	141,088	n.a.	74,838	7,854
Chemicals	1982	m ECUs	50,441	22,234	10,090	6,781

Source: data from Eurostat 1983, 1986

Such an active and broad-based economy inevitably impinges on the environment, both through its direct effects on environmental quality and natural resources and through the impetus it gives to environmental policies. Nor are these effects confined to the Community itself: they also have much wider significance. Wastes discharged by the Community, for example, add to the global sum of pollutants. According to estimates by OECD, the Community is responsible for about 14% of the world emission of sulphur dioxide, 13% of nitrogen oxides and about 9% of hydrocarbons. Human activities within the Community may also affect areas and resources of world importance, both within and outside the Community territory. Atmospheric emissions from the European Community, for instance, have been claimed as a major source of acid deposition in Scandinavia. In the past, Community trade in threatened wildlife species has added to the pressure on some rare plants and animals. Similarly, the European Community itself provides the habitat for a number of globally important migratory wildlife species. These are threatened not only by activities within the Community but also by activities such as hunting, trade and pollution outside the Community borders.

For all these reasons, the European Community takes an active part in a wide range of international initiatives concerned with the environment. As well as being signatory to several international conventions (Table 1.2), it is also involved in the environmental programmes of international organisations such as OECD, the Council of Europe and the Economic Commission for Europe of the United Nations. Indeed, international co-operation on the environment has been - and will increasingly continue to be - one of the main principles of Community policy.

Table 1.2 **Community participation in international conventions concerned with the environment.**

DATE OF CONVEN-TION	INITIATIVE	SCOPE AND FUNCTION
1963	Berne Convention	Setting up a Commission for pollution of the Rhine
1974	Paris Convention (Decision 1986)	Prevention of marine pollution from land-based sources
1976	Bonn Convention	Protection of the Rhine against pollution
1976	Barcelona Convention	Protection of the Mediterranean against pollution
1979	Bonn Convention	Protection of the Rhine against pollution by chemicals
1979	Berne Convention	Conservation of European wildlife and natural habitats
1979	Geneva Convention	Prevention of long-distance transboundary air pollution in Europe (Decision 1984)
1980	Canberra Convention	Conservation of marine fauna and flora in the Antarctic
1983	Bonn Agreement	Co-operation for dealing with pollution of the North Sea by oil and other substances (Ratification 1984)
1983	Barcelona Convention (4th Protocol)	Protocol covering specially protected Mediterranean areas (Ratification 1984)
1985	Vienna Convention	Protection of the ozone layer

Source: Commission of the European Communities 1984

NOTES AND SOURCES

Sources

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CHAPTER 2.

THE POLICY CONTEXT

2.1 ENVIRONMENTAL POLICY AND THE ENVIRONMENT

The state of the environment depends on many different and often contradictory factors. It depends on the character of the natural world, and the natural resources it contains, which form a base for all human activities: on the geology, climate, hydrology, soil, topography and ecology that make up the environment. It is a function, similarly, of man's own activities: industry, agriculture, recreation, forestry, fishing - all the myriad of human actions which modify and influence the environment. And it depends, also, on political actions: on the policies which directly or indirectly affect both the environment and other human activities within it.

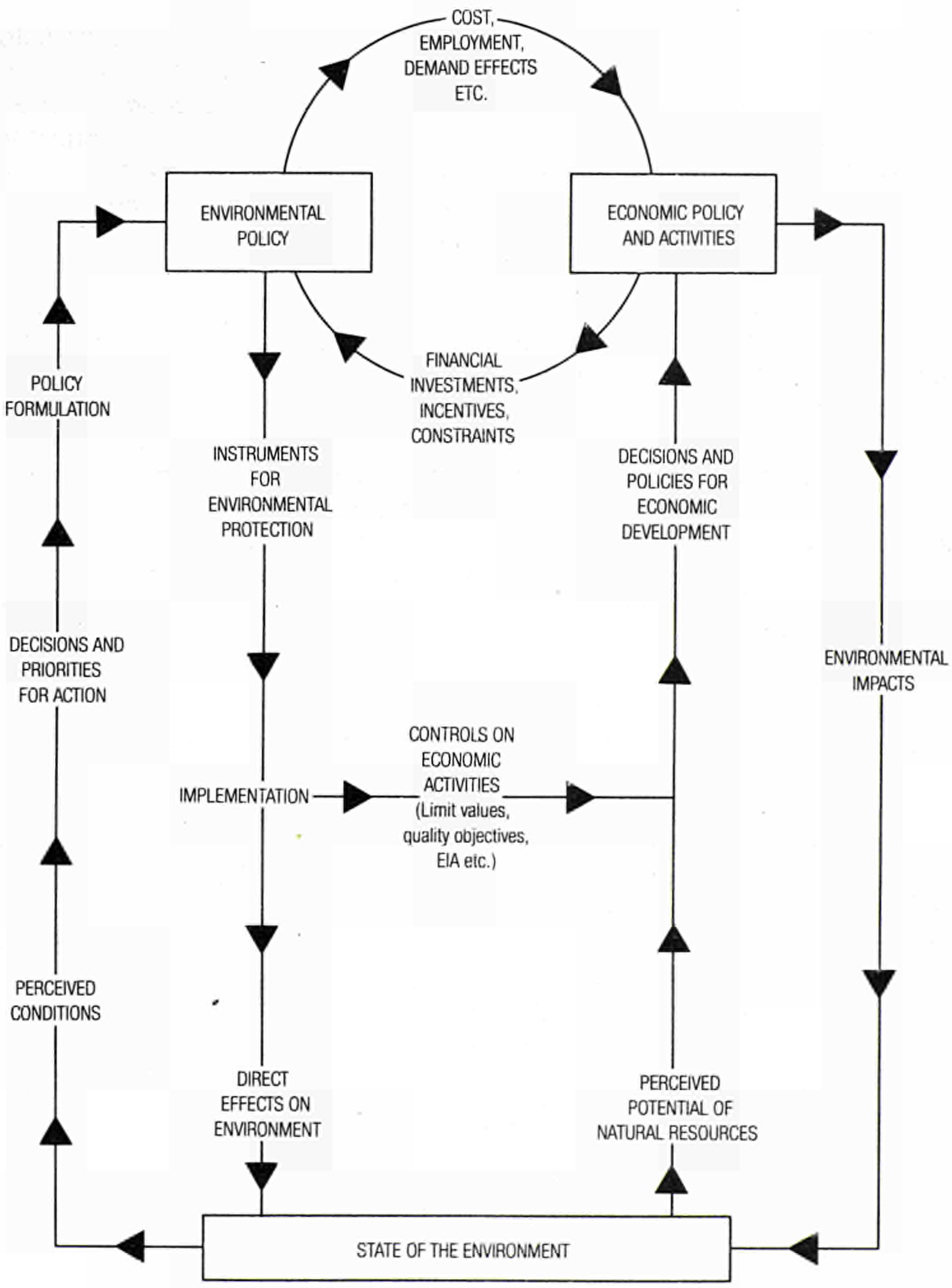
None of these factors can easily be separated. Each interacts with the others. Industrial activities, for example, both condition the state of natural resources and are conditioned by them. Indeed the environment acts as both determinator and determinant of all economic activities. In the same way, environmental policies are a response both to the perceived state of the environment and to the potential effects of economic activities. And, in turn, policies affect both. They alter or adjust the state of the environment, and they act to guide or regulate economic activities which have environmental impacts. Moreover, through affecting the environment themselves, these policies affect the conditions for economic activities - the availability and quality of resources. At the same time, they have an economic (and social) significance in their own right. As well as implications for employment, they influence technological innovation, resource and product substitution, training and education (Figure 2.1).

The role of environmental policies in the European Community is therefore a crucial one, not only to the environment itself but also more widely. It is a role which is performed at many different levels, by different components of the Community. It includes policies developed and implemented at all scales from the local to the regional, to the national and international. Each of these levels is vital, for the problems of the environment, and the needs for action to resolve them, themselves operate at all different scales. It means, however, that Community policy on the environment cannot be seen in isolation. It is complementary to the wide range of policies operating both within the member states and through international bodies (e.g. OECD, ECE, the Council of Europe). It is also, of course, related to other, non-environmental policies, such as the Regional Policy, Common Agricultural Policy or Common Transport Policy, which nevertheless have implications for the environment. Indeed, many elements of environmental control and protection are implemented through such policies, and one of the main aims of the Community's policy is to strengthen the environmental component of sectoral policies.

2.2 EVOLUTION OF THE COMMUNITY'S ENVIRONMENTAL POLICY

It was in 1971 that the Commission made its first detailed communication to the Council of Ministers on the need for a Community policy on the environment. This suggestion received strong support at the United Nations Conference on the Human Environment, held in Stockholm in 1972. At that meeting, attention was drawn to the need for rapid action if the world-wide problems of pollution, soil degradation, resource depletion, ecological damage and climatic modification were to be arrested and controlled. In 1972 the Heads of State and Government of the European Community, meeting in Paris, resolved to take action on the environment. As a result, the Community's First Action Programme on the Environment was drawn up, and formally adopted by the Council of Ministers in November 1973.

Figure 2.1 **The relationship between economics, environmental policy and the state of the environment.**



This programme was both wide-ranging and far-sighted. It laid down the principles on which the Community's environmental policy were to be based, and spelled out the actions which were to be taken. The main principles were that:

i. prevention is better than cure - the policy should prevent nuisances at source rather than merely counteract their subsequent effects.

ii. the polluter must pay - thus the costs of preventing and eliminating nuisances must be borne by the polluter.

iii. action to control pollution should be taken at the appropriate level and the Community and its member states must actively co-operate in international initiatives dealing with the environment.

iv. Community environment policy should aim, as far as possible, at the co-ordinated and harmonised development of national policies, without hampering progress at the national level.

v. environmental policy can and must be compatible with economic and social development.

vi. care must be taken to ensure that activities in one state do not adversely affect the environment in any other, and that major environmental policies in individual countries must no longer be planned and implemented in isolation.

vii. the Community and its member states must take account of the developing countries in formulating their environmental policies.

In this context, four main fields of action were defined, covering:

- reduction, elimination and prevention of pollutants and other nuisances.
- non-damaging use and rational management of land, environment and natural resources.
- general action to protect the environment.
- international co-operation on the environment.

The 1973 Action Programme on the Environment thus provided the framework for environmental policy in the Community. Since 1973, however, it has been updated and re-affirmed on two occasions: by the Second Action Programme in 1977 and the Third Action Programme, adopted in 1983. Over this period, policy on the environment evolved as a new understanding of the problems was gained. Whilst the same principles and themes continued to underlie the policy, therefore, their relative emphasis changed. In the process, environmental policy became recognised as a major force in the Community, and in 1986 acquired full policy status in the revised Treaty of Rome. Now, the Fourth Action programme on the environment (which will guide policy during the period from 1987-1991) is being prepared for adoption by the Council at the end of 1986. As well as continuing and reinforcing established policies, this will focus on a number of new issues. Consequently, more fundamental changes are occurring in the orientation of environmental policy in the Community.

PUBLIC ATTITUDES TO THE ENVIRONMENT

Recent years have seen a significant growth in public concern about the state of the environment in the European Community. The origins of this heightened environmental awareness are a matter of some controversy, and many factors have certainly been involved. During the 1960s, for example, scientific interest in environmental systems developed, with the emergence of Ecology as a major discipline. Some of this thinking was subsequently opened to public debate through books such as Rachel Carson's 'Silent Spring' and studies such as The Limits To Growth, by the Club of Rome. In addition, numerous pressure groups were established, voicing public fears and directing attention to specific problems. At the same time, incidents such as the *Torrey Canyon* accident in 1967, the *Amoco Cadiz* disaster in 1978, and the Seveso catastrophe in 1976 highlighted the dangers of pollution and the potential impacts of human activities.

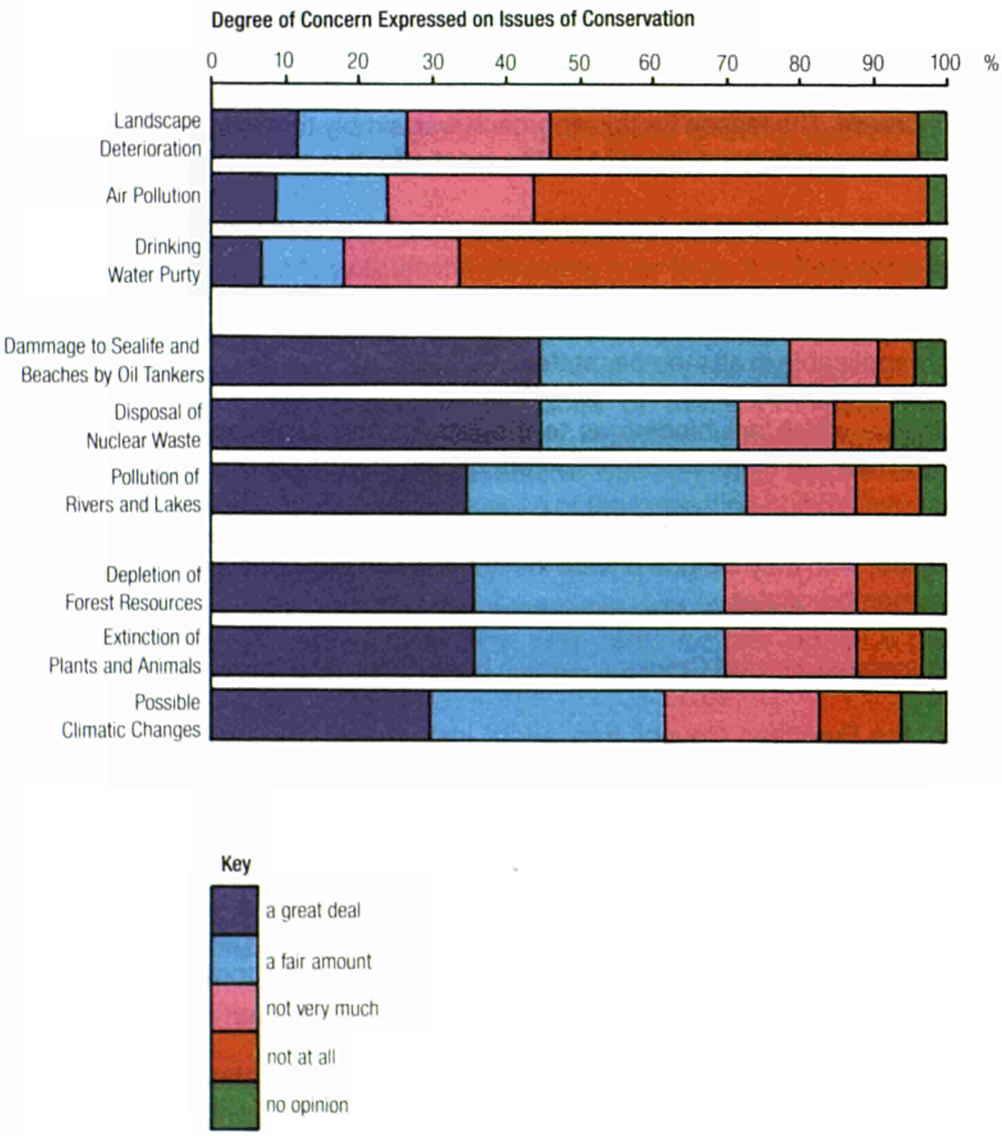
Changing public attitudes to the environment in the European Community have been monitored by a series of opinion polls. The first, in 1973, asked respondents in the then nine member states to list ten problems of national or global concern according to their relative importance. In response, pollution was cited as the most important problem, ahead of inflation, poverty and unemployment. Since then, of course, economic problems have undoubtedly grown in stature, but similar surveys in 1976 and 1978 generally confirmed the earlier findings, with nature conservation and pollution control being ranked among the three most crucial concerns.

More recently, public opinion on the environment has been investigated by a wider survey of the ten member states in 1982, in which almost 10,000 people were asked for their opinions on a range of environmental issues. As in the earlier surveys, the questions which were posed elicited a strong sense of concern about the state of the environment. At the local level, the main worries were about landscape deterioration and noise pollution: over a quarter of the people interviewed were 'fairly' or 'greatly' concerned by these problems. The real environmental fears, however, were about wider issues, at a national or global scale. Over forty per cent of respondents, for example, expressed great concern about marine pollution and the dangers of chemical and nuclear wastes. Over a third were similarly worried about the other issues considered: long-range pollution, air pollution, stream and lake pollution, and damage to plants, animals and forest resources.

Some differences in the level of concern were apparent between member states. On the whole, least concern was expressed in Ireland and Belgium, most in the Netherlands and Germany. Similarly, problems perceived as being the most critical, both at a local and general level, also varied from one country to another (Figure opposite). Overall, however, the main concerns at the national and global scale related to marine pollution, chemical wastes and nuclear wastes. At the local scale, greatest fears were expressed about landscape deterioration and noise pollution.

Opinions about the environment, of course, are not always backed up by a willingness to pay - in economic or social terms - for the improvements demanded. For this reason, people in the sample were asked 'trade-off' questions: whether they would be willing to accept higher prices or some reduction in economic growth in order to protect the environment. The strength of commitment to the environment is indicated by the fact that approximately 60% of respondents felt that priority should be given to environmental protection. Nor were these opinions affected to any significant extent by the regional economic situation of the people interviewed. Comparisons of attitudes in areas of relatively high and relatively low unemployment, for example, revealed almost no differences in the responses to these trade-off questions. The results clearly show, therefore, that even in a time of high unemployment in the Community the need for environmental protection continues to be a priority of increasing importance for most Europeans.

Public attitudes to the environment: responses to a questionnaire survey of Community citizens.



Source: Commission of the European Communities 1983 *The European and their environment* Brussels: Commission of the European Communities

2.3 NEW DIRECTIONS IN ENVIRONMENTAL POLICY

The change which is now being seen in the Community's environmental policy has not occurred dramatically. Nor is it simply one of scope: it is also one of principle and of means. It has been stimulated by the recognition that, for all their success, earlier approaches to the problems of the environment could not supply the complete answer. They were limited not only by the nature of the procedures being used and by the character of the Community itself, but also by the serious lack of financial and staff resources which were available.

2.3.1 Implementation, Enforcement and Operation of Community Policies

Following the adoption of the 1973 Action Programme, the Community introduced a wide range of initiatives to tackle the problems of the environment. From the start, action was mainly through the use of legislative and administrative provisions, designed to reduce pollution or, at the very least, arrest its increase. The reason for this approach was simply that, given the structure of the Community, such provisions were considered to be the most effective and rapid in their influence.

The Community uses five main forms of action, as set out in Article 189 of the EEC Treaty. These are:

i. Regulations - which have general application, and are binding in their entirety and directly applicable in all member states.

ii. Directives - which are binding as to the result to be achieved upon each member state, but leave to national authorities the choice of form and methods.

iii. Decisions - which are binding in their entirety upon those to whom they are addressed, who may include private institutions and individuals and legal persons, as well as member states.

iv. Recommendations and Opinions - which have no binding force.

In addition, the European Council may adopt instruments of a political nature, such as resolutions and declarations.

The main instrument of environmental policy has been the use of Directives, and in all about 120 Directives relating to the environment have been adopted (many of which will be outlined in subsequent chapters). These Directives have mainly been concerned with setting common standards for environmental quality, for emissions and for treatment procedures such as waste storage and disposal. These have been backed up in many cases by the definition of agreed monitoring procedures.

To transform these into action in the field, however, two further steps are required. First, each member state must pass the appropriate national legislation. Secondly, the national legislation must be applied (and enforced) at ground level. During both these steps, the objectives of the initial Directive may be misinterpreted or distorted. Thus, irrespective of the appropriateness, thoroughness or comprehensiveness of the original Directive, what is finally implemented in the field may be very different from what was intended, and a number of Directives have not been as effective as initially hoped (see, in particular, the discussions by Scheuer 1983 and Schneider 1984).

There are a number of reasons why this is so. Inevitably, most member states aim to minimise the degree of change in their own, existing procedures which is necessary to comply with the Directives. They thus tend to interpret the text of the Directive in this light. Especially where the aims and requirements of the Directive are at all vague, this provides considerable scope for modification of the initial intention of the policy. Moreover, in many cases, the Directive has left the decision of how or where to apply its provisions to the member states - for example, in the Fishing Water Directive, and the designation of shellfish waters in the Directive of that name. This has resulted in some cases in marked discrepancies in the action taken in the different member states. Additionally, the machinery for application and enforcement of the Directive's provisions is not necessarily perfect and may vary from region to region or country to country. Consequently, whatever the intention of the member state, the operation of the Directive in the field may be uneven and incomplete.

The European Commission exercises control over the implementation of Directives by Member States. Where the latter do not implement Directives, or implement them incorrectly, in breach of their treaty obligations, the Commission - after following a warning procedure - normally takes action against the member states concerned before the European Court. The majority of such cases relate to the failure to adopt the necessary implementing measures. The more complex, but very significant problem of how rigorously the Directive is being applied in practice, and how effective in environmental terms the measures are, is more difficult to evaluate.

These difficulties arise for a number of reasons, most of which are well-known. Because factors other than Community policies are changing over time, it is frequently impossible to isolate the effects of these policies from those of other factors: for example, changing levels of economic activity, technological development, changes in consumer preference and demand, natural (and often cyclical) changes in the environment, or other national and regional policies affecting the environment. Moreover, information on the state of the environment with and without the environmental legislation (e.g. before and after its adoption) is rarely available in any consistent or comprehensive form. Even where such data are available, it must also be recognised that many of the effects of policy may in fact occur in advance of the legislation coming into force: industries often adopt new standards or procedures in anticipation of the legislation.

The need for reliable and readily accessible data to monitor the effects of environmental policies nevertheless remains a crucial one, and partly for this reason a programme has been adopted to improve data availability and compatability in the Community (CORINE: see Inset, page 28).

The importance of environmental data, however, goes far beyond the evaluation of existing policies. They are also needed to help identify problems and to assess the potential effects of future policies or projects. In this way, action can be more closely directed towards the major problems and policies can be made much more effective and cost-efficient: a 'shot-gun' approach to environmental problems can be avoided. The co-ordinated information system being established under the CORINE programme will undoubtedly play a major role in this context. Equally important will be the Directive on the implementation of environmental impact assessments for major development projects (see Inset, page 32).

2.3.2 Cross-Media Approaches to the Environment

Developments in public and political concern for the environment during the 1960s and 1970s were associated with an increasingly holistic perspective of the world. From this viewpoint, the environment was seen as a system, characterised by a multitude of complex inter-relationships, and in which human activities have considerable, and often unforeseen, effects. Incorporation of this perspective into policy-making, however, is no easy task. For example, full account must be taken of all the significant interactions between pollutants, receiving media and emission sources (e.g. industrial or agricultural sectors). As a consequence, information requirements are potentially formidable, and sophisticated administrative structures are required to operate the necessary procedures.

CORINE: A CO-ORDINATED INFORMATION SYSTEM ON THE STATE OF THE ENVIRONMENT AND NATURAL RESOURCES OF THE COMMUNITY

From the early years of the European Community's environmental policy, one thing has been apparent: that the effective development and implementation of that policy depends upon the availability of appropriate information on the state of the environment. Information is needed for many reasons:

- to provide an overview of the Community so that regional, national and Community policies can be put into a wider environmental context.
- to show where within the Community particularly important environmental resources exist so that the necessary steps can be taken to ensure their protection and wise management.
- to highlight the major environmental problems which exist in the Community, so that the necessary remedial action can be taken as efficiently as possible.
- to show trends in environmental conditions and in the factors affecting the environment so that future problems can be more reliably predicted.
- to monitor changes in the state of the environment so that the success, or otherwise, of Community environmental policies can be assessed.
- to ensure that Community policies operate fairly across the whole Community, and that national and regional policies do not impinge on neighbouring areas or member states.
- overall, to ensure that every action which is taken to protect or improve or manage the environment and natural resources of the Community is taken in as effective and cost-efficient way as possible.

In an area as large and diverse as the European Community, however, the provision of such information poses considerable problems. Admittedly many data already exist at a regional or national level, but all too often these are not readily accessible or are not available in a consistent form. In many parts of the Community data are also lacking or incomplete. Moreover, although much new data collection is taking place in the member states, the methods being used and the type of data being obtained frequently vary, so that the results cannot easily be integrated to give an overview of the Community as a whole.

For all these reasons, one of the major priorities of the Community's Environmental Action Programme has been the improvement of data availability. And, in 1985, one of the most important instruments in this policy was adopted: a Decision to establish - initially on an experimental basis - a co-ordinated information system on the state of the environment and natural resources.

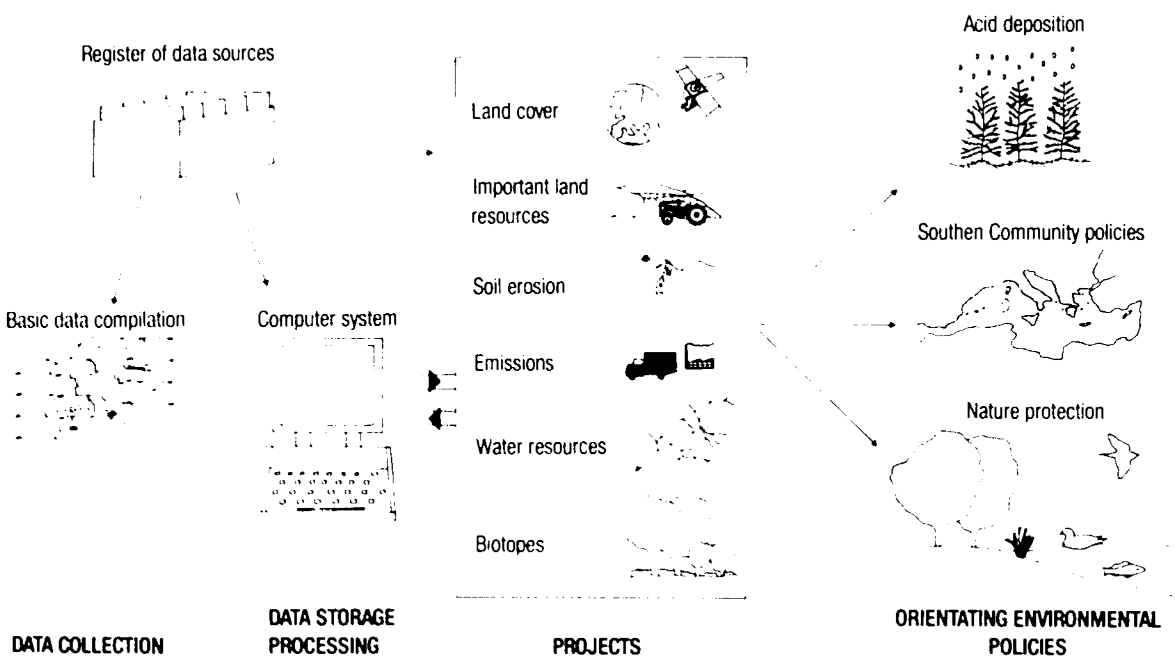
The aims of CORINE are clear. It is to create a consistent and effective framework for the collection, storage, analysis, presentation and interpretation of environmental data within the Community. As such it is concerned not only with collating existing data and making them more readily accessible. It also has the aim of encouraging new data collection and of giving the guidance necessary to ensure that this takes place in an efficient and compatible way.

This cannot be achieved overnight, of course, nor can all the needs for information on the environment be tackled at once. Attention is therefore being focused on a number of inter-dependent priority areas (Figure, below). These include:

- the establishment of a register of biotopes of importance for nature conservation.
- collating and making consistent the wide range of data currently being collected on acid deposition.
- co-ordinating information on the state of the environment and resources in the Mediterranean region.
- more generally, laying the foundations for more consistent data collection and analysis in the member states and at international level.

This programme is as yet in its infancy, and operational results are only beginning to emerge. Some of these results (e.g. on biotopes) are used in this report. Subsequent reports on the state of the environment, however, will be able to draw much more extensively on the data provided through CORINE, and many of the caveats and qualifications expressed in the following pages - about data comparability and consistency - will no longer be necessary. Then it will be possible to obtain a much more reliable overview of conditions in the Community. Then, it will be feasible to develop and assess policies on the environment in a much more informed and objective framework.

The CORINE programme: 1985-1989



At the time of the adoption of the Community's first environmental action programme, in 1973, the procedures for tackling environmental problems in this way were still not wholly evolved. The programme was thus directed mainly at problems within the various media, and in particular at industrial sectors where urgent action was considered necessary and which could not wait the refinement of an interactive procedures. As a result, a broadly sectoral approach was followed throughout the early years of the environment programme, not only by the Community, but by almost all institutions concerned with the environment. To a great extent, the environment was considered in terms of its different media - the air, land, waters, wildlife - and most actions adopted by the Community related specifically to particular media.

In more recent years, the limitations of this approach have become apparent. Many of the problems which have emerged relate not to individual media but to the transfer of pollutants or other substances from one part of the environment to another (e.g. cadmium, acid deposition, nuclear wastes). Action to limit environmental damage is consequently most effective when it is taken at source rather than in each sector of the environment separately. The need, therefore, is frequently to develop policies relating not to the media themselves, but to the flows which link them. Out of this has come the awareness of the need for a preventive, cross-media approach to the environment. Policy in the Community is increasingly following this approach, a particularly notable example being the control of chemicals in the environment (see Inset, page 34).

2.3.3 Towards a More Regionalised Environmental Policy

As Community environmental policies have developed, it has become increasingly clear that many of the environmental problems which currently face the Community differ in their character, magnitude and causes from one part of the Community to another. To take account of this, policies need to be sufficiently flexible to accomodate the variations in circumstances which are encountered.

The reason for this diversity of problems arises from the fundamental diversity of environmental, economic and social conditions in the Community. As was noted in Chapter 1, the physical environment varies markedly, often over short distances, so natural resources differ from one area to another. In the same way, economic and social activities - and thus the pressures acting on the environment - show considerable local and regional variation. As a consequence, the problems facing the Community are far from uniform. The policies adopted to tackle these problems therefore need to be equally varied and flexible (see, for example, Weinstock 1985, Schneider 1984).

Many problems, for example, are extremely localised in their distribution, though they may nevertheless be of Community importance because they involve resources or features of pan-European significance. This is particularly so in the case of protection of rare wildlife species, such as the Mediterranean monk seal. In other cases, the problems are more widespread but differ markedly in their intensity from one area to another. Thus, levels of nitrate pollution in groundwaters vary greatly across the Community, depending on rates of input from agriculture and industry and the specific hydrogeological characteristics of the aquifers. In yet other cases, the problem is more-or-less ubiquitous but may arise from very different causative factors in different areas. Loss of habitats, for example, is occurring throughout much of the Community, but is due variously to agricultural intensification and extension, urban, transport and tourist development, pollution and natural causes.

In all these cases, the use of general, blanket policies has a number of drawbacks. Such policies do not recognise the differences in conditions which exist in different areas. As a result, they may lead to the adoption of inappropriate actions in those areas where problems do exist, or unnecessary actions in areas where the problem is negligible. At best this is likely to result in the policies being more expensive than they need be, with a consequent waste of valuable human and natural resources. At worst they are also likely to be ineffectual for they may not even tackle the basic problems in the crucial areas.

The need in many instances, therefore, is for a more regionalised approach to environmental policies. The policies adopted need to contain the flexibility to permit appropriate measures to be introduced in each area according to the specific conditions. They need, in many situations, to involve not single, Community-wide standards, but minimum standards which can be tightened or strengthened where necessary. They need in other cases to encourage or require specific, on-site action to protect important natural resources or ensure that particular preventive strategies are followed. As a result, they need also to be able to evaluate the nature and magnitude of the problem in each case, so that the appropriate action can be defined and implemented. In this context the adoption of requirements for environmental impact assessments in conjunction with major developments, and the establishment of a Community environmental information system are obviously of fundamental importance.

The problem of regionalisation is not confined to the definition and implementation of environmental standards or other policies. It is also a financial question. The principle established in the Community's environmental policy that the polluter pays means that the responsibility for bearing the cost of eliminating pollution lies with the producer of that pollution. On the other hand, environmental policies must realistically take account of variations in the ability of producers to bear the costs involved. Thus, appropriate financial provisions need to be made on a regional basis to ensure that the environmental requirements for integrated regional development are met.

2.3.4 Economics and Environmental Policy

It is often argued that the priorities of economic development and environmental protection seem to be in direct opposition to each other. The ultimate purpose of environmental policy is to safeguard and improve the quality of life for the existing population and for future generations. In economic terms, the measures which are necessary to meet this objective have certain benefits and costs. The principal benefit comprises limitations of environmental damage arising from previous neglect - for human activities frequently give rise to problems such as pollution, dereliction, loss of habitats and wildlife species, and waste of resources. At the same time, avoidance of environmental damage naturally entails certain costs, which may be perceived as constraints on economic activities. They may demand that detailed environmental impact assessments are carried out before developments are undertaken. They may require the adoption of specific, environmentally sensitive technologies. They may define quality objectives or set emission standards which the industries involved are obliged to meet. Each of these requirements might cause delays in development or create additional costs for the activities concerned: in all cases the costs involved must be weighed against the potential environmental benefit.

To some extent, acceptance of the need for particular measures may be impeded because, while the costs are apparent and borne by identifiable groups, the benefits are more diffuse and accrue in the longer term. Nevertheless, policies must be judged on their merits, and it needs to be recognised that in many instances costs may be more than offset by the many benefits resulting from environmental protection. These benefits include:

- the reduction in costs of environmental damage and the savings in damage repair;
- the employment generation associated with the necessary technological innovation, and all the related multiplier effects on demand and employment;
- the stimulus to demand created for environmentally-friendly products, and their concomitant multiplier effects;

ENVIRONMENTAL IMPACT ASSESSMENT IN THE EUROPEAN COMMUNITY

One of the most important principles of the Community's environmental policy, from the very start, has been that prevention is better than cure. The principle is clearly a crucial one, but how can it be applied? How, for example, can the effects of economic activities be predicted? And how can the sources of pollution be identified? One solution which is being adopted in the European Community is to implement systems of environmental impact assessment.

Environmental impact assessments (EIAs) were first adopted in the USA, within the framework of the National Environmental Policy Act of 1969. Since then, they have become integral parts of planning procedures in many countries, including Canada, France, the Netherlands, Germany, Ireland, Norway and Sweden, as well as several Third World countries. Their objective is straightforward: "to ascertain, as far as is feasible, the full range of impacts on human activities in the environment so that optimal decisions can be taken and adverse consequences avoided" (Caldwell, 1983). Their application, however, may vary considerably, both in terms of the conditions under which they are applied (e.g. for what type of project, at what stage in the planning process), and the manner of their use (e.g. what assessment procedures are employed). For these reasons, one of the needs in the Community was to agree on the general principles to be followed by EIAs, whilst leaving member states free to incorporate them into their existing law and practice in the most appropriate way.

Projects for which EIAs are obligatory

1. Crude-oil refineries (excluding undertakings manufacturing only lubricants from crude oil) and installations for the gasification and liquefaction of 500 tonnes or more of coal or bituminous shale per day.
2. Thermal power stations and other combustion installations with a heat output of 300 MW or more and nuclear power stations and other nuclear reactors (except research installations for the production and conversion of fissionable and fertile materials, whose maximum power does not exceed 1 kW continuous thermal load).
3. Installations solely designed for the permanent storage or final disposal of radioactive waste.
4. Integrated works for the initial melting of cast-iron and steel.
5. Installations for the extraction of asbestos and for the processing and transformation of asbestos and products containing asbestos; for asbestos-cement products, with an annual production of more than 20,000 tonnes of finished products, for friction material, with an annual production of more than 50 tonnes of finished products, and for other uses of asbestos involving more than 200 tonnes per year.
6. Integrated chemical installations.
7. Construction of motorways, express roads and lines for long-distance railway traffic and of airports with a basic runway length of 2,100 m or more.
8. Trading ports and also inland waterways and ports for inland-waterway traffic which permit the passage of vessels of over 1,300 tonnes.
9. Waste-disposal installations for the incineration, chemical treatment or land fill of toxic and dangerous wastes.

To this end, a proposal for a 'Council Directive Concerning the Assessment of the Environmental Effects of Certain Public and Private Projects' was submitted to the Council of Ministers in 1980. After long and difficult discussions at all levels in the Community, the Directive was finally adopted in 1985. Member states are obliged to comply with its provisions within three years.

The Directive identifies two types of project, listed in annexes to the main text. Annex 1 includes projects which, mainly by their nature or size, can be expected to have an impact in almost all circumstances (Table opposite). For these, an EIA is obligatory. Annex 2, on the other hand, outlines projects related to agriculture, extractive industries, manufacturing, energy production, infrastructure and waste disposal which will not, perforce, cause significant environmental effects but which may do so under certain circumstances. In these cases EIAs are required where considered necessary by the member states.

No attempt is made in the Directive to specify the exact procedures to be applied in performing the EIA. Nevertheless, for the sake of consistency, a broad outline of what the EIA should include is given. It is therefore stated that the EIA should identify, describe and assess the direct and indirect impacts of a project on:

- human beings, fauna and flora
- soil, water, air, climate and landscape
- the interactions between these factors
- material assets and cultural heritage.

The information provided thus includes a description of the project and of the environment to be affected; the alternatives studied by the developer; significant effects; mitigation measures; and a non-technical summary. This information provides both a basis for consultation with other authorities and the public, and for decisions to be made about the project. In addition, the Directive specifies that, where a project is likely to have a significant effect on the environment in another member state, the information should also be made available to that state.

Without doubt this Directive will play a crucial role in environmental policy in the Community in the years ahead. It will help to avoid impacts on the environment as a result of development and will make both developers and the public more environmentally conscious. It will also help to provide data on the environment which can more rationally be compared with other relevant information - for example on the economic and social implications of any planned development. Admittedly there may be some cost involved - in delays to projects (especially where the developer has not thought carefully or soon enough about the environmental implications), and in applying the necessary environmental protection measures. But these costs will be offset not only by the environmental improvements which are obtained, but also by the greater efficiency in fulfilling the necessary environmental protection: for example, by identifying much more clearly where problems exist, what the necessary remedies are, and how best to apply them in relation to specific projects. This will reduce the need for much more costly blanket controls on the environment and economic activities.

This, however, is not the only role of EIA. Increasingly in recent years it has been recognised that the need is to evaluate not only individual projects but the policies and plans which underlie them. In the future, therefore, attention is likely to be focused more on introducing EIAs even earlier in the development and decision-making process. This will ensure the much more efficient use and protection of the Community's environmental resources.

CHEMICALS IN THE ENVIRONMENT: AN EXAMPLE OF A PREVENTIVE POLICY

The problems posed by chemicals in the environment are both serious and far-reaching. Many chemicals are hazardous or toxic, not only to humans but also to other organisms. Consequently, they may have direct impacts upon human health and on wildlife populations. Moreover, many chemicals are highly mobile: they move freely and swiftly through the environment and may thus contaminate a wide range of media. At the same time, some chemicals are persistent. Even when released into the environment in small quantities, therefore, they may accumulate until they reach toxic levels.

For all these reasons, the control of chemicals in the environment has been a priority concern in the European Community, and a number of actions have been adopted over the last ten years. All are based on the same fundamental principle: that prevention is best achieved by controlling the chemical at source.

It is this principle which thus underlies the Sixth Amendment - the Directive which sets the framework for Community policy on chemicals in the environment. This was passed in 1979 as an amendment to the original 1967 Directive on the classification and packaging of dangerous chemicals in the Community. Its aims are simple:

- to provide adequate protection for people and the environment from the potentially harmful effects of chemical substances.

- to establish uniform notification procedures for new chemicals and classification and labelling procedures for all dangerous chemicals.

- to protect the viability of the chemical industries while facilitating trade within the Community by avoiding potential trade barriers.

As such, the Directive establishes a single 'doorway' through which all new chemicals must pass as they enter the Community market. As they do so they can be screened for their potential human and environmental impacts. This is achieved by requiring manufacturers or importers to file a notification on the chemicals, giving, amongst other things, information on the production quantities, uses, safety measures, toxicological and ecotoxicological tests, and ways of rendering the substance harmless. More stringent tests are required for substances with production levels of over 100 t/yr or 500 t total, and again when marketing levels reach 1,000 t/yr or 5,000 t total.

These requirements apply to all chemicals first brought onto the market in the European Community after 18 September 1981. The Directive has now (August 1986) been in force, therefore, for about five years. Over that time more than 100 new chemicals have been notified, many of which are classified as dangerous.

This, however, represents only one part - and a small part - of the overall story, for the Directive also provides for the classification and labelling of existing chemicals. All substances which were on the market between 1 January 1971 and 18 September 1981 are included in the European Inventory of Existing Commercial Chemical Substances (EINECS), which is due for publication in 1986. It is a formidable list, containing some 95,000 chemicals. So far about 1,000 of these have been identified as dangerous and classified and labelled accordingly. Of the remainder, possibly a further 20,000 are also dangerous; but it will be many years before they have all been investigated and evaluated.

The Directive also defines exactly what is meant by 'dangerous'. This term covers, for example, substances which are very basic, harmful, corrosive, carcinogenic or which may damage the environment. The substances which are of most concern to the public are those known to cause cancer. The Commission is in the process of drawing up a list of carcinogenic substances; at the present time 27 have been classified (see Table, below), and a further 58 are under consideration.

Substances classified as carcinogenic under the Sixth Amendment Directive (as at mid-1986)

1. Benzidine
2. Salts of benzidine
3. 2-napthylamine
4. Salts of 2-napthylamine
5. Zinc chromate
6. Benzene
7. Bis-(chloromethyl)-ether
8. (Chloromethyl)-methyl-ether
9. 4-aminobiphenyl
10. Salts of 4-aminobiphenyl
11. Epichlorohydrin
12. 2-nitropropane
13. 3,3'-dichlorobenzidine
14. Salts of 3.3'-dichlorobenzidine
15. 1,2-dibromoethane
16. 4,4'-methylenbis (2-chloroaniline)
17. Salts of 4,4'-methylenbis (2-chloroaniline)
18. Calcium chromate
19. Strontium chromate
20. N,N-dimethylnitrosamine
21. Dimethyl sulphate
22. Diethyl sulphate
23. Acrylonitrile
24. Cadmium chloride
25. 1,2-dibromo-3-chloropropane
26. 5-nitroacenaphthene
27. 2-methylaziridine

In these ways the Directive provides both for the clasisification and for the notification and labelling of chemicals. This ensures that dangerous chemicals are not marketed and used inappropriately because manufacturers are required to identify in advance the potential risks and to take the necessary steps to control them.

The classification and listing of chemical substances is clearly a crucial step in any attempt to control their impact on the environment. Nevertheless, it is not sufficient on its own. However rigorous the notification procedure, chemicals may still escape into the environment either by illegal release of listed substances or through industrial accidents. The catastrophic impact of accidents was all too starkly demonstrated by the Bhopal incident in India in 1984, when the escape of methyl gas from a chemical plant led to the deaths of several thousand local inhabitants and the long-term injury of many more. Closer to home was the accident at Seveso in Italy, in 1976, when a dioxine leakage resulted in 193 people being injured.

The Seveso accident did not go unnoticed. As a result of the incident, the Community adopted a Directive in 1982 to control major accidents from certain industrial activities. It allocates the responsibility for controlling such accidents carefully between the plant operators, the member states and the European Commission. Manufacturers must consider the potential risk of accidents in their plants and introduce the necessary measures to avoid accidents. In addition, they must adopt plans and procedures for limiting the size and effects of accidents. Member states must ensure that these responsibilities are met. The Commission must maintain a register on accidents. Moreover, the Directive lists 178 dangerous chemicals - among which are more than 50 toxic or highly toxic substances, about 60 explosive substances and 20 carcinogens - which are subjected to strict notification procedures whenever they are produced in quantities greater than a specified threshold. For the most dangerous substances, such as TCDDs, the threshold quantity is 1kg; for some flammable liquids it rises to 50,000 tonnes.

Together, the Sixth Amendment and Seveso Directive provide the backbone to the Community's policies on the control of chemicals in the environment. By design this is a preventive policy. Its aim is to minimise the problems posed by chemical substances by ensuring that the smallest possible quantities ever reach the environment. Because of this it is impossible to evaluate its effect by analysing change or improvement in environmental conditions. Its success is reflected not in what is but what might have been.

- the improvement in environmental conditions created for other activities (i.e. those not responsible for the damage); for example, increased tourist opportunities or agricultural yield as a result of reduced industrial pollution;

- the savings in resource use and reduction in wastes by all the activities concerned.

Unfortunately, it is inherently difficult to assess many of these benefits and data on many components in the balance are scarce (c.f. Section 10.4). As a result, many of the costs and benefits of environmental policies are not included in national accounts. Even so, evidence is increasing that the economic benefits of environmental policies are often much higher than has generally been thought, and that - especially in the longer term - the net economic effects are positive (see, for example, OECD Conference on Environment and Economics, Conclusions, June 1984, Paragraph 8). Moreover, direct economic benefits to industry should not be overlooked. Increasingly, for example, it is seen that the adoption of strategies such as recycling, energy conservation and raw material substitution can have direct advantages in terms of reducing costs or making the end products more marketable. In addition, many companies have cited other benefits from adopting pollution control measures, including improvements in public image and better staff relationships.

Nevertheless, it also has to be admitted that, as with any form of investment, the perception of costs and benefits of environmental measures is sensitive to the overall economic climate. When the economy is in recession, for instance, environmental measures may appear less acceptable because they are more readily viewed as a threat to the viability of industrial enterprises.

The importance of the economic dimension in environmental policy was, in fact, recognised very early in the Community. The First Action Programme on the Environment stated the need for environmental policy to go hand in hand with economic and social development. Since then, this principle has been restated and developed in the Second (1977) and Third (1982) action programmes. Similarly, the European Council, meeting in March 1985, stressed that environmental protection policy can contribute to economic growth and employment. The same point was made by the Western European Summit in Bonn, in May 1985, and has been further emphasised by three recent OECD Ministerial Conferences. All agree that continued environmental improvement and sustained economic growth are essential, inter-related and mutually supportive policy goals.

This objective is now being pursued in a number of ways. The introduction of environmental protection measures, for example, is being re-evaluated in the light of these considerations. There is increased emphasis on value for money in environmental policy through assessment of costs and benefits of environmental measures. This takes into account the possibilities for cost savings by the phased introduction and implementation of environmental standards, over a time period which gives the industries involved sufficient opportunity to adjust, and thus does not damage their viability. The polluter pays principle, similarly, will remain a central feature of Community policy, subject to exceptions to allow for variations in the ability to pay from one part of the Community to another. Indeed, in certain circumstances - and particularly in disadvantaged areas of the Community - the transition to higher control standards may need to be eased by the provision of state aids for pollution control. Continued stress is also being placed on the need to reduce wastes and to develop cleaner technologies: many of the more polluting industries are associated with relatively obsolete and inefficient technologies, so such policies may help to encourage more efficient production systems, as well as reducing pollution.

A further development will be a greater recognition of the environmental dimension in all Community policies. This will promote full recognition of potential adverse effects, and hence the inclusion of environmental benefits in the assessment of policy measures.

These new developments in environmental policy are of great importance. A flourishing economy undoubtedly provides the scope for an active and effective environmental policy, though of course it does not guarantee it. Improved use of natural resources - avoiding waste, damage or unnecessary conflict - can increase economic efficiency. Integration of environmental protection into the Community's economic planning, therefore, is essential for economic as well as environmental reasons. Indeed, environmental protection and the rational use of natural resources can be regarded simply as a balanced and sensible long term economic policy. It is the recognition of this that will guide environmental policy in the Community in the coming years.

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PART TWO

ECONOMIC ACTIVITIES

CHAPTER 3.

URBAN AND INDUSTRIAL ACTIVITIES

3.1 INTRODUCTION

3.1.1 The Importance of Urban and Industrial Activities

In the European Community, as in any modern society, the quality of human life is fundamentally affected by the character of urban and industrial activity. For the majority of European citizens, towns provide the physical and social framework of their daily life. It is difficult to be precise because of the problems of definition, but in most European states 60% or more of the population live in towns of greater than 20,000 persons. They not only work there, but they shop, eat, travel and sleep there. The state of the urban environment - the noise, fumes, dust, odours, scenery and wildlife - thus has a major influence on their personal well-being. And the state of that environment, in turn, depends upon the activities that go on within the town. It depends on the nature and intensity of industrial activity, the levels of atmospheric emissions and effluents, the volume of traffic, the far-sightedness of planning procedures, the degree of pollution control, and the efficiency of waste collection.

Industry, similarly, governs much of our life. Over 36% of the labour force in the European Community is directly employed in industry and services, while extractive, manufacturing and service industries provide almost all of us with the material goods and social provisions we need.

The effects of urban and industrial activities, however, are not restricted within the urban boundary, for not all industry is confined to towns and much takes place in rural areas. Moreover, just as industry provides goods, services and markets to the surrounding area, so it also shares its environmental impacts. The pollutants generated by industry or released by urban activities spread through the atmosphere, along streams and in groundwaters, and may ultimately impinge upon the entire countryside. The demand for raw materials by urban industries may stimulate quarrying and mining and more intensive agricultural practices far away from the town itself. Urban and industrial activities may occupy only a small part of the land, therefore - in the case of the European Community no more than 5% of the total territory - but their influence is far-reaching. Almost everywhere they act as a major pressure on the environment, and a fundamental determinant of the quality of life.

3.1.2 Causes and Effects of Change in Urban and Industrial Activities

Urban and industrial activities are not static. Over time, for a wide range of reasons, they change and fluctuate. In the short-term, most economic activities experience changes in fortune related to the so-called 'business cycle'. In the longer-term, more fundamental changes occur as some industries expand and others decline. These more persistent, structural trends relate to the effects of changes in competition from overseas suppliers, changes in the state of external markets, adjustments in consumer attitudes, technological developments, product substitution, variations in labour productivity and employment preference, and economic policy.

All these changes affect the environment. Increased production, for example, may lead to a greater demand for raw materials and land for construction, to depletion of some resources, to higher rates of waste generation and emissions, to increased traffic. These may in turn increase pressures on the environment and encourage pollution. On the other hand, improved economic activity may provide more profit for investment in environmental technology and for resource exploration. In the same way, reduced levels of economic activity may have a range of effects. They may lead to environmental improvements by generating lower rates of emissions and lower pollution levels, and they may help to reduce rates of resource depletion. Conversely, they may exacerbate environmental problems: by discouraging environmental investment and the introduction of more efficient pollution-control methods or clean technologies; by creating larger areas of dereliction and abandoned industrial land; or by slowing down the search for new (and in some cases environmentally less damaging) reserves of natural resources.

In recent years the European Community, like most of the western world, has experienced a relatively persistent period of industrial stagnation, due in part to long-term, structural changes in the global economy. It has been speculated that these changes will have a marked effect on the environment, although - because of the complex responses just mentioned - there is little agreement about the direction of their influence. In fact, it is almost always difficult to predict or decipher the environmental effects of changing industrial and urban activities. Often different effects counteract each other; in other cases they may be mutually amplifying. Moreover, many other factors are influencing the environment: natural processes such as climatic change, weathering and erosion, vegetation succession and species competition; environmental policies which may impose constraints on emission levels, specify standards for environmental quality, or identify particular resources or habitats in need of protection and amelioration. The effects of these various factors can rarely be separated, so in most cases the changes perceived in the environment cannot be attributed with confidence to single causes. Nevertheless, the basic point remains: urban and industrial activities provide one of the main forces for environmental change.

3.2 THE URBAN AND INDUSTRIAL CHARACTER OF THE EUROPEAN COMMUNITY

3.2.1 Population Distribution and Urbanisation

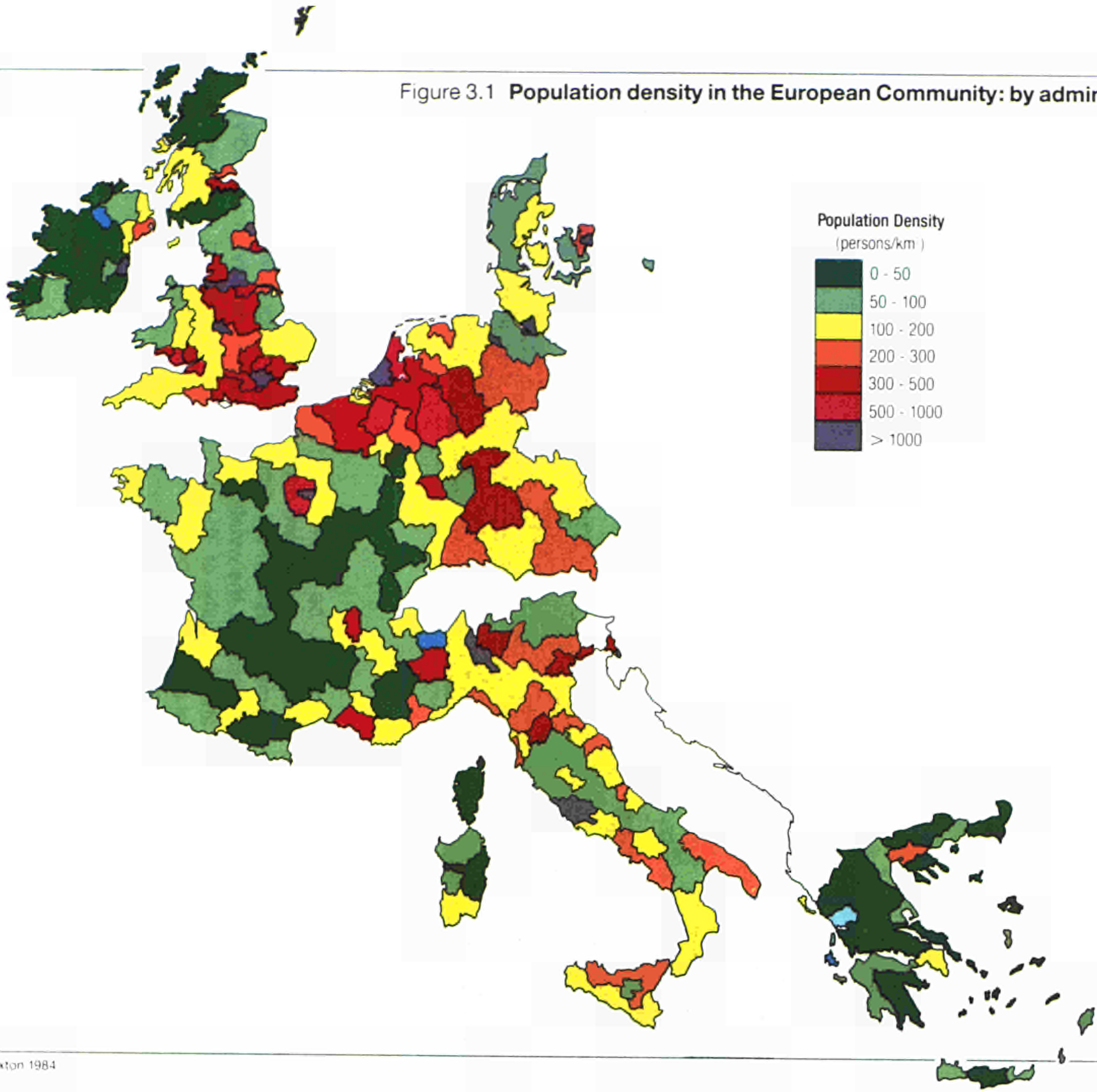
The distribution of population in the European Community is shown in Figure 3.1. In detail the pattern is complex, but three broad zones can be defined:

i. a 'core zone' of high population density, forming an arc running from north-west England, through the London region into the lower Rhine, making up the 'heavy industrial triangle' of western Europe. In addition, discrete areas of high population density are associated with major conurbations such as Paris, Milan and Rome.

ii. a central region of intermediate population density, extending from southern Britain, through Germany and into northern Italy and southern France.

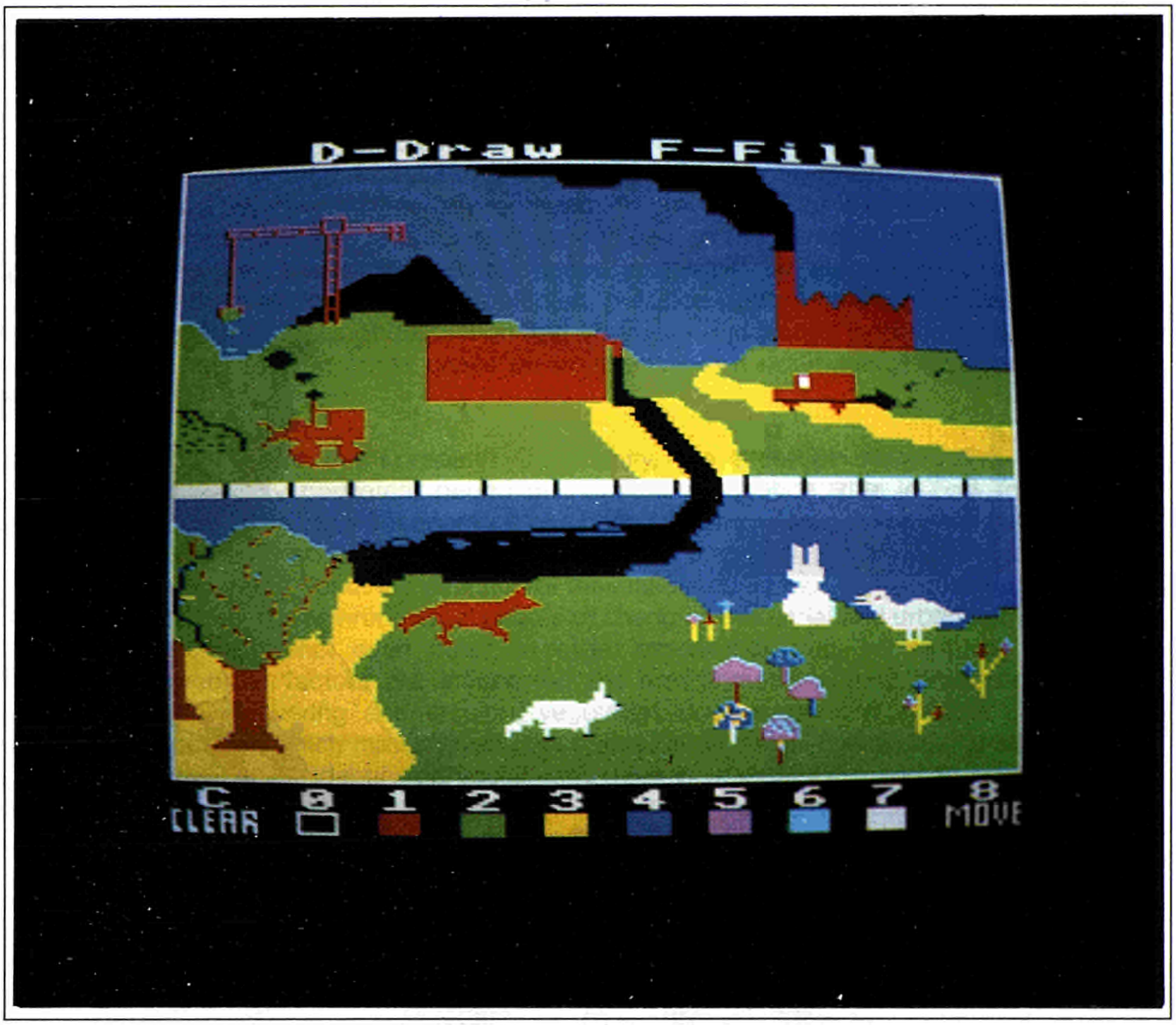
iii. an outlying zone, covering much of Ireland, northern Britain, central and western France and Greece in which population density is below 100 per square kilometre. This is a dominantly rural zone and includes a large proportion of the Less-Favoured Areas as delimited by the European Community.

Figure 3.1 **Population density in the European Community: by administrative region.**



Source: data from Paxton 1984

Plate 3.1 **The environmental impacts of industrialisation: a child's view.**



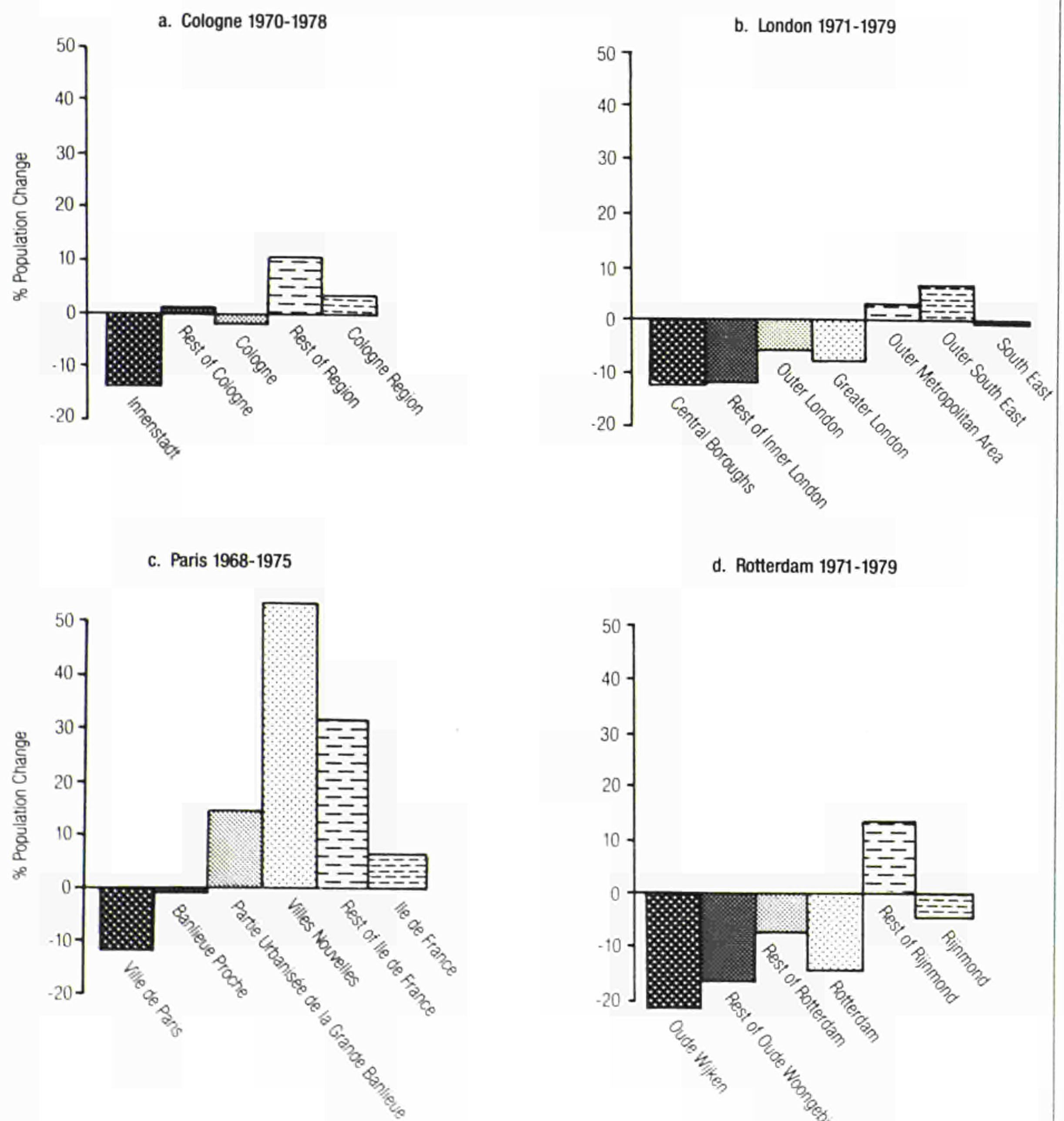
Picture: Matthew Briggs (age 10)

These zones must, of course, be defined with care. Variations in the size of the administrative units used to determine population density, for example, affect the pattern. Nevertheless, the broad pattern corresponds with the distribution of major towns and cities in the European Community (Figure 1.8). Moreover, the variations in population density undoubtedly have important environmental implications. Many of the more densely inhabited areas are also characterised by intense industrial activity: the presence of high levels of pollution in these areas thus affects a disproportionate number of people. These areas are also those where pressures on agricultural land, natural habitats and water resources are often at a maximum. Conversely, the zones of low population density are generally those where environmental damage has, to date, been limited, and thus where the greatest potential for wildlife and landscape conservation tends to exist.

The population of the European Community, however, is not static. Important, and in some cases complex, adjustments in the distribution are occurring as people migrate from some areas and into others. To look at these flows on a large-scale, regional basis would have little meaning, for in rural areas especially the changes are extremely localised. The only valid generalisation is probably that the trend towards rural depopulation, which characterised the early half of this century, is gradually being reversed through a process of 'counter-urbanisation' - the movement of people out of towns into outlying villages and small towns.

This new trend is reflected in the pattern of population change in many urban areas (Figure 3.2). Whilst the details vary, it is apparent that populations in the inner city areas are declining, and those in the outer city areas (the suburbs) are increasing. The processes are complex - not merely a simple migration of people from inner city to outer city areas. The overall effect, however, is for depopulation of the central zones of large cities, accompanied by population growth in the fringe areas. This effect is seen clearly in the case of Paris, in Figure 3.3a.

Figure 3.2 **Population change in urban areas: a. Cologne 1970-78; b. London 1971-79; c. Paris 1968-75; d. Rotterdam 1971-79.**

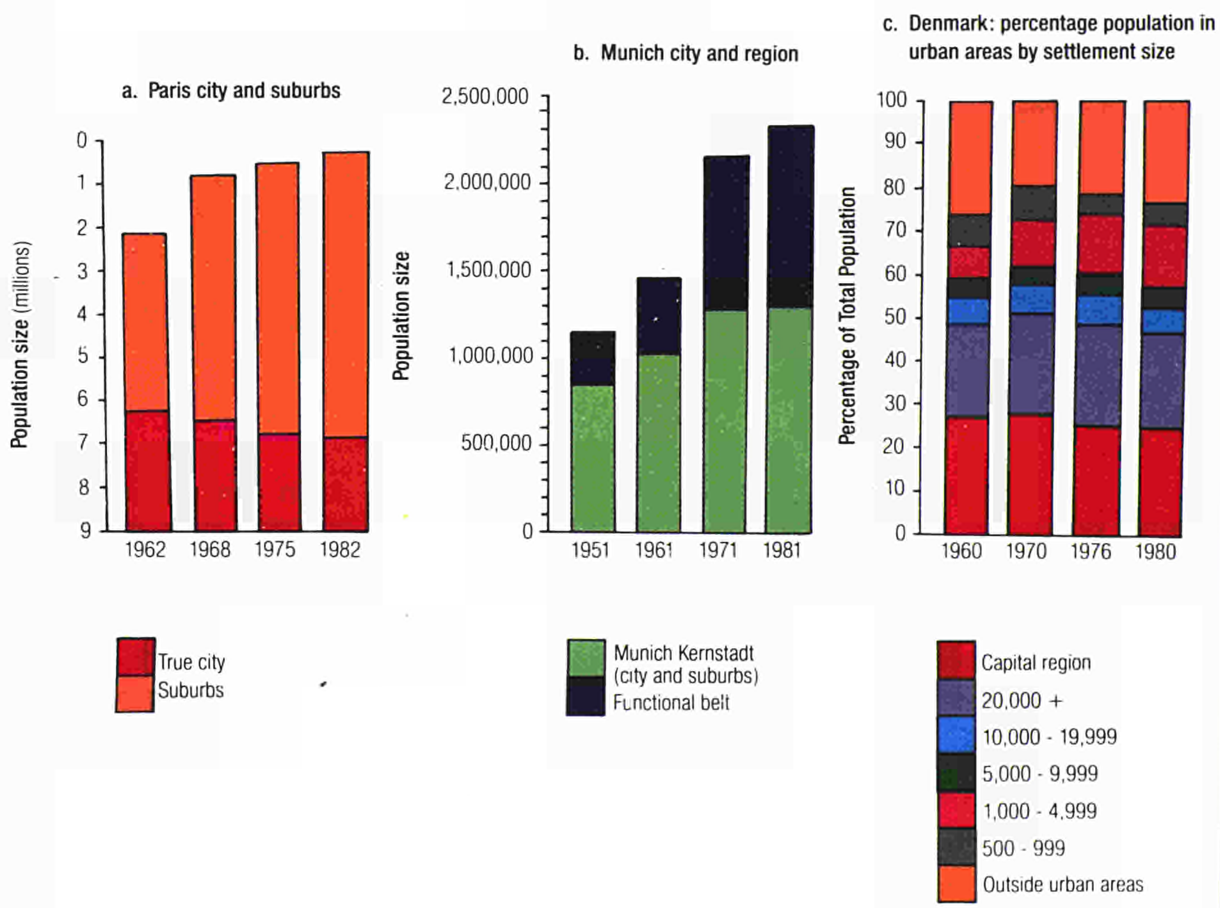


Source: data from Council of Europe 1983

This process is not confined to the city area. Counter-urbanisation also extends to the city periphery and to towns beyond the city region. As Figure 3.3b shows, for example, population growth is greater in the 'functional belt' of Munich than in the city and its suburbs. Similarly, in Denmark, it is clear that the population in the capital region of Copenhagen is declining, whereas that in smaller towns (especially those between 1000 and 4999) is increasing. Since 1970, there has also been a significant increase in the population of non-urban areas (Figure 3.3c).

The causes of all these changes are a matter of some debate: they probably relate to changing public attitudes and aspirations, declining employment in some urban areas coupled with new employment opportunities in some rural industries (e.g. tourism), and the effects of regional policies. The implications, however, are manifold. Urban growth is now focused on more peripheral zones and in rural communities. As a consequence, these areas are experiencing expansion of built-up land, with resulting loss of agricultural land and natural habitats. Population growth in these areas is similarly causing increased pressure on the existing sewerage and waste disposal systems, and in some cases leading to problems of stream pollution. At the same time, human intrusion into surrounding rural areas is encouraging damage to and disturbance of farmland and wildlife.

Figure 3.3 **Trends in counter-urbanisation: a. Paris; b. Munich and its functional belt; c. Denmark.**



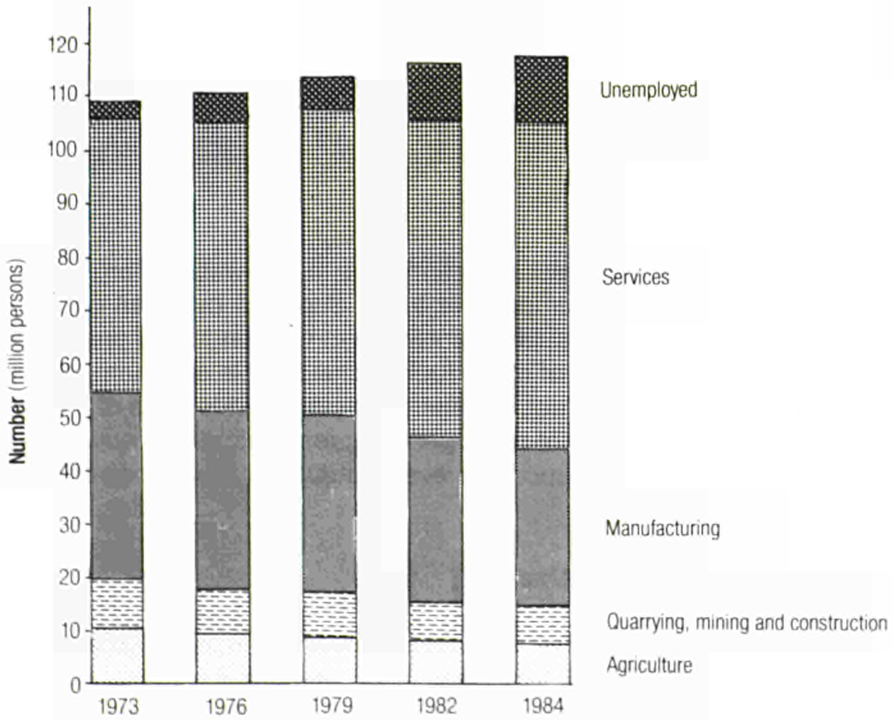
Sources: data from Recensement Général de la Population de la France 1954-1982; Heinritz and Lichtenberger 1984; Burtenshaw and Court 1984

3.2.2 Industrial Activity and Employment

The world-wide changes in economic conditions and technological developments that have occurred in recent decades have affected the European Community as everywhere else. Considerable adjustments in economic activities have therefore been taking place, with the decline of some industries and the rise of others. An indication of these trends at a very general scale is shown in Figure 3.4. As can be seen, levels of employment have gradually fallen in agriculture, mining, construction and manufacturing over the last 15 years, while service industries (and the unemployed) have both increased.

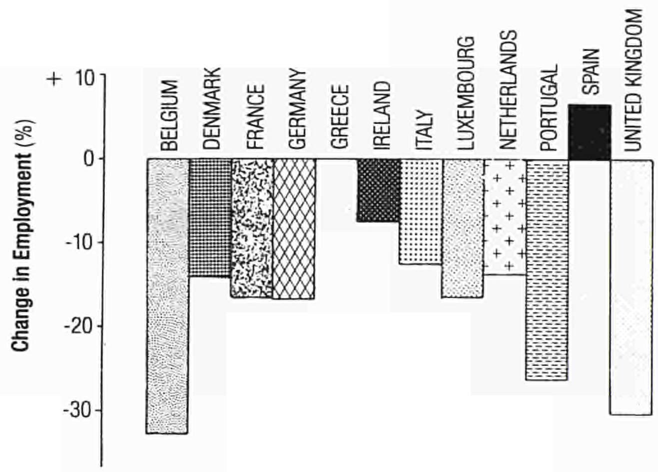
These trends have not been identical throughout the Community, nor are they true for all branches of industry. In manufacturing, between 1974 and 1982 for example, employment levels fell by 37% in man-made fibres, 27% in footwear, clothing and textiles, and 24% in metal processing; yet only by 5-6% in food, drink and tobacco, chemicals and motor vehicle manufacturing. Partly because of the different importance of each of these industries in different member states, and partly because of different pre-existing levels of mechanisation, the overall impact on employment in manufacturing has varied markedly from country to country (Figure 3.5). Although employment levels have fallen almost everywhere, the changes range from a rise of about 10% in Portugal to a decline of over 25% in the United Kingdom and Belgium.

Figure 3.4 **Employment in major sectors in the European Community, 1975-1984.**



Source: data from Eurostat 1984a, 1986.

Figure 3.5 **Changes in employment in manufacturing in Community member states, 1974 - 1984.**



Source: data from Eurostat 1984

Admittedly trends in employment do not reveal the whole picture of industrial change: they hide, for example, the effects of technical innovations on production levels and the role of imports in maintaining levels of consumption. Consequently, these changes in industrial activity cannot simply be related to changes in environmental conditions. Nevertheless, the fact that industrial activity is changing undoubtedly has environmental implication; numerous examples will be seen in subsequent chapters of how these effects have operated. In the remainder of this chapter we will consider trends and patterns in specific industrial activities with particular environmental significance.

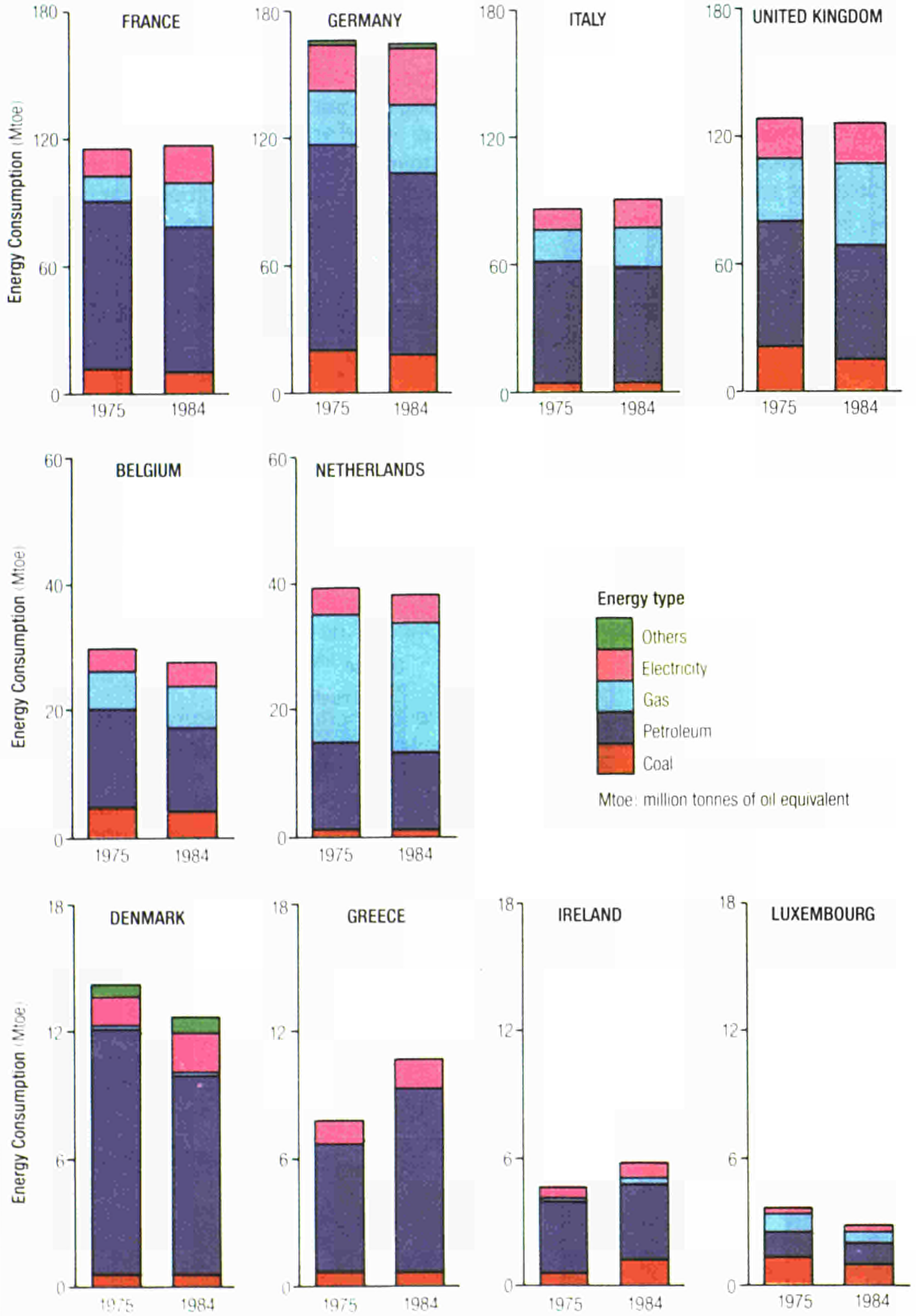
3.3 ENERGY

Despite growing interest in recent years in renewable energy sources, the vast majority of the Community's energy consumption is today supplied by fossil or nuclear fuels. As such, the energy sector is one with particular importance in relation to the environment. At all stages in the extraction, processing and use of these fuels, considerable environmental impacts may be caused. Moreover, in the short-term at least, the energy sector provides one of the most sensitive barometers of economic activity - and thus of more general pressures on the environment - for the demand for energy is intimately dependent upon the level of industrial production and consumption.

3.3.1 Energy Production and Use

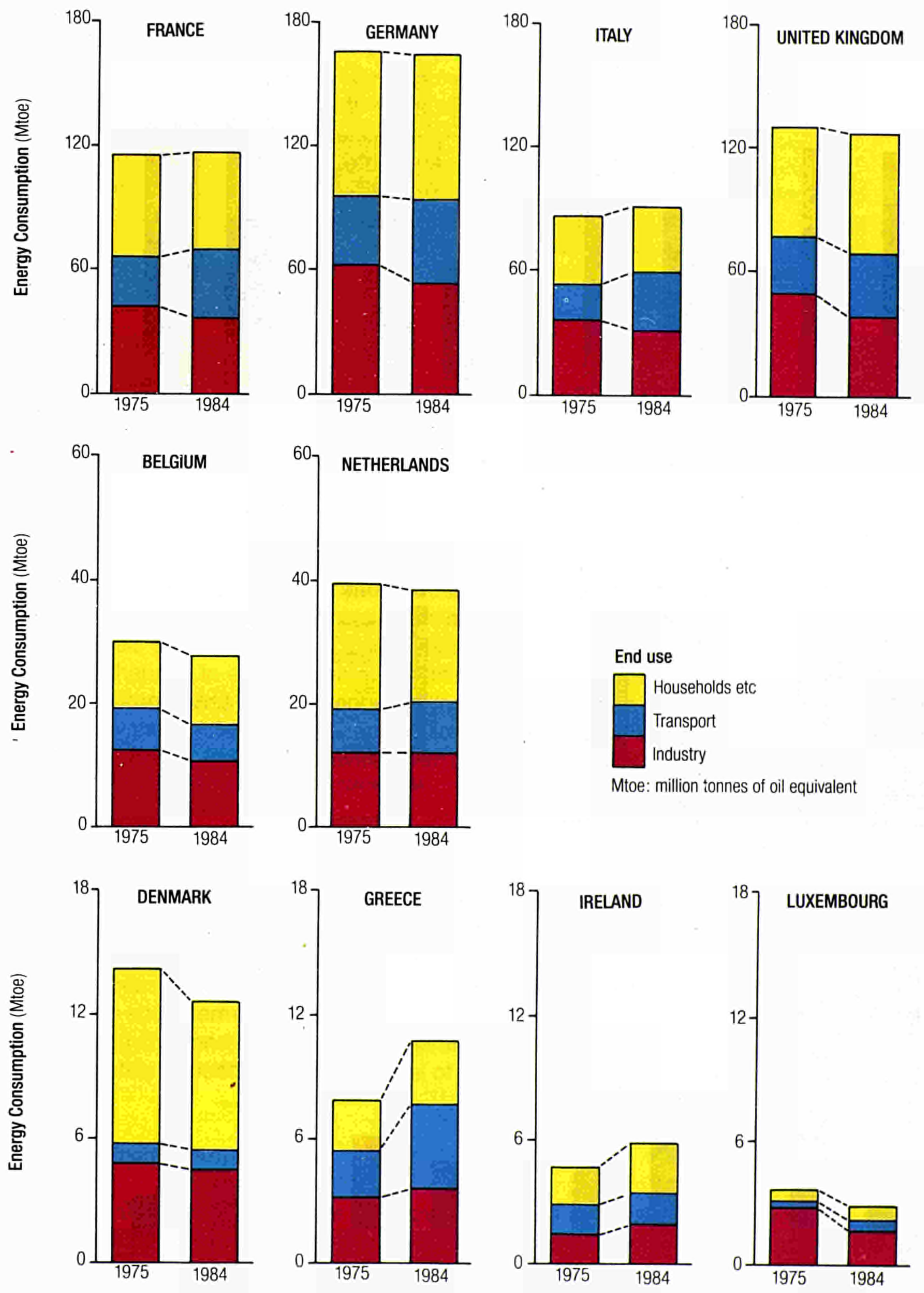
Over the last 10-20 years, energy production and use have undergone fundamental changes. Prior to the 1970s, the trend was clear. Demand for energy was rising and projections for the future indicated that it would continue to do so. The increased demand was due partly to expanding levels of industrial production, and partly to greater rates of 'luxury' consumption for domestic purposes and transport. The main increase was thus in the use of oil. By 1973, however, the situation had changed dramatically. As a result of the Middle East War and action by oil-producing countries to limit output, world oil prices had risen by 400% since 1972. Demand fell strongly, triggering off complex reactions in many western economies, which, to some extent, have

Figure 3.6 **Energy consumption by energy type in Community member states, 1975 and 1984.**



Source: data from Eurostat 1984, 1986

Figure 3.7 **Energy consumption by end use in Community member states, 1975 and 1984.**



Source: data from Eurostat 1984, 1986

still not restabilised. Subsequently, demand picked up again, but between 1979 and 1981 oil prices again doubled, and the effects were repeated. Now (1986) prices are falling once more, though how permanent the effect will be is as yet unclear.

The effects of these changes have been complex because of the opportunities for fuel substitution which exist in many sectors and the tendency, also, towards increased energy efficiency and conservation. Comparisons of consumption by energy type in 1975 and 1984, however, are shown in Figure 3.6. (In considering these data we must remember that 1975, the base year used, was a period of decline in energy usage in all member states). One trend is clear: with the exception only of Italy and Greece, oil consumption has fallen everywhere. This however, has been at least partly compensated by increased use of other energy types, especially gas and electricity (the latter itself a product of oil, coal or more rarely nuclear fuels). In most countries, coal consumption has either declined slightly or remained steady.

The changing patterns of consumption are a result of adjustments in many different parts of the economy. Energy usage can broadly be subdivided into three main categories: household, transport and industry. Figure 3.7 compares consumption by these three different sectors in 1975 and 1984 for each member state. Again, certain patterns are clear. With the exception of Greece and Ireland, industrial use of energy has declined, reflecting amongst other things the recession which has hit many industrial activities - and particularly the high energy-consuming sectors. In contrast, use of energy for transport has increased, largely due to growth in private car ownership in the Community (1975 was also something of an exceptional year because of the reaction by motorists to sharply increasing petrol prices). Household usage of energy has changed less consistently: it rose in the United Kingdom, Greece, Ireland and Luxembourg, but declined or remained steady in other member states. As will be seen in Chapter 5, these changes are having an impact on both the magnitude and character of atmospheric emissions, and thus on air quality.

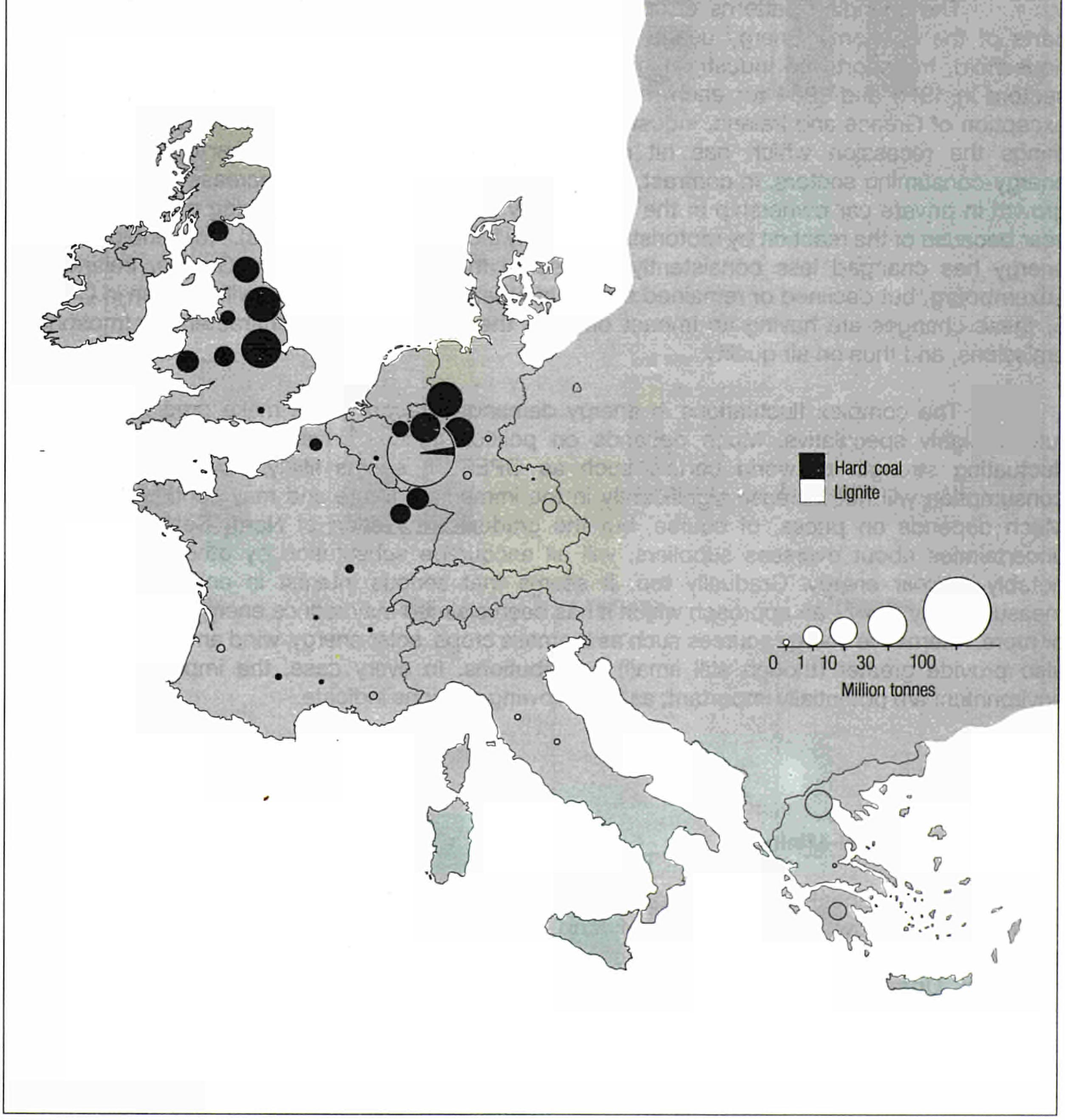
The complex fluctuations in energy demand in recent years make predictions for the future, highly speculative. Much depends on political factors, investment decisions and the fluctuating strength of world cartels such as OPEC. It seems likely, however, that energy consumption will not increase significantly in the immediate future and may continue to decline. Much depends on prices, of course, but the gradual exhaustion of North Sea reserves, and uncertainties about overseas suppliers, will all encourage substitution by other sources, most notably nuclear energy. Gradually too, it seems that serious interest in energy conservation measures may grow - an approach which it has been claimed may reduce energy demand by 20% or more. Alternative energy sources such as biomass crops, solar energy, wind and tidal power may also provide greater (though still small) contributions. In every case, the implications for the environment are potentially important, as the following sections indicate.

3.3.2 Coal and Coal-Mining

The potential impacts of coal mining on the environment are considerable. Open-cast mining can swallow up large areas of land, both through the direct effects of mining and through the dumping of spoil (which commonly amounts to 80% or more of the extracted material). Underground mines similarly produce large quantitites of spoil, while surface subsidence is a hazard above mine shafts. In addition, both mining operations and subsequent storage, transport and processing of coal can produce significant dust and noise pollution. Above all, however, the use of coal as a fuel is responsible for extensive air pollution: combustion releases large quantities of solids, and gases such as sulphur dioxide, nitrogen oxides and carbon monoxide.

Within the European Community, coal mining represents an industry of major importance. In 1982, approximately 0.6 million people were employed in the industry and total output of coal (hard coal plus lignite) amounted to over 230 million tonnes - about 25% of the total energy requirement of the Community. The distribution of this activity (and thus its potential impact on the environment) is markedly regionalised, however, with two main areas of production: one stretching from Scotland through the English Midlands to southern Wales, the other focused on the Ruhr - Lorraine region of Germany and France (Figure 3.8). Together, these areas account for about 95% of the total hard coal output of the Community. The main centres for lignite production are in the region of Cologne and the eastern regions of Germany. Small areas of production are also located in France and Italy, while production in Greece is of some importance.

Figure 3.8 **The regional production of coal in the European Community, 1981.**



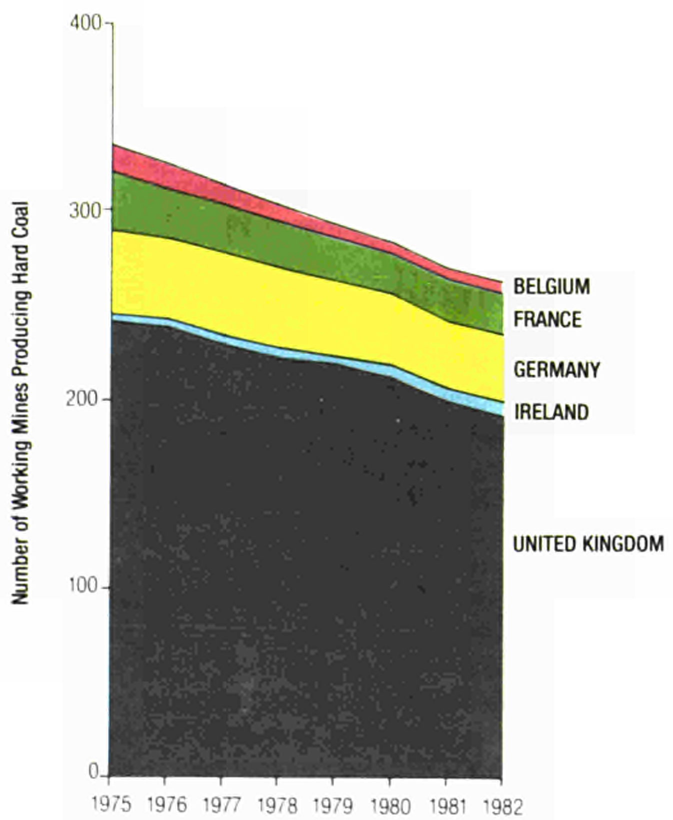
Source: data from Eurostat 1984

Throughout these regions, the composition of coal and lignite varies considerably. One of the most significant variations is in sulphur content, because this influences the levels of SO_2 pollution caused by coal combustion. In Germany, sulphur levels range from 0.5% to 4%, with an average of about 1%. In the United Kingdom, the average content is about 1.7%, with a range from about 0.77% to 2.3%. Similar variations in calorific value also occur. Nevertheless, due to low productivity and financial losses, mines are currently being closed in Scotland, which is a region with some of the lowest sulphur contents and highest calorific values in the Community.

These variations undoubtedly account for many of the differences in atmospheric emissions from coal combustion in different parts of the Community, and should, perhaps, be considered when policies for future coal production are being developed.

In recent years, in fact, the coal mining industry has been undergoing fundamental changes, and large numbers of mines have been closed throughout the Community (Figure 3.9). The greatest loss has occurred in the United Kingdom where between 1975 and 1982 a total of 47 mines were abandoned (20%). Similarly, in Germany, 9 mines (20%), in France 8 mines (27%) and in Belgium 8 mines (57%) were closed over this period.

Figure 3.9 **Numbers of working coal mines in Community member states, 1975-1982**



Source: data from Eurostat 1983

The effects upon coal production have been less marked largely because of the preferential closure of smaller or less productive pits, and because of improvements in productivity in the remaining pits. Nevertheless, the dominant trend in output is downwards, especially in France and Belgium where coal production fell by 55% and 42% respectively between 1970 and 1982. In addition, production in Italy and the Netherlands ceased completely.

The reasons for these changes are numerous and complex. Coal mining is particularly sensitive to changes in other sectors of the economy, and a major effect has been declining demand for blast furnace coke for pig iron production. In addition, other coal-consuming industries and domestic users have tended to shift to other fuels. Only the electricity generating industry has increased coal consumption considerably, while oil and gas use in power stations has fallen in importance. In total, coal consumption has therefore remained more-or-less at a static level in recent years, but there has been an increase in the consumption of imported coal.

3.3.3 Oil, Gas and Petroleum

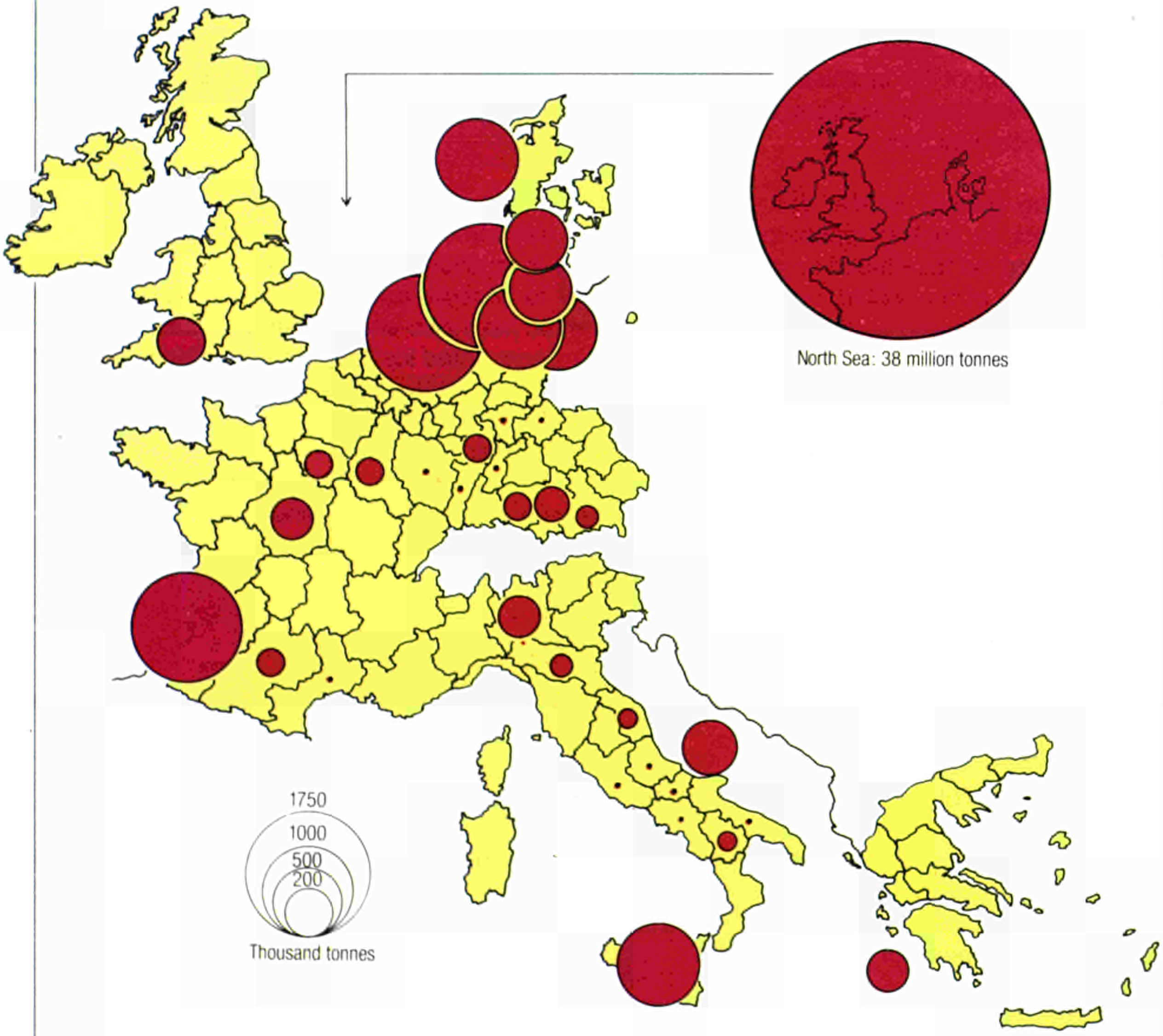
As with other fossil fuels, the production and use of oil exert considerable pressure on the environment. Significant discharges of oil, for example, occur during drilling operations when cuttings contaminated with oil can be released. Similarly, releases may take place during piping, transport and storage of crude oil, as well as from refineries and subsequent handling of the refined petroleum products. These discharges have particular effects on marine environments, because many of the oil releases occur at sea, whilst much of the oil spilled on land or discharged into the atmosphere is eventually washed into the oceans. Moreover, major spillages of oil from wells and shipping accidents, although rare, have at times caused serious and widespread pollution of marine ecosystems.

Even more crucial in many cases, however, are the emissions of solids and gases during combustion processes. The use of petroleum products as a vehicle fuel is especially important, and traffic is a significant source of atmospheric pollution by sulphur compounds, certain carbon compounds and nitrogen oxides, as well as additives such as lead. For all these reasons, oil production and use have widespread environmental implications.

The distribution of crude oil production in the European Community is shown in Figure 3.10. As can be seen, production is concentrated in the North Sea and almost 90% of total crude oil output is derived from British waters, while some 25% of natural gas comes from the Netherlands. With the development of North Sea oil and gas production, and with the decline in demand for oil, the European Community has become increasingly independent of overseas supplies. Net imports of crude oil and petroleum products have accordingly fallen, and by 1984 stood at only 299 million tonnes, half of the 1973 level. Oil refining throughput has fallen by a third over the same period, largely because of lower European oil consumption and the opening of new refineries in the Third World. On the one hand this has helped to reduce the discharges of oil and atmospheric pollutants from refineries. On the other hand, releases of oil during well cutting and extraction have undoubtedly increased, while the reduction in the use of oil has been compensated by increases in other energy sources, notably nuclear energy. As with coal, the composition of these oil reserves (and of imported oil supplies) varies. Fuel oil used in France, for example, has average sulphur contents of about 3.3%; that in Italy about 3%. In contrast, Germany uses fuel oils with sulphur contents as low as 2%, while in the Netherlands the average is only 1.5%. Clearly these differences have considerable effects on the levels of sulphur emission from refineries and other sources.

One of the new fuels which has helped to replace oil as an energy source is natural gas. This supplied only 7% of the Community's energy needs in 1970, but 19% by 1984, with the prospect of further though limited growth in its market share. Compared with today's alternatives it

Figure 3.10 **The regional production of crude oil in the European Community, 1981.**



Source: data from Eurostat 1984

has to be regarded as both a clean and a quiet fuel in all its stages of production, distribution and consumption. Currently, the Community imports gas from three main sources: Norway, USSR and Northern Europe. At current consumption rates, known world reserves will last for about 50 years, thus roughly doubling the life of proven oil reserves.

3.3.4 Nuclear Energy

Over the last ten years, nuclear energy has made a rapidly increasing contribution to the energy balance of the European Community (Figure 3.11). Between 1975 and 1984, for example, nuclear energy production rose from about 20 million tonnes oil equivalent (toe) to almost 100 million toe. By 1983 there were thus some forty-one major nuclear power stations in the Community, operating a total of 56 facilities (Figure 3.12). These included twenty six pressurised water and pressurised heavy water reactors, seven boiling water reactors, seventeen gas-cooled reactors and two fast-breeder reactors.

The growth in the use of nuclear energy has been due to a number of factors. Developments in nuclear technology in the 1960s overcame many of the problems of energy production and led to reduced costs of nuclear energy. In addition, rising costs of other fuels, related to the oil crisis of the 1970s, helped nuclear energy to become commercially competitive. Fears about the longevity and availability of world oil reserves have also encouraged a switch to nuclear energy. Thus, by 1986, the capacity of nuclear facilities accounted for 32% of the electricity needs of the Community (14% of total energy production). Over the next five years, the compliment will rise by about 50% as facilities already under construction or commissioned come on-line, after which there is likely to be a slower increase of about 10% to the year 1995.

Production of nuclear energy involves a number of steps and in general terms these are:

i. manufacture of UF_6 from uranium concentrates.

ii. enrichment of UF_6 in the U-235 isotope.

iii. conversion of the enriched UF_6 into UO_2 powder, which is sintered enclosed in tubes to give fuel pins.

iv. use of these fuel pins in the reactor to generate energy.

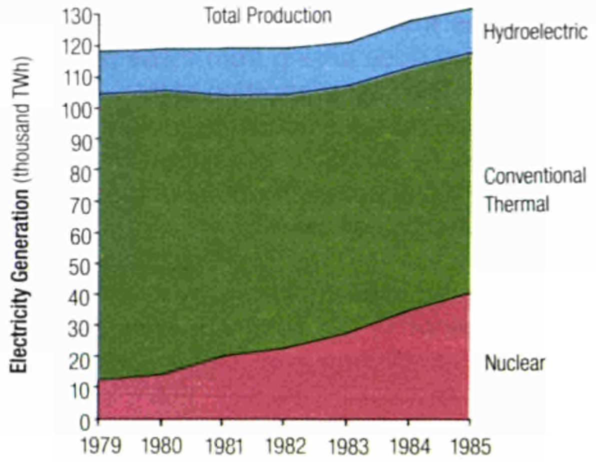
v. storage and reprocessing of the spent pins in order to recover the usable plutonium and uranium.

vi. disposal of waste products.

To a greater or lesser degree, each of these steps may involve releases of radioactive substances into the environment, and as a consequence public concern about the nuclear industry has emerged in recent years. In an independent survey by Faits and Opinion, in 1984, for example, 9,900 people in the then ten member states of the Community were asked for their opinions on nuclear energy. Thirty-eight percent of those interviewed expressed the view that nuclear power stations posed “unacceptable risks” (against 43% who believed the risks to be “worthwhile”).

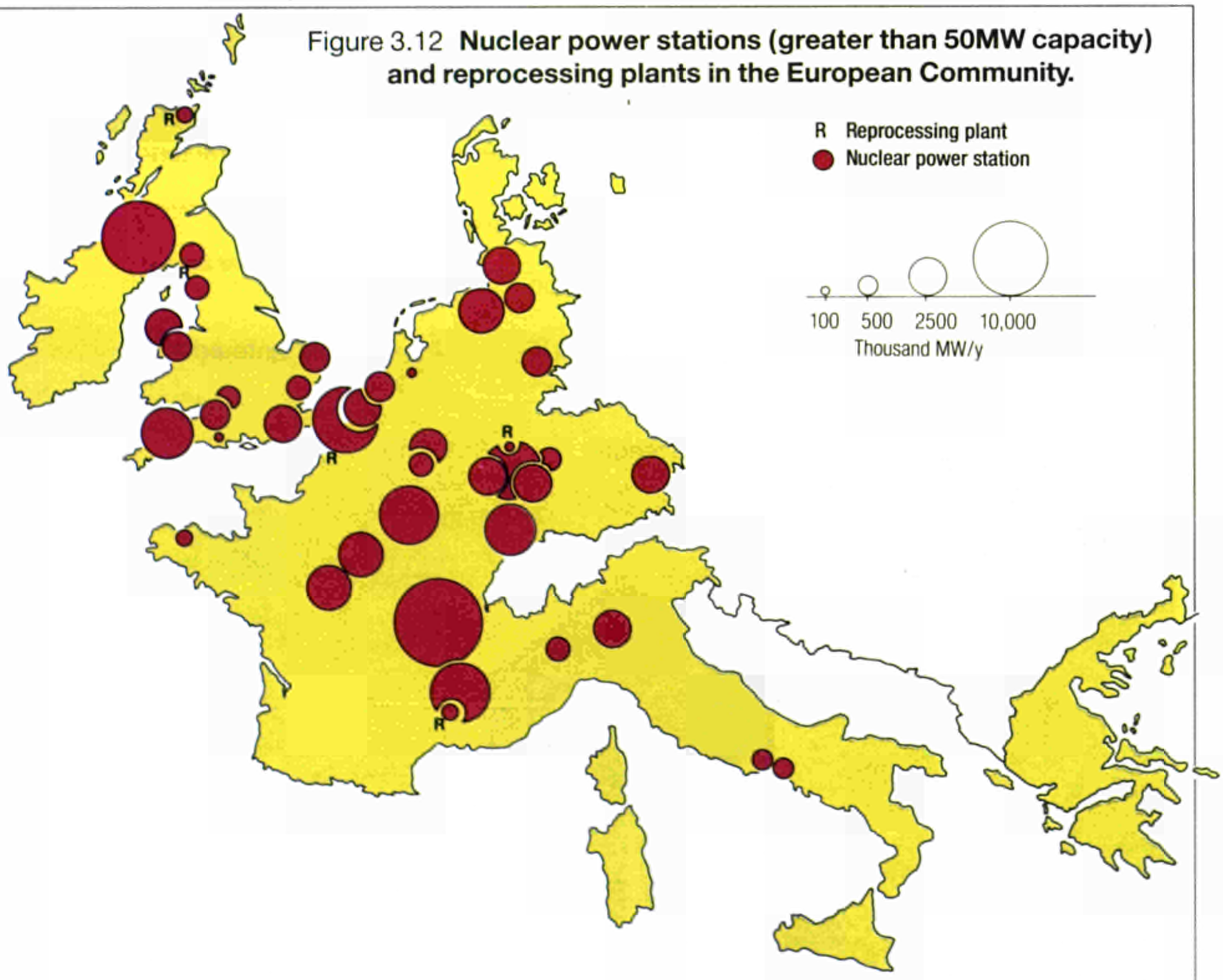
In practice much of this public concern is based upon only a partial understanding of the nuclear energy industry. Nuclear power stations release relatively small quantities of radioactivity into the environment: an estimated 5700 man-rem in the Community as a whole in 1978. This represents an average of 30 man-rem from liquid water reactors, and about 270 man-rem from

Figure 3.11 **Electricity generation in the European Community, 1979-1985.**



Source: data from Commission of the European Communities 1985

Figure 3.12 **Nuclear power stations (greater than 50MW capacity) and reprocessing plants in the European Community.**



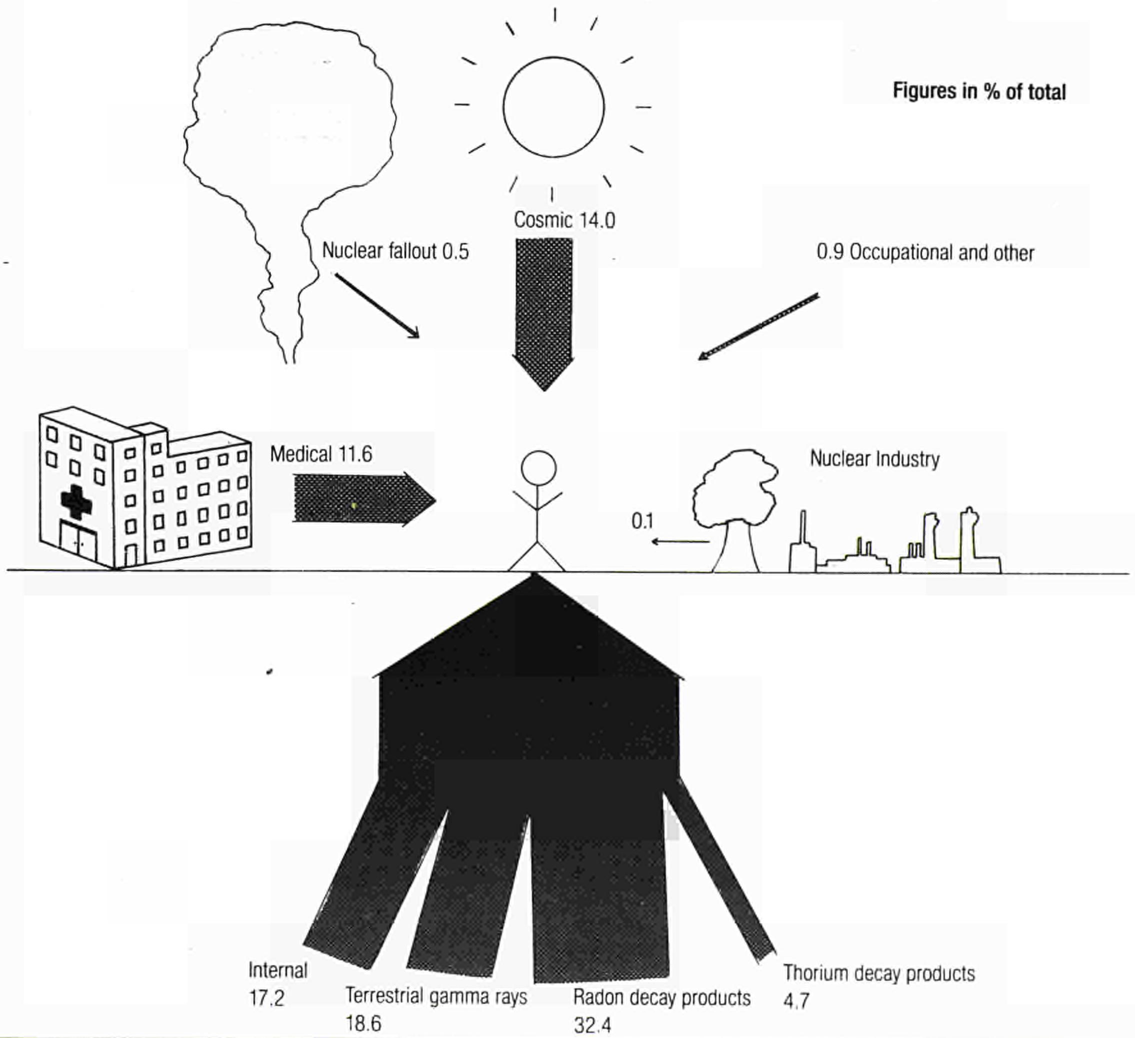
Source: data from Luykz and Fraser 1983

gas-cooled reactors. Carbon-14 is in all cases the dominant radionuclide involved, making up about 80% of the total, and airborne effluents account for some 96% of the annual emission.

By comparison, releases from nuclear fuel reprocessing plants are up to an order of magnitude higher. The total effective dose arising from these processes in the Community in 1978 was estimated at 44,500 man-rem. The vast proportion of this - about 85% - derives from Sellafield in the United Kingdom, and the main releases occur via liquid effluents. The radionuclides involved, however, vary from plant to plant. At Sellafield caesium-137 makes up about 70% of the total emission, at La Hague ruthenium-106 accounts for 60% of the total, and the much smaller release from Marcoule in France is dominated by carbon-14.

Whilst these releases of radioactivity into the environment may appear formidable, they need to be placed in a wider context. The total effective dose of radiation in the European Community is estimated as about 5×10^7 man-rem. Of this, only about 4×10^4 man-rem (0.01%) is due to radioactive discharges from nuclear energy; the remainder is due to natural sources, weapons testing and other uses, especially medical (Figure 3.13). Moreover, radioactive emissions from liquid water reactor nuclear power stations have fallen markedly because of the introduction of new and more efficient reactors.

Figure 3.13 **Sources of human exposure to radioactivity.**



Source: data from Department of the Environment 1985

Plate 3.2 **The nuclear power station and reprocessing plant at La Hague, France.**
Plate 3.3 **One aspect of the environmental impact of energy production: spoil tips associated with coal mines in South Yorkshire, England.**

Photo: D. J. Briggs

Photo: South Yorkshire County Council

Nevertheless, these general figures disguise more localised patterns. Around Sellafield, for example, it is estimated that some members of the public may receive 20 - 30% of their annual effective dose of radioactivity from effluents. In circumstances such as this, the potential effect of the nuclear energy industry on human health has aroused particular public anxiety. Similarly, as the accident at the Chernobyl nuclear power station in the USSR in 1986 has shown, there is also a risk of exposure from installations outside the European Community. It is, as yet, too early to evaluate the effect, if any, of that particular incident on the population of the Community, but it highlights the importance of transboundary pollution and the need for internationally agreed early warning systems on accidents involving all forms of hazardous substances, not least radioactivity.

3.3.5 Environmental Implications

The production and use of energy are clearly fundamental parts of any industrialised society, and are vital to economic development or industrial growth. Energy production and use, however, also pose a range of environmental threats and problems. For these reasons, the energy sector is of considerable environmental significance in the European Community, and many of the problems discussed in later chapters derive from energy industries, related services and energy use.

In general terms these problems involve three main types of environmental impact:

i. the direct health hazards to workers and neighbouring communities caused by the acquisition, transport, handling and processing of fuel materials. These include the risks of fire, explosions, spills or leaks of toxic materials, mine collapse and occupational accidents.

ii. land loss and environmental disruption due to the use of the land surface for energy production. This includes the loss of habitats and agricultural land to energy infrastructure (e.g. oil terminals, refineries, power stations), and to spoil heaps, mines and quarries; the effects of land subsidence and flooding; and the severance of land by roads, railways and pipelines.

iii. environmental pollution. This includes discharges of radioactive substances to the land and seas from nuclear power stations and associated processing plants; the release of heat, gases, chemicals and solids into the atmosphere and streams by power stations and transport; noise and pollution from mines, power stations and traffic; and the visual impacts of buildings, power lines and discharged substances.

3.4 METALS

The production, processing and use of metals are of fundamental importance to the industrial economy of the European Community. In terms of output, for example, the Community is second only to the USSR in the production of pig iron, crude steel and finished rolled products and is the world's largest producer of iron ore. In addition, the Community is a major importer of many metals, including cobalt, tin, molybdenum and zirconium.

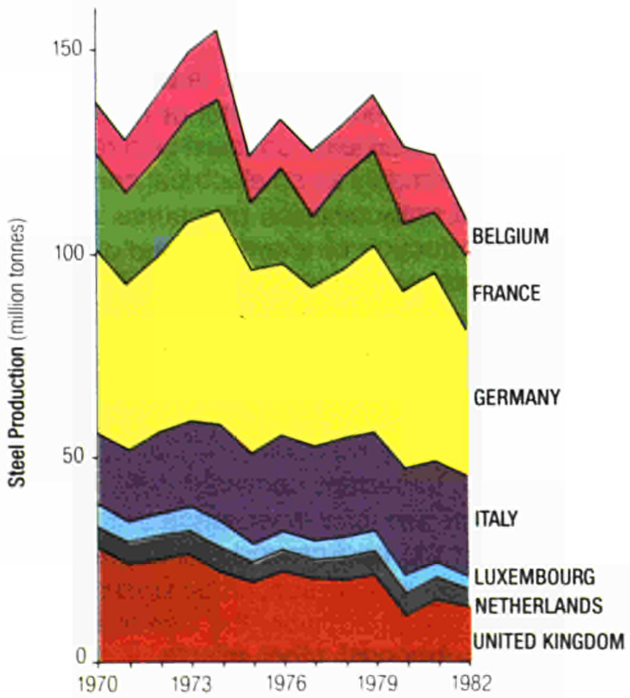
All these materials have far-reaching environmental importance. Extraction of mineral ores may create large areas of disturbance and large volumes of waste. Processing and use of the metals may result in the emission of pollutants to the atmosphere, and discharges of effluents to streams and land. Moreover, many of the residues are both biologically toxic and environmentally damaging. As a result they may accumulate in food chains and be widely dispersed through the environment. In recent years, therefore, the European Community has devoted increasing attention to the control of pollution from these sources. In this section, we look at some of the main metals whose impact on the environment we will consider in later chapters.

3.4.1 Iron and Steel

Iron and steel production has always been a major industrial activity in the European Community. Indeed, the very foundation of the Community was motivated by the need to co-ordinate production and marketing of iron and steel in western Europe. Iron and steel manufacturing, however, have been undergoing fundamental changes in recent years, as demand has fallen and competition from overseas has increased.

The decline in demand for iron and steel has a number of causes. A primary factor has been the general economic recession, which has limited demand for many consumer durables. Competition for European markets by overseas manufacturers of steel-based products such as motor vehicles, household implements and even heavy industrial plant has also reduced the demand for steel. Heavy industries like ship building have similarly been affected by overseas

Figure 3.14 **Production of crude steel in Community member states, 1970-1982.**



Source: data from Eurostat 1983

competition as well as by the global reduction in trade. At the same time, technological developments have seen the substitution of iron and steel by other materials (e.g. aluminium, alloys and plastics) in many applications, further depressing demand.

The effects of these changes have been felt throughout the iron and steel industry. Production of raw iron, for example, has fallen persistently in recent years, and between 1979 and 1982 a further 45% decline in output was recorded. This decline was most marked in the United Kingdom, where annual production fell from 1.1 million tonnes in 1979 to only 0.1 million tonnes in 1982. In France, the main producer, there was a 30% fall in production over the same period, from 9.8 million tonnes to 6.2 million tonnes.

Similar changes can be seen in the production of crude steel (Figure 3.14). Between 1974 and 1982, total output in the Community fell by about 30%, though the effects have not been equally distributed across all member states. Again, the most rapid declines have occurred in the United Kingdom (51% between 1970 and 1982), France (23%) and Germany (20%). On the other hand, production in Italy has actually increased by about 39% over the same period.

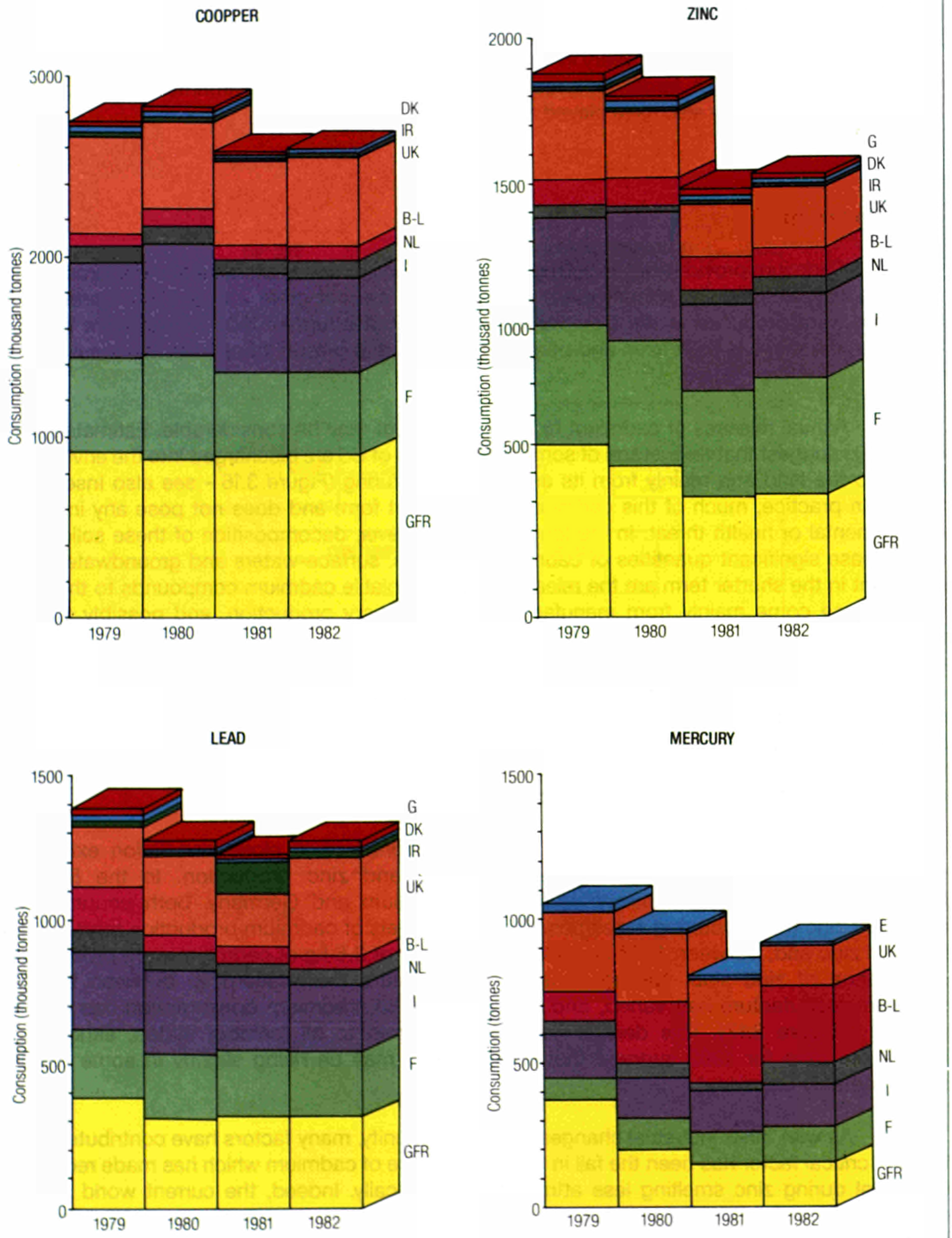
These changes have wide-ranging environmental implications, for iron and steel production have for many years left their mark on the environment. Ore extraction has resulted in large areas of land being lost to quarrying and spoil, while steel processing represents an important source of atmospheric emissions. In general, the fall in production might therefore be expected to reduce some of these impacts on the environment and lead to an improvement in environmental conditions. In addition, large steel processing works are included within the ambit of the Directive aimed at controlling emissions from major combustion plants, which was adopted in 1984. This will undoubtedly diminish further some of the adverse environmental effects of iron and steel production in the Community.

3.4.2 Copper, Zinc, Lead and Mercury

Like many other heavy metals, copper, zinc, lead and mercury are widely used in the European Community, although all have environmental or health effects to a greater or lesser degree. Of the four, copper and zinc are of least concern with respect to toxicity and are indeed essential nutrients. Copper is used primarily as an electrical conductor, as a basis for alloys and whenever a ductile metal with good anti-corrosion properties is required. Zinc has a variety of commercial uses, including the production of alloys, pigments, plastics and batteries, and for galvanising and plating. By comparison, lead is highly toxic. It is known to impair haemoglobin synthesis in children and may cause sub-clinical neurological disorders, especially in the young. Traditionally it has been extensively used wherever a highly maleable material is required, and thus was used for water pipes and roofing materials. Cost factors, technological developments and health considerations have resulted in the decline of these functions, and today lead is employed mainly in battery manufacture, paints, and metal production (e.g. for bearing metals). In addition it is an important constituent of petrol, in which it is used as an 'anti-knock' agent to reduce pre-ignition (see Inset, page 156). This probably now represents one of the main sources of lead in the background environment, although paints, pipes and batteries are locally important.

Mercury is similarly toxic. Amongst other effects, it can damage the central nervous system and cause kidney malfunction. It also accumulates readily in the environment and mercury poisoning has been implicated in the high mortality of birds of prey in many parts of the world. Its uses are varied. In the past it has been used as a herbicide; today its main functions are in the manufacture of drugs and chemicals (e.g. caustic soda and chlorine), in paint and in fulminates (e.g. detonators). Another main pathway for entry into the environment, however, is probably its release during fossil fuel combustion.

Figure 3.15 **Consumption of copper, lead, zinc and mercury in Community member states, 1979-1982.**



Source: data from Eurostat 1985

In fact, direct release of these metals into the environment during production is likely to be limited in the European Community, for, in all four cases, the main supply of raw metal comes from overseas and domestic production is relatively small - varying from 0.1% in the case of copper to about 20% in the case of mercury. Recovery of wastes is also important, and accounts for 33% of copper supplies, 45% of lead and 26% of zinc, although only 4% of mercury usage. Moreover, releases are probably declining, for in recent years consumption of lead, zinc and mercury has fallen markedly, albeit with a slight recovery in 1982 (Figure 3.15). This reflects changes in demand from the main consumer industries, largely as a result of economic recession. Environmental controls on the use of these metals may also have played a part.

3.4.3 Cadmium

Cadmium provides a particularly interesting and important example of metal production in the European Community. Annual levels of production are not great - only 3586 tonnes of raw cadmium were produced in the Community in 1982 - but a further 1905 tonnes were imported. Moreover, the metal is both toxic and persistent and for that reason it has been the focus of much attention.

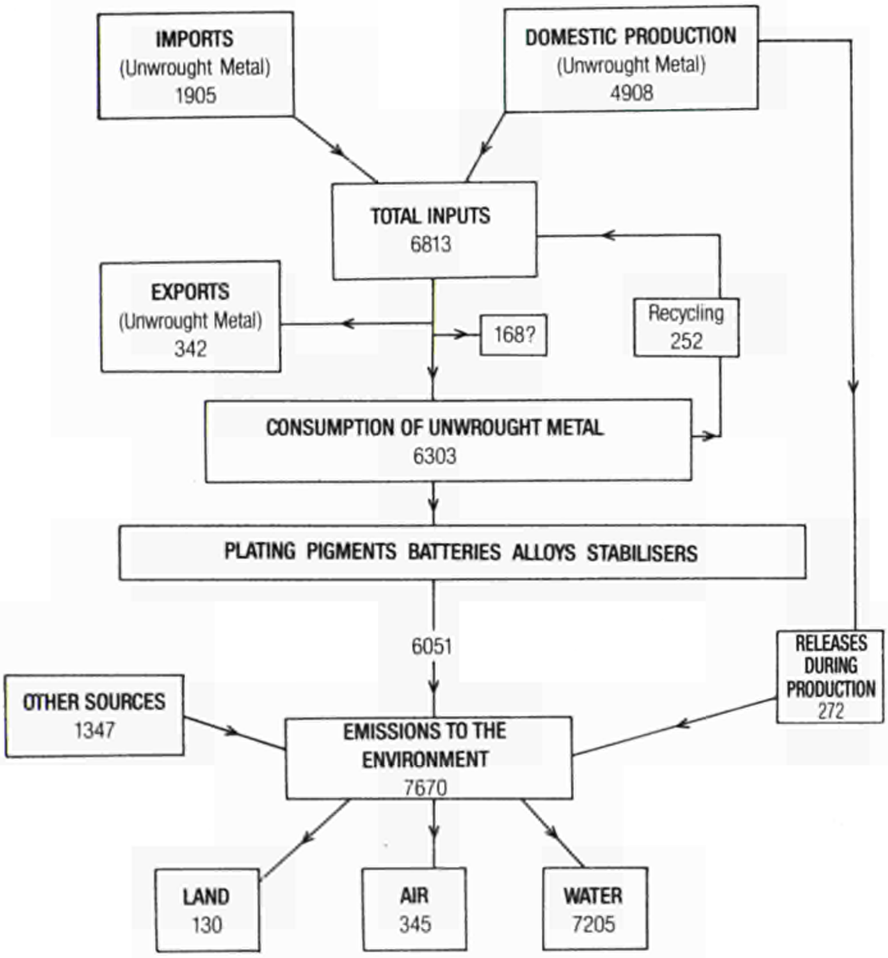
Annual releases of cadmium to the environment may be considerable. Estimates for the mid-1970s suggest that an average of some 6000 tonnes of Cd are discharged into the environment, mainly to the land and mainly from its use in manufacturing (Figure 3.16 - see also Inset, pages 66-67). In practice, much of this cadmium is in an inert form and does not pose any immediate environmental or health threat. In the longer term, however, decomposition of these solid wastes may release significant quantities of cadmium into soils, surface-waters and groundwaters. More important in the shorter term are the releases of more volatile cadmium compounds to the air and water. These come mainly from manufacturing and primary production, and possibly total 350 tonnes per year.

Unlike most metals, primary cadmium is rarely obtained by the extraction and processing of high grade ores. Instead, the vast majority is produced as a by-product of zinc smelting. Many zinc ores contain small quantities of cadmium (often in the order of 0.1% to 0.3%) which are volatilised during processing. The cadmium-rich dusts, sludges or other residues can then be recovered and refined to yield high purity cadmium.

Because of this dependence on zinc manufacture, a close correlation exists both geographically and temporally between cadmium and zinc production. In the European Community, the main cadmium producers are Belgium and Germany, both countries with important zinc manufacturing industries. Over time, levels of cadmium production tend to follow those of zinc and, between 1977 and 1981, an average of 3.6 kg of cadmium were produced for each tonne of zinc slab. Nevertheless, in recent years the relationship between zinc and cadmium manufacture has varied, and since 1979-1980, cadmium consumption has declined markedly (Figure 3.17). This decline has been common to all member states, although the incomplete data for 1982 suggest that consumption may be rising slightly in some member states (notably Germany).

As with other industrial changes in the Community, many factors have contributed to this trend. A critical factor has been the fall in the market price of cadmium which has made recovery of the metal during zinc smelting less attractive economically. Indeed, the current world price for cadmium (about 2.5 ECU/kg) is below production costs. As a consequence, there is a disincentive for zinc producers to use cadmium-rich ores. Cadmium production in the European Community, however, has declined markedly more rapidly than in other parts of the world, so world prices are clearly not the only force involved.

Figure 3.16 **Cadmium: production, consumption and releases into the environment, 1981.**



Sources: data from Hiscock 1980; Bevington 1984; Commission of the European Communities 1985

CADMIUM IN THE ENVIRONMENT: A CROSS-MEDIA PROBLEM

Like almost all pollutants, the effect of cadmium in the environment is both wide-ranging and complex. It is released from many different sources, and as a result of many different processes. Once in the environment, it is both mobile and persistent. It is transferred freely from one locality to another. It accumulates in and contaminates many different media: the atmosphere, the soil, waters, and wildlife. Ultimately, it may cause health damage in humans. It is, therefore, an important cross-media problem (see Figure opposite).

Not all cadmium, of course, is anthropogenic in origin. Low 'background' levels of cadmium occur naturally, largely as a result of weathering of cadmium-rich rocks and minerals. Superimposed on these, however, are releases from human activities, which, at least locally, give rise to considerable enrichment in the environment. The main 'human' inputs come from:

- emissions during the processing of cadmium from zinc and other sources, and the manufacture of cadmium-containing products;
- the use and disposal of cadmium-containing products;
- use of phosphate rock containing cadmium impurities (e.g. in the production of fertilisers and detergents);
- combustion of coal containing cadmium impurities.

From these sources cadmium is dispersed widely throughout the environment. Cadmium is emitted into the air, for example, by volcanic action and from the incineration of wastes, fuel combustion, production of cadmium-containing products and sewage sludge disposal. It may remain in the atmosphere for between a few hours and several days, depending on particle size and atmospheric conditions. During this time, it may be transported considerable distances, and 50% or more of the cadmium deposited on land in Denmark is believed to come from outside the country. In most situations, however, by far the greater majority of the cadmium is deposited close to its emission source, either by dry deposition or wash-out. In this way it enters the soil and water.

Cadmium deposited from the atmosphere is supplemented in the water by releases from industry, from phosphate fertilisers and from sewage sludge. Its fate in the water depends on a number of factors including the chemistry of the water and the sediment concentration. Much may be fixed into insoluble compounds by reactions with carbonates, hydroxide or sulphide. Some, also, is adsorbed onto clay particles. In all these cases, the cadmium then tends to be deposited in the sediments, where it may reach high concentrations (e.g. in estuarine areas). Over time, however, release from the sediments also occurs, as a result of organic matter decomposition, anaerobic oxidation and displacement by by other ions. In addition, significant quantities may be transferred from the aquatic sediments to the land by flooding and dredging: as much as 27 t/month are spread on the land in dredge spoil from the Rhine and Meuse catchments.

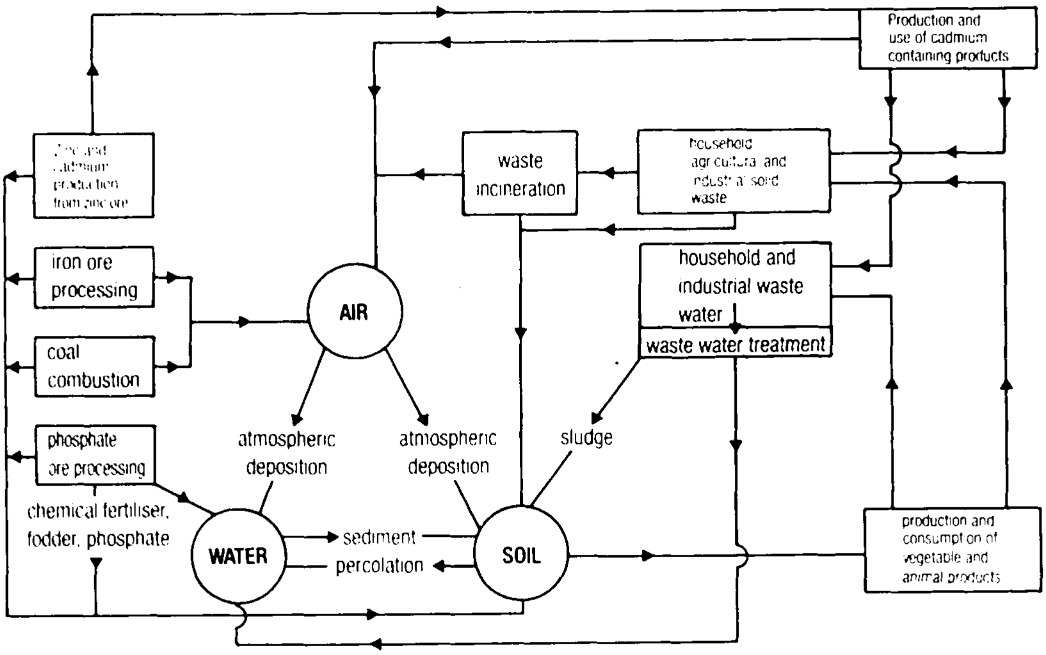
To this input to the land must be added several other important sources of cadmium: deposition from the atmosphere, fertiliser use, sewage sludge, disposal of solid wastes, weathering of cadmium-bearing rocks and leaching from cadmium-containing products. Together, these possibly result in an input to the land of almost 3000 tonnes of cadmium per year in the European Community. Much of this input is retained in the soil, but smaller amounts may be taken up by plants and removed in harvesting, or leached from the soil into groundwaters and streams.

From all these media, cadmium enters foodchains. Plants take up cadmium from the soil; terrestrial animals ingest it from the plants and absorb it through inhalation of cadmium-containing dusts; aquatic animals take in cadmium in the water and sediments with which they come into contact. As it is passed up the foodchain, the concentration of cadmium in the bodies of the organisms increases. Evidence for biotoxic effects is limited, but at concentrations as low as 3 mg/kg some plants begin to be affected, whilst salmonids and aquatic invertebrates such as *Daphnia* are particularly sensitive to cadmium.

The effects of cadmium on humans is even less certain. The main source of exposure is via food, but locally, especially in urban areas close to multiple point and non-point sources, 'hotspots' may develop where increased rates of cadmium intake may cause serious pulmonary and gastrointestinal problems. The main concern, however, is with its potential renal effects; cadmium accumulates in the kidneys and may lead to kidney dysfunction. In addition, there is growing evidence that it is a possible carcinogen. The level of intake necessary to generate such effects is markedly higher than that to which the general population is ever likely to be exposed. Some groups of people, however, may be much more at risk: namely workers who are in regular contact with cadmium-rich environments, smokers, and people subject to dietary deficiencies.

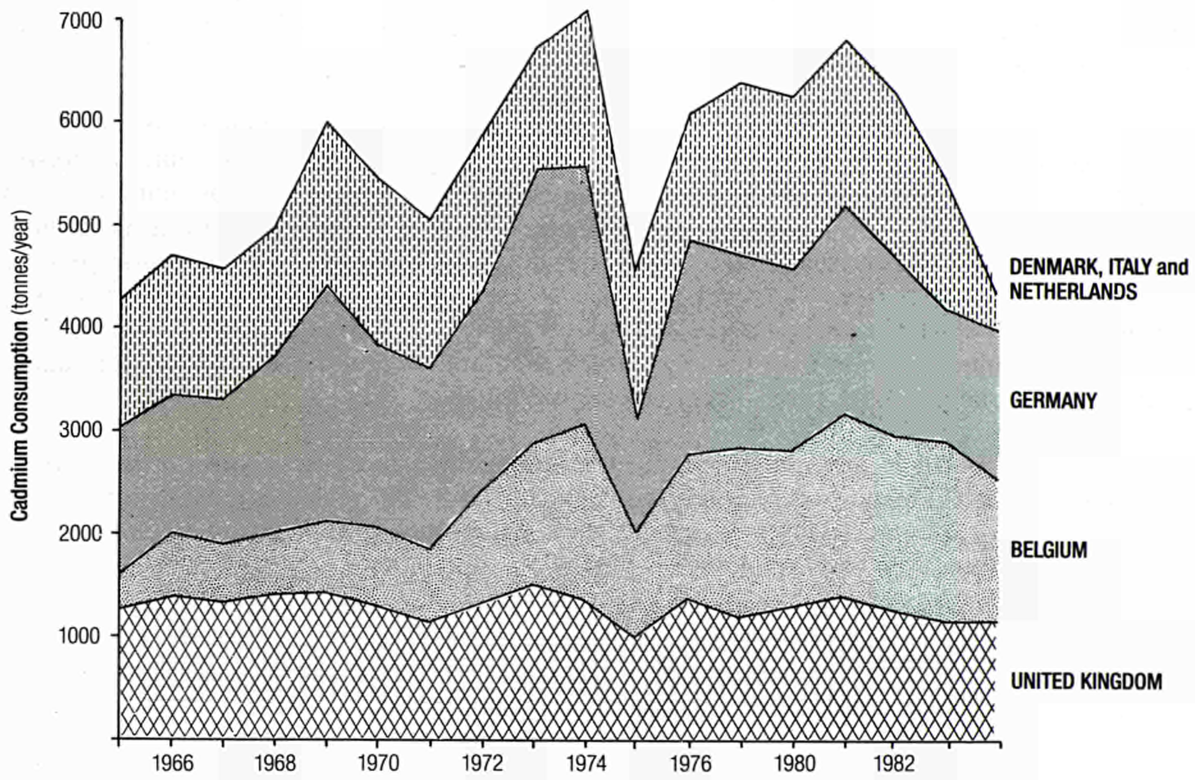
Because of these potential environmental and health effects, the control of cadmium is a major priority in the Community. And it is a problem which is being tackled in the only effective way available: by control at source so that releases of cadmium into the environment are minimised. It is an approach which increasingly is being adopted for many other pollutants.

The flow of cadmium through the environment.



Source: Ministry of Housing, Physical Planning and Education 1985 *Environmental program of the Netherlands, 1985-1989*. The Hague: Ministry of Housing, Physical Planning and Education

Figure 3.17 **Cadmium consumption in Community member states, 1965-1982.**



Source: data from Hiscock 1980

One factor of significance in the Community has been the general economic recession of recent years. This has hit some industries more than others and has resulted either in a reduction of output (and hence of demand for raw materials such as cadmium) or has led to the search for cheaper raw material substitutes. Another factor of possibly even greater significance has been the adoption of pollution control legislation, including stringent limits on cadmium emissions.

These influences can be seen in the main cadmium-consuming industries. Traditionally, cadmium has five main uses:

i. electroplating - mainly for ferrous metals;

ii. pigments - about 80% for plastics, the remainder for glass, paints, ceramics and enamels;

iii. stabilisers - mainly for polyvinylchloride (PVC);

iv. battery electrodes - predominately in nickel-cadmium rechargable batteries;

v. alloys - in a wide range of processes, including brazing, soldering and strengthening.

All these applications have experienced fluctuating circumstances in recent years. Use in batteries has generally grown due to the rising demand for rechargable batteries in the electronics industry. A marked decline has occurred, however, in cadmium usage both as a stabiliser and for electroplating. In part, this reflects the declining fortunes of these industries, but more important has been the introduction of emission controls in the Community and the ban on cadmium-plating elsewhere (e.g. Sweden). This has encouraged the industries concerned to seek environmentally more acceptable alternatives, although, to date, there has been only limited success in the search for substitutes. Barium-zinc and calcium-zinc compounds are being used as replacements for cadmium in PVC production, and nickel, zinc, chromium, silver and gold can sometimes be used as alternatives for plating. In many cases, however, the substitutes are more costly, less effective or themselves environmentally hazardous. As a result, substitution is becoming more difficult. In the future, it therefore seems likely that cadmium consumption will fall only slowly - and in any case, as it declines the problem of disposal in zinc wastes will increase. Without doubt, cadmium production, usage and disposal will continue to need careful monitoring if its environmental impacts are to be controlled.

3.5 CHEMICALS

The chemical industry is extremely diverse in character. At one end of the spectrum it includes the large-scale production of bulk chemicals, such as sulphuric acid, vinyl chloride and titanium dioxide, which are generally primary products used in other manufacturing processes. At the other extreme, it includes the specialist production of fine chemicals, such as pharmaceuticals, dyestuffs, food additives, pigments and pesticides.

Almost all these chemicals have environmental implications and hazards occur at a number of points in their manufacture and use. Deliberate discharges, for example, occur as emissions and effluents released from chemical plants or during waste disposal. Unintentional discharges may occur as a result of accidents during production, storage, transport or the use of the chemicals. Moreover, many of the chemicals sold on the market may have direct, adverse health effects, if misused. For these reasons, considerable attention has been directed at national and Community level to the control of the production, storage, transport, marketing and use of chemicals.

3.5.1 Titanium Dioxide

In its refined state, titanium dioxide (TiO_2) is a white oxide of great opacity. This property, together with its purity and stability, make it an ideal pigment, and it is widely used in paints, lacquers and inks. These account for about 55-65% of the total consumption of titanium dioxide in the European Community, the remainder being used mainly in plastics, textiles and rubber. The titanium dioxide itself is relatively inert and poses no specific health or environmental problems. Its production, however, is of considerable concern, for it results in the generation of a wide range of wastes, many of which act as major environmental pollutants. As a result, in 1978, the European Community adopted a Directive on wastes from the titanium dioxide industry. A second Directive on monitoring requirements (883/82) was adopted in 1982 (Table 3.1).

The European Community imports all its raw titanium dioxide, but in 1984 had sixteen plants producing a total of about 870,000 tonnes of refined TiO_2 (Figure 3.18). A small quantity is produced by the chloride process, during which high grade natural rutile (with a titanium dioxide content of about 96%) is chlorinated to yield titanium tetrachloride. This is mechanically separated then oxidised to give refined TiO_2. Because it uses high grade starting ores, it produces little waste material. The scarcity of these ores, however, limits its application and at present plants using this process have a capacity of only about 140,000 tonnes.

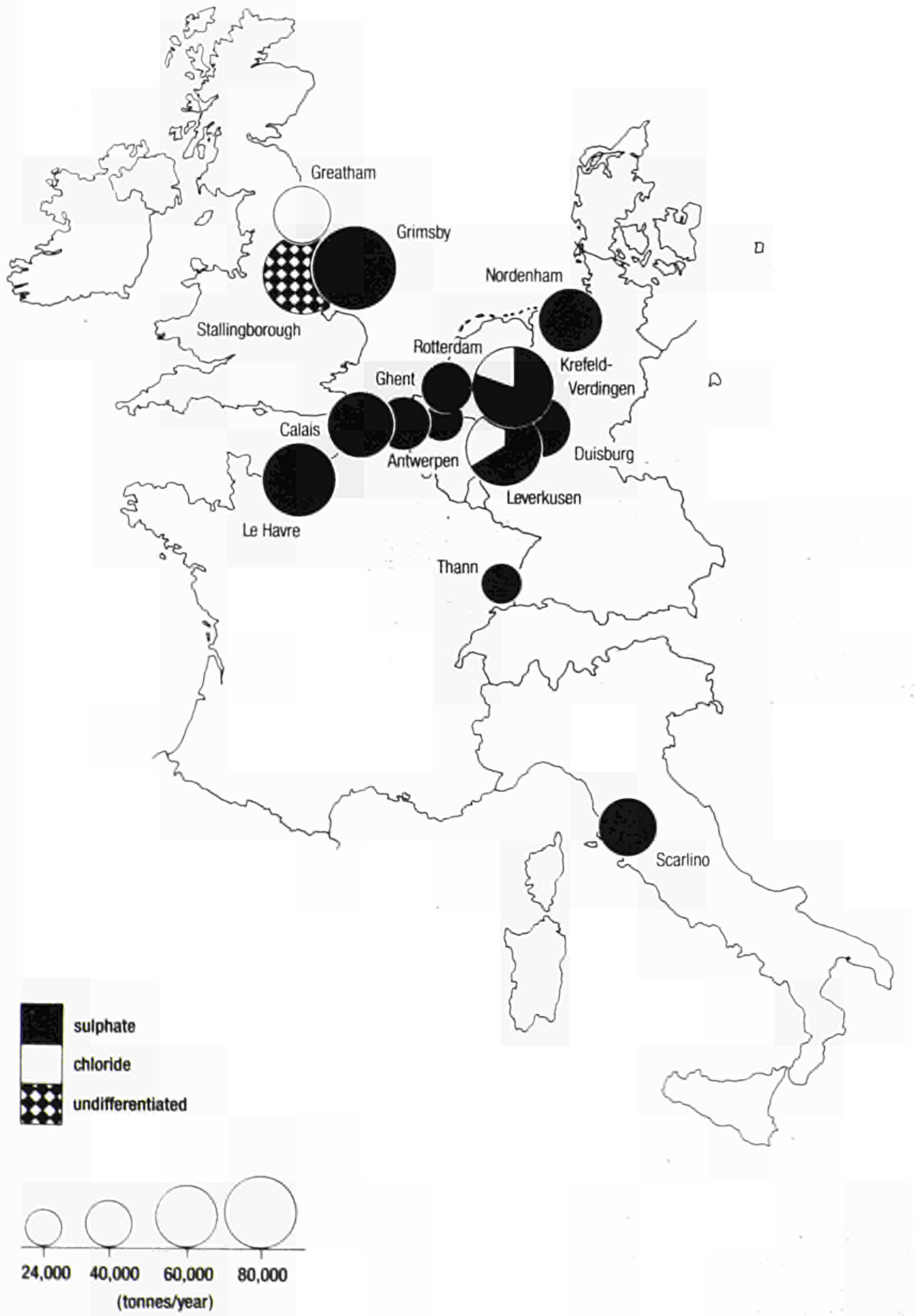
The majority of plants in the Community, therefore, employ the alternative, sulphate process. This takes ilmenite or slag (partially processed ore) as its starting ore, and extracts the titanium dioxide by a three-stage process of acidification in sulphuric acid, separation by crystallisation, dewatering and hydrolisation, and high temperature calcination. The end product is then ground and may be further treated to give high quality pigment.

Table 3.1 **Community actions on chemicals**

DATE	ACTION	ABBREVIATED TITLE	OBJECTIVE
1967	Directive (67/548)	Classification, packaging and labelling of dangerous substances	Sets down laws, regulations and administrative provisions (amended in 1969, 1970, 1971, 1973, 1975)
1973	Directive (73/404)	Laws on detergents	Establishes biodegradability of detergents at 90%
1973	Directive (73/405)	Biodegradability of anionic surfactants	Establishes laws relating to biodegradability
1976	Resolution	Chlorofluorocarbons in the environment	Limits production and use of CFCs and encourages use of substitutes
1978	Directive (78/176)	Waste from the titanium dioxide industry	Promotes prevention and recycling of waste; regulates waste disposal; lays down system of authorisation for disposal
1978	Decision (78/618)	Toxicity and ecotoxicity of chemical compounds	Establishes scientific advisory committee on toxicity and ecotoxicity of chemical compounds
1979	Directive (79/831)	'Sixth Amendment'	Combines 1967 Directive and later amendments; provides for system of notification of new chemicals; instructs Commission to create inventory of existing chemicals.
1980	Decision (80/372)	Chlorofluorocarbons in the environment	Limits production of CFCs; requires reduction of 30% in use in aerosols
1981	Decision (81/437)	Inventory of chemical substances	Lays down criteria and procedures for preparation of EINECS inventory
1982	Directive (82/501)	Major accident hazards of certain industrial activities	Sets up notification system for dangerous substances, installation and major accident hazards
1982	Decision (82/795)	Precautionary measures on chlorofluorocarbons in the environment	Requires member states to co-operate in in reducing CFC emissions and in developing clean technologies for use in refrigeration, solvents, foam plastics
1982	Directive (82/883)	Wastes from titanium dioxide industry	Sets out procedures for surveillance and monitoring of wastes

Source: Commisson of the European Communities 1984

Figure 3.18 **Titanium dioxide production in the European Community, 1983**



Source: data from Commission of the European Communities 1983 and 1984

Plate 3.4 **A modern chemicals works. Despite improvements in plant design and environmental protection measures, chemicals industries still represent a significant source of environmental pollution. Not the least problem comes from the threat of accidents; the Community has therefore adopted a Directive to combat such accidents (the Seveso Directive - see Inset page 35).**

Photo: D. J. Briggs

Compared to the chlorine process, this produces large amounts of waste at all stages in the treatment. The separation phase, for example, leaves strongly acidic 'mother liquors' containing 20-23% free sulphuric acid, while weaker acids are produced during subsequent washing. When ilmenite is the starting ore, crystalline ferrous sulphate (copperas) is generated during the separation phase, while residues of unreacted ore occur after acidification. In addition, atmospheric emissions of sulphur dioxide and sulphur trioxide are released from both the digestion towers and calcination kilns, and dust is produced during grinding of the original ore and refined titanium dioxide.

The majority of these wastes are disposed of at sea, either via pipelines (i.e.as discharges) or by dumping from ships. Smaller quantities of neutralised liquid wastes are also discharged into freshwaters, while insoluble solid wastes may be disposed of by landfill.

The fate of all the wastes is a matter of concern because of their potential environmental impacts. Discharge or dumping at sea, for example, may result in acidification of the seawaters - at least locally and briefly - while land disposal may result in contamination of streams and groundwaters. Consequently, disposal within the Community is subject to a number of controls, including the Paris Convention which relates to discharges at sea, and the Oslo Convention, which covers dumping. In addition, the Community Directive on wastes from the titanium dioxide industry, adopted in 1978, aims to reduce - and eventually eliminate - all pollution from such wastes.

Without doubt, these actions have had some success. In Germany, for example, the quantity of acid effluent discharged at sea fell from 1.8 million tonnes in 1978 to 1.3 million tonnes in 1983. At the same time, discharges of copperas fell from 150,000 tonnes to 110,000 tonnes. Similarly, there was a 25% reduction in liquid waste discharges from France between 1979 and 1980. Nevertheless, large quantities of wastes are still released into the environment and in 1982 the European Community adopted a new Directive on monitoring requirements and procedures, strengthening many of the controls on waste disposal. Since any upturn in the economy is likely to result in increased levels of production of titanium dioxide, these controls will play a vital role in preventing environmental damage from the industry in the future. In order further to decrease pollution from titanium dioxide production, and to improve competition between the industries concerned, the Commission has presented a new proposal to the Council. No decision has yet been taken, but in the meantime several member states have decided to ban dumping of wastes at sea.

3.5.2 Chlorofluorocarbons

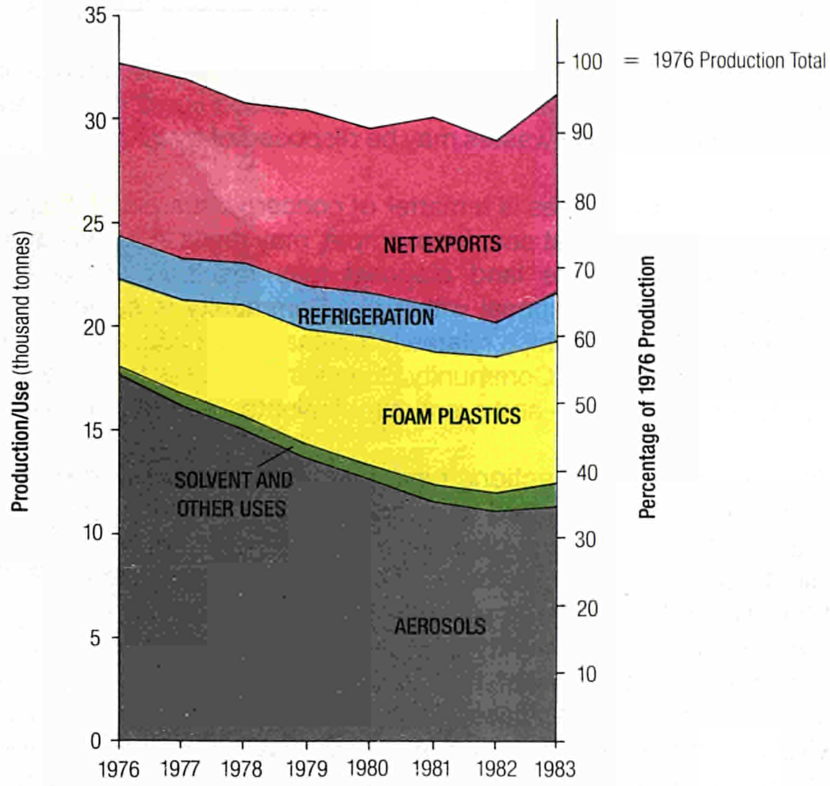
Chlorofluorocarbons (CFCs) are freons (halogenated hydrocarbons) which are used for a variety of purposes, including aerosol propellants, refrigeration, solvents and foam plastic production. Traditionally, the European Community produces most of the CFCs it uses, and it also exports considerable quantities. In recent years, however, the effects of CFC emissions to the environment (especially to the atmosphere) have been viewed with increasing concern because of their potential impacts on the atmosphere, and between 1978 and 1982 three actions were taken at Community level to limit production and control losses (see Table 3.1):

i. A Resolution in May 1976 to control CFC production and use.

ii. A Decision in March 1980 stipulating that production of CFC 11 and CFC 12 should not be increased in any member state, and that a 30% reduction (relative to 1976 levels) of CFC usage in aerosols should be attained by the end of 1981.

iii. A Decision in November 1982 requiring member states to co-operate in reducing CFC emissions and in developing "cleaner" technologies for CFC usage in the refrigeration, solvents and foam plastics sectors.

Figure 3.19 **Production and use of CFCs in the European Community, 1976-1983.**



Source: data from Commission of the European Communities 1983

The extent to which these actions have been successful can be seen, in part, from the data in Figure 3.19. Between 1976 and 1982, total annual production of CFCs in the Community fell from 326,433 tonnes to 288,279 tonnes, (with a small rise in 1981 when Greece joined the Community) before rising again, to 310,193 tonnes, in 1983. This reduction was entirely due to a decline in demand for CFCs for aerosol fillings. From 1976 to 1983, usage in aerosols fell by 36%, to 113,895 tonnes. At the same time, however, other uses increased markedly: by 66% in the case of foam plastics and 160% in the case of solvents.

Several factors have no doubt played a part in these trends. The growth in the use of CFCs for foam plastics manufacture appears to be mainly associated with the increasing demand for polyurethane and polystyrene for thermal insulation - a development itself triggered off by increasing energy prices. Their use as a solvent is largely related to increasing demand for dry cleaning chemicals. On the other hand, the decline in the use of CFCs as aerosol propellants must be seen largely as a result of the Community legislation on production. This reduction in use has been achieved in most cases by using non-CFC propellants such as hydrocarbons and dimethylether. It is notable, however, that the fall in demand for CFCs in this sector began some years before Community legislation was introduced. This is not to imply necessarily that other factors have been operating; rather it indicates the way in which manufacturers anticipate planned action and adopt alternative production processes in advance of legislation.

What will happen in the future is not clear. The marked upturn in output seen in 1983 reflects the slower decline in the use of CFCs in the aerosols sector as Community targets have been reached; the annual increase in usage in other sectors now more than compensates for the reduction in aerosols. Given the buoyant demand for foam plastics and solvents this increase seems likely to continue. Current Community policy is aimed now at controlling emissions rather than limiting output, so the question for the future is whether cleaner technologies can be introduced sufficiently rapidly to reduce emissions despite the increase in production.

It must also be borne in mind that the Community is not operating in isolation with regard to chlorofluorocarbons. The environmental effects of CFCs - on ozone production and thus on levels of ultra-violet radiation at the ground surface, for example - are global in scale. For these reasons, trends within the European Community need to be viewed in a wider context: at this scale, it appears that, after several years of decline, annual production of CFSs has stabilised at about 750,000 tonnes. The continued release of chlorofluoro- carbons into the atmosphere, however, undoubtedly means that CFCs will remain a cause of concern for the foreseeable future.

3.6 SERVICES

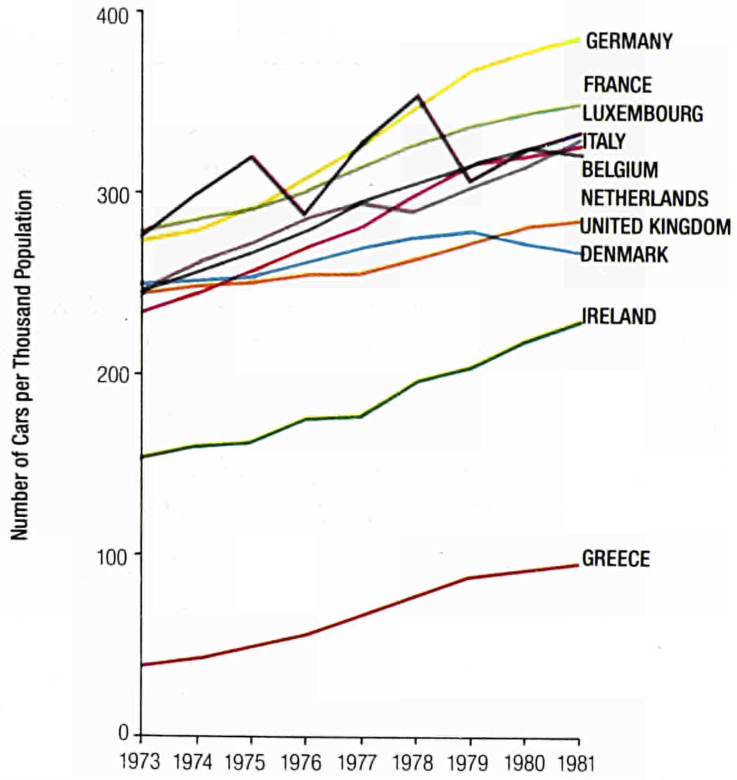
3.6.1 Transport

The growth in ownership and use of private cars is one of the dominant social trends in all industrial countries. In Britain alone, the number of cars increased from 3 million in 1951 to 12 million in 1971 and 15.9 million in 1981. At the same time, several other trends have also been occurring. Rail transport has declined or remained steady, and in many member states the length of the rail network has been reduced as more remote lines have been closed. Freight traffic has accordingly been diverted to roads, and both the number and weight of lorries have increased. Shipping traffic has been undergoing major structural changes, with a reduction in the number of registered ships but an increase in the average size. Air travel, particularly for tourism, has expanded dramatically.

Several of these trends are illustrated in Figures 3.20 to 3.22. Unfortunately, comprehensive and compatible data on road traffic volumes (e.g. in vehicle kilometres per year) are not available, but changes in vehicle ownership are shown in Figure 3.20. The overall pattern is clear, with a steadily increasing number of cars in all member states and with a close correlation between level of economic development and level of car ownership. Within this general pattern, however, a number of variations are apparent. The rate of growth is generally greatest in those countries with a low stock of vehicles: in Greece, Ireland and Italy. The effects of the so-called oil crisis during the early 1970s are also apparent, with a temporary reduction in the rate of growth (and, in a few cases, a small decline in absolute terms).

These changes reflect many different forces operating in the Community. Increased wealth (as measured by per caput disposable income) has undoubtedly allowed more people to own cars. In many cases, however, much of the growth in the market for cars is due to expansion of business vehicles. Social factors are also involved, with many more women driving and more households owning 'second' cars. In addition, there is a complex relationship - part cause and part effect - with changing provision of public transport. Reduced availability of public transport is a stimulus to private car ownership; this, in turn, reduces the profitability of public transport.

Figure 3.20 **Car ownership in Community member states, 1973-1981.**

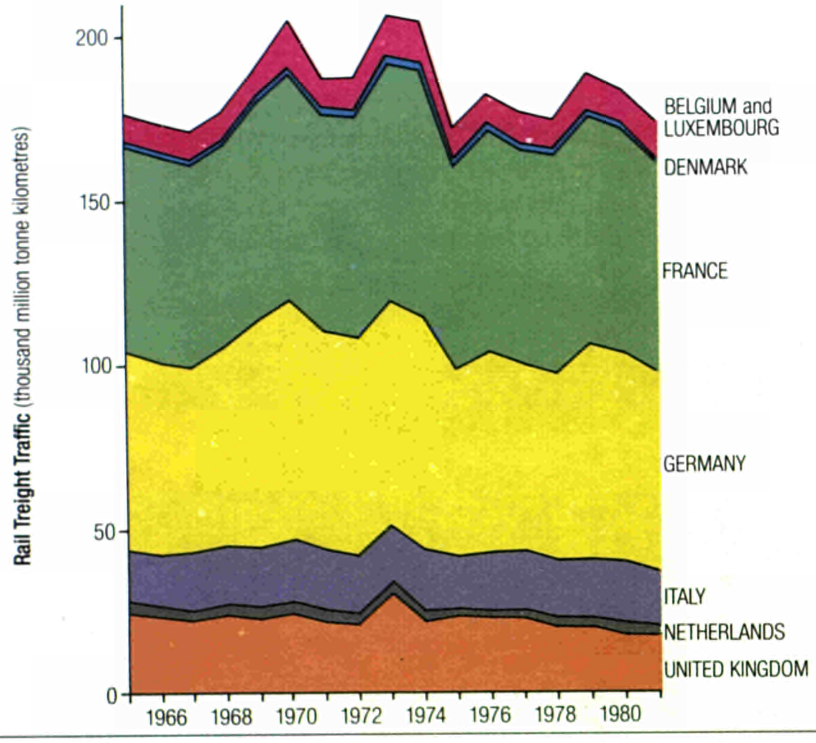


Source: data from Eurostat 1984

At the same time, an even more persistent increase in commercial road traffic has occurred. Between 1973 and 1981 the number of goods vehicles on Community roads rose from 7.08 million to 8.76 million, an increase of over 20%. This has been accompanied by a sharp increase in average vehicle weight and engine power. The effects on the environment have not risen proportionately, for improved engine and suspension design have meant that exhaust emissions and noise levels (per unit haulage weight) have fallen, but overall impacts have undoubtedly increased. Moreover, the greater flexibility of movement of these vehicles, compared to the rail traffic which they have displaced, means that they penetrate further into the environment and have far more widespread effects, especially within residential communities.

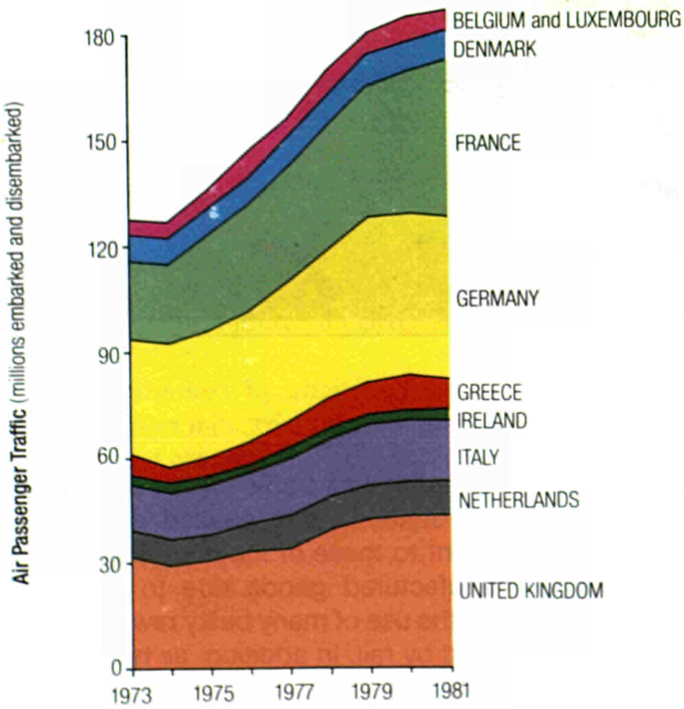
All the changes which are occurring in road vehicle and usage have important social and environmental implications. Socially, the expanding use of cars has increased the mobility of large sectors of the population, altered the living and working patterns of many communities, and increased the demand for tourism and other facilities. It also led during the 1960s and 1970s to a marked increase in road accidents, although since 1977 there has been a slight decline again in some member states, partly because of improved driver-training and driving standards, more importantly because of improvements in vehicle safety design. (The exceptions are Italy and Greece). Environmentally the impacts include greater exhaust emissions, increased road construction and consequent loss of land and habitats and greater tourist pressures on remote areas.

Figure 3.21 **Rail freight traffic in Community member states, 1965-1981.**



Source: data from Eurostat 1984

Figure 3.22 **Air passenger traffic in Community member states, 1973-1981.**



Source: data from Eurostat 1984

Plate 3.5 **Road traffic continues to present a major source of environmental pollution: exhaust emissions include carbon monoxide, sulphur dioxide, nitrogen oxides and lead. The control of these emissions is thus a major priority. Noise pollution from traffic, also, is a cause of considerable concern (see Inset, page 79).**

Photo: D.J. Briggs

Figure 3.21 shows changes in rail freight traffic for the period 1965 to 1981. In general, a consistent trend exists in all member states; traffic peaked during the early 1970s and has subsequently declined to levels equivalent to those of the mid-1960s. The reasons for this decline are varied: the fall in output of manufactured goods due to economic recession is in part responsible, as is the change away from the use of many bulky raw materials (such as coal, and iron ore) which have traditionally been moved by rail. In addition, as has been noted, there has been a tendency to transfer freight traffic to roads, especially since the development of containerisation and the associated improvements in vehicle design. Whilst lorries clearly have advantages of flexibility in terms of their route and timing, however, they are generally less efficient in terms of energy consumption than rail (with a ratio of about 3:1 per tonne freight kilometre).

NOISE

Importance of noise pollution

It is mainly in the highly industrialised countries, characterised by high volumes of traffic, that noise is perceived as a serious environmental nuisance. The extent to which it is seen as a problem depends on psychological and sociological factors, but it is clear that, like other pollutants, noise not only reduces the quality of life but may also provide a significant health hazard. It has been shown, for example, that people living near to busy main roads tend to have higher blood pressure. Those already subject to such health problems - and particularly people who are subjected to high noise levels both at home and at work - may be at risk from health damage by noise pollution. Moreover, apart from the hazard for human health, noise pollution may have ecological impacts, for several species are known to be sensitive to noise.

Sources of noise pollution

Since noise diffuses only a short distance from its source, noise nuisances are generally localised. Nevertheless, noise pollution may derive from a wide range of sources. The main source is traffic, which as a result can have major detrimental effects on the quality of the environment. Additional sources are industrial equipment, construction activities, sporting activities, and exercises by low-flying military aircraft. Most of these are associated with more densely urbanised areas, but in recent years the problem has increasingly encroached on rural areas as a consequence of infrastructural and economic development.

Community measures to control noise

Measures to reduce noise nuisances in the European Community have been based on three main approaches:

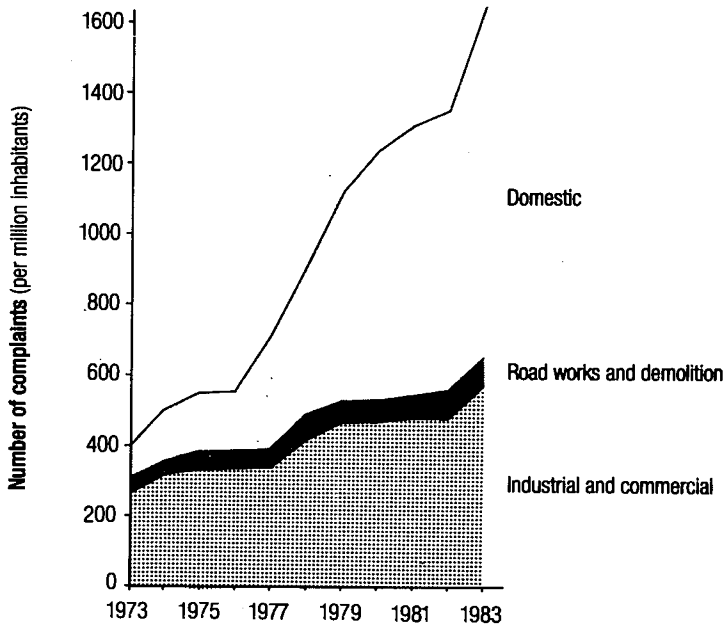
i. combatting noise at source, for example by reducing noise emissions from vehicles, construction equipment, industrial machinery and domestic appliances, etc.

ii. reducing noise nuisances by zoning of urban areas - for example by segregating residential areas from industrial or other areas characterised by high levels of noise by appropriate physical planning.

iii. application of 'passive' protection measures such as noise barriers along roads or noise insulation in buildings.

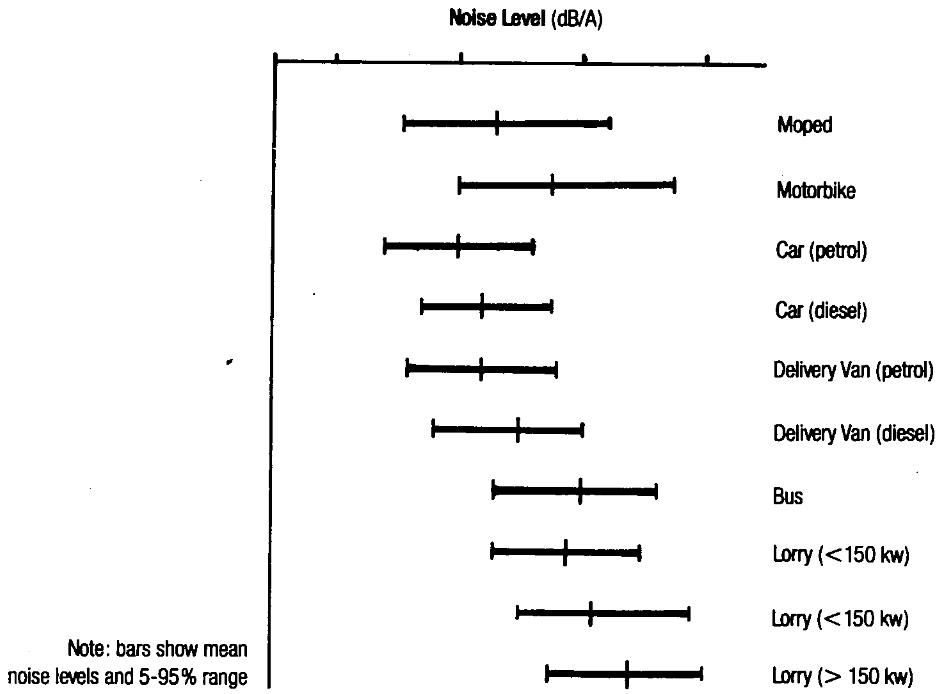
The Community has so far concentrated its attention principally on measures to control noise at source, and a number of Directives establishing noise emission standards have been adopted. This approach stems to a large extent from the fundamental principle to harmonise products within the Community.

Official complaints about noise pollution in the United Kingdom, 1975-1984.



Source: data from Department of the Environment 1985.

Noise emissions from vehicles in Germany.



Source: data from Umweltbundesamt 1984.

Levels of noise in the environment

Because of the strong subjective component in the perception of noise physical measurements of noise pollution provide only a partial picture of the real problem. One of the most reliable indicators of the problem is therefore public opinion; the opinion poll on the environment conducted by the European Commission in 1982, for example, showed that noise was seen as the second most important problem at the local level. Similarly, the incidence of official complaints by the public about noise nuisances give a useful measure of the extent of the problem. According to this barometer, the problem is getting worse, as the data in the figure opposite illustrate: numbers of complaints in England and Wales have doubled between 1975 and 1985. In France, today, approximately 25% of the population are exposed to an average daily noise level of more than 65 dB(A); in Germany the figure is 15-20%.

Amongst the different sources of noise, traffic is undoubtedly the most important. Aggregated data on traffic, however, do not provide a particularly sensitive or reliable index of noise generation, because different components of the traffic have different emission levels. Cars, for example, produce relatively little noise, and in any case have increased relatively slowly in numbers in recent years. Conversely, lorries are a much more important source of noise, and these have increased much more rapidly, with a rise of 20% in total freight volumes between 1973 and 1981.

In addition to noise from road traffic, public complaints indicate concern with noise from several other sources, including industrial plants, building sites, aircraft landing and taking off, low-flying military aircraft and sporting activities. Undoubtedly, air passenger traffic has expanded considerably over the last 10-15 years, though improvements in engine design have meant that noise emissions may not have risen proportionately. In general, however, there are too few data on these other sources of noise to make valid assessments of the situation in the Community.

On the basis of the available evidence, it can thus be stated that about 25% of the total population complain about noise pollution. About 15-25% of the population are probably exposed to a noise level which is sufficient to pose a significant health threat. It is not possible with the available data to determine whether the measures already taken are reducing the scale of the problem in the Community, but as far as road traffic is concerned it seems that the problem is in fact getting worse. The situation seems to be deteriorating particularly in urban areas, despite the more widespread construction of noise barriers along roads.

In the future, significant reductions in noise are likely to come mainly from the reduction of vehicle noise by more rigorous controls and by the introduction of quieter vehicles. Certainly this is possible, for the technology already exists to produce lorries with noise levels 10 dB(A) less than those currently on the road. On this basis, twenty of the new lorries would produce no more noise than one existing vehicle of similar size and capacity. The same is true of motor cycles. The adoption of such technology would inevitably increase the price of the vehicles, but this must be set against the costs of the passive measures of protection which would otherwise be needed (or the damage costs if no preventive action is taken). At the same time, improvements in the situation are also likely to be achieved by the application of environmental impact assessments. By requiring environmental effects of infrastructural developments to be taken into account at the planning stage, these will encourage better design against noise from major projects such as road and industrial developments.

Sources: see Notes and Sources, page 91

The most rapid and persistent increase in transport has occurred in air traffic. Levels of passenger traffic in Community member states between 1973 and 1981 are shown in Figure 3.22 and the trend is clear. From 1973 to 1979 there was a marked rise in traffic, amounting to an increase of about 41% in the Community as a whole. This reflects not only advances in aircraft design, facilitating cheaper fares, but also fundamental social changes in the Community. Since then, traffic has continued to rise, though at a much slower rate - largely, perhaps because of the effect of oil prices on fares, and general problems of economic recession. The environmental effects of the growth in air traffic include greater problems of noise around airports (though this is partly offset by improved engine design), increased demand for land, and increased emissions in the upper atmosphere.

3.6.2 Water Supply

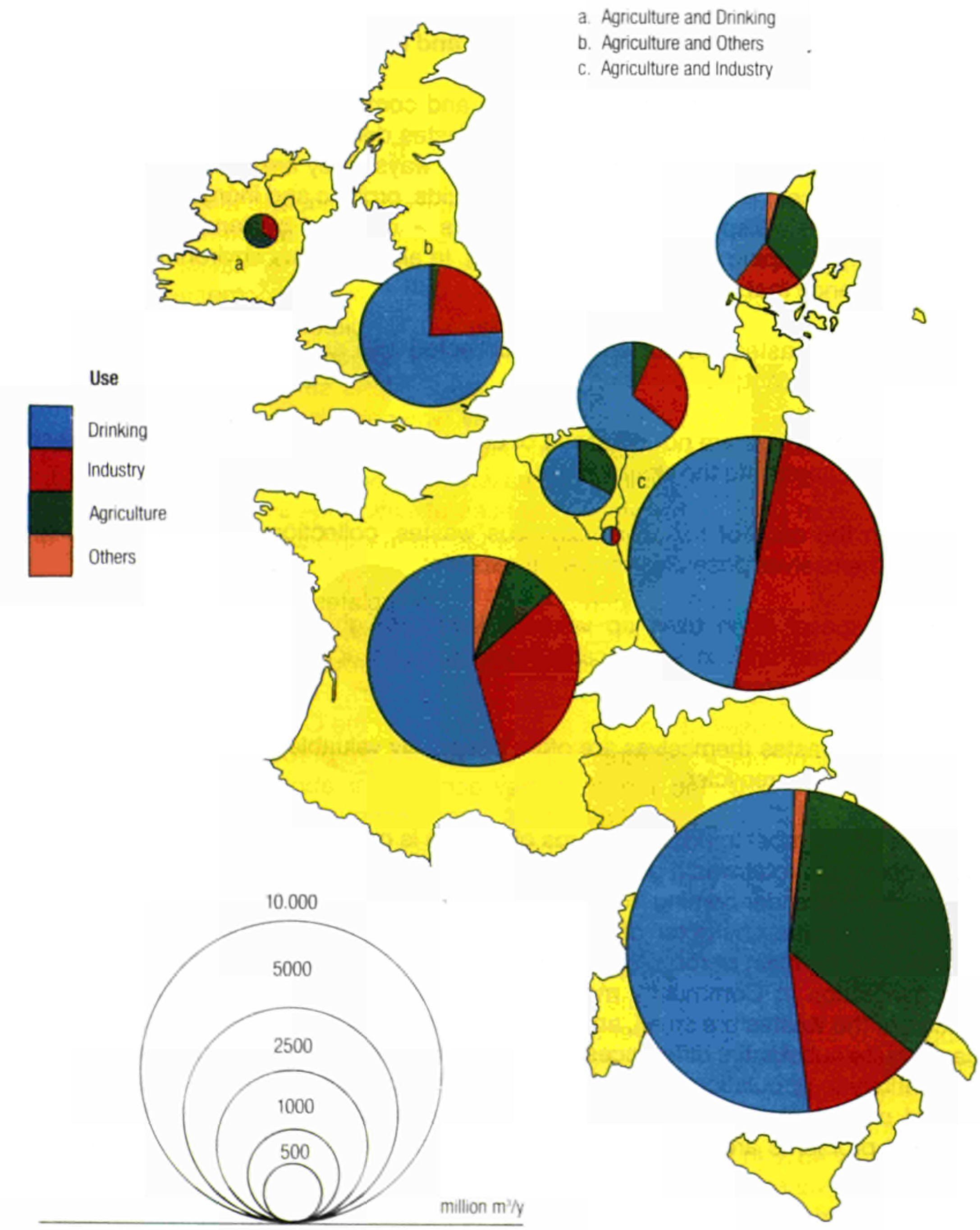
Although water is a resource of fundamental importance to almost all human activities, data on its abstraction and use in the European Community are often lacking and unreliable. Different estimates of annual rates of withdrawal by individual member states, for example, may vary by as much as 50%, masking any short-term trends and making comparison between different countries highly suspect. Much of the problem relates to the circumstance that only a limited part of total water usage is provided by public water supply services, and records on other abstractions are often incomplete. In Denmark, for example, all water use is strictly monitored and licenses are necessary for all abstractions. In France, conversely, water abstraction is generally free, and returns only have to be reported to the Agences Financières de Bassin above certain threshold levels. Water usage for irrigation is particularly difficult to measure, for much abstraction takes place directly from private sources and involves only small quantities at any time. Similarly, direct abstractions for industrial purposes are not monitored in any rigorous manner in several member states.

On the whole, the most accurate information relates to groundwater abstraction, and Figure 3.23 shows total consumption and end uses of groundwater by nine member states (no data are available for Greece). As might be anticipated, use of groundwaters is greatest in those areas lacking reliable surface water resources (e.g. Italy, southern France and Denmark). The general dominance of domestic uses of water is also clear, and in the Community as a whole these uses account for 55-60% of total consumption. Industrial uses are of roughly equal significance only in Germany, (though in the United Kingdom they account for about half of total water use - i.e. groundwater plus surface water). Agricultural uses (although variously defined) are of most importance in the more arid, southern regions (e.g. Italy), and in intensive livestock rearing areas (e.g. parts of Ireland and Denmark).

Because of the problems of data availability, it is difficult to identify clear trends in water abstraction in the European Community. Data for England and Wales show that usage has declined in recent years - by about 22% since 1973. This is mainly due to reduced demand by electricity generating stations: old, inland power stations which relied on stream or groundwaters have been replaced by coastal power stations using re-circulating cooling systems fed by seawater. In contrast, the evidence available for many other member states indicates a trend of rising water consumption. According to information provided by the OECD, for example, total consumption between 1970 and 1980 increased by 43% in Germany, by 34% in Italy and by 63% in Greece. Moreover, per capita usage of water still varies substantially. Annual usage per inhabitant is still four to five times higher in Belgium, the Netherlands and Italy than it is in the United Kingdom.

The environmental effects of water usage are varied. Water supply facilities - especially reservoirs - clearly use up land which could be put to other functions (e.g. agriculture), but they may also serve as recreational facilities and habitats for wildlife. Irrigation may lead to soil erosion and salinisation, but it clearly increases agricultural productivity in most cases. More important on the whole, therefore, are the effects of water usage (and other activities) on water quality. Most industrial

Figure 3.23 **Total consumption and end uses of groundwater in Community member states, 1981.**



Source: data from Commission of the European Communities 1982

and household uses of water, for example, result in pollution: thermal pollution in the case of power stations, contamination by heavy metals and other substances in the case of many manufacturing industries. In addition, of course, both groundwater and surface waters are susceptible to pollution by discharges from industrial and agricultural activities: the increasing problem of nitrate pollution is one which will be discussed in Chapters 7 and 8. Given the limited availability of water in many parts of the Community these effects can only be viewed with concern. Control of water pollution, and the protection of water supplies, remains one of the major issues in the European Community.

3.6.3 Municipal and Industrial Waste Generation and Disposal

The problem of urban wastes is a large and complex topic, and one which is receiving increasing attention in the European Community. Wastes derive from many different sources, take many forms, and are disposed of in a wide variety of ways. They are produced by households, by industry and by services. They include solids and liquids, organic and inorganic materials, toxic and non-toxic substances. Disposal - where it occurs - may be by landfill, by incineration, by decomposition, by dumping at sea, or by recycling. In all cases, the environmental concern arises from the circumstance that:

i. many wastes are not efficiently collected and are therefore available to pollute the environment;

ii. many others are not disposed of effectively, with the result that they may still release pollutants into the environment;

iii. in the case of toxic or hazardous wastes, collection, transport and disposal may themselves pose environmental hazards;

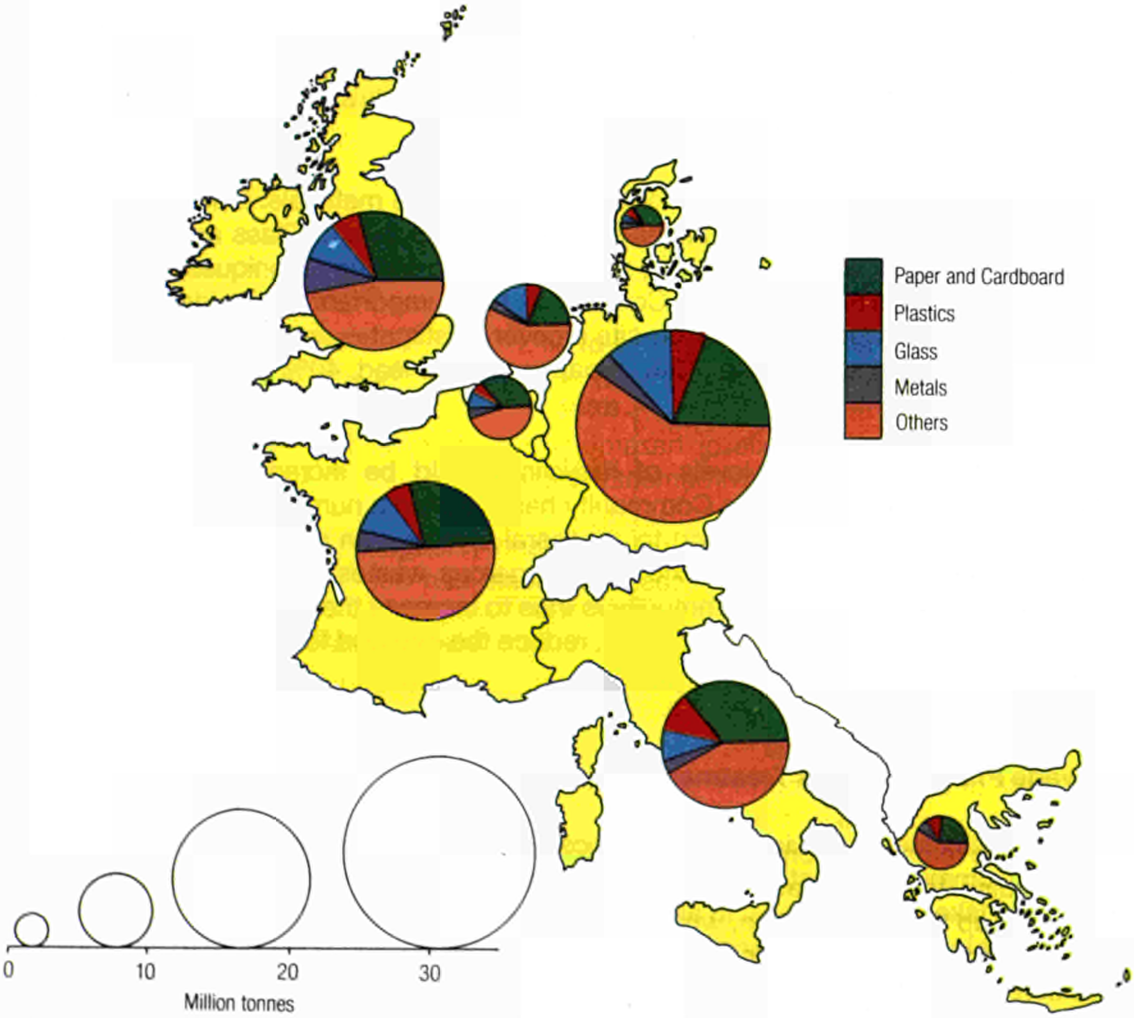
iv. disposal often uses up valuable land (though often the land may ultimately be restored and, in some cases, disposal can actually be used to help reclaim old quarries etc.);

v. the wastes themselves are often potentially valuable resources which could in many cases be recycled.

One of the most important groups of wastes is municipal waste. This probably accounts for about a quarter of total waste generation, and the majority of it - 75% or more - is derived from households, the remainder coming from small industries and commercial activities. Its composition varies according to the character of the town concerned, but in general paper, cardboard and plastics make up the main portion, while glass, metal and other materials comprise the remainder. Levels of generation in Community member states are shown in Figure 3.24. Variations in the composition of the wastes are small, and probably relate mainly to differences in definition. On the other hand, quite substantial differences in quantities of wastes generated are seen, and these do not relate entirely to population size; as much as anything, they are likely to reflect variations in the efficiency of municipal waste collection services. According to this interpretation, the greatest environmental problems are thus likely to be in Greece, where quantities of waste collected are small.

Industrial wastes are probably among the largest category of wastes in the European Community. They vary markedly in character, comprising paper, glass, metals, plastics, textiles, oil compounds, chemicals, food wastes, animal wastes, sediment and rubble. The character and quantity of industrial waste generated in each member state are not known in any detail, but undoubtedly vary according to differences in industrial structure and activity. A significant portion, however, is composed of hazardous or toxic substances - perhaps as much as 20% of the total

Figure 3.24 **Amount and composition of municipal wastes in Community member states, 1981.**



Source: data from OECD 1985

industrial waste materials by weight. These wastes pose particular problems of both transport and disposal. Not the least problem is that, in the past, disposal has often been uncontrolled, and old landfill sites are often found to contain hazardous wastes. Today, disposal tends to take place in carefully selected sites, but these are few and far between. As a result, the wastes have to be transported great distances, and often across national frontiers; the risk of accidents and leakages during this process is significant, especially where the routeways taken pass through densely occupied areas.

Disposal of both municipal and industrial wastes is, in fact, a matter of considerable concern in the European Community. At present, about 50 - 60% of the wastes collected are disposed of by dumping. Much of this takes place in landfill sites, and disposal at sea is controlled by international conventions to which the Community or its member states are party: most notably the London Convention of 1972, the London Convention of 1976 and the Barcelona Convention of 1976. The importance of dumping varies between countries, however, accounting for about 90% of total waste disposal in the United Kingdom, but only 28% in Denmark. Incineration provides the other main means of disposal, and about 30% of the Community's wastes are treated in this way. Decomposition makes up most of the remainder.

Disposal is not the only means of dealing with waste materials. In many cases it is also possible to recycle the wastes. This is already done to some extent. Glass and paper are widely recovered from municipal wastes, mainly by voluntary public sorting techniques, and overall about 5% of domestic refuse is recycled in the Community. More importantly, considerable quantities of industrial waste are recycled, mainly by on-site recovery. Estimates are inevitably uncertain but as much as 50% of iron and steel waste, 45% of paper, 45% of lead, 40% of tin and 35% of copper may be recycled at present.

Undoubtedly, however, levels of recycling could be increased given a favourable economic climate, and the European Community has adopted a number of actions to encourage re-use of wastes in this way. In addition to a general Directive on wastes (75/442), these cover waste oils (75/439), PCBs (76/403), toxic and dangerous wastes (78/319) and paper (81/972). One of the main objectives of the Community is thus to increase the efficiency of waste recycling in order to conserve the resources themselves, reduce the demand for landfill sites, and minimise pollution from wastes.

3.6.4 Sewage Production and Treatment

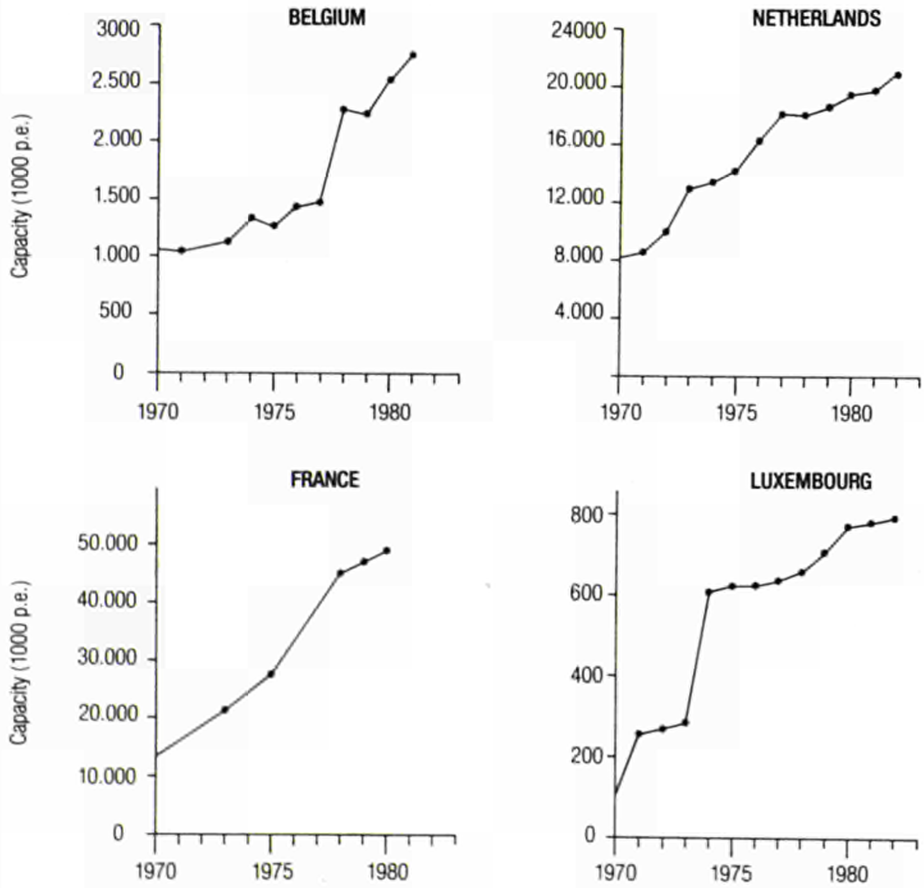
Sewage effluents provide one of the most important sources of environmental pollution in the European Community. Most of the effluent is discharged into streams, from where it may be transported into lakes and the seas. In all these environments the organic compounds and nutrient elements present in the effluent may stimulate biological activity and contribute to eutrophication of the water bodies. Similarly, heavy metals contained in the sewage may accumulate in the waters and sediments, and may eventually enter food chains. In addition, small but increasing quantities of sewage are disposed of on land. While this provides a useful source of organic fertiliser for agriculture, it may also result in problems of pollution. Heavy metals may accumulate in the soil. Soluble nutrients and solids may be washed into surface waters. Nitrates and other compounds may be leached into groundwaters.

The magnitude of all these effects depends upon the quantity and quality of the sewage effluents. These, in turn, depend upon social and economic factors such as the character of industrial and residential activities, and the degree of sewage treatment prior to its discharge into the environment. In recent decades, all these factors have changed. Sewage production has expanded due to increasing per caput consumption and greater waste generation by industry. The character of the sewage produced has also changed as industrial processes and technology have developed.

Most importantly of all, perhaps, sewage treatment has improved as the number, capacity and efficiency of sewage plants has increased and as more households and industrial plants have been connected to the sewerage system.

Trend data on all these aspects are not available for all member states, but Figures 3.25 and 3.26 indicate changes in the sewerage infrastructure for selected countries. In both Luxembourg and Belgium the capacity of the sewerage system has expanded in line with increasing numbers of plants. In the Netherlands (and probably the United Kingdom, although data on capacity are not available), the capacity of the system has increased mainly by improving the efficiency of the existing plants. In this context a critical factor is the type of treatment - whether biological or mechanical. Of the two, biological treatment is by far the more efficient, generally removing about

Figure 3.25 **The capacity of sewage treatment plants in Community member states.**

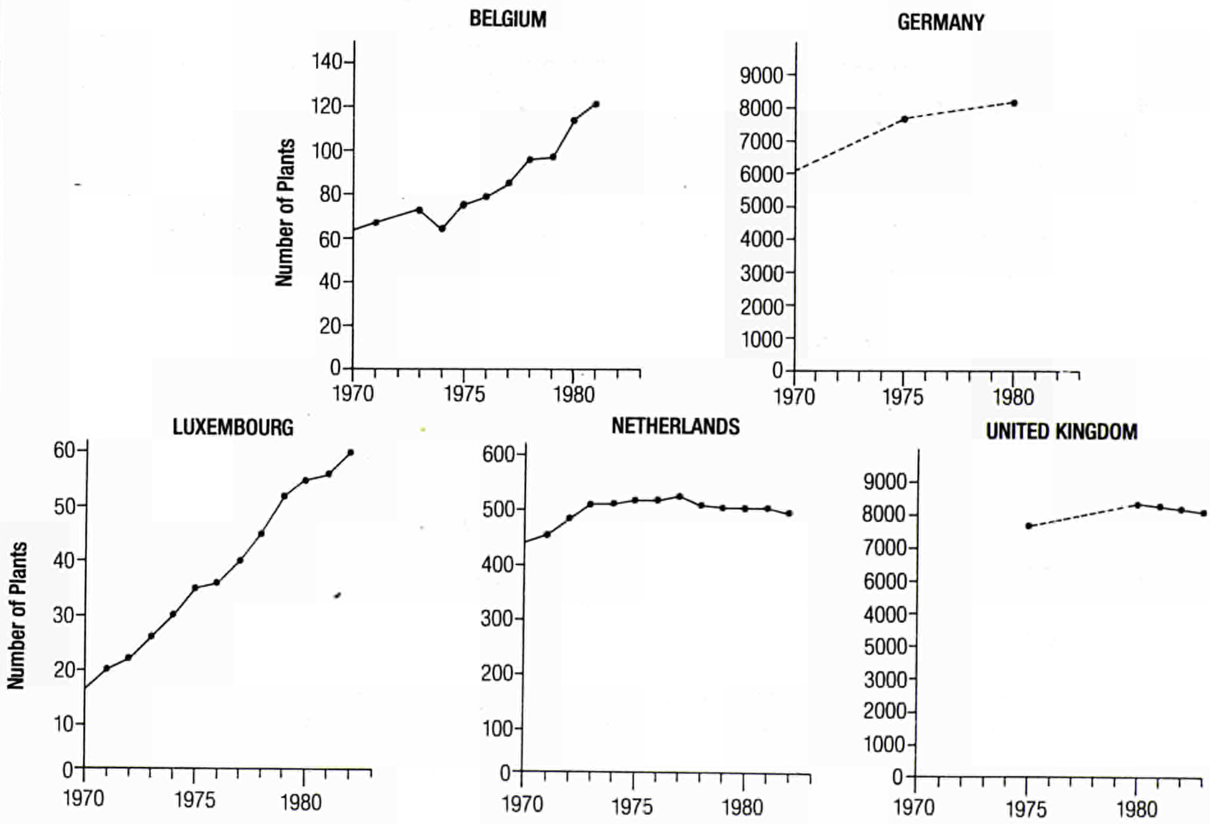


Source: data from SOBEMAP 1981; Ministère de l'Environnement 1984; Netherlands Central Bureau of Statistics 1982

50-75% of the organic load compared to about 30% by mechanical treatment. As a result, attention has been focused on either increasing the capacity of existing biological treatment plants or converting mechanical plants to biological processes. In the Netherlands, for example, the capacity of biological treatment increased from about 12.3 million p.e. to 17.5 million p.e. between 1975 and 1980, while that of mechanical plants declined from 2.6 million p.e. to 2.0 million p.e.. (Load and capacity are measured in population equivalents - p.e. - on the basis of the estimated biological oxygen demand of the sewage. Unit values used in the Community vary from 54 to 60 g BOD per inhabitant per day.) As Figure 3.26 shows, this change has been achieved without any significant change in the number of treatment plants.

The effects of these developments on sewage discharges have been marked. In all northern European countries, for example, the improvements in treatment have more than kept pace with increases in sewage generation, so that quantities of untreated sewage released into the environment have declined. The situation in southern Europe, however, is less satisfactory. In Greece and Italy (and Spain and Portugal also), the capacity of treatment plants is undoubtedly rising, but the level of treatment remains very low in many areas. The majority of sewage, therefore, still enters the environment in an untreated form in these countries.

Figure 3.26 **Numbers of sewage treatment plants in Community member states.**



Sources: data from Sobemap 1981; Ministère de l'Environnement 1984; Netherlands Central Bureau of Statistics 1982

3.7 SUMMARY AND CONCLUSIONS

All the urban and industrial activities that we have discussed in this chapter have impacts on the environment. And each one spreads through the environment, from source activity to atmosphere to land and waters, into the wildlife, and eventually back to man himself. Changes or developments in urban and industrial activity therefore have important and unavoidable environmental implications. The main trends which are occurring at present include:

i. in the realm of population distribution and urbanisation

- a decline in inner city populations
- a marked increase in outer city and outer-periphery populations
- an expansion of the urbanised area.

ii. in the industrial sector

- a general decline in employment
- a levelling off of demand for energy in the Community as a whole, though with a continued rise in several southern member states.
- a gradual decline in the use of coal and oil and a marked increase in the use of gas and nuclear power
- a reduction in the output of most heavy industrial goods (especially metal-based products)
- a slight decline in the production of many bulk chemicals but a rapid increase in the range of chemicals being manufactured and marketed.

iii. in the service sector

- a continued increase in the level of car ownership
- a shift in traffic from rail to road
- a steady rise in the volume of air passenger traffic
- an increase in levels of water consumption in many countries
- an increase in quantities of waste generation (especially of toxic and dangerous substances) but improvements in waste collection services
- improvements in the sewage treatment services.

These changes can be attributed to a number of inter-related factors: e.g.

- the effects of the 'oil-crisis' of the 1970s
- increased competition from, and loss of markets to overseas producers
- structural adjustments in the economies of member states

- general economic regression in western Europe
- technological developments
- changes in consumer and worker attitudes and preferences
- impacts of national and Community policies (including environmental policy).

Similarly, these changes have a wide range of social and environmental implications. In the case of the environment, many of the effects may be counteractive, so that the net impact is difficult to predict. For example, we might anticipate:

- reduced levels of emission due to changes in industrial structure and lower rates of industrial activity BUT increases in emissions due to more restricted opportunities for investment by industry in emission control
- increased levels of urban waste and sewage generation due to expanding urban populations and per caput consumption, BUT reduced levels of discharge to the environment because of improved recycling, collection and treatment facilities
- increased traffic volumes BUT reductions in emission per vehicle due to improvements in design.

The nature of the impacts on the environment will depend on the relative strengths of these opposing forces. In every case, however, the mitigating force (i.e. the factors acting to minimise environmental effects) is greatly dependent on the character and strength of environmental policy. This will determine, for example, the pressure placed on industry to control emissions, the commitment of national authorities to waste and sewage treatment, and the emission standards adopted by vehicle manufacturers. In this context, the Community has a vital role, for it acts as a major force for the adoption of many environmental policies. Future impacts on the environment will thus be determined to a large extent by the appropriateness of these policies, insofar as they are implemented by member states.

NOTES AND SOURCES

Data availability

In general, availability of data on urban and industrial activities in the European Community is adequate. The Statistical Office, for example, collects a wide range of data, according to agreed and consistent definitions, and these are published regularly by Eurostat. Small discrepancies can nevertheless occur in the information from different member states and as always care is needed in interpreting the data presented in this chapter. Moreover, it must be remembered that most of the data presented here are indices of economic activities: the exact nature of these activities varies from one place to another, as does their impact on the environment. Consequently, these data cannot be translated directly into measures of environmental pressure. It can also be mentioned that data availability is still relatively poor in the case of solid waste generation and disposal, sewage treatment and discharges, and water use.

Notes on figures

Figure 3.1 Overall, the data used here are consistent and reliable, but small discrepancies may arise because of differences in the dates of national censuses, and because in some member states expatriates resident in other countries may also be counted in their place of origin.
Figure 3.4 Data on agriculture in this figure include farming, forestry and fishing.
Figure 3.8 1980 data for the United Kingdom.
Figure 3.14 Not shown: Denmark (1984 production 548,000 tonnes); Greece (895,000 tonnes); Ireland (166,000 tonnes). 1983 data are all provisional.
Figure 3.16 Emission figures for cadmium are based on extrapolation of data for 1975-80.
Figure 3.23 Data for Greece unavailable.
Figure 3.24 Data for Denmark and Ireland refer to 1979; data for the Netherlands refer only to household wastes; data for Luxembourg not available.
Figure 3.25 Data may contain inconsistencies due to lack of information in some areas on treatment plants with a capacity less than 2000 p.e.
Figure 3.26 As above.

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CHAPTER 4.

AGRICULTURE, FORESTRY AND FISHING

4.1 INTRODUCTION

4.1.1 The Importance of Agriculture, Forestry and Fishing

In the previous chapter, we considered urban and industrial activities as occurring in relatively localised areas, from which their effects spread into the surrounding environment. Their importance for the environment thus lay not in the areal extent of these activities, but the intensity and scope of their impacts. Agriculture, forestry and fishing provide a very different picture. Per unit area they tend to be much less intensive, and cause much less environmental disruption. On the other hand, they are geographically far more extensive. Approximately 102 million hectares of the Community, for example, are described as being agriculturally utilised, constituting about 62% of the total land area. Of the remainder, about 38 million ha (23%) are classified as woodland and forest, most of it used for timber production. A further 16 million ha (10%) are under semi-natural pasture or moorland which, while not cultivated, are used for extensive grazing. In other words, about 95% of the Community land area is directly affected by farming or forestry. In addition, the seas around the Community provide vital fishing grounds.

The population employed in agriculture, forestry and fishing is not large. In 1984 a total of about 7.85 million were involved in these activities, representing about 6.7% of the workforce. Within the rural areas, however, these occupations are clearly of fundamental importance. They frequently provide the only source of employment and they also affect intimately the cultural character of the rural societies. At the same time, the output from these activities is vital, not only to the rural populations but to the whole economy of the European Community. A major objective of the Community's policy is to be as self-sufficient as possible in all major resources, and in the case of agriculture this is now the case for all commodities with the exception of maize (66% self-sufficiency in 1981), rice (74%), fresh fruit (84%), citrus fruits (43%) and oils and fats (47%). Indeed, in some commodities production far outreaches demand, with the result that large quantities of meat, milk powder, butter and wine are annually stock-piled.

Agriculture, forestry and fishing also have major environmental implications. Over the years, agriculture has left an almost indelible mark on the landscape. Practices such as forest clearance, tillage, planting, grazing, harvesting, fertiliser and pesticide application, drainage and irrigation have helped to shape the surface of the land. They have created, modified and destroyed habitats. They have eliminated some species, encouraged others, and altered the course of natural succession. They have caused soil erosion and sedimentation in streams, lakes and reservoirs. They may affect runoff processes and stream hydrology. And they produce chemical pollutants which may be washed into rivers, lakes, groundwaters and seas. At the same time, commercial fishing and whaling have affected stocks of both seafish and marine mammals, and in some cases threatened the very survival of the species concerned. Given the vast spatial extent of all these processes, it is apparent that their impacts on the environment are all-pervading.

4.1.2 Causes of Change in Agricultural, Forestry and Fishing Activities

Over the last 30-40 years, agriculture, forestry and fishing have changed markedly. As with industrial and urban activities the changes are complex and can be attributed to a number of different factors, including external economic influences, changes in consumer preferences, technological development and government and Community policy. As agriculture, forestry and fishing change, however, so their impact on the environment alters. It is therefore important to understand some of the main forces affecting these activities and the responses they provoke.

The changes have probably been most acute in the case of agriculture. Over recent decades levels of employment in farming have fallen, the total land area has declined, the number of farms has diminished. On the other hand yields of almost all crops have increased. Between 1961 and 1981, for example, the average yield of barley in the Community rose by 49%, that of wheat by 64% and maize by 114%; over the same period milk yields per cow increased by about 30%.

How have these increases in yield been obtained? The immediate answer lies in technological developments - in the 'means of production'. Mechanisation has increased dramatically, with greater use of tractors, combines, milking machines, grain-drying equipment and other machinery. Improvements in the design of existing machines have also enabled better results to be obtained under field conditions. At the same time, inputs of fertilisers, pesticides and animal feedstuffs have increased, while drainage and irrigation have been intensified and extended. Perhaps most significant of all have been the developments in crop and livestock breeding, which have led to the introduction of higher yielding, more disease-resistant plant varieties and animals.

These improvements and innovations are the result of many separate research developments, made over many years of study and experiment. Their implementation, however, is in part attributable to the stimulus for innovation, intensification and agricultural expansion provided by national and Community policies. The overriding force in this context is the Common Agricultural Policy. The objectives of the CAP are set out in Article 39(1) of the Treaty of Rome and might be summarised as being to improve the earnings of the agricultural community, whilst at the same time providing a stable market and an adequate supply of food to consumers at reasonable prices. These objectives are pursued through two main instruments: a system of intervention pricing and direct grants to farmers for agricultural modernisation and land improvement. In practice, the operation of the CAP has had the effect of over-rewarding production in an era of technological progress and relatively static domestic consumption, with the result that some unwanted production has been supported and costly surpluses have emerged. Recently, however, the basis for a new approach to agriculture has emerged, with the publication of a Green Paper, calling upon agriculture to take a more positive role in environmental protection.

In the case of forestry and fishing rather different forces have been at work. Over recent years the area under forestry has grown, although the area cut each year has tended to decline. Silvicultural practices have also become gradually more intensive, with increased mechanisation of land preparation, planting and harvesting, increased inputs of fertilisers and pesticides, and a wider range of species being employed. Nevertheless, compared to agriculture, the changes are less dramatic, and nor is Community policy such a strong force. Instead, forestry policies are largely a national responsibility, and as a result they tend to vary significantly from one country to another. Thus the level of support per unit area of forestry is considerably higher in the Netherlands, Germany and the United Kingdom than it is in Ireland, Denmark, Belgium or Luxembourg. These support-subsidies typically cover practices such as primary afforestation, re-afforestation, land improvement (e.g. drainage, fertiliser application), access construction, fire prevention and ecological conservation. Together with preferential taxation arrangements for forest lands they have undoubtedly encouraged an extension of forestry in many member states. In the last few years, however, several of these policies have been re-assessed and, in some countries, less positive attitudes are being taken towards forestry.

The question of fishing has for long been a controversial one in the European Community, and considerable problems have been encountered in trying to resolve the conflicts of national interest. The dominant trend has none the less been for a decline in fish production, not least because of declining fish stocks in many of the main fishing grounds and a need for conservation. This need has to some extent provided a driving force behind the search for a Community fisheries policy. These aspects are discussed in more detail in sections 4.5 and 4.6.

4.2 EMPLOYMENT

As has been noted, the labour force in the agricutural sector has declined consistently in recent years, reflecting increased mechanisation and capital intensification of farming and forestry, and the constraints imposed on fish production. These changes are undoubtedly having considerable social significance and, in some areas, altering the structure of rural communities. They are also associated, however, with increasing environmental pressures as modern farming systems become more widely adopted. This section therefore reviews the present distribution of agricultural employment in the Community and indicates recent trends in member states.

In fact, there are a number of difficulties involved in interpreting employment data in agriculture, for the data include not only full-time workers but also many part-time workers, yet may exclude unregistered labour such as that provided by members of farm-holders' families. Some indication of the situation is provided by the data in Table 4.1, taken during a sample survey of the labour force in 1977. Then, approximately 12 million people were identified as being involved in agriculture, though these represented only 7.0 million AWUs. Moreover, only 28% of the total agricultural labour force were found to work full-time, whilst non-family (i.e. independent hired) labour constituted only about 8% of the labour force. These data are clearly dated now, for data from later surveys are not yet available in full. Results of the 1983 survey of agricultural holdings, however, indicate a total of 13.4 million people engaged in agriculture, representing about 7.0 million AWUs.

The distribution of this labour force across the Community is far from uniform. Major differences occur between mountain and lowland areas, and between northern and southern regions. In the United Kingdom, for example, only 2.4% of the total labour force was employed in agriculture in 1982, while in Belgium the figure was 2.6%. In contrast, the agricultural sector

Table 4.1 **The structure of agriculture in the Community, 1977 (1983 data in brackets).**

A. EMPLOYMENT	Number ('000)	AWUs ('000)
Total engaged in agriculture	12,206	(13,386)
(full-time workers)	(3,418)	(3,418)
Farm-holders	5,615 (6,425)	3,470
Farm-holder's family	5,615 (6,065)	2,715
Hired (non-family) workers	976 (900)	830
B. FARMS AND LAND USE	**Number ('000)**	**Area ('000 ha)**
Total holdings	5,646	86,281
Holdings with tractors	4,065	—
Holdings with arable land	4,404	44,866
Holdings with permanent pasture	3,105	36,242
Holdings with permanent crops	2,423	4,745
Holdings owner-occupied	—	55,479

AWU: annual work unit - the amount of work carried out by a full time adult employee in one year.

Source: data from Commission of the European Communities 1982, 1985 accounted for 11.3% of the labour force in Italy, 15.4% in Ireland and 27.2% in Greece. The regional distribution of the agricultural labour force for 1975 (the most recent comprehensive data available) is shown in Figure 4.1. As this indicates, the areas with the highest proportion of agricultural labour occur in southern and central Italy, south-west France and Ireland. This distribution should not be interpreted as providing a direct indication of where agricultural activity is most intense; indeed, almost the opposite. Where the agricultural labour force is at its lowest - in southern and eastern England, Belgium and central Germany - is in general where agriculture is most mechanised and capital intensive. In contrast, areas with a large agricultural labour force are in many cases those in which agriculture is still relatively traditional and of low intensity.

This pattern is a reflection of the changes in agricultural structure which have occurred in recent decades. Between 1960 and 1973, for example, the total agricultural labour force in the original six members of the Community fell from 15.2 million to 8.2 million, an annual decline of 4.6%. "To put it more graphically", in the words of the 1981 report on *The agricultural situation in the Community* (page 22), "this means that farmers and farm workers left the land in the Six at the rate of one a minute between 1960 and 1973".

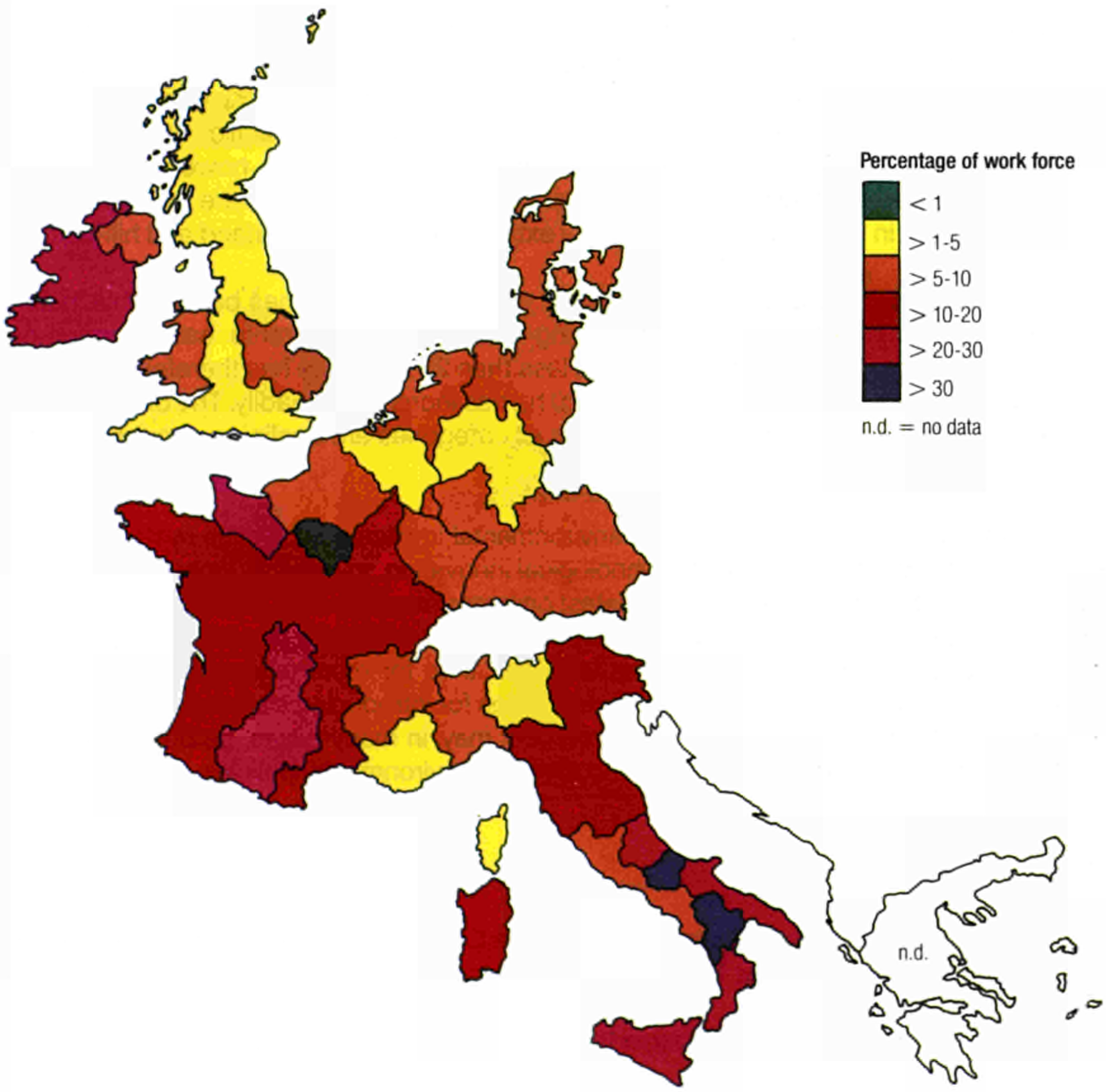
Since then this trend has continued. In the current ten members of the Community, the labour force declined by 2.5 million between 1973 and 1982, an average annual loss of about 2.4%. Rates of decline vary, however, from one member state to another. In the United Kingdom, which already has a very small agricultural labour force, the annual rate over recent years is about 1.5%; in Denmark and the Netherlands much the same. Conversely, in Germany, France and Belgium it is over 3%, and in Greece (where data are incomplete) possibly as high as 8%. (In Spain and Portugal, similarly, the rates of decline are high, averaging between 4 and 5% per year over the last ten years). These differences seem to reflect differences in levels of technology. Changes are most rapid in agriculturally less developed areas, where the scope (and pressure) for migration of workers away from the land is high. Conversely, as agriculture becomes more intensive, this process of migration tends to slow down and the labour force stabilises at a lower level.

As this indicates, a dominant force in the decline in the agricultural labour force has been technological development. Mechanisation, changes in management practices and increased rationalisation and amalgamation of farms have enabled agriculture to operate with a progressively smaller workforce. This has provided a 'push factor' driving labour from agriculture, and reducing the replacement of workers leaving due to retirement or death. In addition, important 'pull factors' have operated, most significantly the major wage differential between agricultural and industrial employment; this has encouraged workers to leave farming for other occupations and has also deterred new employees from entering agriculture.

4.3 FARMING STRUCTURE AND LAND USE

The changes in the agricultural labour force outlined in the previous section are but one aspect of fundamental adjustments which are occurring in agriculture in the Community. At the same time, the structure of farming is changing: farms are becoming larger and spatially less fragmented, ownership and tenure are changing, the area of land devoted to agriculture as a whole and to particular crops and farming systems is constantly varying. All these changes have important social and environmental consequences. The responsibility for maintenance of the land and the workforce is in some cases moving from local family-occupiers of farms to more remote commercial owners. Increasing farm size is allowing more large-scale production techniques to be employed, with associated increases in field size, level of mechanisation, extent of drainage, and quantities of inputs. Changes in the crops being grown and in the farming system are likewise altering the visual character of the countryside and causing modification to habitats which are part of the 'traditional' farming landscape. In this section, therefore, we examine the pattern and trends of farming structures in the Community and outline general changes in agricultural land use.

Figure 4.1 **Regional distribution of agricultural employment in the European Community, 1975.**



Source: data from Clout *et al.* 1985

4.3.1 Farm Structure

The general structure of agriculture in the Community during the period 1977-81 is shown in Tables 4.1 and 4.2. A number of telling characteristics are present. With a total utilised agricultural area of 86.3 million ha (excluding Greece) and a total of 5.6 million holdings, the average farm size is about 15 ha. The distribution of farm sizes is markedly skewed, however, with over 46% of holdings being less than 5 ha in area. These account for only a little over 7% of the total agricultural land area. In contrast, the 6.2% of holdings which are greater than 50 ha in size comprise 42.2% of the agricultural land. Approximately 64% of the utilised agricultural area is held in owner-occupied farms.

All these characteristics show marked spatial variablility. In 1981, for example, Italy contained over 55% of farms of less than 5 ha in the Community, whereas Belgium, Denmark, Ireland, Luxembourg, the Netherlands and the United Kingdom together accounted for only 5.5% of holdings below 5 ha. Conversely, the United Kingdom and France included over 70% of farms greater than 50 ha; in the United Kingdom these accounted for almost 82% of agricultural land (Figure 4.2). To some extent this pattern provides an indication of the degree of agricultural intensification across the Community, contrasting the large, highly mechanised farms in the United Kingdom and, to a lesser extent Luxembourg, France, Denmark and the Netherlands, with the smaller and more traditional farms of Greece and Italy. The picture needs to be interpreted with caution, however, for there is not a perfect relationship between farm size and level of intensification; many of the largest holdings (e.g. those in Scotland) are in fact associated with very extensively farmed moorland and hill-land.

Nor is the farm structure fixed. In recent years a clear trend has been visible in almost all member states as mechanisation and changing patterns of ownership have encouraged the amalgamation of farms. The number of holdings less than 20 ha in size has therefore declined whilst the area of land contained in farms greater than 20 ha has increased steadily. The only exception is in the United Kingdom where farms and farm area in all categories are declining, though even here the decline is slowest in the largest size classes.

All these changes have significant environmental implications, for the system of tenure and farm size act as important influences on technological innovation. In general, innovation is inhibited by small farm size or by tenancy systems; it is greatest on larger, manager-occupied farms which have both the commercial incentive and the capital for investment. This undoubtedly provides the opportunities for far more comprehensive management of the land and thus for more extensive modification of the environment. It also, however, creates greater possibilities for introducing environmental protection and control measures. Thus the effects on the environment may, in many cases, be beneficial rather than adverse. Much clearly depends on the rigour and scope of environmental policies.

4.3.1 Land Use

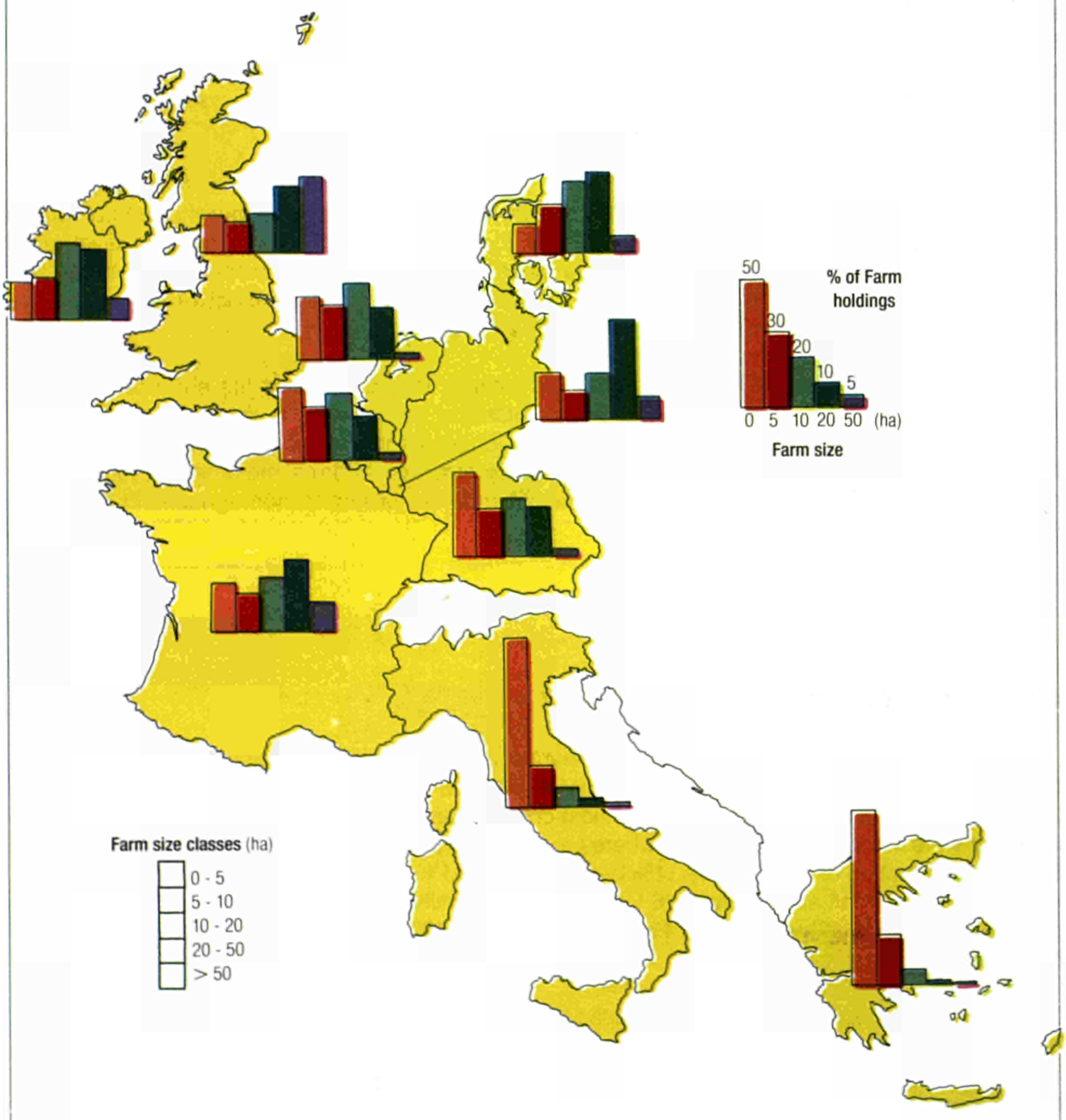
The distribution of agricultural land use in the Community is indicated in Figure 4.3. Like all classifications of farming typology, this needs to be interpreted with care. In particular, it is based

Table 4.2 **Farm size in the European Community, 1981.**

FARM SIZE	% of holdings	% of area
1 - 4.99 ha	46.7	7.1
5 - 9.99 ha	17.1	7.6
10 - 19.99 ha	14.9	13.5
20 - 49.99 ha	15.0	29.7
> 50 ha	6.2	42.2

Source: data from Commission of the European Communities 1985

Figure 4.2 **Distribution of farm size in Community member states, 1981.**



Source: data from Commission of the European Communities 1982, 1985 upon production value rather than area, so it tends to emphasise high value systems (e.g. horticulture) at the expense of spatially more widespread, low value systems such as extensive grazing. Moreover, the figure relates to data for the period 1972-1974, so is now clearly somewhat dated.

The figure nevertheless emphasises a prominent feature of European agriculture, namely its great diversity. Four main land use combinations can be distinguished. Livestock farming, for example, predominates in a wide arc from the western Alps through the Bordeaux area to Ireland, and in a belt running from the northern Alps to the Netherlands. In contrast, arable cropping occurs in two main zones - one covering eastern England and the Paris Basin, the other centred on eastern Italy and Sardinia. Flowers, vegetables and permanent crops (e.g. olives, vines) are concentrated almost exclusively in Mediterranean regions, encompassing southern France, Corsica, Liguria and Sicily. Elsewhere, mixed farming systems tend to be prevalent.

These distributions are of considerable environmental significance, in that the effect upon the environment depends to a great extent upon the character of the farming system. Such broad scale patterns, however, can reveal only part of the story, for at the more detailed level great variations in farming methods occur, and it is these - the techniques of cropping, the types and quantities of fertiliser and pesticide used, etc - that determine the real impact of farming on the landscape, soil, water resources and wildlife.

The distribution of land use in the Community is not static. In the short-term, annual adjustments are made in cropping as part of rotational systems or in response to perceived management, economic or climatic factors. In the longer term, changing market conditions and technological developments lead to more general adjustments. At the same time, the total area of agricultural land is varying as land is reclaimed, abandoned or lost to non-agricultural uses (see section 6.3.1).

4.4 THE MEANS OF PRODUCTION

As has been noted already, one of the most important trends in agriculture in the European Community has been the continued growth in yields. Cereal production, for example, rose by almost 20% between 1973 and 1982 despite an almost constant area of arable land. The greatest increases in output were in the United Kingdom, where production rose by 43%, Italy (17%) and France (11%). Similarly, production of milk rose by 14% betwen 1973 and 1981, although the number of dairy cows in the Community fell slightly from 26.1 million to 25.0 million. Meat production showed an even greater increase, rising by 24% from 19.2 million tonnes in 1973 to 24.1 million tonnes in 1983 - again despite a fall in livestock numbers.

The explanation of these increases lies almost wholly with improvements in agricultural efficiency. The twentieth century has seen major changes in the techniques used in agriculture. Early in this century the development of an organised commercial fertiliser industry took place, and since then the application of artificial fertilisers has increased dramatically. Since the 1930s the use of tractors, combines, balers, grain-driers and milking machines has expanded. The discovery and development of pesticides during the 1940s led to their widespread adoption as a means of crop protection and seed cleaning. Animal and plant breeding have similarly improved, with the instigation of national breeding establishments, careful control of breed quality by registration and, in the case of livestock, extensive cross-breeding to combine the beneficial attributes of the original breeds.

Plates 4.1-4.2 **Contrasting aspects of agriculture in the European Community. The great environmental, cultural and economic diversity of the Community is reflected in its range of farming landscapes and systems. The photographs here reflect just two extremes of this variety.**

Plate 4.1 **A traditional farming scene in Crete.**

Plate 4.2 **Intensive cereal production in eastern England.**

Photo: H. R. Singleton

Photo courtesy of South Yorkshire Country Council

Plates 4.3-4.4 **Many modern farming practices have significant impacts on the environment. Two of the most important are agricultural drainage and pesticide application.**

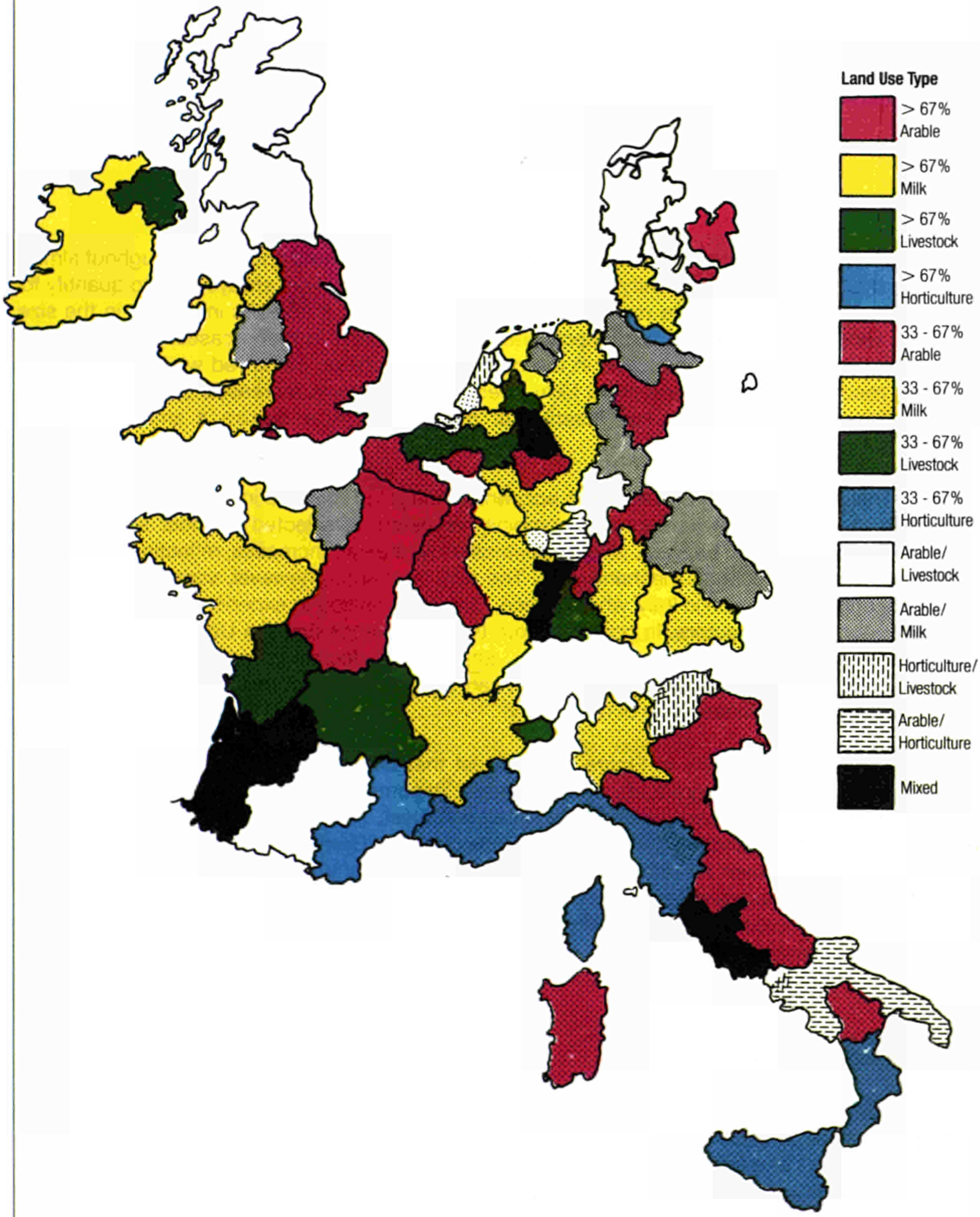
Plate 4.3 **An agricultural drainage operation in Northern Ireland (supported by Community regional funds): the scheme is draining an area of upland moorland in the Mourne Mountains.**

Plate 4.4 **Pesticide spraying.**

Photo: B. Walley

Photo: M. Saul

Figure 4.3 **Regional distribution of agricultural land use in the European Community, 1979-81.**



Source: after Van Hecke 1982

Together with developments in drainage and irrigation these innovations have helped to increase considerably the yields and quality of both crops and livestock, and to reduce waste during harvesting and storage. They have also had major environmental impacts. Fertilisers have contributed to pollution and eutrophication of water resources; pesticides have entered food chains and, in a number of instances, resulted in greatly increased mortality of wildlife species. Agricultural drainage has encroached on wetland habitats; mechanisation has resulted in the removal of hedgerows to facilitate cultivation operations; improved crop protection has eliminated many plant species and threatened the fauna which depends on them. This section therefore outlines the changes occurring in the means of agricultural production.

4.4.1 Mechanisation

The pattern of increase in the level of mechanisation is a trend apparent throughout almost all farming systems in the Community. It is, however, a trend which is not always easy to quantify for it is not simply a matter of more machines being used. Instead, it involves increases in the size, work-rate, range of applications and effectiveness of machinery; in many cases, these developments may actually permit a reduction in the number of machines employed whilst nevertheless extending mechanisation to many more farm operations. Moreover, increased specialisation and rationalisation of farm holdings has meant that many farms now require a smaller range of implements.

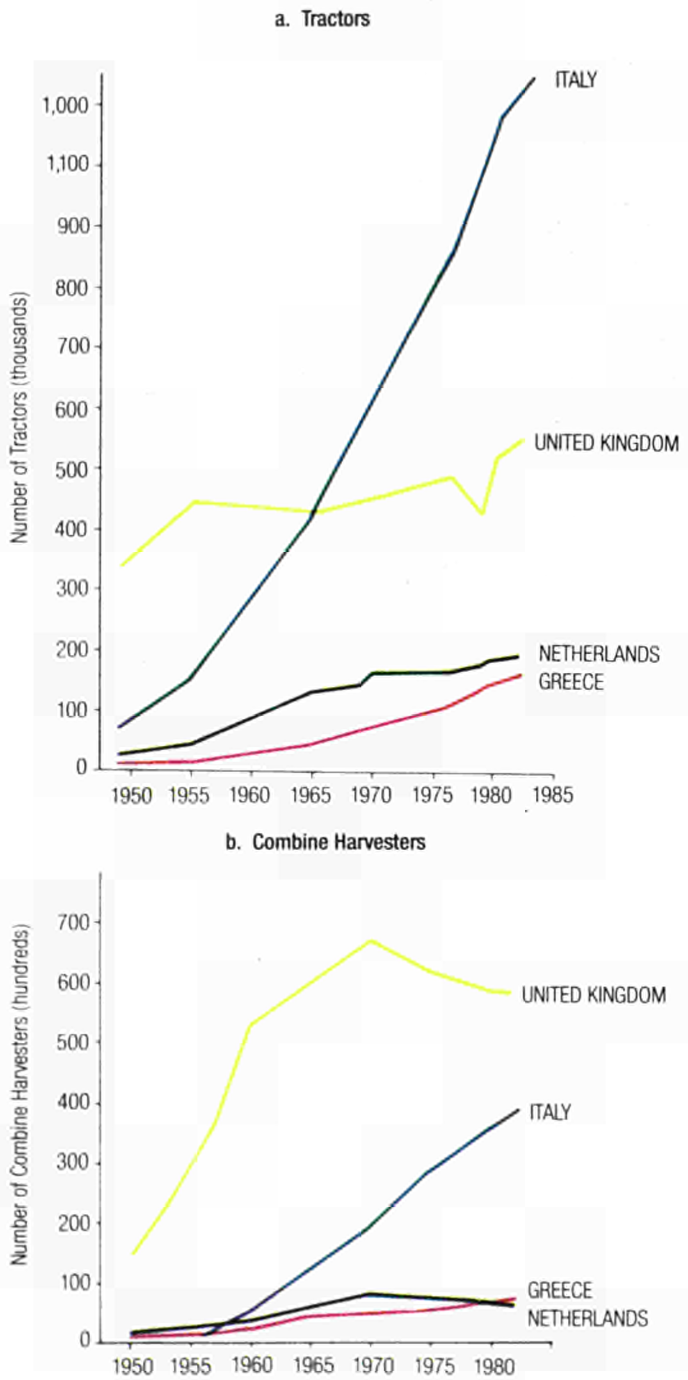
These factors must be taken into account in analysing the data in Figure 4.4. This shows changes in the numbers of tractors and combine harvesters in selected member states for the period 1965 - 1982. As can be seen, all the countries show marked increases, reflecting the general tendency towards agricultural mechanisation. The rate of change, however, varies markedly. The fastest rate of growth is seen in Italy, while Greece, also, is beginning to experience a relatively rapid increase in numbers of tractors. In contrast, both the Netherlands and the United Kingdom show slow rates of growth in the number of tractors, and a small decline in recent years in combine harvesters. This reflects the circumstance that farming in these countries is now almost fully mechanised in terms of these types of machinery.

These trends shown in Figure 4.4 suggest that differences in levels of mechanisation between member states are gradually being reduced. To some extent this is probably true, but, as the data in Figure 4.5 indicate, major differences still exist. Numbers of tractors per thousand hectares of agricultural land are still some 4-5 times higher in Germany than in Greece or Ireland; milking machines are over ten times more abundant in Germany than Italy. Such differences in levels of mechanisation are reflected by the degree of agricultural impact on the environment. Put simply, machinery increases the capability of the farmer to manage his land and consequently to modify the environment.

4.4.2 Drainage and Irrigation

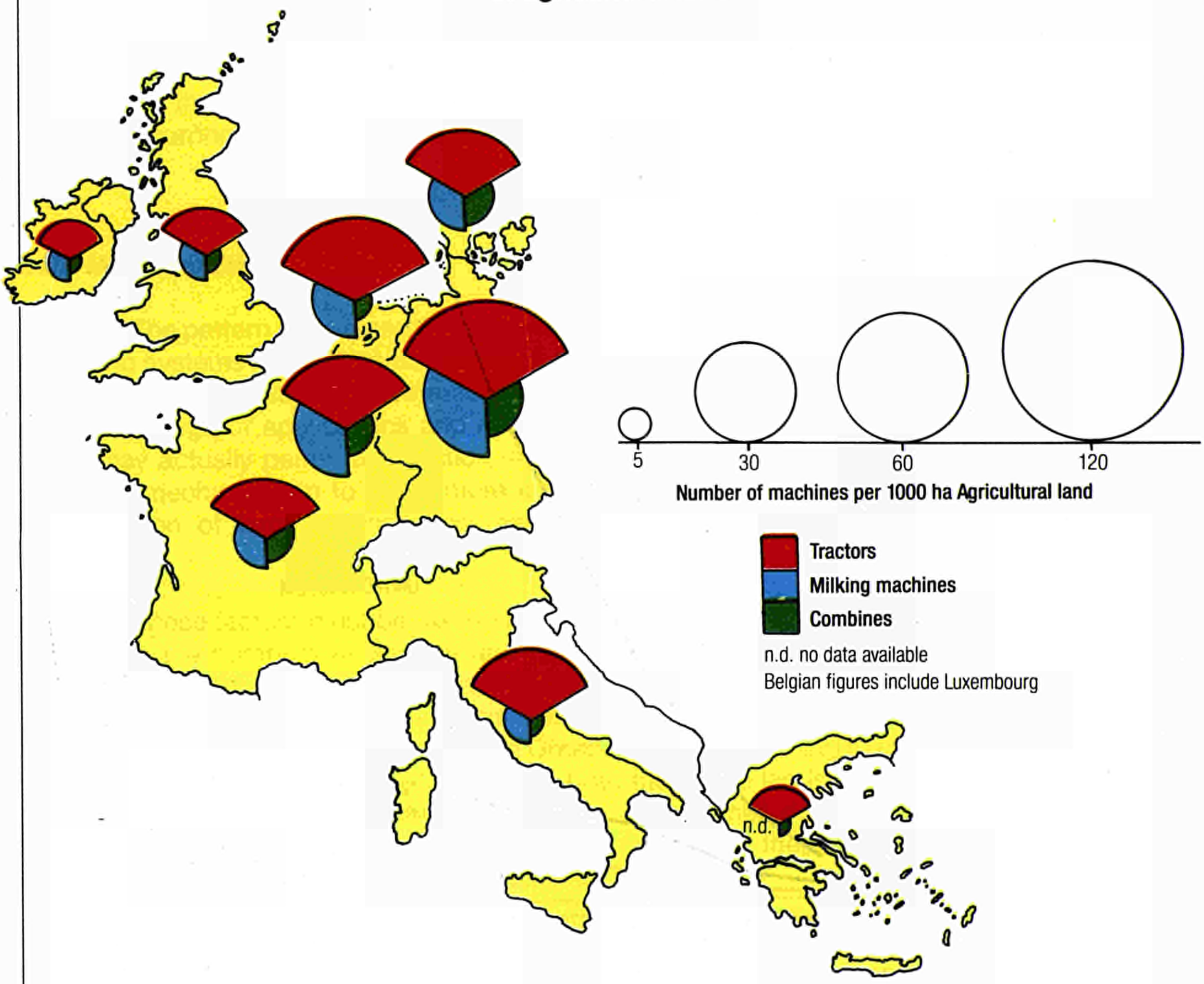
The importance of agricultural drainage as a means of improving yields and facilitating farming operations can hardly be over-emphasised. Throughout much of northern and western parts of the Community - in a zone covering up to a third of the total land area - annual rainfall exceeds potential evapotranspiration, and the problem of excessive soil moisture contents is severe. Even outside this region risks of soil moisture excess may exist due to seasonally high rainfall amounts or high rainfall intensity. How serious these effects are on agricultural productivity depends on soil conditions and the nature of the farming system. Especially on heavy soils or in low-lying areas where rates of water removal by natural drainage and runoff are low, the benefits of agricultural

Figure 4.4 **Trends in agricultural mechanisation in selected member states: a. numbers of tractors; b. numbers of combine harvesters.**



Source: data from F.A.O. 1963–84

Figure 4.5 **Levels of agricultural mechanisation in Community member states: numbers of tractors, combine harvesters and milking machines per 1000 ha of agricultural land.**

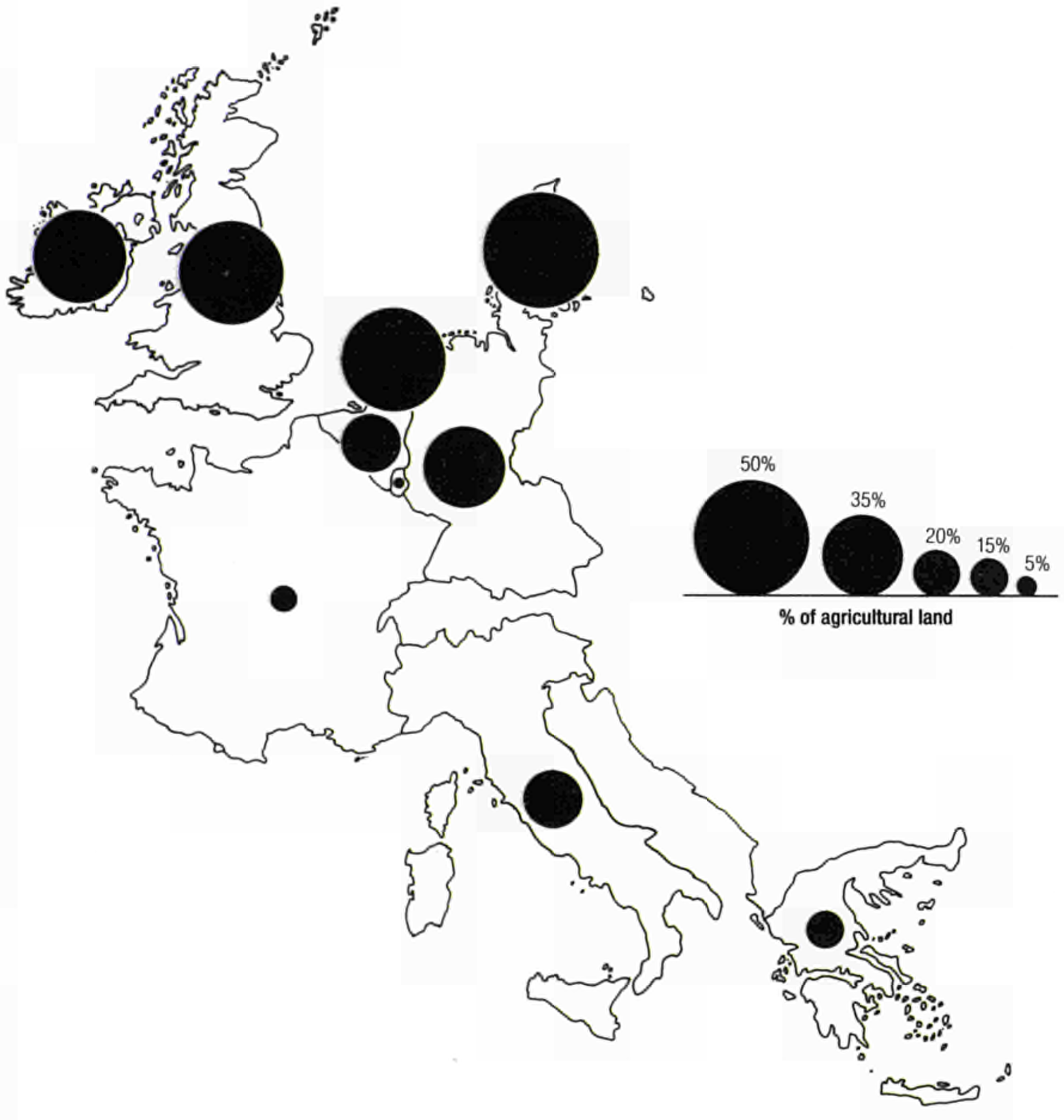


Source: data from Eurostat 1986

drainage are clear. Crop performance is improved, with increases in yields often up to 100% or more; access to the land by livestock or machinery is greatly extended, allowing longer grazing seasons and providing the opportunity for more timely tillage; disease is reduced; and the quality of the output is enhanced.

Not surprisingly, therefore, considerable investment has been devoted to agricultural drainage, especially in northern and western regions of the Community. As has been noted, data are scarce and unreliable, but a broad picture of the extent of drainage is provided by Figure 4.6. This shows that under-drainage is most extensive in the United Kingdom with 50% or more of the agricultural land area drained in England in 1979. In the rest of the United Kingdom, Denmark, Ireland and the Netherlands agricultural drainage has probably occurred on about 40-50% of the land, in Germany about 35% and Belgium 20-25%. No data are available from this source for Italy or Greece but a separate survey in 1976 by Nosenko and Zon (reproduced in Green (1979)) indicated that about 24% and 15% of the agricultural land respectively was drained in these two countries.

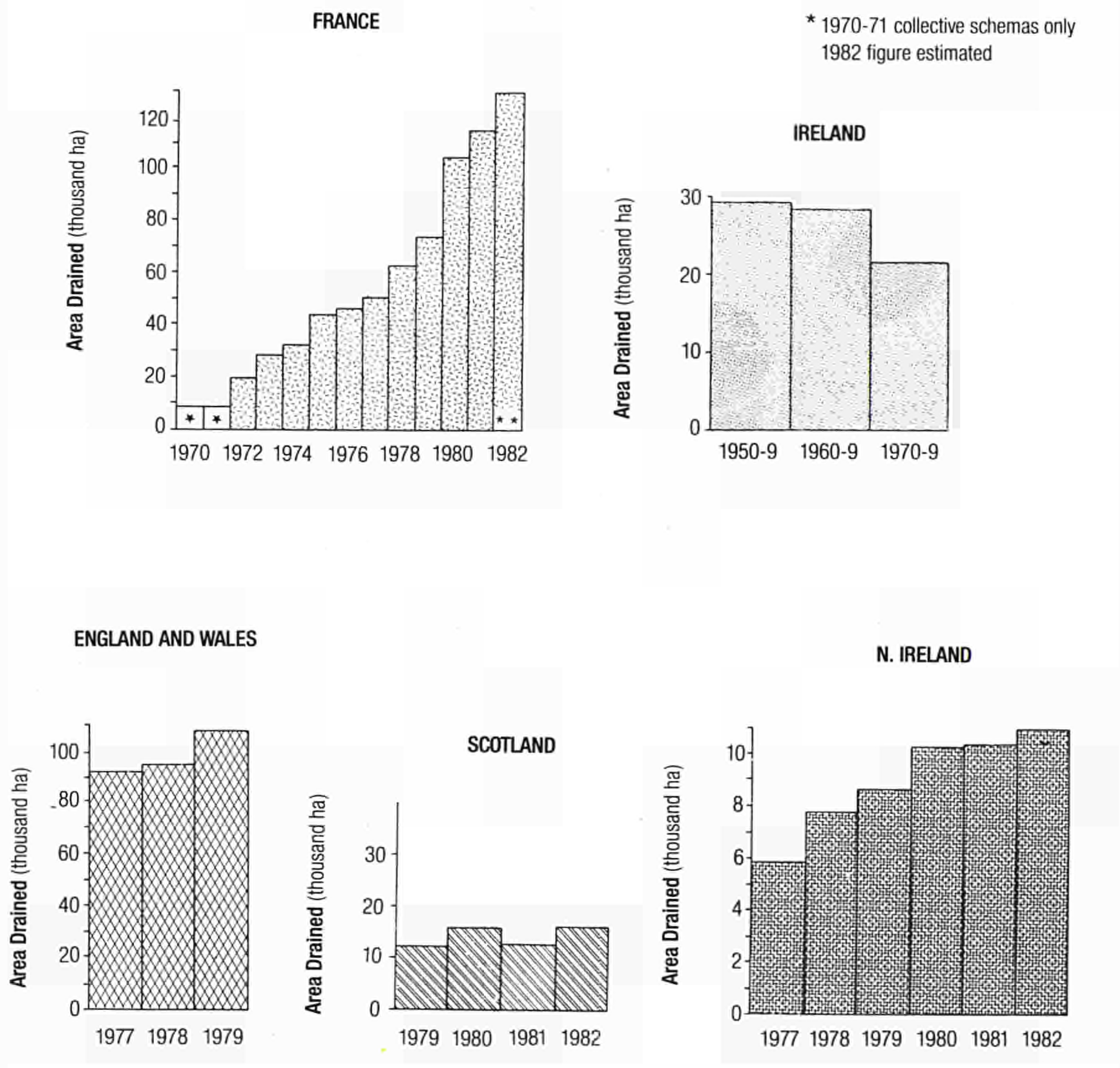
Figure 4.6 **Extent of agricultural under-drainage in Community member states.**



Sources: data from Green 1979, 1980; Baldock 1984

Whilst the absolute figures of the extent of drainage included in this map must be viewed with caution, the spatial pattern is clear and is supported by more detailed surveys in individual member states or regions. Moreover, although the extent of drainage is undoubtedly increasing, this broad pattern probably persists. Thus, the fastest rates of drainage are currently occurring in the United Kingdom, the Netherlands, Denmark and Ireland, where the problems are most acute. Detailed data for all countries are not available but the trends for England, France, the Netherlands and Ireland are shown in Figure 4.7. In Ireland and the Netherlands the annual rate of drainage operations was relatively steady for the period of the data; in England and France, however, it has continued to increase.

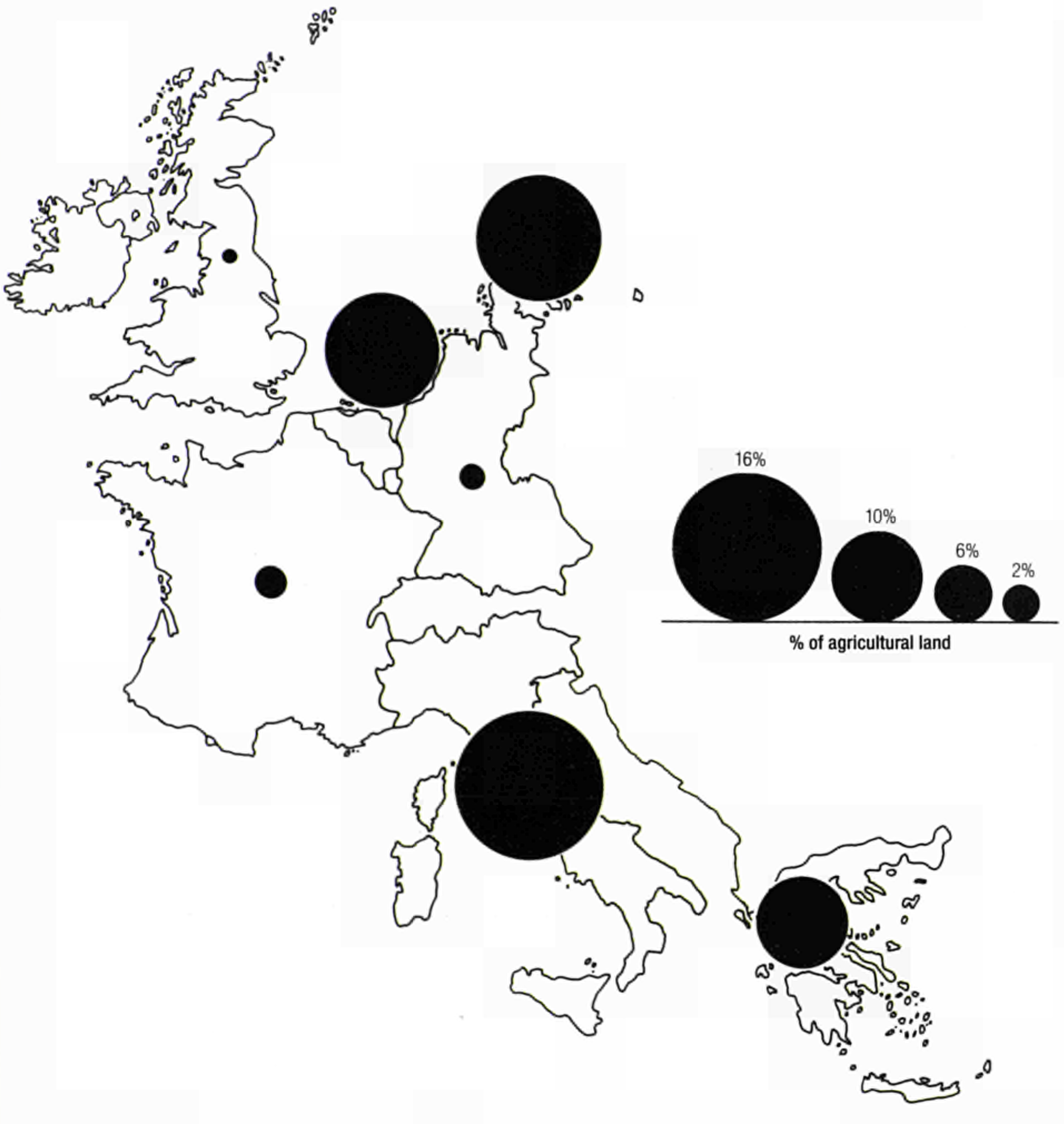
Figure 4.7 **Rates of agricultural drainage installation in selected member states.**



Sources: data from Green 1979, 1980; Baldock 1984

The situation with regard to irrigation is rather different. Irrigation is required in cases where evapotranspiration during the growing season exceeds rainfall such that crops suffer from moisture deficiencies. In general terms these conditions are most common in southern and eastern parts of the Community. Specific irrigation requirements, however, vary with crop type and soil conditions. Moreover, irrigation - unlike drainage - can often be carried out using portable equipment and thus the extent of irrigation can be adjusted from year to year according to the particular climatic conditions and market prices. As a consequence, amounts of irrigation (insofar as they are known) may vary greatly from one year to another, and trends in irrigation use are closely correlated with climate.

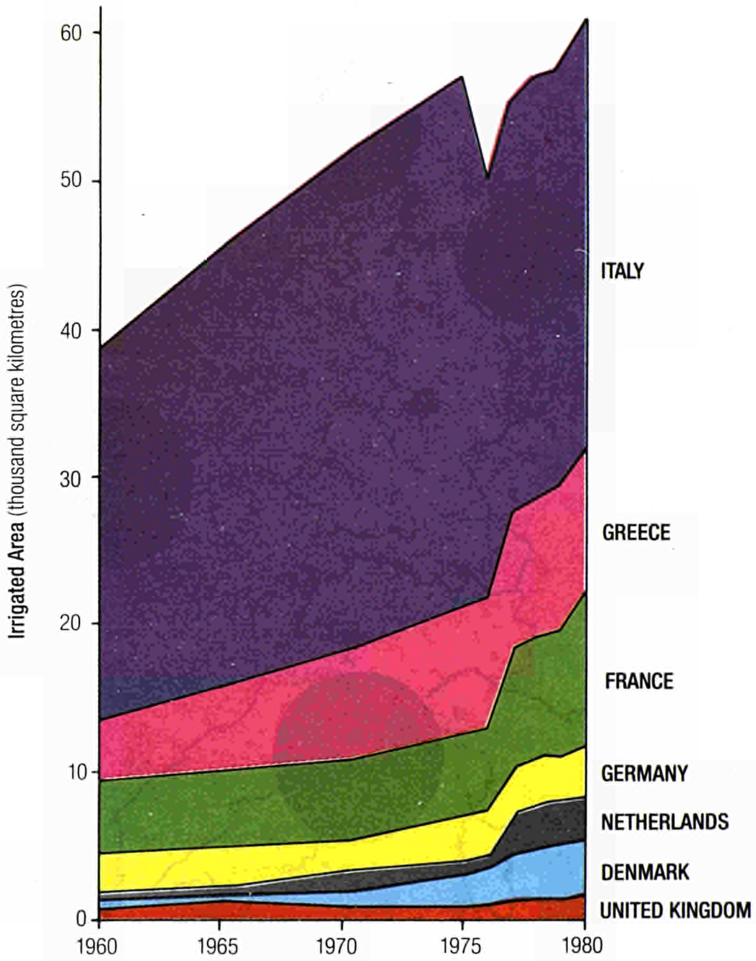
Figure 4.8 **Extent of agricultural irrigation in Community member states, 1980**



Source: data from OECD 1985

Because of the transient nature of much irrigation, data are inevitably poor. An indication of the proportion of land irrigated in each member state in 1980, however, is provided in Figure 4.8. As is to be expected this shows most extensive irrigation in Italy, Greece and France. Trends in irrigation are illustrated in Figure 4.9. The effects of short-term climatic fluctuations are apparent, with a sharp increase in the extent of irrigation in northern areas in 1976-1977 (during the drought) but a marked fall in Italy, which experienced relatively cool conditions in that year. Over and above this there is a general pattern of increasing areas of irrigation, most notably in Denmark, the Netherlands and France. These trends seem likely to

Figure 4.9 **Areas of land irrigated in Community member states, 1960-1980.**



Source: data from OECD 1985

continue so long as market (or intervention) prices make the additional expense of irrigation worthwhile. Since, during dry years, market prices are normally high, the economic benefit of even small increases in yield are often considerable.

Both drainage and irrigation have considerable environmental importance. Drainage may alter rates of throughflow and runoff and, depending on catchment characteristics, may reduce or increase the 'flashiness' of stream discharge. By lowering the soil water table it also affects the growth of many plant species and may alter the ecology of the surrounding area. Above all drainage leads to loss of, or disturbance to, wetlands and has contributed to the decline in many plant and animal species. Similarly, irrigation may affect hydrological and ecological conditions and may also encourage soil salinisation or erosion. For these reasons these practices need careful monitoring.

4.4.3 Fertilisers

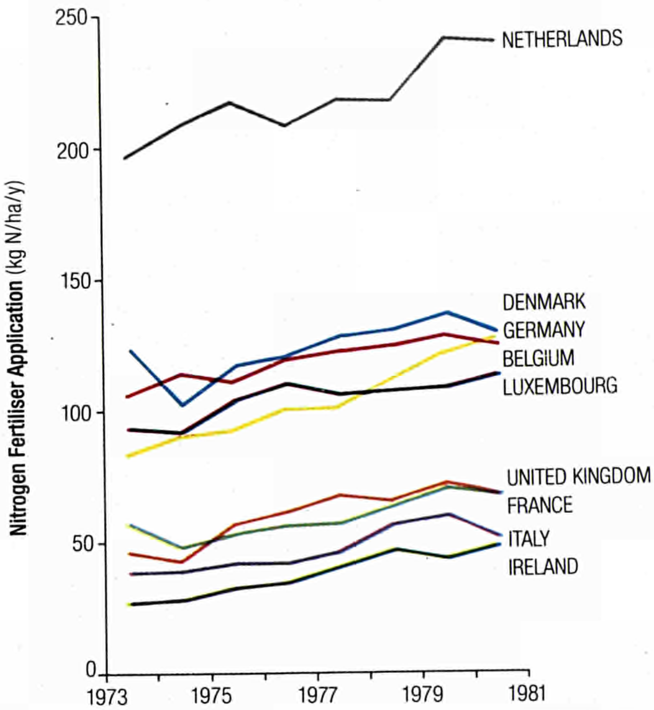
Since the establishment of the fertiliser industry during the late nineteenth century, by Liebig in Germany and by Lawes and Gilbert in England, the use of inorganic fertilisers in agriculture has grown progressively. Initially the rate of growth was slow, and in the United Kingdom, for example, total applications increased by less than 100% between 1900 and 1940. From then until 1980, however, they increased sevenfold. Similar patterns of growth have been recorded in Germany, France, the Netherlands, Belgium and Denmark.

The reasons for this vast expansion in the use of inorganic fertilisers are varied. The need for fertilisers to replenish nutrient losses in harvested materials and by processes of leaching, erosion and volatilisation has long been known. Traditionally, these nutrients have been provided by organic manures - mainly farmyard manure, slurry or gülle derived from farm livestock. Changes in the structure of agriculture and in market conditions during the last 30-40 years, however, have made the use of inorganic fertilisers more attractive. The shift from systems of mixed livestock - arable farming to more specialised cereal cropping or grazing systems has meant that, on arable farms at least, little farmyard manure is available. Costs of transport of manure from livestock farms to arable areas are, on the other hand, prohibitive. Market costs of inorganic fertilisers have also been relatively low. In addition inorganic fertilisers have practical advantages of ease of handling, storage and application, while their guaranteed chemical composition and their more predictable effects on crop growth make accurate calculations of optimal rates of application much easier. Finally, it has been recognised that yields can be increased by applying higher rates of fertiliser nutrients than used in the past, or available solely from animal manures. Thus, inorganic fertilisers have tended to expand in all farming systems, often at the expense of animal manures.

The trend in recent years for use of nitrogen fertilisers in each member state is indicated in Figure 4.10, and for N, P and K fertilisers for the Community as a whole in Figure 4.11. The main patterns are clear. At a Community level, the use of all fertilisers is increasing, though most rapidly in the case of nitrogen. Rates of nitrogen fertiliser application are also rising in all member states, but more markedly in those with a low base-rate of use. The importance of nitrogen in this respect is partly because it is more readily lost by leaching, denitrification and volatilisation, and thus has limited residual effects and needs constant replenishment. At what level these fertiliser inputs will level out is not yet clear. Beyond certain levels, the marginal increase in yield due to fertiliser applications declines markedly, but it is now clear that yields continue to respond positively at least up to nitrogen applications of 1000 kg/ha for grass crops and 400 kg/ha for many cereals. At these higher rates of application, however, the marginal response is small; whether or not it is economically cost-beneficial depends upon the ratio of fertiliser costs to market price of the crop, which cannot easily be predicted. As oil prices rise and, with them, the cost of fertilisers, the break-even point for fertiliser application rates is likely to be lowered. Nevertheless, current application rates in most countries are still well below the limit of cost-effectiveness, and there is every reason to believe that rates of application will continue to expand in many member states. Given that nitrogen fertilisers represent a major source of aquatic pollution, this trend has major environmental implications.

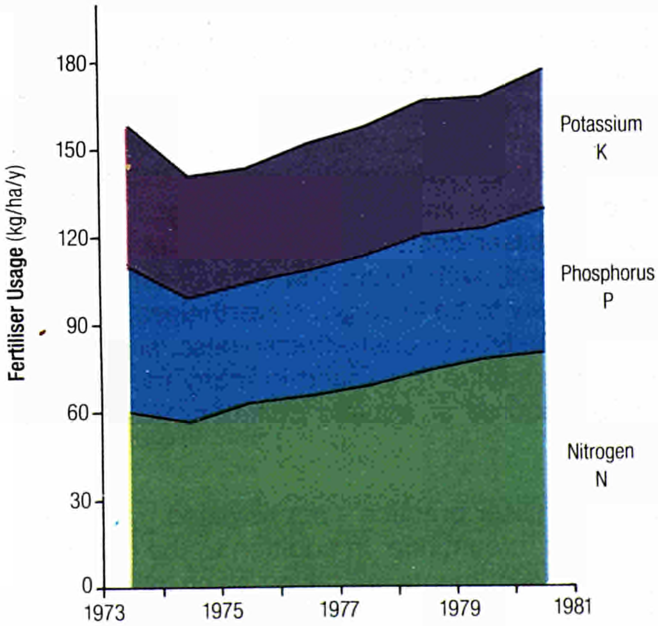
Other changes in fertiliser practice - not revealed by these data - are also occurring, and likewise may be expected to continue. In addition to the changes in quantities of N, P and K being used, for example, developments are taking place in the forms of fertiliser. In particular, liquid forms of nitrogen fertiliser, which provide the nutrient in more readily available form for plant uptake, are being increasingly adopted. About 30% of the nitrogen applied in Denmark is now in this form, and in other member states the quantities are growing. On the other hand, the use of calcium as a fertiliser appears to be declining in some member states. Data are not available in anything like a comprehensive form, but levels of use appear to have risen by about

Figure 4.10 **Average rates of nitrogen fertiliser application in Community member states, 1973-1981.**



Source: data from Eurostat 1984

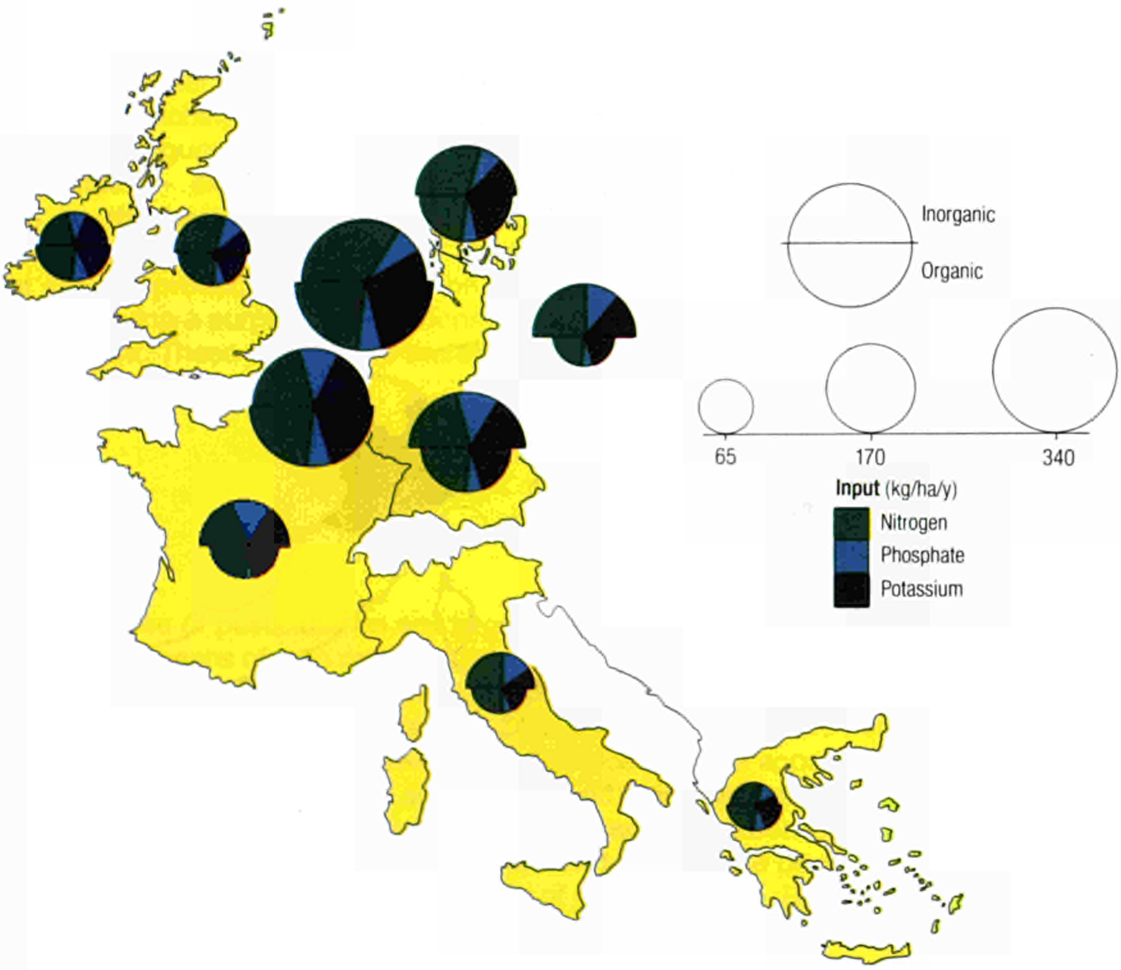
Figure 4.11 **Rates of nitrogen, phosphorus and potassium fertiliser application in the European Community, 1973-1981.**



Source: data from Eurostat 1984

by about 15-20% in the United Kingdom. This has considerable significance, for calcium compounds have traditionally been used to maintain soil pH against the natural acidifying action of rainfall and similar effects of organic manures and artificial fertilisers. Reductions in the use of lime are thus likely to lead to increased soil acidification.

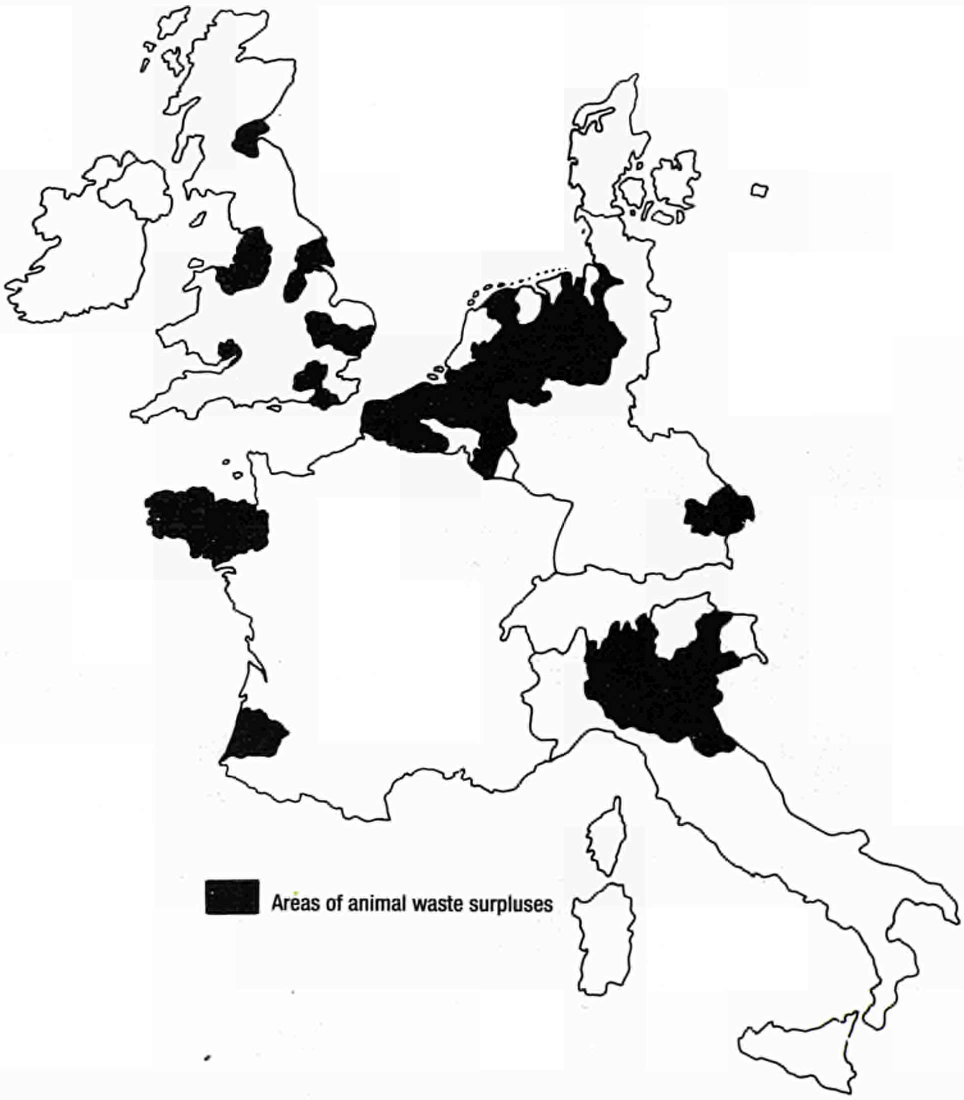
Figure 4.12 **Nutrient inputs to the soil from inorganic and organic fertilisers (including field returns by cattle at pasture) in Community member states.**



Source: data from Commission of the European Communities 1978

Similarly lacking are data on changes in the use of organic fertilisers. As has been noted, in cereal-growing areas the use of manure has undoubtedly declined, but this trend may at least in part be ccmpensated at a Community level by increased production and returns of animal wastes in livestock rearing areas. Indeed, in these latter regions higher stocking densities have resulted in severe problems of livestock waste disposal, especially in feedlot systems.

Figure 4.13 **Areas of animal waste surpluses in the European Community.**



Source: data from Commission of the European Communities 1978

The broad pattern of nutrient inputs to the soil from inorganic and organic fertilisers is shown at a national level in Figure 4.12. Organic inputs in this map include both the application of manures and natural returns by livestock at pasture. The values quoted are expressed as kilograms per hectare of agricultural land, and are thus somewhat misleading for they do not show the actual levels of field application: in practice, high levels may be applied on some parts of the land, but none or very low levels on other parts.

Nevertheless, a number of points emerge from these data. First, it is clear that a general correlation exists between rates of inorganic and organic nutrient inputs. This reflects the circumstance that high rates of fertiliser usage occur in those countries with high grazing intensities - that is, both are related to the intensity of agriculture. Second, it is apparent that the Netherlands stands out as having the highest rates of nutrient input, while Greece, Ireland, Italy and the United Kingdom have relatively low application rates. (The values for the UK are low because of the large area of moorland in upland regions which is classified as 'agricultural land' but which is used only for extensive grazing and thus receives little or no fertiliser). Third, it is notable that in all countries organic inputs remain important as nutrient sources and, in the case of potassium, generally provide the majority of inputs.

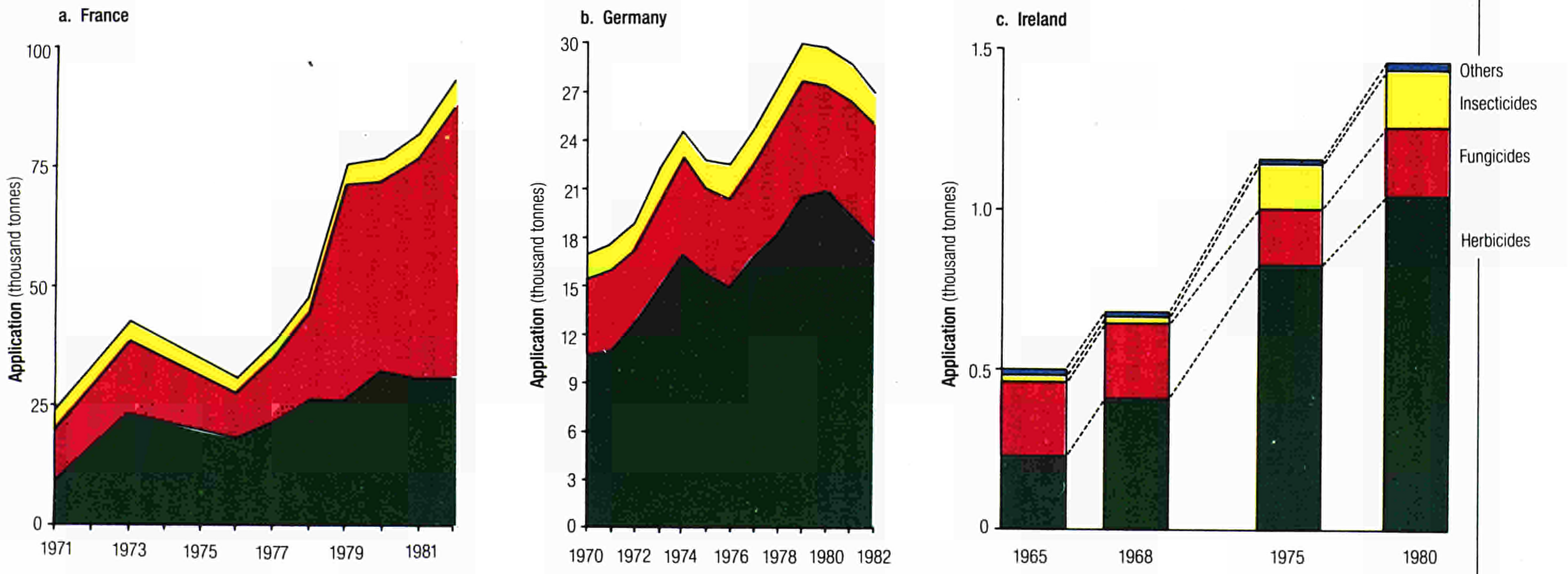
The question of organic fertiliser inputs has particular significance. In any intensive livestock system the disposal of surplus animal wastes may present problems, for the manures cannot be applied to the land throughout the growing season due to problems of access to arable land and of sward rejection by cattle if they are spread on grazed pasture. On the other hand, storage of manure and slurry poses considerable costs and technical difficulties. The problem is particularly acute where regionally high livestock densities occur, for in these areas it is not possible to sell surpluses to neighbouring farms. In these cases excessively high levels of manure may be spread on the available land, or long term storage of the surpluses may be carried out. In either event, there exists a high risk of pollution by seepage from slurry silos, or by runoff and leaching from manures in the field. Some indication of the extent of this problem is indicated in Figure 4.13 which shows areas with significant surpluses of animal wastes (in 8 member states - excluding Greece, Ireland, Spain and Portugal). These areas have been defined on the basis of a modelling procedure which computes the quantities of nitrate, phosphate and potassium produced by the regional livestock population. Areas where the annual rate of production exceeds the annual crop requirement on the available land are defined as having a surplus. Calculations are based on 1972-73 livestock data, but are likely to be still relevant. These regions are therefore the most vulnerable to problems of pollution from animal wastes.

4.4.4 Pesticides

The use of pesticides on any large scale is a relatively recent phenomenon. Prior to the 1940s, the main means of crop protection was either by hand-weeding and scaring, or by the use of chemical poisons including compounds of copper, lead, mercury and cyanide. With the development of organochlorine pesticides such as DDT, DDD and dieldrin, however, the potential for chemical control of a wide range of pests, weeds and diseases become apparent. Use of these pesticides therefore increased rapidly, not only against crop and livestock pests but also against human pests such as the mosquito. The effects were dramatic, but not always beneficial. Gradually during the late 1950s and early 1960s evidence emerged that residues of these pesticides were accumulating in food chains and leading to increased mortality of predatory birds. Raptors such as falcons, hawks, eagles and osprey were particularly affected, largely as a result of eggshell thinning which reduced breeding success and contributed to declining populations. As a consequence, alternative forms of pesticide were sought, and during the 1960s more target-specific, less persistent compounds such as organophosphates and carbamates were developed. In recent years the use of these has expanded considerably.

The value of pesticides to modern agriculture cannot be denied. Even today, crop losses in the field to pests and diseases probably average about 30% on a world-wide basis. A further loss of 20% of the harvested crop probably occurs due to diseases and pest attack during storage, so that only 55-60% of the potential yield is actually available for food processing.

Figure 4.14 **Annual levels of pesticide usage in France, Germany and Ireland.**



Sources: data from Ministère de l'Environnement 1984; Umweltbundesamt 1984; FAO 1976-1984

Additionally, without pesticides the costs of labour would increase dramatically. In the case of sugar beet production, for example, it has been estimated that a reduction in labour requirement of about 75% has been possible due to elimination of the need for hand-weeding and consequent developments in planting and harvesting techniques.

Given these potential benefits it is not surprising that high levels of pesticide application have continued, despite their environmental hazards. Data on pesticide usage are scarce, however, so actual rates of application or trends in usage are difficult to identify. Moreover, data which aggregate different types of pesticide of different concentration, toxicity, specificity and persistence may be grossly misleading. The data presented in Figure 4.14 are, at best, only general indications of recent changes, therefore, and must be interpreted with caution. Nevertheless, the overall trends are clear. In all three countries, usage of all groups of pesticide increased at least until the late 1970s. Since then, applications of herbicides and insecticides have begun to level off or even decline.

Many factors clearly affect the levels of pesticide usage in the European Community, including the type of crop being grown, the weather and the incidence of pests and diseases in any year. Fears about the environmental impacts of more persistent compounds, however, have led to the adoption of a number of controls on pesticide usage, and these have undoubtedly resulted in changes in the application of some substances. In particular, use of organochlorine and mercury compounds has fallen in response both to national legislation and to Community Directive 79/117 which aims to phase out the use of persistent pesticides and to encourage the introduction of less persistent alternatives. Even so, the continued impact of pesticide residues on groundwaters, lakes, streams, the seas and wildlife means that it is vital to obtain better data on pesticide usage in the Community.

4.5 FORESTRY

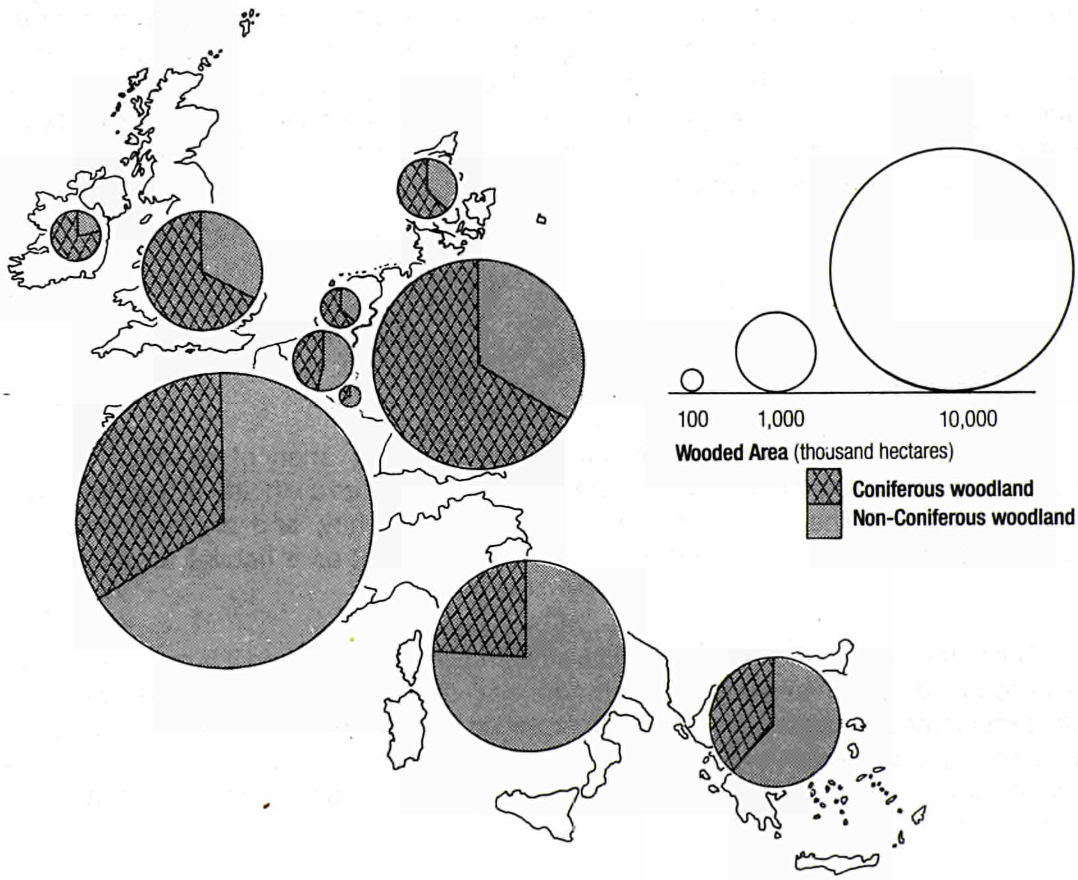
The forests of the Community are important for a wide variety of reasons. They constitute an important resource in their own right, yielding timber which - as a whole - is a scarce commodity within the Community. They also provide an important amenity, and are extensively used for recreation. In addition, they are important ecologically, and act as a habitat for many species of wildlife.

These various functions are not always directly compatible, and it is only the use of forests for timber production which has any direct commercial value. Consequently, while forestry activities often take precedence in forest planning and management, they may also have important social and environmental impacts. Furthermore, the use of forests involves various conflicts of interests which create significant problems in terms of environmental and resource planning, both at regional and Community level.

In total, forests cover an area of about 35 million ha in the European Community. The definition of forested land, however, is far from consistent, and great care is needed in interpreting data on their distribution and character. Forests may range, for example, from young, even-aged stands of artificially planted conifers to ancient mixed woodlands; and from tall, dense forest to relatively open scrub and garigue. Similarly, the use and ownership of forests vary considerably. The majority - some 80% - is exploited for commercial purposes, but this includes intensively managed plantations at one extreme and semi-natural, sporadically harvested woodland at the other.

The data presented in Figure 4.15, showing the distribution of coniferous and deciduous forest at a national level, must therefore be viewed with caution. What it does show is that coniferous forest tends to predominate in northern countries, while deciduous woodland is more abundant in the south; and that marked variations in the extent of forest cover occur in member states. Allowing for differences in the total national area, therefore, it can be seen that Luxembourg (with 31% of the total area under woodland) is the most densely forested country, followed by Germany (29%) and France (27%). These member states contrast with Ireland (only 6% of the land area forested), the Netherlands (8%), the United Kingdom (9%) and Denmark (11%).

Figure 4.15 **Extent and composition of woodland in Community member states.**

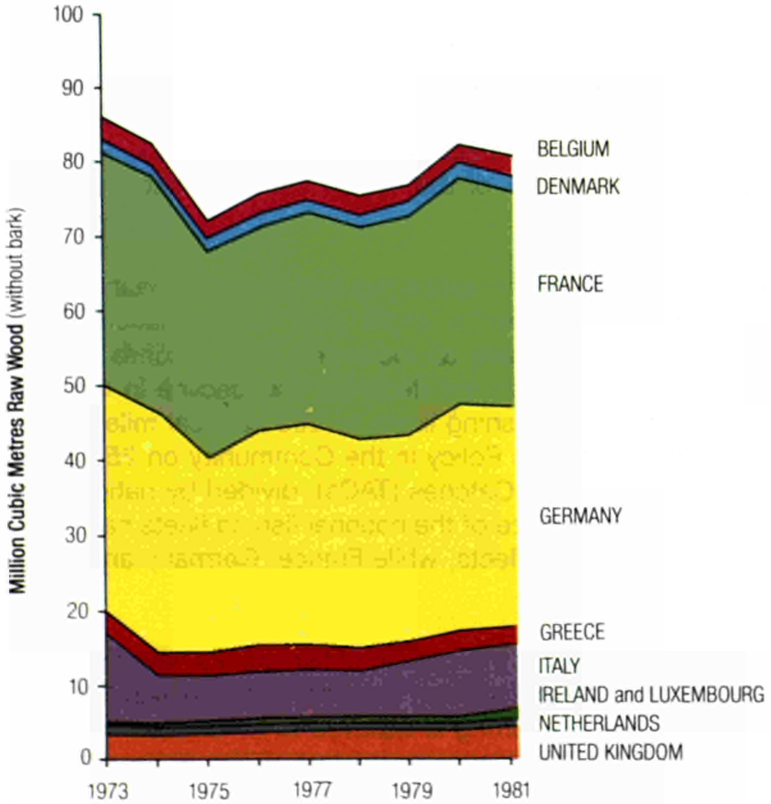


Source: data from Commission of the European Communities 1983

What the data do not show, on the other hand, are the differences in the character of the woodland, or the regional patterns in its distribution. Much woodland in southern parts of the Community, for example, is sparse and open; it covers large areas but is rarely dense. In contrast, in Denmark most of the forests are confined to scattered areas of steep valley sides, which are of relatively low agricultural value and have thus not been taken into cultivation. In the United Kingdom, forest land is concentrated in the uplands of Scotland and northern England, and on the poorer acidic soils of the old heathlands in the south of England. Indeed, throughout the Community, forests tend to be associated with the more marginal areas, where climate, soils and topography restrict agricultural development.

As this indicates, the present distribution of forests is closely related to the history of land use and clearance, and especially the extension of agriculture. For many centuries, the area of forest has been declining as land was cleared for farming. Since the early 1900s, however, this pattern has been reversed to some extent. Between 1972 and 1974, the area of forest increased at an average rate of 350,000 to 400,000 ha per year. Some 55% of this was due to deliberate planting and most of the rest to natural regeneration and coppice growth. The main areas of afforestation were in France, Italy and the United Kingdom. Data for more recent years are lacking, but the trend is believed to be continuing. In Ireland, for example, the area of forestry increased by about 40%, while in the United Kingdom it rose by about 10%. In contrast, in Belgium there was a decline of almost 12% (OECD 1985).

Figure 4.16 **Raw wood production (total removed) in Community member states, 1973-1981.**



Source: data from Eurostat 1984

Against this background, raw wood production (i.e. total annual removal of timber) has fallen over the last ten years (Figure 4.16). This is largely due to declining demand for wood products, partly as a consequence of economic recession and partly due to technological developments which have seen the substitution of wood materials by plastics and other compounds. One effect of this has been to enable member states to increase their reserves of growing timber. A longer term implication is that the average age of forest stands will increase. This has ecological as well as commercial significance, for most mixed or deciduous woodlands become ecologically richer as they grow older.

4.6 FISHING

Community policy on fishing has developed gradually since 1976 because of the fundamental changes in internal fishing conditions which have required the appropriate measures in the management of marine resources. It has been fraught with problems, including that of sharing out available catches, access to coastal waters (distance of fishing limits from the shoreline) and the general concern about fish stocks and the dangers of overfishing.

Fishing is an important activity in the European Community. In 1981, for example, the total fish catch in the Community amounted to some 5 million tonnes, while the fishing fleet comprised over 55,000 vessels (1.2 million GRT). In 1986, with the accession of Portugal and Spain, the total increased to some 80,000 vessels (2 million GRT).

Data on the size of national fishing fleets (for the period before the accession of Portugal and Spain) and the total fish catch in Community Member States are shown in Figures 4.17 and 4.18. Caution is needed in interpreting these data, however, due to marked differences in the character of fishing carried out in the different areas. It is notable that Italy has by far the largest fishing fleet but accounts for less than 10% of the total fish catch. This is because its fleet comprised mainly small, coastal vessels often fishing for shellfish and other shallow water species, often on a part-time basis. In contrast, Denmark, with a fleet of less than 7,000 vessels, accounts for about 40% of the fishing catch - most of it from a small industrial fleet of some 100 vessels.

Since 1973, the overall fish catch has remained reasonably constant at a little over 5 million tonnes per year. There has been a slight shift in the national contributions: Denmark, the Netherlands, Ireland and Italy have all increased their catches while the United Kingdom and Germany have experienced significant declines. The decline in German and British catches was largely due to the extension of fishing limits to 200 nautical miles offshore during the 1970s. The adoption of a Common Fisheries Policy in the Community on 25 January 1983 - which led to the establishment of Total Allowable Catches (TACs), divided by national quotas - helped to reinstate stability. At the same time, the size of the national fishing fleets has also changed. Italy, Ireland and Greece have all expanded their fleets, while France, Germany and Belguim have all reduced their number of vessels.

In the past, fears about the decline of fish stocks have led to stringent controls on fishing. For example, the catches of herring from the North Sea declined progressively between 1973 and 1980 and the total biomass of herring is believed to have fallen from about 3 million tonnes in the early 1960s to less than 300,000 tonnes by the late 1970s. At the same time, the average age of the population fell markedly. Fishing for herring was stopped and all fishing activities for the species banned for several years. As a result of these conservation measures, herring stocks are now rapidly returning to their earlier levels (Figure 4.19). The lesson is clear: careful monitoring of fish stocks is essential if overfishing and the loss of marine resources are to be avoided and the collapse of other fishing stocks is to be prevented.

Figure 4.17 **Size of the fishing fleet in Community member states, 1973-1982.**

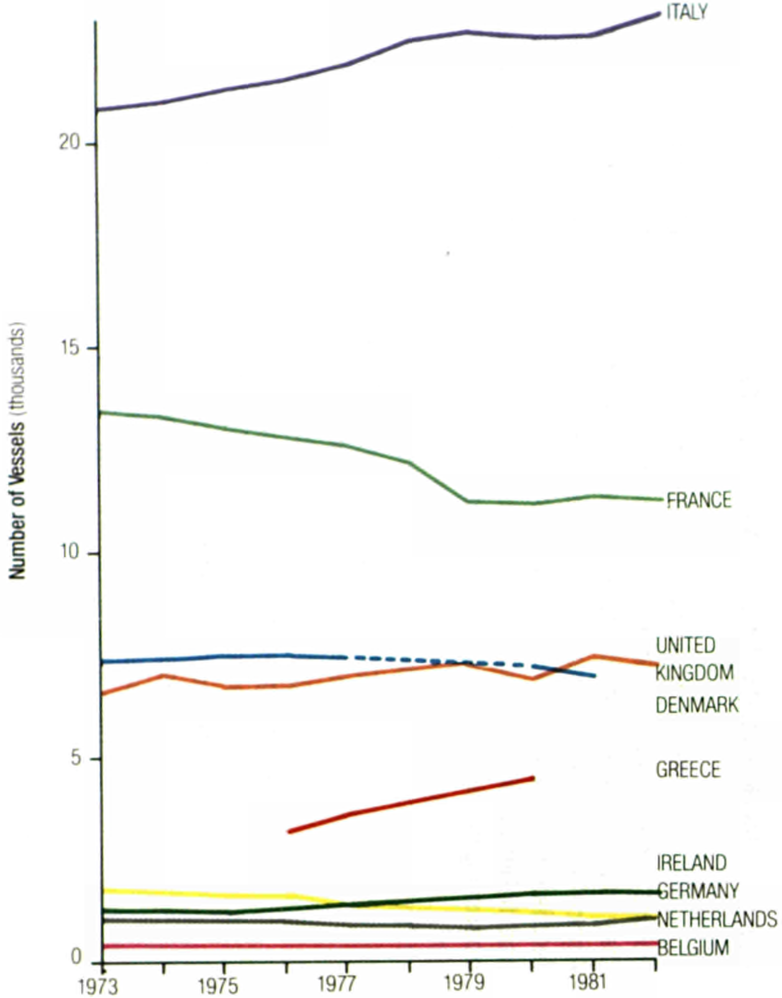
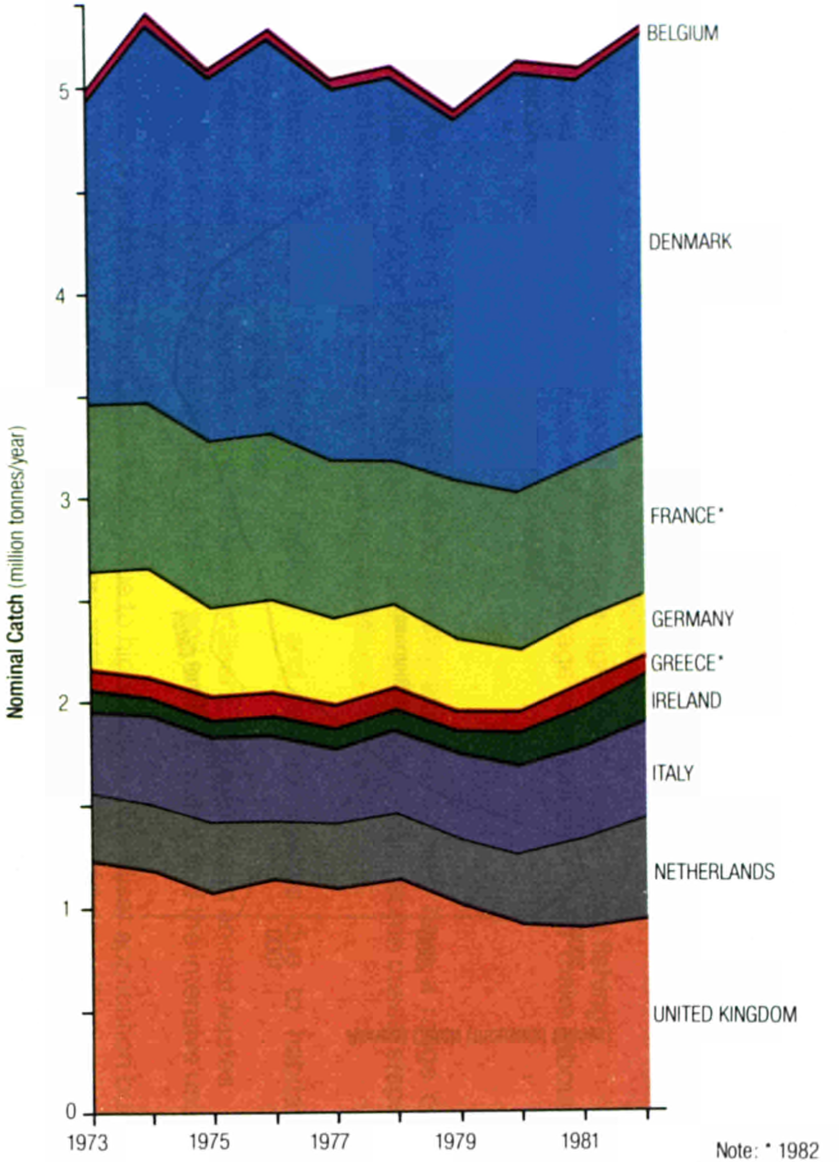
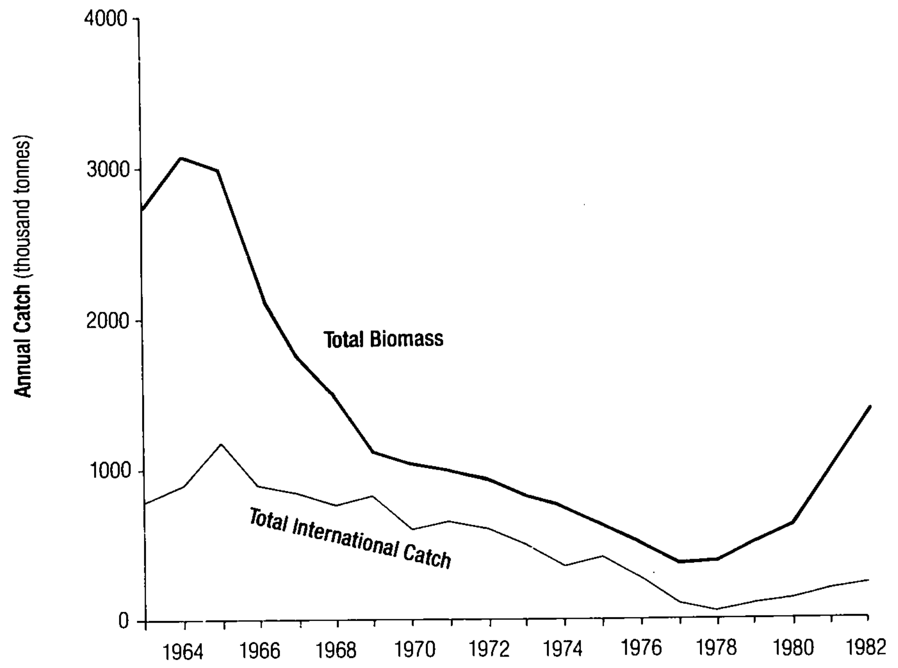


Figure 4.18 **Total fish catches in Community member states, 1973-1982.**



Note: * 1982 figures estimates

Figure 4.19 **Annual catches and biomass of North Sea Herring.**



Source: data from International Conference on the Protection of the North Sea 1984

4.7 SUMMARY AND CONCLUSIONS

Agriculture, forestry, and fishing are intimately related to the environment. By their very nature they involve the management and exploitation of ecological resources, and consequently they have a direct and crucial impact upon the quality, distribution and abundance of wildlife. Agriculture and forestry also influence the visual character of the environment, while animal wastes, fertiliser residues and pesticides may act as important environmental pollutants. Agriculture, forestry and fishing are changing, however, and in this chapter we have seen some of the trends which are occurring in the Community. These include:

i. in the realm of agriculture:
   - a progressive decline or levelling off of employment
   - a general increase in yields
   - a slight decline in the total area of agriculturally-utilised land
   - the growth in high-intensity livestock units
   - an increase in the level of mechanisation
   - an increase in the extent of drainage and irrigation
   - increasing inputs of inorganic fertilisers
   - increasing inputs of pesticides
   - higher levels of production of animal wastes.

ii. in the realm of forestry:
   - a continuing expansion in the area of forested land
   - a tendency towards increased mechanisation and inputs of fertiliser
   - a reduction in the area of the land felled each year
   - a tendency towards the planting of monospecies plantations

iii. in the realm of fishing:
   - a slight increase in the size of the fishing fleet
   - a reduction in the annual fish catch.

These trends can be attributed to a number of different factors, most notably:

- Community and national policies favouring agricultural intensification
- technological developments and innovation in agriculture, forestry and fishing
- increasing labour costs which act to encourage mechanisation and make labour-intensive systems economically less viable.

These changes taking place in agriculture, forestry and fishing also have a range of environmental implications. Many of these have aready been recognised and, in some cases, steps have been taken to alleviate them. In general, however, the effects include:

- increased pressure on terrestrial habitats and wildlife species due to habitat disturbance, pollution and drainage
- increased water pollution due to misuse of fertilisers, pesticides and animal wastes
- increased risks of soil erosion due to loss of soil organic matter and the intensive use of heavy machinery
- increased problems of soil acidification due to higher rates of fertiliser application but (in some areas) a reduction in the use of lime and the effects of acid deposition
- marked changes in the visual character of the landscape due to afforestation, hedgerow removal, wetland drainage, etc.
- a reduction in fish stocks due to over-fishing of some species and to pollution in some areas.

Many of these effects are undoubtedly serious, though they need to be seen within the context of a naturally dynamic environment. Moreover, the impacts of agriculture, forestry and fishing are not acting with equal severity everywhere. Nevertheless, the increased intensity of modern agricultural systems, in particular, mean that the magnitude of agriculturally-induced changes is probably greater than ever before. At the same time, pressures on the environment from other sources are also growing, so habitats, water resources and land resources are all more vulnerable to damage. The potential effects of agriculture, forestry and fishing must therefore command close attention. In this context, the recent Green Paper on agriculture and the environment published by the Commission of the European Communities is of the utmost importance, for it heralds a more environmentally-sensitive approach to agriculture in the Community, and suggests that agricultural policy in the future should place more emphasis on its role in environmental protection.

NOTES AND SOURCES

Data availability

Although a wide range of data on agriculture, forestry and fishing are collected by the Statistical Office of the European Communities, by member states, and by the FAO, data availability on these activities remains something of a problem. Much of the difficulty in acquiring data relates to the nature of these activities: they tend to be carried out by small, more-or-less independent enterprises which vary their practices from year to year according to economic, environmental and even personal conditions. Indeed, the very definition of these enterprises is often difficult due to the temporary and varied nature of many of the activities. As a result, data on many of the items discussed in this chapter may be inconsistent or incomplete, and considerable care is needed in their interpretation. Particular weaknesses in data availability may be noted in the case of irrigation, land drainage, pesticide usage and land use.

Notes on Figures

Figure 4.1 Data refer to full-time workers (including farm owners, family workers and hired labourers) only.
Figure 4.3 Data for Greece not available; all other data are shown for NUTS level II regions.
Figure 4.4 Considerable discrepancies may exist within these data due to differences in the way classifications of land use are interpreted at different times and in different countries.
Figure 4.7 Interpretation of data on agricultural land drainage need especial care, for definitions of the term 'drainage' are often inconsistent even within a single member state. In general, these data refer only to underdrainage (e.g. pipes) and ditching, but in some cases arterial drainage may also be included.
Figure 4.8 As above.
Figure 4.9 Data on irrigation are not generally reliable, for much irrigation is carried out in a piecemeal manner by individual farmers, as the need arises. Moreover, definitions used vary markedly between member states (see also notes on Figure 4.10).
Figure 4.10 Data for Denmark and France refer to land provided with irrigation facilities; data for the United Kingdom refer to England and Wales only.
Figure 4.11 Data on use of chemical fertilisers relate in principle to deliveries to agricultural merchants during an agricultural year and take no account of changes in merchants' stocks or actual uses by farmers.
Figure 4.12 As above. Potassium fertilisers expressed as K_2O, phosphorus as P_2O_5, nitrogen as N.
Figure 4.13 Data on organic inputs are calculated from livestock densities (1 livestock unit = 1 cow) and Danish estimates of manurial composition.

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PART THREE

STATE OF THE ENVIRONMENT

CHAPTER 5.

THE AIR

5.1 INTRODUCTION

5.1.1 The Importance of Air Quality

Air pollution affects our lives and the quality of our environment in many different ways. At the very least it is inconvenient and discomforting. Unpleasant odours, the acrid taste of chemical pollutants, or the sting of dust in the air can reduce our enjoyment of the environment. Equally, atmospheric pollution can cause disruptions and hazards by encouraging the formation of smog which hinders road traffic and may close airports (e.g. Milan). Apart from the potential financial costs involved in such delays there may also be large social costs because of increased accident rates. More direct costs are caused by the damage to buildings and structures (e.g. Athens). Corrosion of metals, acid attack of stonework and the deposition of dusts, oils and chemical residues on walls and windows all involve considerable expense in cleaning and repair.

More subtle, but of equivalent importance, can be the longer-term damage to agricultural crops, forests and soil fertility. Crop yields and tree growth, for example, may be reduced by the direct effect of pollutants on foliage and rates of photosynthesis, by the generation of toxic conditions in the soil, by the loss of nutrients due to enhanced leaching, or by changes in climate induced by pollutants. Indeed, in recent years, the problems of die-back of forest trees as a result of these effects have caused widespread concern (see Inset p. 170). In the same way natural habitats and the wildlife species they support can be adversely affected; not only terrestrial vegetation but aquatic habitats such as lakes and streams may be contaminated by pollutants washed or deposited from the atmosphere, or by the nutrients leached from the surrounding soils. Finally, and in many ways most crucially, air pollutants can be a serious health hazard. Even minute quantities of elements such as mercury, cadmium and lead and residues of organic compounds such as polychlorinated-biphenyls, can be highly toxic when absorbed over long periods of time. Moreover, the persistence of many of these substances means that they tend to accumulate in living cells and are passed up through food chains to higher organisms, including man. Similarly, widespread pollutants such as sulphur dioxide, nitrogen dioxide and ozone all have direct health effects.

5.1.2 Pressures on the Atmosphere

It is clear that the air is subject to a wide range of pollutants, derived from many different sources. Not all of these are man-made, and natural processes such as volcanic activity, biological respiration and decomposition, and fire often contribute large quantities of solids, gases and vapours to the atmosphere. Nevertheless, many of the minor constituents of the air - and often those with the greatest toxicity - are at least partly dependent upon human activity. The significance of various activities as sources of air pollutants is outlined in Table 5.1.

One of the most important of these activities is combustion of fossil fuels. This takes place both in stationary sources such as power stations, heavy industrial plants and residential houses, and in mobile sources such as road, rail and air traffic. The pollutants emitted vary with fuel type and combustion process to some extent, but in general include compounds of carbon, sulphur and nitrogen as well as heavy metals.

Table 5.1 **Sources of major air pollutants.**

	Solids	CO	CO_2	SO_2	NO_X	Cd	Cu	Hg	Pb	Zn	HC	Rdn
Mining/quarrying	×					×	×	×	×	×		
Power stations	×	×	×	×	×	×		×				×
Metal processing		×	×	×		×	×	×	×	×		
Chemical processing						×					×	
Oil refining				×	×						×	
Paint/pigment manufacture						×		×	×		×	
Battery manufacture									×			
Pharmaceutical production								×			×	
Waste incineration	×	×	×	×	×	×	×	×	×	×	×	×
Pesticide manufacture/use											×	
Fertiliser manufacture/use					×	×						
Food processing/distribution											×	
Traffic	×	×	×	×	×				×		×	
Electrical apparatus							×			×		
Domestic heating	×	×	×	×	×	×		×			×	
Military activities	×	×	×	×	×	×	×	×	×	×	×	×
Agriculture	×					×					×	

Rdn = radionuclides
HC = hydrocarbons

Another major source is provided by industrial processing. The manufacture and use of metals, plastics, pigments, solvents, batteries and pharmaceuticals, for example, often involves emission of a wide range of substances. These processes act as important sources not only for heavy metals but also organic compounds such as polychlorinated biphenyls (PCBs) and chlorofluorocarbons (CFCs).

Almost all these processes are sensitive to change in the economic climate and thus we might expect that levels of emissions have generally declined in recent years as industrial production has fallen. Although this may be partly true, it is also clear that developments in industrial technology and materials have led to changes in the nature of production. Consequently, while many traditional sources of these pollutants are currently undergoing recession, several 'new' industries are now expanding, and with them levels of emissions from these are rising. At the same time, new carcinogens and mutagens are being discovered amongst atmospheric pollutants. As industrial technology changes, it is therefore likely that many new sources of health risk will emerge and grow.

Table 5.2 **Community actions on air quality.**

DATE	ACTION	ABBREVIATED TITLE	OBJECTIVE
1970	Directive (70/220)	Air pollution by positive ignition engines of motor vehicles.	Lays down procedures and limit values for emissions from motor vehicles. (Latest amendment in 1983 includes small diesel engines.)
1972	Directive (72/306)	Emissions from diesel engines for use in motor vehicles.	Lays down procedures and limit values for visible smoke emissions from diesel engined motor vehicles.
1975	Directive (75/716)	Sulphur content of certain liquid fuels.	Provides for reduction of sulphur content of gas-oil; defines and specifies methods of checking.
1977	Directive (77/537)	Emissions from diesel engines for use in agricultural vehicles.	Lays down approval procedure and defines emission limits.
1978	Directive (78/611)	Lead content of petrol	Limits lead content of supergrade petrol at 0.4 g/l (with exemption for Ireland).
1978	Resolution	Chlorofluocarbons in the environment.	Limits production and encourages substitution.
1980	Directive (80/372)	Chlorofluocarbons in the environment.	Limits production of CFCs ans sets objective of 30% reduction in their use in aerosols.
1980	Resolution	Transboundaryair pollution by sulphur dioxide and particulates.	States objective of controlling sulphur and particulate pollution.
1980	Directive (80/779)	Air quality limit values and guide lines dor sulphur dioxide and suspended particulates.	Defines standards for sulphur dioxide and particulates and specifies sampling and analytical methods.
1981	Decision (81/462)	Long-range transboundary air pollution. vehicles.	Concludes Geneva Convention calling for controls on long-range pollution.
1982	Decision (82/459)	Exchange of information on air pollution	Establishes procedure and monitoring network for collecting standardised data on air quality.
1982	Decision (82/795)	Precautionary measures concerning chlorofluocarbons.	Consolidates and provides for re-examination of earlier measures on CFCs.
1982	Directive (82/884)	Limit value for lead in the air	Fixes a limit value of 2 $\mu g/m^3$ mean annual lead concentration and outlines sampling procedures.
1984	Directive	Air pollution from major industrial plants	Specifies measures to be taken to limit air pollution from new and existing industrial plants.
1985	Directive	Air quality standards for nitrogen dioxide.	Lays down limit value and guide values for nitrogen dioxide.
1985	Directive	Lead content of petrol.	Calls for reduction in lead content of petrol to 0.15 g/l and requires unleaded premium grade petrol to be available by 1/10/1989
Proposed Directive		Limitation of emissions of air pollutants from large combustion plants.	Specifies reduction in targets for sulphur dioxide, nitrogen oxides and dust for new plants and defines measurement procedures.

Source: Commission of the European Community 1984

COMMUNITY ACTIONS ON AIR POLLUTION: THE EXCHANGE OF INFORMATION ON ATMOSPHERIC POLLUTION BY SULPHUR DIOXIDE AND PARTICULATES

One of the most basic requirements of any environmental policy is for reliable data. These are neeeded to show where environmental problems exist, what trends are occurring, and how successful policies have been. This is true no less in the case of air pollution than other problems. Moreover, because of the long distances over which pollutants may be transported, it is more than ever essential that the data are consistent and compatible, over time and between measuring stations.

It was with these aspects in mind that the Council of the European Community adopted a Decision in 1975 for the establishment of a system of information on air pollution throughout the Community. The aims were to provide data, initially on sulphur dioxide and particulates, which would help in:

i. monitoring of long term trends in air pollution;

ii. monitoring improvements in pollution levels as a consequence of national or Community legislation on the environment;

iii. providing a data base on air pollution for studies of pollution transport across regional, national and Community boundaries;

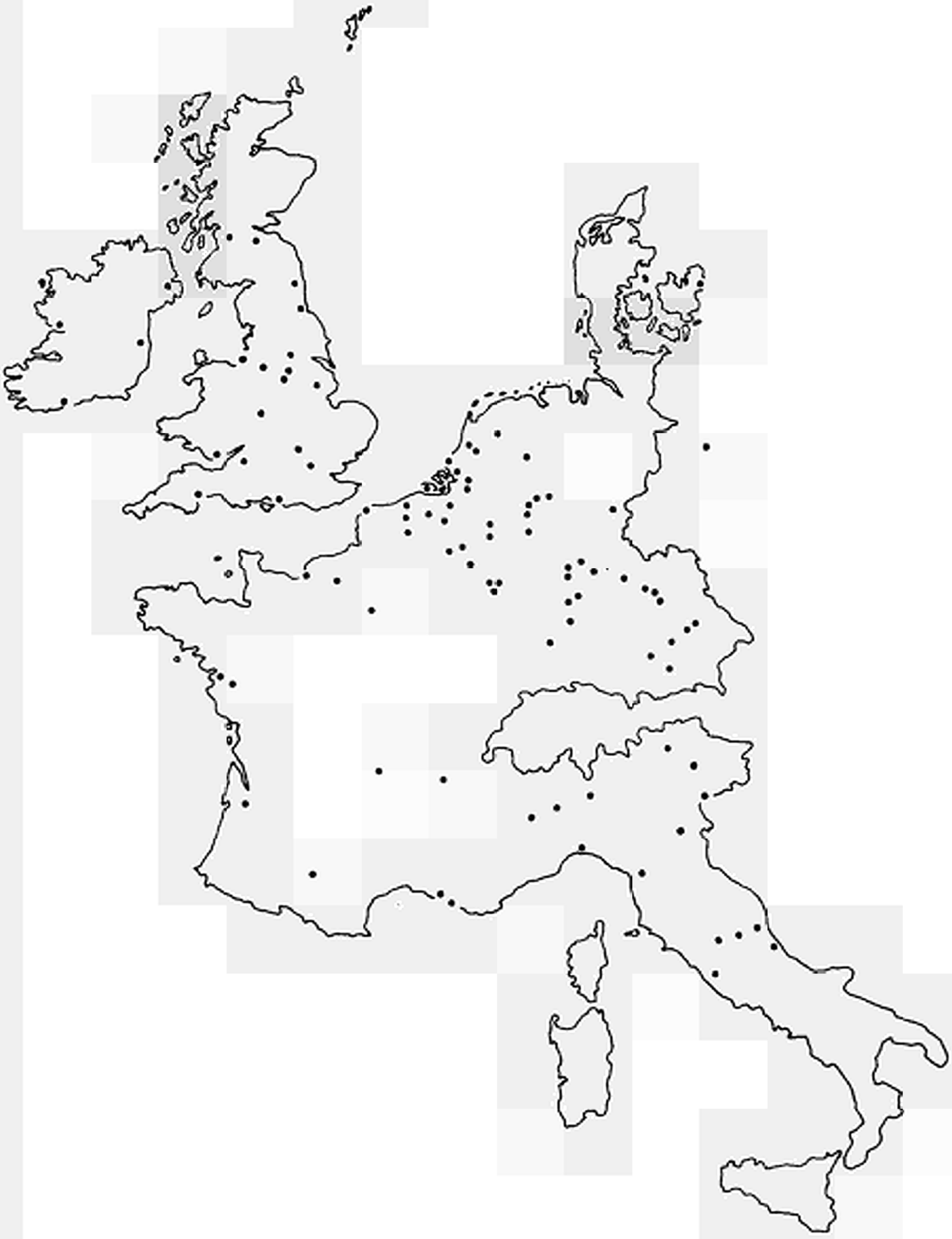
iv. providing data for use in epimediological studies of the harmful effects of air pollution on human health;

v. providing a Community contribution to the world-wide study of the Global Environment Monitoring System by U.N.E.P.

In setting up this system, national co-ordinators (nominated by the member states) selected some 350 stations in a total of 95 places throughout the Community (Figure opposite). Each of these stations was considered capable of supplying regular and reliable data on SO_2 and particulates, although the measurement and sampling methods used varied from one locality to another.

The system for the Exchange of Information was set up in 1976, and the first set of results (for that year) were published in 1979. Since then, the system has been maintained, and data have so far been compiled for the period 1976 to 1983. Inevitably, not all the data are complete: failures of equipment, measurement errors and the need for maintenance all cause gaps in the data. Nevertheless, as the data base expands its value increases considerably, and the results are already providing an important means of monitoring trends in urban areas. (Examples of the results are shown in Figures 5.3 and 5.7). At present, however, the network of stations does not give a truly representative picture of conditions across the Community, and contains relatively few sites in more remote areas. As awareness grows of the effects of long distance pollution, the need for more stations in rural localities and an extension of the network to include other pollutants will be recognised.

Distribution of sampling stations in the Community Exchange of Information on atmospheric pollution.



Source: Commission of the European Communities 1979-1984 *Exchange of information concerning atmospheric pollution by certain sulphur compounds and suspended particulates in the European Community*. Brussels: Commission of the European Communities.

5.1.3 Community Action and the Atmosphere

It is apparent that emissions to the atmosphere are greatly influenced by policies which affect the levels of industrial and agricultural activity. Thus, atmospheric quality is at least partly dependent on Community policies on industry, energy and agriculture. Moreover, the Community is committed to an environmental policy aimed at minimising and preventing pollution, and to this end a number of measures have been taken to reduce atmospheric emissions and improve air quality. These generally operate in three ways - by:

- setting 'limit values' on emissions of pollutants from specified sources;
- defining ambient air 'quality standards' which member states should ensure are attained by a specified date, using whatever methods are appropriate;
- controlling the use of certain substances in industry and calling for the development of substitutes.

Major measures adopted by the European Council or proposed by the Commission are summarised in Table 5.2. Besides establishing air quality standards, many of the earlier Directives were concerned with controlling emissions from motor vehicles which, until the late 1970s, were perceived as probably the main source of air pollution. Since then, attention has also been given to industrial sources, and two areas of action in particular, have been defined: control of emissions (and associated long-range pollution) from industrial plants and power stations, and use of fluorocarbons. In 1985, for example, a Directive on air quality standards for nitrogen dioxide was adopted. This lays down limit values and guide values for NO_2. The limit value of 200 $\mu g/m^3$ represents the 98th percentile calculated from mean hourly values (or shorter intervals) throughout the year. Guide values of 50 $\mu g/m^3$ (mean) and 135 $\mu g/m^3$ (98th percentile) were also specified. These limits are to be attained by 1st July 1987 wherever possible, or by 1st January 1994 at the latest in exceptional circumstances.

5.2 PARTICULATES AND BLACK SMOKE

Many types of particulates occur in the atmosphere. Many of the more visible are of natural origin. They include silt and grit eroded from the surface by the constant action of the wind, and fine ash and dust ejected by volcanic activity. Whilst these materials are quantitatively important as contributions to the total load of particulates in the atmosphere, however, their environmental and health implications are generally considered to be relatively small. Far more important are the particulates derived from man-made sources.

These, too, are highly variable. They include relatively coarse particles of soil solids released into the air by agricultural activities such as tillage, dust and debris from streets and construction sites, soot and other particulates emitted from household and industrial chimneys, and fine aerosols (<10 micrometres in diameter) produced either by industrial processes or by secondary decomposition of pollutants in the atmosphere. Given their variety, it is not suprising that their health effects are equally diverse. Many of the particulates are simple irritants which can cause eye and lung damage. More important are the aerosols which are often biologically toxic. These can easily be inhaled and may reach deep into the lungs. They include hydrocarbons such as benzene and vinyl chloride, pesticide residues (e.g. dieldrin, endrin, heptachlor), radionuclides (e.g. strontium-90, iodine-131) and heavy metals (e.g. cadmium, mercury). In many cases, the active substances are either attached to or dissolved in inert carriers, such as water vapour and fine soil particles.

5.2.1 Emissions

As has been mentioned, emissions of particulates and black smoke derive from a wide range of man-made sources. Chief amongst these is the combustion of fossil fuels - in industry, power stations, households and transport. Estimates are inevitably crude, but this probably accounts for about 95% of the anthropogenic emissions of particulates in the Community, the remainder coming mainly from agriculture, mining, quarrying and construction activities.

Data on annual emissions of particulates and smoke are sparse and rarely comparable. Figure 5.1, however, shows recent changes in emissions for six member states for which reasonably reliable estimates are available. Despite the obvious differences in the parameters considered, the time intervals of the data, and the classifications of the sources, the general trends are broadly consistent, at least within the four more industrialised countries (France, Germany, the Netherlands and the United Kingdom). Over the last 10 - 15 years, annual emissions have fallen steadily. The decline was most rapid in the early 1970s and has since levelled out to some extent, but, by 1980, emission levels were about half of those in 1970.

The causes of this decline, and the changes which lie behind this general pattern are complex. One major factor has been a reduction in the use of coal, both in industry and households. This was prompted in part by the increasing cost advantages of oil and other fuels, but also by the introduction of clean air policies in many areas of the Community which have encouraged a switch to smokeless fuels. Since then the trend has undoubtedly been accentuated by the economic recession which has affected older, heavy industries.

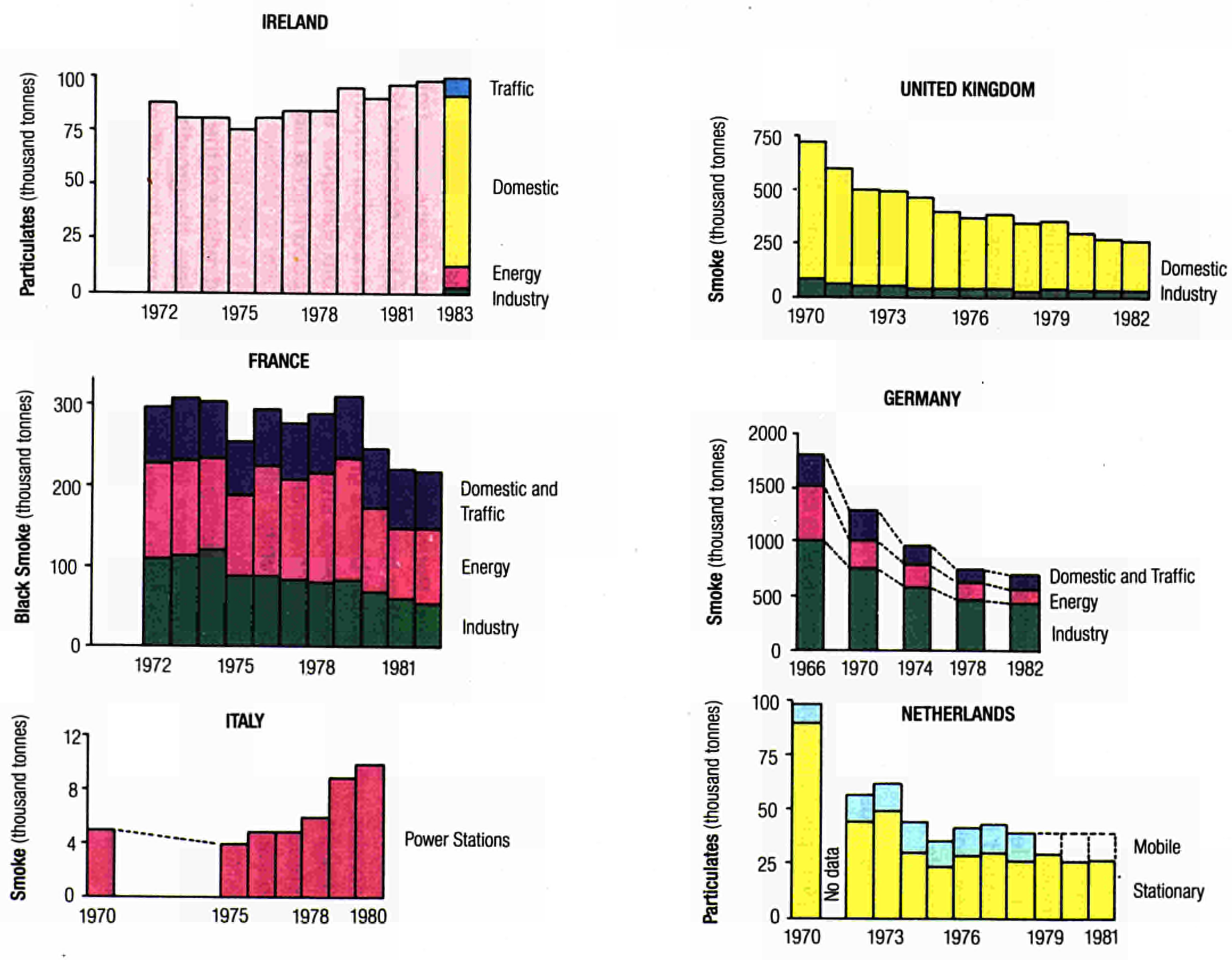
The shift away from industrial and domestic combustion of coal to the use of other energy sources, however, has been accompanied by a parallel increase in electricity production in power stations. Coal is still widely used in these power stations but the quantities of smoke emitted are relatively small due to the efficient particulate removal systems which are normally employed. As a result, emissions from the energy sector have generally decreased relatively little, although their relative contributions to total smoke and particulate emissions have risen in some countries.

The final sector of importance is transport. Several changes have occurred in this area, affecting levels of smoke emissions. Petrol engines have become cleaner, and unit emissions (e.g. per kilometre) have fallen. On the other hand, the volume of traffic has increased considerably in the last two decades, while there has also been a growth in diesel cars and an expansion in the use of roads for freight transport. Consequently, smoke emissions from transport sources have either remained steady or increased slightly. In either case they now account for a larger share of smoke and particulate emissions in the Community.

While these trends are common to the more industrialised regions of the Community, they are probably not valid in countries such as Greece, Ireland and Italy. Here, the growth in industrial activity, energy production and traffic - albeit from a very low base - has more than offset any technological developments or policy effects. Thus, as Figure 5.1 shows, emissions in both Ireland and Italy are rising.

Future trends in the Community are difficult to predict. The declining use of coal in industry and power stations has to some extent been halted, and in some areas coal consumption is again increasing. Renewed industrial growth may also stimulate emissions. Further innovations to help remove particulates from flue releases are, however, possible, and improvements in engine design may reduce emissions from traffic. More critical, though, is likely to be the change in the character of particulate emissions. Data on finer particles are scarce, but there is reason to believe that aerosol releases have generally been increasing. Given their greater toxicity, as well as their effects on atmospheric visibility, this may result in growing health and environmental problems even while the total particulate emissions are declining or remaining steady. Clearly, one focus of future concern must be on these finer particulates.

Figure 5.1 **Annual emissions of particulates and smoke in selected member states.**



Sources: data from Cabot 1985; Ministère de lÈnvironnement 1983; ISTAT 1984; Department of the Environment 1985; Umweltbundesamt 1984; Netherlands Central Bureau of Statistics 1975-1982

Plate 5.1 **Old industrial plants provide a major source of traditional atmospheric pollutants.**

Plate 5.2 **Atmospheric pollutants such as sulphur dioxide, nitrogen dioxides, particulates and hydrocarbons cause many forms of environmental damage: to wildlife and habitats, to forests and crops, and to buildings. One of the most unfortunate effects is corrosion of architectural features, such as this statue in Athens.**

Photo: D. J. Briggs

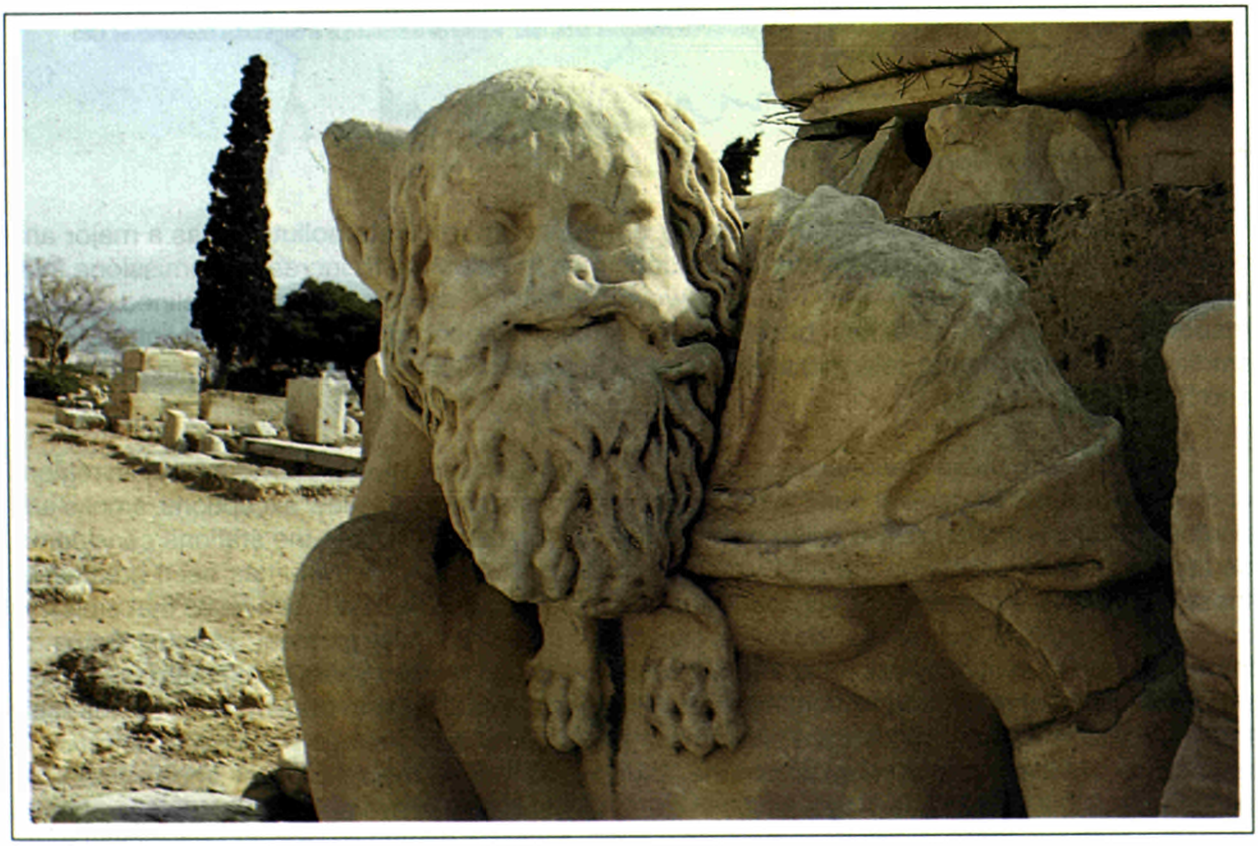
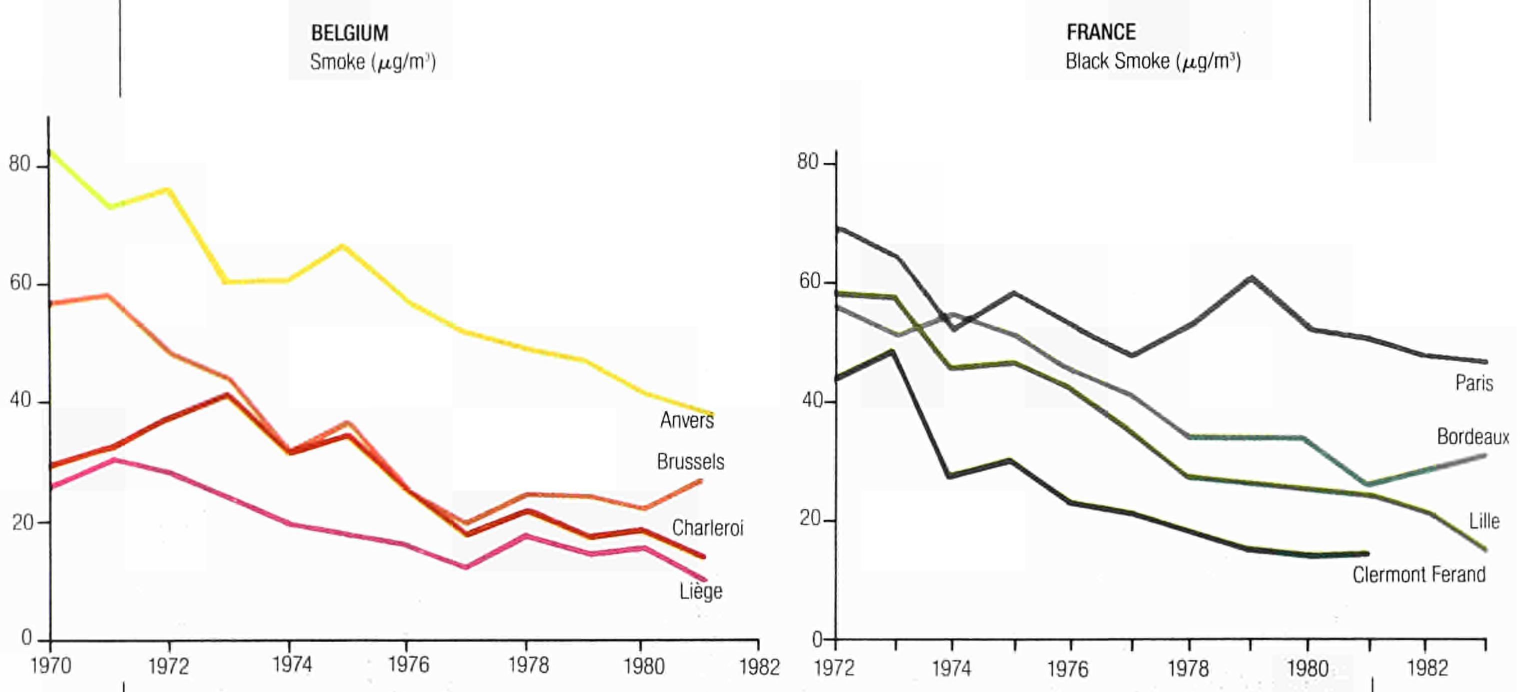


Photo: D. J. Briggs

Figure 5.2 **Average concentrates of smoke at selected sites in the European Community, 1970-1983.**



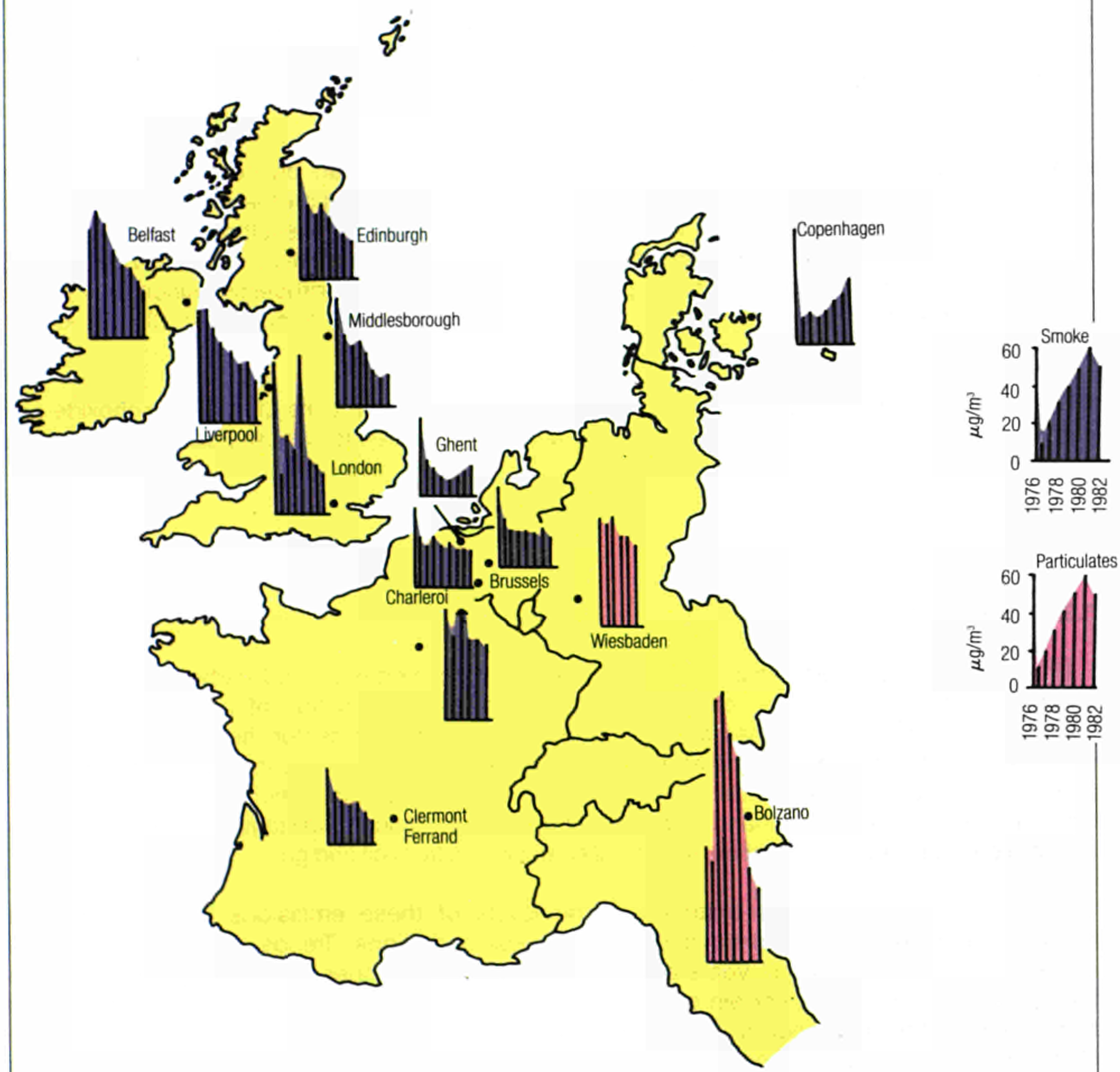
Sources: data from Institut National de Statistique, Ministère des Affaires Economiques 1978-1982; Institut de la Statistique et des Etudes Economiques 1983

5.2.2 Atmospheric Concentrations

During the early half of this century, smoke and particulate pollution was a major and growing problem as atmospheric concentrations rose in response to increasing emissions from man-made sources. Since the 1960s however, levels of emissions have declined and, in response, the atmosphere has become less smoky. Recent changes in concentrations of smoke and particulates at selected stations in the European Community are shown in Figures 5.2 and 5.3.

Although these stations are not intended to be representative of individual towns, regions or member states, the general trend is both clear and consistent. With a few exceptions, smoke and particulate concentrations have fallen over the last 10-15 years. Amongst the stations considered, certain more subtle patterns are also visible. In general, the rate of decline has been greatest at those sites with the highest pollution loads, largely because it has been in those areas that emission control policies (especially on domestic sources) have had the greatest effects. Rates of improvement in pollution levels have also diminished slightly in recent years as the effects of these policies have reached their maximum extent. Future trends are difficult to predict, but it seems likely that there will be a tendency for many sites to converge at an annual average smoke concentration of about 20 - 25 micrograms per cubic metre. Clearly this will represent a major improvement on pollution levels of 20 - 30 years ago, which showed a typical annual average of 50 - 100 micrograms per cubic metre in urban areas.

Figure 5.3 **Smoke and suspended particulate concentrations in the European Community, 1976-1982.**



Source: data from Commission of the European Communities 1979-1984

5.3 CARBON MONOXIDE AND CARBON DIOXIDE

Carbon monoxide and carbon dioxide are substances which occur naturally in the earth's atmosphere. The main source of carbon monoxide (CO) is the decomposition of organic matter, and at a global scale this accounts for about 90% of its content in the atmosphere. Carbon dioxide, on the other hand, is part of a complex cycle, and the carbon dioxide content of the atmosphere is maintained by plant and animal respiration and by exchange with the oceans. In addition, both substances are released by human activities, particularly combustion processes.

Within the range of naturally occurring concentrations in the atmosphere, neither carbon monoxide nor carbon dioxide have any adverse health or environmental implications. Pollution of the atmosphere from artificial sources, however, can result in significant effects. In the area of health, for example, carbon monoxide inhibits absorption of oxygen by haemoglobin as a result of producing carboxyhaemoglobin and can thus lead to oxygen deficiencies, with resulting symptoms of angina, impaired vision and poor physical and mental co-ordination. Critical levels depend on the length of exposure to the gas, but short periods (ca. 1 hr) of exposure to atmospheric concentrations of 100 mg per cubic metre or more are known to have significant effects.

In contrast, carbon dioxide has no short-term toxicological effects below concentrations of about 10 g/m^3. This level is well above that which can be sustained in an open atmospheric environment. Nevertheless, since the industrial revolution there has been a steady increase in the level of carbon dioxide in the atmosphere, mainly as a result of the combustion of fossil fuels. Although there is still some debate, the consequences of this change may be serious, for carbon dioxide - and other gases - play a vital role in climatic processes since they reflect outgoing infra-red radiation which is then retained within the atmosphere (the so-called 'greenhouse effect').

For these reasons, emissions and atmospheric concentrations of carbon monoxide and carbon dioxide are of considerable significance, and long-term trends in these pollutants need to be viewed with concern.

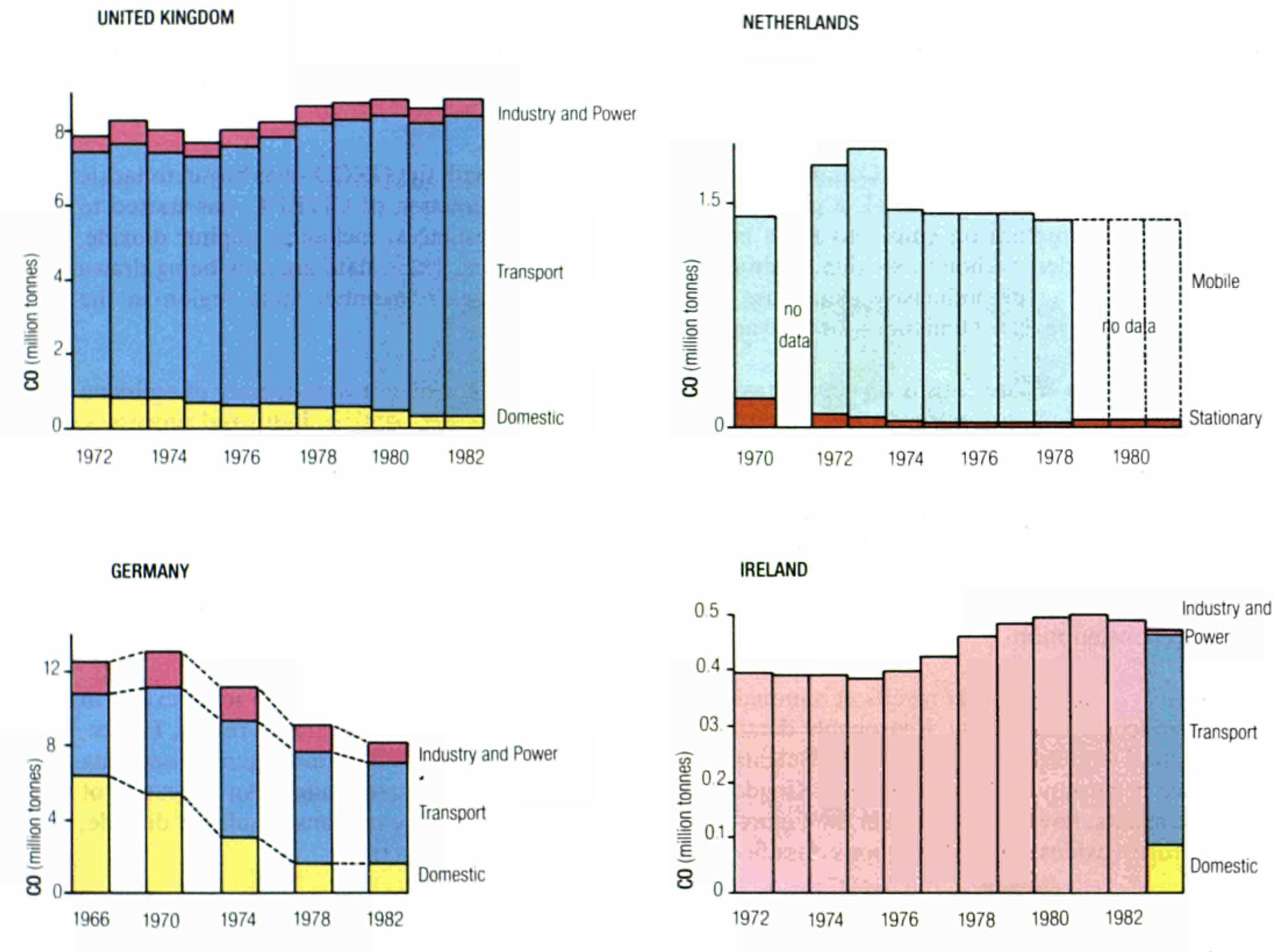
5.3.1 Emissions

By far the major source of 'man-made' carbon monoxide and carbon dioxide is the burning of fossil fuels. In the case of carbon monoxide, combustion of petrol is particularly important, and in most countries of the Community the transport sector therefore produces the majority of carbon monoxide emitted to the atmosphere - 90% or more in many member states (Figure 5.4). The remainder is derived largely from fuel combustion in households and industry. Carbon dioxide, on the other hand, is produced by all fuels, though qualitatively the main releases are from coal and coke combustion, with smaller emissions from oil and gas.

In recent decades, changes in the levels of these emissions have occurred in response to changing economic and technological conditions. Trends in carbon monoxide emissions for the last 10 - 15 years are shown for several member states in Figure 5.4. Within the limitations of the data, certain general observations are possible. In both Germany and the Netherlands, there has been a slight decline in emission levels since the early 1970s; in the United Kingdom and Ireland on the other hand, emissions have risen slightly (by 10 - 15%) over this period.

Given that these are calculated data rather than measured values, it is important to exert care in interpreting these trends. Since calculations are based upon factors such as the level of economic activity, road vehicle usage, type of combustion process and so on, it would be unsurprising to find that the observed trends correlated with this same set of factors. Nevertheless, the changes in carbon monoxide emissions appear to relate to a number of contradictory effects. Emissions from domestic sources have generally declined as the use of coal for household heating has diminished. This has been particularly significant in Germany, which uses coal producing relatively large quantities of CO_2. Conversely, transport emissions have increased substantially as traffic volumes have risen. Emissions from industry and power stations have declined slightly due to changes in combustion processes. Overall, the trends in each member state therefore reflect the relative strengths of these opposing effects.

Figure 5.4 **Annual emissions of carbon monoxide in selected member states.**



Source: data from Department of the Environment 1985; Umweltbundesamt 1984; Netherlands Central Bureau of Statistics 1978-1982; Cabot 1985

5.3.2 Atmospheric Concentrations

Data on atmospheric concentrations of carbon monoxide and carbon dioxide in the European Community are generally lacking because few stations monitor these compounds on a regular basis. Globally, it is calculated that carbon dioxide concentrations have increased from about 500 milligrams per cubic metre at the start of the century to about 600 milligrams per cubic metre at the present day. Current rates of increase probably average about 0.7 milligrams per cubic metre per year. Atmospheric concentrations are spatially markedly variable, however, and probably average two to three times this level close to the emitting sources in urban areas.

AN EMISSIONS INVENTORY FOR THE COMMUNITY

The emphasis which is rightly placed by the European Community on a preventive environmental policy implies, amongst other things, that control of pollution is better achieved at source rather than, after emission, in the open environment. In the case of air pollution this is particularly important, for as the problems of acid deposition, forest dieback and the recent Chernobyl disaster have shown, once released into the atmosphere pollutants may travel vast distances and damage a wide area. A major problem in this context, however, has always been the acquisition of data on emissions and emission sources. Until now, information has been incomplete and inconsistent, with the result that it has not been possible either to quantify the amounts and types of emissions in any detail or to define the main areas of emissions.

In recent years the Community - in close co-operation with the OECD - has begun to tackle this problem. Starting in 1984, a group of experts, under the direction of CITEPA, has started to collate information on emissions for a number of different substances, including sulphur dioxide, nitrogen oxides, carbon monoxide, hydrocarbons and particulates. These data are now being drawn together in a comprehensive data base which can show, for each member state region in the Community, levels of emissions for 1980 and 1983.

To achieve this is no simple task. The survey needs to consider a wide variety of emission sources, including electrical power plants, industrial boilers, district heating, industrial processes, traffic, agriculture and natural sources. For each of these, emission factors have to be defined, based on knowledge about conditions such as the type of combustion process, fuel composition, plant size and operating rate. For these purposes, the study group has provided reference emission factors, but different factors are eventually used, based on experience and measurements. For large power plants calculations are carried out on a plant by plant basis, using actual rates of fuel consumption; for smaller installations, aggregated emissions are assessed on the basis of estimated fuel consumption.

To date, only results at national level are available, and even these vary to some extent in their scope and quality. Reasonably detailed and complete data are available for Germany, France, Spain, Denmark, the Netherlands, Belgium, Luxembourg and Portugal; rather more generalised data have been provided for the United Kingdom and Italy. Data for Greece are limited. An indication of the results, however, is given in the Figure opposite. This shows data on emissions of sulphur dioxide, nitrogen oxides and hydrocarbons classified according to source and fuel type.

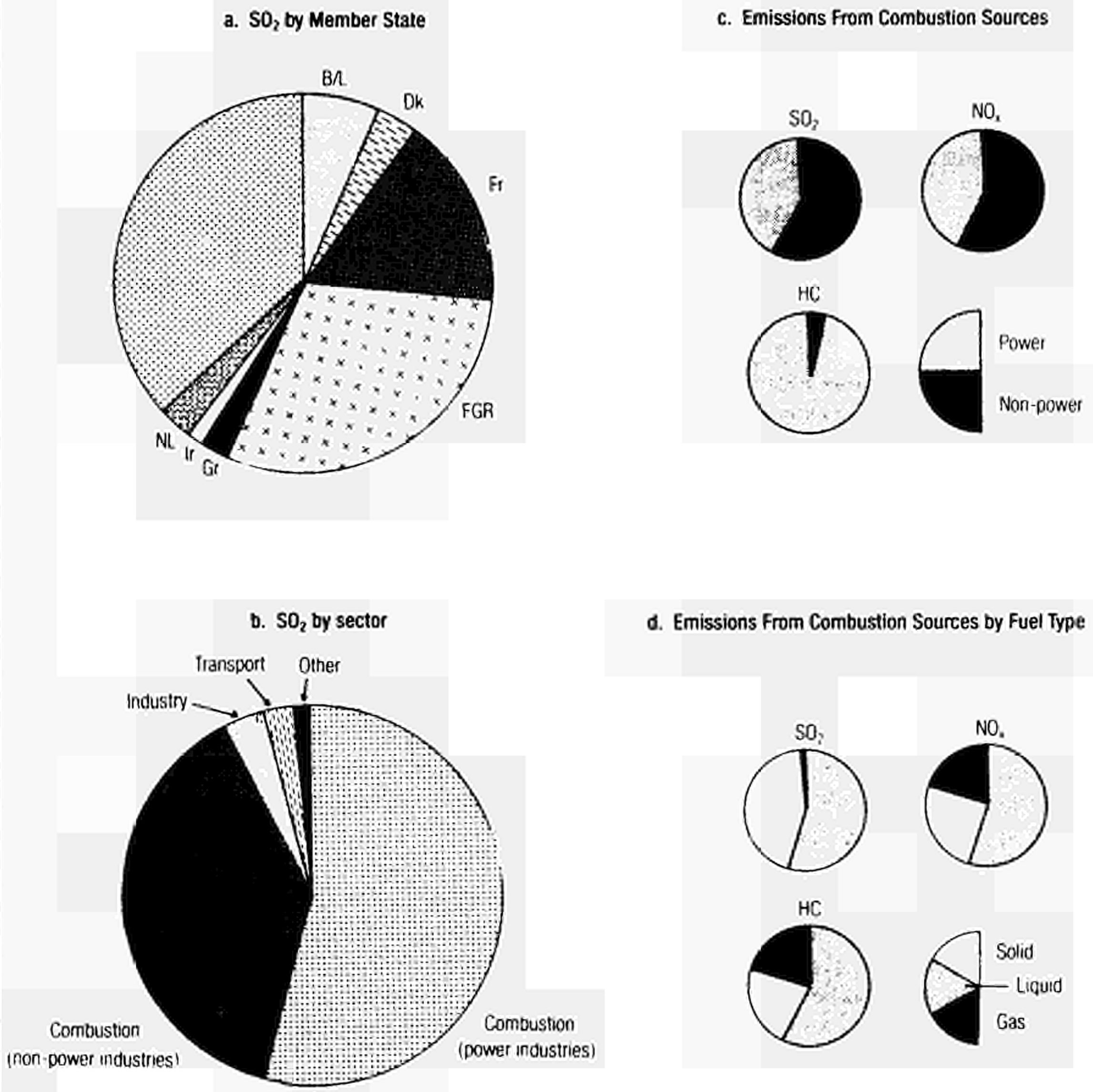
The data illustrate a number of different aspects of emissions in the Community. In the first diagram, for example, the quantities of sulphur dioxide emitted by each member state is shown. The considerable differences in emissions is clear, mainly reflecting differences in the size and level of industrialisation in member states. The second diagram indicates the source of these emissions by sector. As can be seen, combustion processes make up the vast majority (about 92% overall) of sulphur dioxide emissions, most of the remainder coming from industry and the transport sector.

The third diagram shows emissions of sulphur dioxide, nitrogen oxides and hydrocarbons from the combustion sector. In the case of both SO_2 and NO_x, power production is the major source, accounting for about 58% of total emissions from this sector. By contrast, only 4% of hydrocarbon emissions come from power production.

The significance of different fuels as sources of these emissions is shown in the fourth diagram. In general, solid fuels represent the main source, producing 55% of both sulphur dioxide and nitrogen oxides, and 58% of hydrocarbons. Liquid fuels account for 40% of SO_2 emissions from combustion processes, 25% of nitrogen oxides and 22% of hydrocarbons. Gas sources make up the rest: a mere 5% in the case of sulphur dioxide, but about 20% of NO_x and hydrocarbon emissions.

Together, these data show some of the information which is being collected by the Community's inventory of emissions. They are data which will have considerable value, not only for formulating policies by showing where action is needed, but also for monitoring the effects of policies by providing a baseline against which future changes in emission levels can be compared.

Sulphur dioxide, nitrogen oxides and hydrocarbon emissions from Community member states, 1980.



Carbon monoxide concentrations show similar spatial variations. The average ambient level of CO in the atmosphere ranges from about 1-100 milligrams per cubic metre. Highest concentrations occur in urban areas, especially close to roadways, motorways and other emission sources and here (e.g. in road tunnels and at busy junctions), carbon monoxide may pose significant health risks. Concentrations are lowest in rural areas. Changes in recent years are difficult to determine, due to lack of data. Because of the rapid exchange of CO between the atmosphere, oceans and land, however, atmospheric concentrations rapidly adjust as emissions are reduced. Consequently, in countries such as Germany and the Netherlands, where CO emissions have declined during the last 10 - 15 years, it may be expected that atmospheric concentrations have fallen also. Elsewhere the picture is less clear, but in many urban areas in southern Europe, it seems likely that CO levels are increasing due to the rapid expansion in volumes of traffic.

5.4 SULPHUR DIOXIDE

Sulphur dioxide enters the atmosphere naturally mainly during the oxidation of organic matter, or by release during volcanic activity. Together with releases from weathering reactions, these sources account for about one half of the sulphur dioxide in the atmosphere at a global scale. In many industrial countries, however, these natural inputs are greatly supplemented by emissions from artificial sources, most notably power stations, industry and oil refineries. Indeed, at a regional level, these man-made sources may provide as much as 90% of the annual flux of sulphur dioxide into the atmosphere.

The effects of these inputs are a matter of growing concern and controversy. It has long been known that sulphur dioxide can have adverse health effects on humans, and relatively short periods of exposure to concentrations of about 25 mg/m^3 may impair lung activity and result in bronchitis and related problems. These effects appear to be most serious under wet, cold conditions and, together with high levels of smoke, sulphur dioxide was implicated in the death of 5000 people in the infamous 'London smog' of 1952.

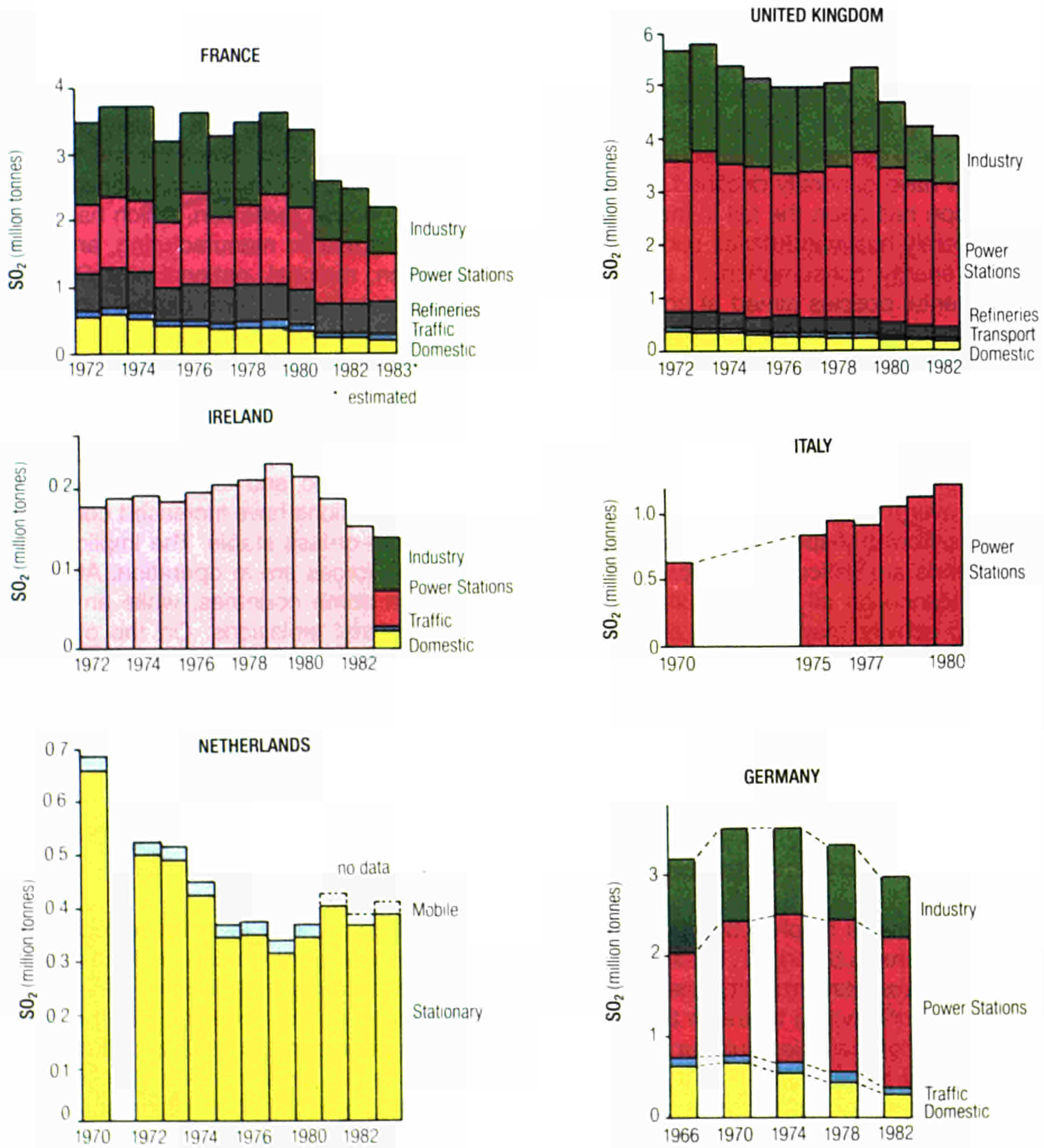
Less dramatically, but more widely, sulphur dioxide can also impair plant growth. The mechanisms by which these effects operate, and the critical levels at which they occur, are far from generally agreed. The problem is complicated by the circumstance that many of the effects of sulphur dioxide are amplified by synergistic reactions with other pollutants such as NO_x and ozone. Moreover, a number of indirect effects possibly occur, including soil acidification and inhibition of nutrient cycling and uptake. It has been suggested, however, that forest growth may be inhibited at sulphur dioxide levels as low as 500 $\mu g/m^3$, while some grasses and cereals are possibly sensitive to sulphur dioxide concentrations of 300 - 400 $\mu g/m^3$.

While many of these implications of sulphur dioxide pollution remain a question for debate and research, the potential importance of its effects have attracted much attention. The European Commission has therefore proposed actions to reduce substantially sulphur dioxide emissions, and the Council has also taken action to establish a system for the exchange of information on air pollution through which data on levels in the atmosphere of sulphur dioxide and other pollutants are collated and published (see Inset p. 134).

5.4.1 Emissions

Like many other atmospheric pollutants, sulphur dioxide is derived from a wide range of artificial sources. Releases from sulphuric acid plants may be locally important, while considerable quantities may also be emitted from the use of this and related chemicals in industrial processes such as smelting and fertiliser production. Small emissions may similarly occur from fertiliser application. By far the majority of releases, however, derive from the combustion of fossil fuels,

Figure 5.5 **Annual emissions of sulphur dioxide in selected member states.**



Sources data from Institut National de la Statistique et des Etudes Economiques 1983. Cabot 1985. Netherlands Central Bureau of Statistics 1975-1982. Department of the Environment 1985. ISTAT 1984. Umweltbundesamt 1984 especially coal, lignite and heavy oils. This takes place at two main levels: from high-level emitters such as power station and oil refineries which use tall chimneys, and from low-level emitters such as industry, households and transport.

The relative contributions of these different sources vary markedly across the European Community according to economic structure, the types of fuel and combustion process used, and the extent of emission control. In Germany, Greece and the UK, where relatively high sulphur-content fuel is used, solid fuels provide the main source of emissions. In the Netherlands, in contrast, low sulphur coal is used, and most emissions therefore derive from oil used in power stations, which account for two-thirds of the annual releases to the atmosphere.

Recent changes in quantities of sulphur dioxide emissions from various sources are shown in Figure 5.5. Considerable variation exists from year to year, due mainly to weather conditions and differences in fuel quality, but the overall trend is apparent. Since the late 1960s total emissions have generally declined. The causes of these declines are themselves varied. A major contribution has been the fall in industrial output due to economic recession, which has affected most severely heavy industries such as steel production and related manufacturing, and thereby reduced energy consumption in these sectors. In addition, regional, national and Community environmental policies aimed at combatting sulphur dioxide emissions have played a major part. These have encouraged the introduction of improved flue gas-cleaning techniques and a shift to the use of low-sulphur fuels. Cost advantages have similarly helped to promote energy conservation and the adoption of alternative energy sources.

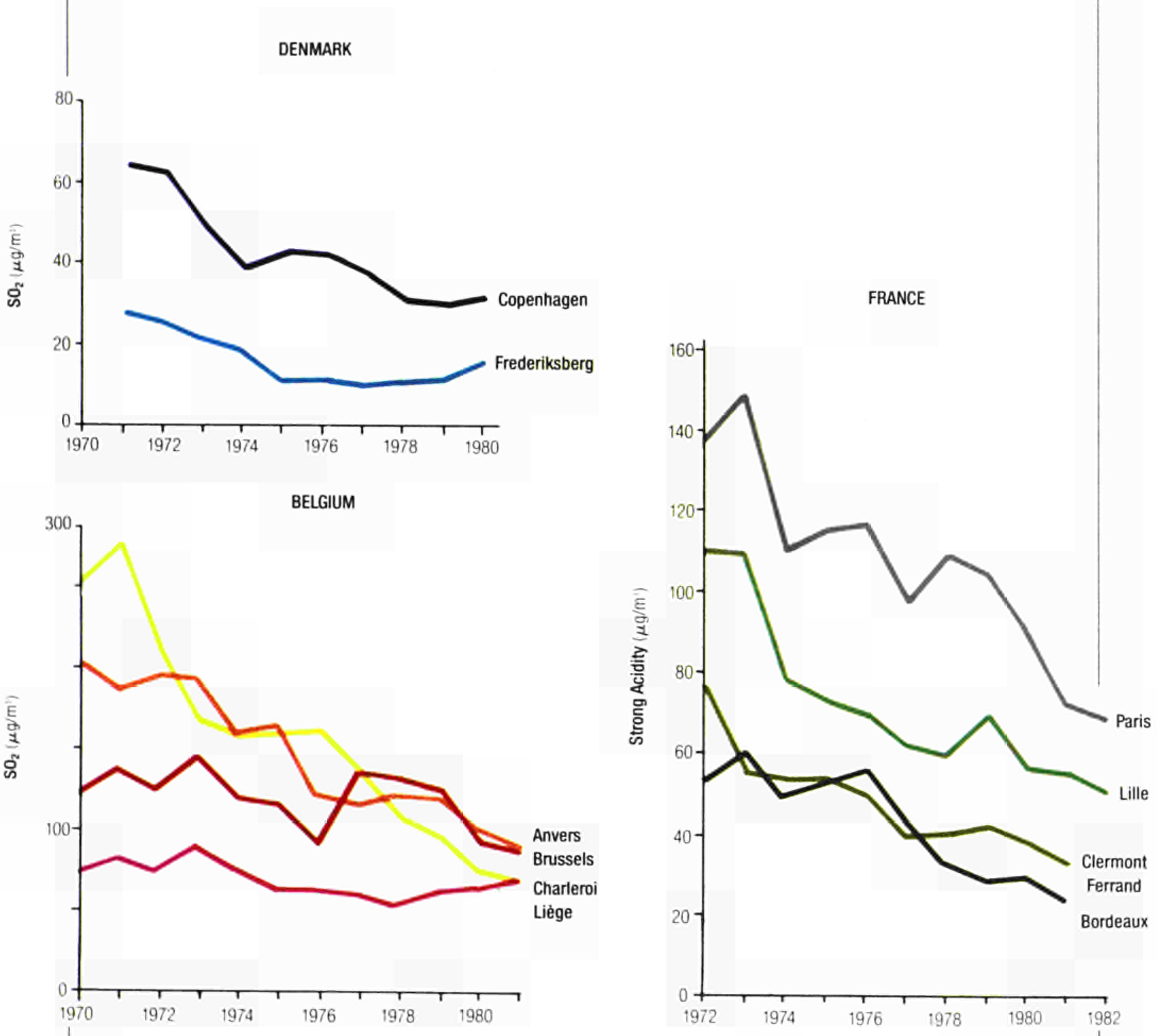
Together these developments have led to a gradual change in the importance of different sources of sulphur dioxide. In general, emissions from domestic and industrial sources have declined over the last 10 - 15 years, while those from power stations have increased considerably. Emissions from transport and refineries have remained more-or-less stable. The implications for future trends are difficult to decipher, for several conflicting forces are in operation. Attempts to reduce reliance on oil are encouraging a return to coal in some countries, while an upturn in economic activity may increase energy demand and industrial emissions. On the other hand, conversion to nuclear power (e.g. in France) may help to reduce sulphur dioxide releases. Most important of all, however, is likely to be the adoption of the flue gas desulpherisation technologies which are now available. In this context, Community environmental policies relating to sulphur dioxide emissions are likely to play a major role: in particular the proposed Directive for a reduction in sulphur dioxide emissions from power stations by 60% of 1980 levels by 1995.

5.4.2 Atmospheric Concentrations

Trends in sulphur dioxide concentrations and strong acidity at selected localities are shown in Figures 5.6 and 5.7. These examples have been chosen partly because of the availability of relatively complete runs of measurements, and partly because they illustrate the range of conditions found within towns in the Community. It should be noted, however, that the data are not directly comparable: sulphur dioxide concentrations represent, in reality, pollution levels approximately twice those indicated by strong acidity values. In addition, considerable variation occurs within individual towns due to local factors (e.g. the proximity of emission sources) and these data refer only to urban sites. Sulphur dioxide concentrations in rural areas are generally much lower.

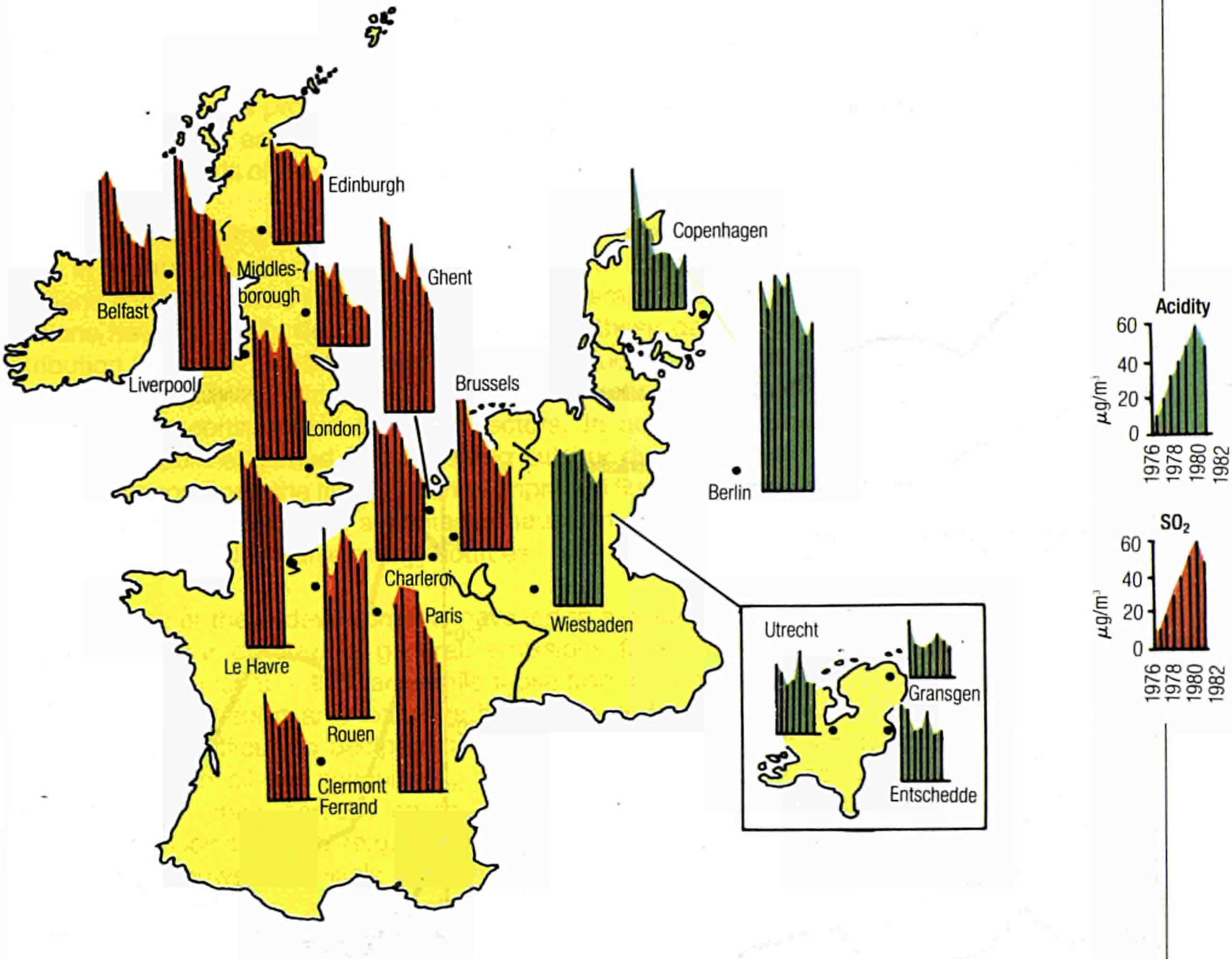
The trends shown by these data are broadly consistent. Sulphur dioxide concentrations are falling at almost all sites, and most markedly at sites with high ambient sulphur dioxide levels. At first glance these changes are somewhat surprising in view of the much smaller reductions in emission levels noted previously, and the growing concern about rainfall acidity and sulphur dioxide pollution being expressed in the European Community and elsewhere (see section 5.7). They reflect, however,

Figure 5.6 **Average annual sulphur dioxide concentrations and strong acidity at selected sites in the European Community.**



Sources: data from Danmarks Statistik 1983; Institut National de la Statistique et des Etudes Economiques 1983; Institut National de Statistique, Ministère des Affaires Economiques 1978-1982

Figure 5.7 **Sulphur dioxide concentration and strong acidity in the European Community.**



Source: data from Commission of the European Communities 1979-1984

the changing pattern of emissions. As has been noted, low-level emissions are generally declining, and as they do so, sulphur dioxide concentrations in the surrounding urban areas are falling. On the other hand, high level emissions (from power stations especially) are increasing. This is leading to greater long-distance transport of sulphur dioxide and, perhaps, higher atmospheric concentrations in more remote, rural areas. Unfortunately, data are not available for a sufficient length of time for remote sites to demonstrate this effect, but the likelihood is that future problems of sulphur dioxide pollution are likely to increase in rural areas.

5.5 NITROGEN OXIDES

The importance of pollution by nitrogen oxides has become increasingly apparent in recent years, as the complex reactions between these gases, volatile organic compounds and sulphur compounds and ozone have been discovered. This has led to much greater attention being devoted to the sources of nitrogen oxides and their fate in the atmosphere.

Nitrogen oxides (NO_x) comprise a wide range of gases including nitric oxide, nitrogen dioxide, nitrous oxide, nitrogen trioxide, and nitrogen pentoxide, together with various acids such as nitrous acid, nitric acid and peroxynitric acid. The majority of these inputs to the atmosphere occur in the form of nitric oxide, most of it (at a global scale) as a result of natural processes such as the breakdown of soil organic matter and burning of vegetation. At a more local level, however, significant quantities of NO_x are emitted to the atmosphere by human activities, most notably oil combustion for transport purposes and in power stations and industry. In addition, small quantities of nitrogen oxides are produced by fixation of nitrogen gas by lightning, atmospheric oxidation of ammonia and the downward flux of oxides from the stratosphere.

Once in the atmosphere, nitrogen oxides undergo a number of reactions, many of them relatively rapid and all of them closely inter-dependent. Nitric oxide, for example, is almost instantaneously oxidised to nitrogen dioxide by reaction with ozone (O_3). This, in turn, may dissociate to reform NO, or may be further oxidised to nitric acid. In addition, nitrogen dioxide may react with organic compounds to form peroxyacyl-nitrates (PAN).

All these reaction products may have significant health and environmental effects. Nitrogen dioxide, for example, may cause respiratory problems, while both NO and NO_2 are instrumental in the formation of smog which can lead to pulmonary and bronchial disease. In addition to health effects, smog also causes inconvenience and reduces the visual quality of the environment. Similarly, the various oxides of nitrogen are implicated in ecological damage through the formation of acid deposition and toxic effects on vegetation. These effects occur in most instances through synergistic relationships with sulphur dioxide, ozone and PAN.

5.5.1 Emissions

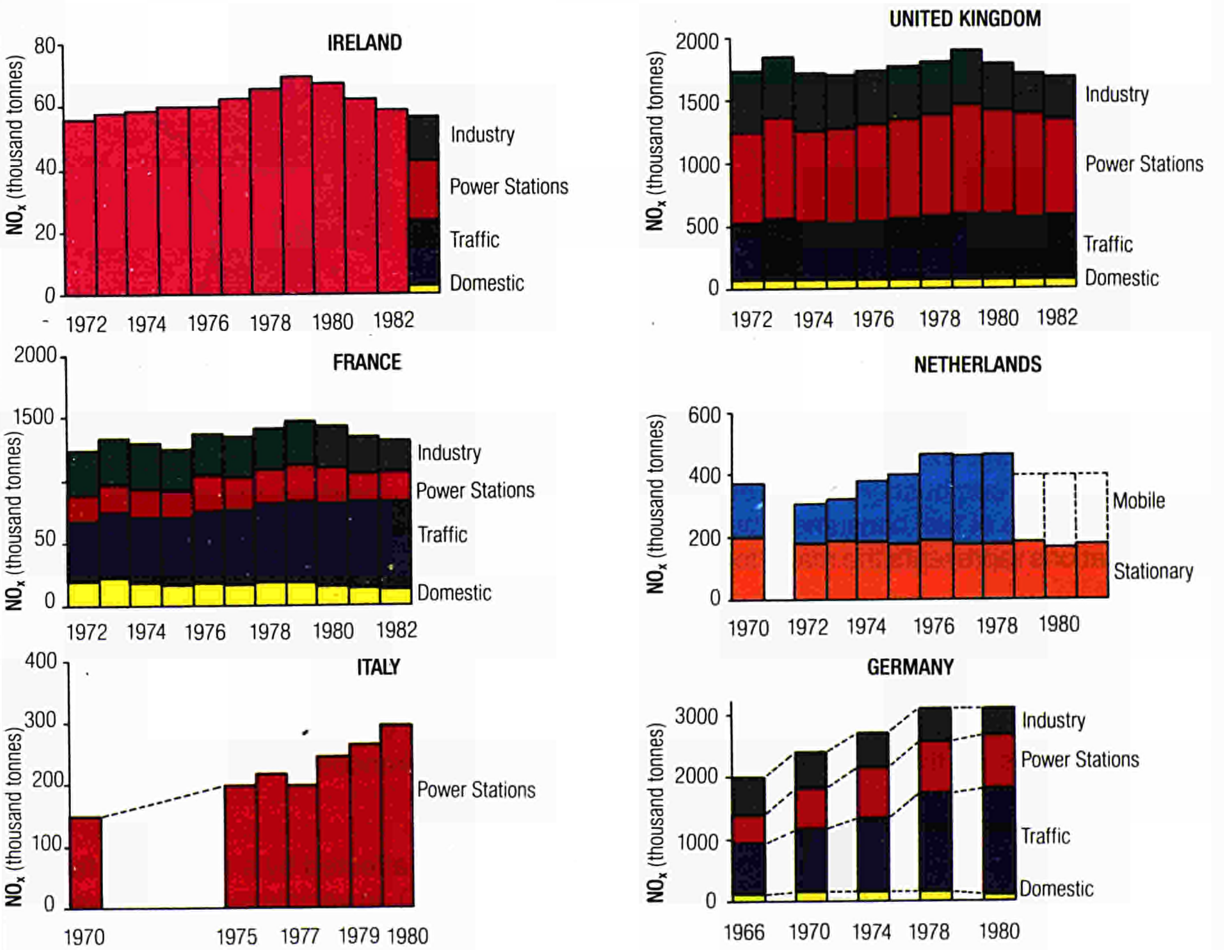
Although small quantities of nitrogen oxides are emitted by other industrial and agricultural processes, by far the majority of NO_x emissions in the European Community are derived from the combustion of fossil fuels. Over the Community as a whole, in 1983 for example, total emissions probably amounted to over 8 million tonnes. Levels of emission vary, however, according to three main factors: the type of fuel, the combustion process and the quantity of fuel consumed. High temperature combustion of diesel fuels and petrol tends to produce the greatest rates of emission per tonne of fuel consumed, but, at a Community level, hard coal and lignite consumption in power stations represents the major form of fuel use.

As a consequence, emissions of NO_x in the European Community are dominated by two main sources: transport and power stations. In the Community as a whole, motor vehicles account for about 50% of total emissions, and releases from power stations about one-half to two-thirds of the remainder. At a national scale, there are some variations in these figures, but overall differences in the quantities of emissions reflect differences in these two activities (Figure 5.8).

Recent trends in NO_x emissions are likely to have been affected by a number of factors. Generally traffic volumes have risen, and, although controls on NO_x in vehicle exhausts have been applied since 1983, it is too early for this to have had a significant effect on the current vehicle fleet. Consequently, emissions from this source are likely to have increased. In many member states, electricity generation has also expanded, with the result that emissions from power stations may similarly have risen slightly. On the other hand, declining economic activity and the first initiatives to introduce controls on emissions from industrial sources - encouraged in part by Community proposals for environmental quality legislation - may be helping to reduce emissions in some sectors.

The net effect of these conflicting forces in recent years is seen in the emission trends for member states, shown in Figure 5.8. Remembering that these are estimated emissions, derived from energy-based models, if the assumptions or equations used in these models change, so do the estimated emission values. In the United Kingdom in 1983, for example, nitrogen dioxide emissions, apparently rose sharply, to 1.86 million tonnes. This was not due to any real change in human activities, but to the introduction of new emission factors for road vehicles, based upon better monitoring of in-service performance. This showed an almost 50% rise in emission of NO_x from this source compared to previous estimates, more than cancelling out the reductions seen in other sectors.

Figure 5.8 **Annual emissions of nitrogen oxides in selected member states.**



Source: data from Cabot 1985; Institut National de la Statistique et des Etudes Economiques 1983; ISTAT 1984; Department of the Environment 1985; Netherlands Central Bureau of Statistics 1975-1982; Umweltbundesamt 1984

Nevertheless, looking at the data as a whole, we can recognise general trends. In several cases the dominant trend during much of the 1970s has been upwards. In the last few years, however, there is some indication that emissions are stabilising, possibly due to a levelling off in the growth in vehicle usage. For the immediate future it seems likely that this situation will persist, and emissions will remain relatively constant. In the more distant future, with the prospect of a revival in industrial activity - and if emission standards remain the same - the possibility exists that the potential for emissions will again rise. Nevertheless, technologies such as catalytic converters are now available to control NO_x emissions, and the fitting of these to power stations and cars will enable emissions to be greatly reduced. Much will therefore depend on the degree of stimulus given to such control measures by Community legislation on NO_x emissions and ambient atmospheric concentrations.

5.5.2 Atmospheric Concentrations

The general lack of data on nitrogen oxide concentrations in the atmosphere makes it difficult to distinguish patterns or trends in the European Community. On the basis of information on emissions, however, it may be anticipated that NO_x levels are rising, both in urban areas (as a result of increased traffic) and more widely (due to high level emissions from power stations). Highest concentrations undoubtedly occur in enclosed urban areas, and in 1982 sites in Athens, for example, registered median $N0_x$ concentrations of 80 micrograms per cubic metre (with a peak value of 260 micrograms per cubic metre). Similar concentrations have also been recorded in a number of other southern European cities (e.g. Milan), but generally NO_x levels elsewhere in the Community are considerably lower. Table 5.3 shows average and maximum values for a range of different localities. In considering these it is important to bear in mind that the figures quoted are derived in the main from one (or a few) measurement stations in each locality; marked variation may well occur in the surrounding area and the values cannot be viewed as averages for the individual town or region. What is clear, however, is that concentrations in urban areas show large variations

Table 5.3 **Nitrogen dioxide concentrations in urban areas in the European Community.**

Town	Year	Concentrations ($\mu g/m^3$) Mean	Maximum
Anvers (Belgium)	1982	55	113
Athens (Greece)	1982	80	260
Brussels (Belgium)	1979-80	35	262
Charleroi (Belgium)	1982	47	144
Frankfurt (Germany)	1980	30	151
Ghent (Belgium)*	1982	62	208
Liege (Belgium)*	1982	60	336
London (U.K)	1981	35	157
Molenbeek (Belgium)*	1982	68	197
Paris (France)	1981	40	170
Vilvorde (Belgium)*	1982	66	188

* December 1st, 1981 - February 28th, 1982
Source: data from OECD (1985a), Institut de Statistique, Ministere des Affaires Economiques (1982).

over time, with peak levels often many times greater than the average. This reflects both weather conditions and transient emissions such as traffic which result in short-term fluctuations. Generally maximum values occur during peak periods of traffic movement under damp, cloudy winter conditions, but the effects are not necessarily confined to these areas. In many towns a diurnal cycle is seen. Peak values in towns occur during the day, but, later, the pollutants diffuse outwards to give highest values in surrounding suburban and rural areas in the evening. Thus city workers may be subject to much higher total doses of NO_x than average measurements at a site imply.

LEAD POLLUTION FROM MOTOR VEHICLES

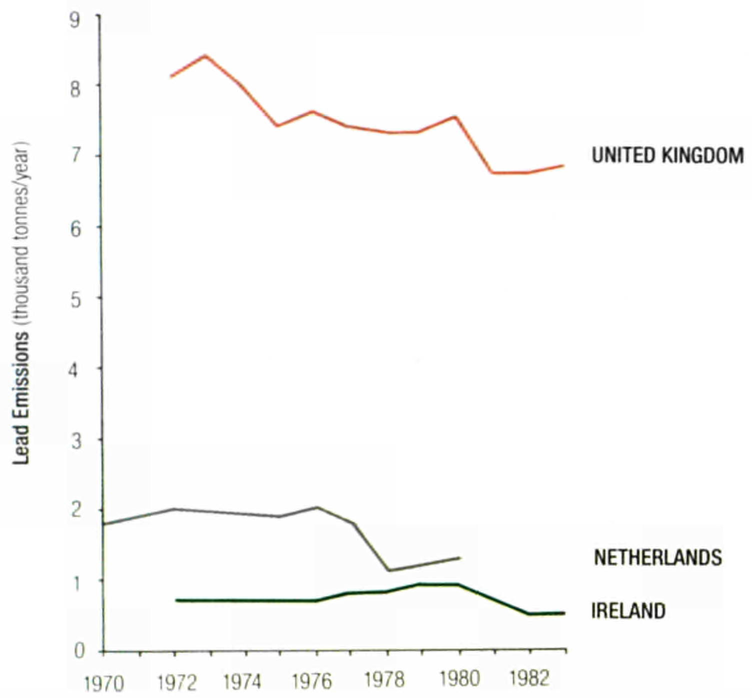
Lead is a particularly persistent and toxic pollutant. At blood lead levels above about 35 micrograms per decilitre, it has a range of clinical effects, including kidney and liver damage. Evidence has also been growing, however, to suggest that sub-clinical effects may be caused at significantly lower levels. Children living in areas of high ambient atmospheric lead levels (e.g. close to motorways), for example, appear to suffer abnormally high incidences of neurological disorders, and the proposal has been put forward that prolonged exposures of children to lead pollution may induce retardation of mental development and increased hyperactivity.

Whilst some of these adverse health effects remain unproven, the problem of lead pollution is clearly of considerable concern. Attention has therefore been focused on reducing emissions to the atmosphere from the major source: road traffic. Traditionally, lead has been added to petrol as an anti-knock agent, but 70-75% of this is returned to the atmosphere in vehicle exhausts. A large proportion is deposited on roadside verges, where it accumulates on the vegetation before being washed onto the soil. Within the soil the lead is reasonably stable, and little is taken up by plants. Deposits collecting on roadside crops or grassland, however, may be ingested by man or animals, whilst significant quantities of lead are transported further afield as airborne particles or adsorbed to dust, where it may be inhaled or ingested by humans. In both cases the lead may ultimately enter the bloodstream.

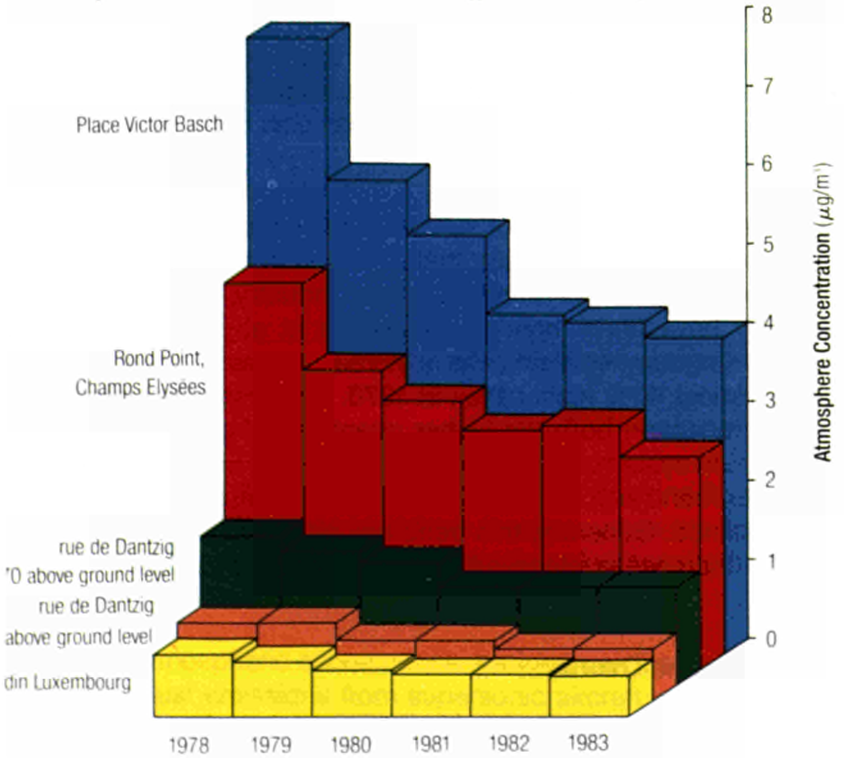
With the rapid increase in the use of road vehicles in recent decades, lead emissions rose markedly. At the same time, concern over the effects of lead pollution grew, until, by the mid 1970s, both national governments and the European Community began to take action to curb emissions. In 1978, for example, the Community adopted a directive limiting the lead content of petrol to 0.4 g/l. As a result, while petrol consumption has continued to increase, lead emissions in many countries have fallen. The upper figure (opposite) shows the pattern for three member states. As can be seen, emissions have fallen by about 20% in the United Kingdom since 1972 and by almost 45% in the Netherlands between 1976 and 1978. The implications are almost certainly a reduction in the concentration of lead in the atmosphere, especially in urban areas. The lower figure (opposite) illustrates the situation in Paris, where atmospheric lead levels fell by 40-50% between 1978 and 1983.

The European Community is determined to maintain this improvement, and in 1985 adopted a further Directive (85/210) on the lead content of petrol. This noted that present refinery technology allowed for a reduction in lead contents of petrol to 0.15 g/l without any adverse effects on vehicle performance, and that the ultimate elimination of lead in petrol would improve health protection. It therefore calls for member states to reduce lead concentrations to 0.15 g/l as soon as possible, and to ensure the availability of unleaded petrol (with Pb levels below 0.013 g/l) by 1st October 1989. In consequence, one of the main routeways by which lead enters the air will be all but closed.

Lead emissions in selected member states.



Atmospheric lead concentrations in different areas of Paris, 1978-1983.



Department of the Environment 1985, Netherlands Central Bureau of Statistics 1975, 1978, 1982; Ministère de l'Environnement 1985; see Notes p. 175

5.6 ORGANIC COMPOUNDS

Organic pollutants comprise a wide variety of hydrocarbon and other substances, many of which are highly reactive and have considerable environmental and health implications. At a global scale, the most abundant atmospheric hydrocarbon is methane, which is produced mainly by such natural processes as organic matter decomposition. On average its concentration in the air is between 1 and 6 p.p.m. by volume, but because of its relatively low reactivity, its environmental significance is low. More important are the less abundant but more volatile organic compounds, such as ethylene oxide, formaldehyde, phenol, phosgene, benzene, carbon tetrachloride, chlorofluorocarbons and polychlorinated biphenyls. All of these are produced mainly by human activities, and they are almost all known, or suspected, carcinogens. Several, also, are possible mutagens or teratogens (i.e. substances which increase the incidence of congenital malformations).

As well as their direct effects on human health, many organic compounds have more widespread environmental implications. Chief amongst these is their tendency to act as precursors for photochemical oxidants: they react with compounds such as nitrogen oxides and oxygen in the presence of sunlight to produce ozone and other oxidants. These, in turn, contribute to the formation of smog and aerosol pollution, and may have a number of toxicological effects, including eye, throat and lung irritation. In addition, they are believed to inhibit plant growth and to encourage deterioration of rubber and other compounds.

5.6.1 Hydrocarbon Emissions

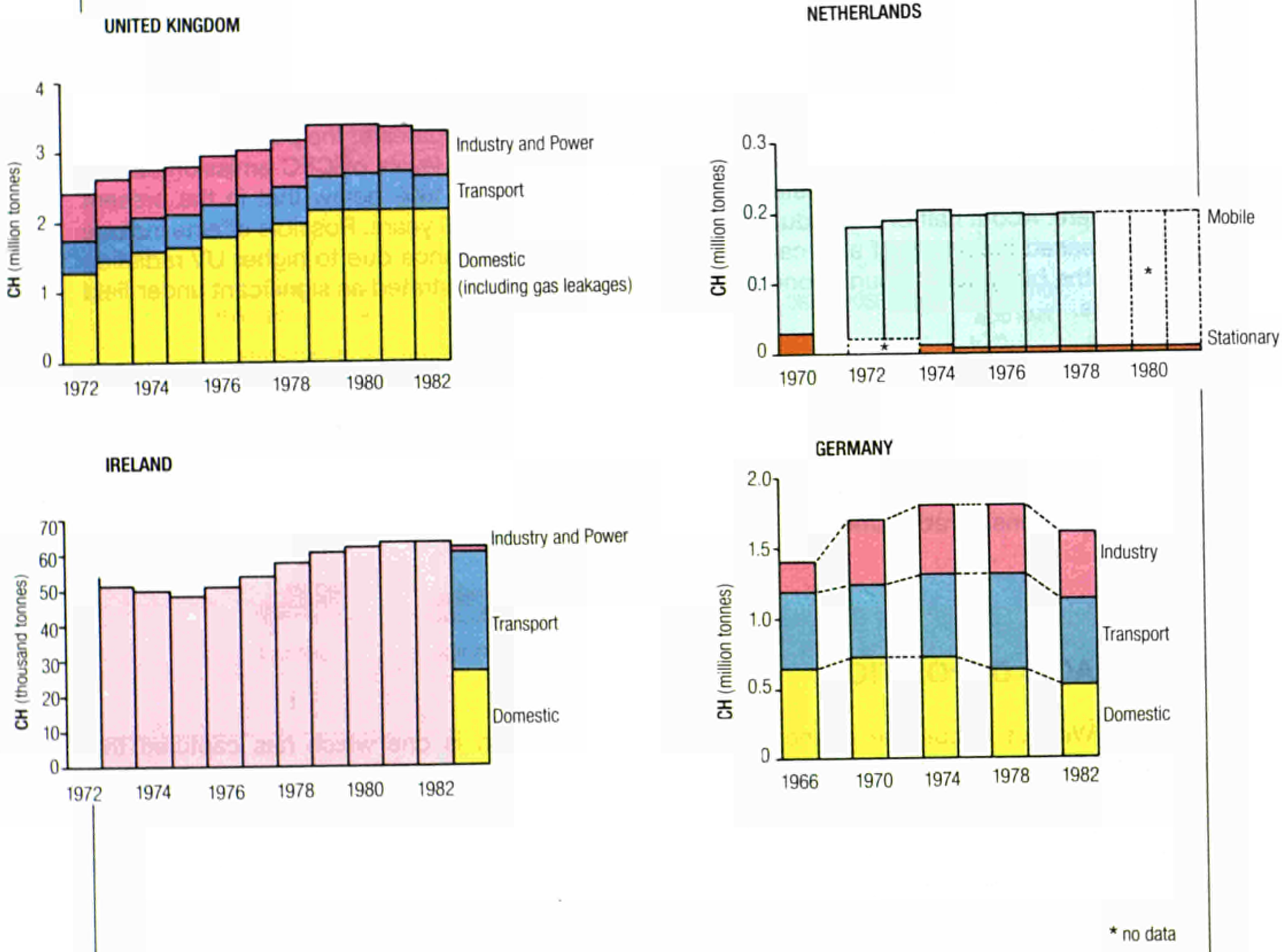
The major sources of man-made hydrocarbon emissions include traffic, the production and use of organic chemicals, the transport and processing of crude oil, and the use and distribution of natural gas. The relative contributions of these different sources vary greatly from one country to another, as the data in Figure 5.9 show. In the United Kingdom, for example, gas leakage was believed to be by far the most important source, accounting for two-thirds of total hydrocarbon emissions. In contrast, in the Netherlands, mobile sources contribute 95% of the annual release of hydrocarbons, the main emissions (about 80%) coming from passenger cars. The extent to which these differences reflect real variations in emission sources, or are a product of different computational models, is not clear. More recently, for example, the estimates of releases by gas leakage in the United Kingdom have been shown by British Gas to be over-estimated by a factor of three.

Given these varied sources, it is not suprising that emission trends for hydrocarbons vary markedly between member states (Figure 5.9). In the Netherlands, emissions appear to have fallen during the early 1970s due mainly to a fall in releases from industry, households and other stationary sources. Since then they have been more-or-less stable at about 0.2 million tonnes per year. Conversely, in the United Kingdom, emissions have increased steadily over the last 10 - 15 years so that by 1982 they were almost 40% higher than in 1970. This was interpreted as being due to an increase in gas leakage, reflecting both the higher quantities of gas being used and the gradual ageing of the gas distribution system. Losses from transport and industry have remained steady. In Germany, a more complex trend can be observed: emissions increased until the mid-late 1970s, since when they have declined. Generally, this trend has reflected the reduction in emissions from domestic sources, but the increase in releases from the transport and industry sectors.

5.6.2 Chlorofluorocarbons and Ozone

Despite increased concern about CFCs and their potential effects, relatively few data are available either on emissions or on atmospheric concentrations. This is largely because of difficulties and costs of measuring trace species such as CFCs in the atmosphere or in flue gases. Most

Figure 5.9 **Annual emissions of hydrocarbons in selected member states.**



Sources: data from Department of the Environment 1985; Cabot 1985; Netherlands Central Bureau of Statistics 1975-1982; Umweltbundesamt 1984

information is therefore based on theoretical models or extrapolations from sparse measured data. In general, trends and broad patterns derived from these sources are believed to be reasonably reliable, but details are unknown and, as yet, understanding of atmospheric processes is insufficient to allow predictions to be made with certainty.

Concern about atmospheric ozone concentrations was first voiced in the late 1960s when it was suggested that exhaust emissions from supersonic aircraft might deplete ozone concentrations in the stratosphere. The role of ozone in filtering out ultra-violet radiation had long been known, and it was feared that any substantial reduction in ozone concentrations would result in increased UV penetration of the atmosphere and a consequent rise in the incidence of skin cancer. In the event, these fears appear to have been unfounded, and it is now accepted that the effects of supersonic aircraft on ozone levels are likely to be negligible. More recently, however, a new threat to ozone concentrations has been identified in the form of chlorofluorocarbons.

As noted in section 3.5.2, chlorofluorocarbons (CFCs) are produced mainly as aerosols and refrigerants. Both sources provide considerable quantities of emissions to the atmosphere, and until the early-mid 1970s, when various environmental controls were introduced, these releases were growing as the use of CFCs expanded.

Within the atmosphere, CFCs have a long life, for few decomposition or removal processes occur, and they consequently disperse into the stratosphere. Here they take part in a number of processes, including reactions with ozone. As a result of these processes ozone is broken down and stratospheric concentrations may decline. Estimates of the potential long-term effects vary, but recent calculations suggested that, at present levels of CFC emission, ozone concentrations would eventually stabilise at a level about 11 - 16% below that in the present stratosphere. About half of this reduction will occur in the next 50 years. Possible effects include both increased incidence of skin cancer and ecological disturbance due to higher UV radiation inputs to the biosphere, though none of these have been demonstrated as significant under field conditions.

In the light of this concern, the European Council has adopted a number of actions to limit CFC production, and between 1976 and 1983 output fell by about 5% (see Figure 3.19). The use of CFCs in aerosols, however, has fallen by over 35%, and since these undoubtedly represent a major input pathway to the atmosphere, emissions have probably fallen significantly. Nevertheless, because of the long life-span of existing atmospheric chlorofluorocarbons, it is likely to be a considerable time before any detectable effects of the reduced emission levels are seen.

5.7 ACID DEPOSITION

Without doubt, the phenomenon of acid deposition is one which has captured the attention of public, politicians and scientists alike in the last few years. It is a phenomenon which is seen to have had wide-ranging repercussions on the environment. It is implicated in damage to forests, acidification of lakes, impairment of crop growth and damage to buildings. Consequently, attempts to tackle the problem of acid deposition have become one of the major priorities of environmental policy in the Community.

The term 'acid rain' was first coined over 100 years ago in describing the character of rainfall around Manchester in the United Kingdom. For many years thereafter its significance was hardly considered, and it was not until the late 1960s that scientific and public attention returned to the phenomenon. Then a paper by Svante Oden demonstrated that rainfall in Sweden was becoming progressively more acidic, mainly as a result of long-range transport of sulphur and other compounds from industrial areas of Britain and central Europe. Soon afterwards, further reports cited evidence of increasing acidity in Swedish lakes, and, before long, a flood of studies and counter-studies was being published. As a result of the concern which these investigations stimulated, an international project - the Co-operative Technical Programme to Measure Long-Range Transport of Air Pollution (LRTAP) - was set up, collecting data on emissions of sulphur dioxide across the whole of western Europe and Scandinavia and monitoring sulphur dioxide and rainfall acidity at almost 80 stations. When this project was terminated in 1977, its work was continued by a new study - the Co-operative Programme for Monitoring and Evaluation of Long-Range Transmission of Air Pollutants in Europe (EMEP) - which called on data from some 60 measurement stations in twenty countries.

Figure 5.10 **The formation of atmospheric acidity and acid deposition.**

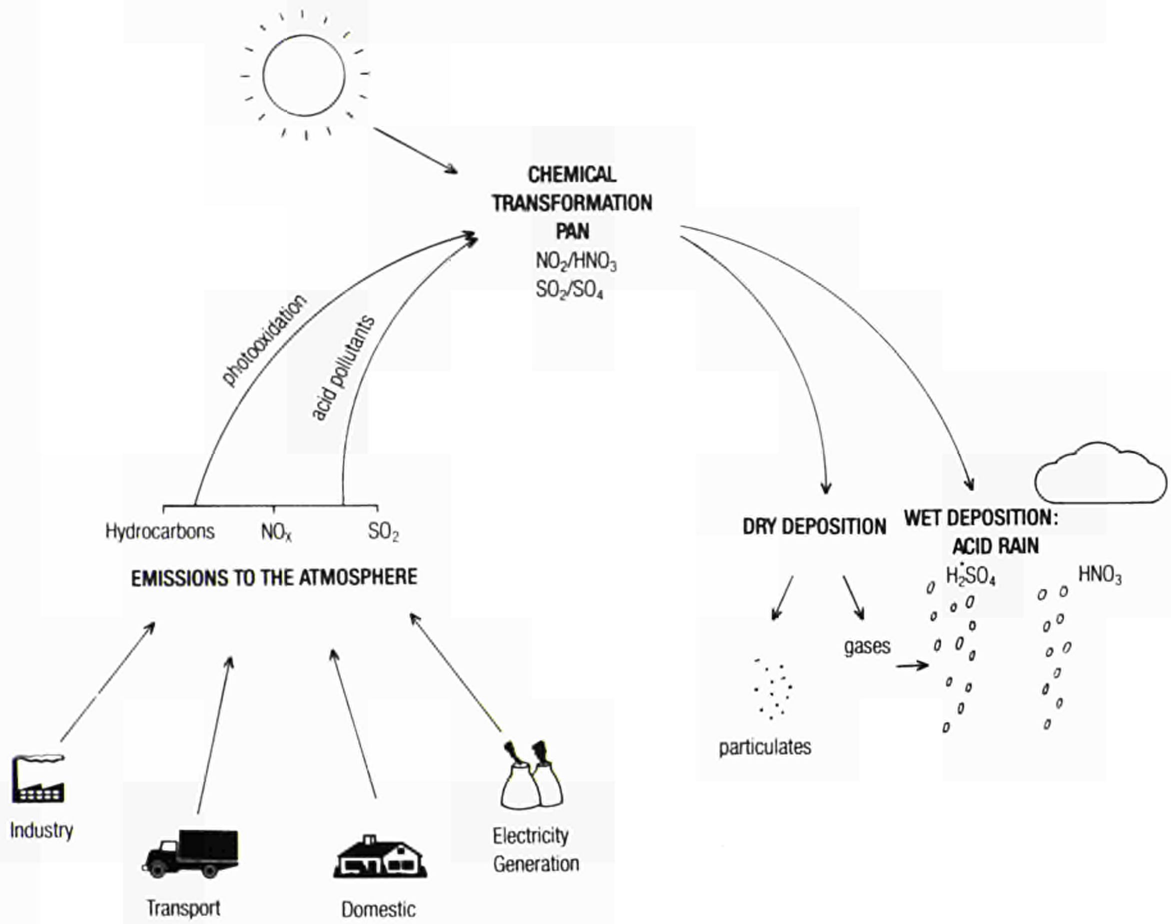
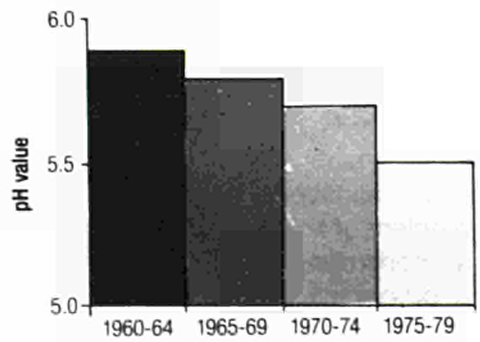
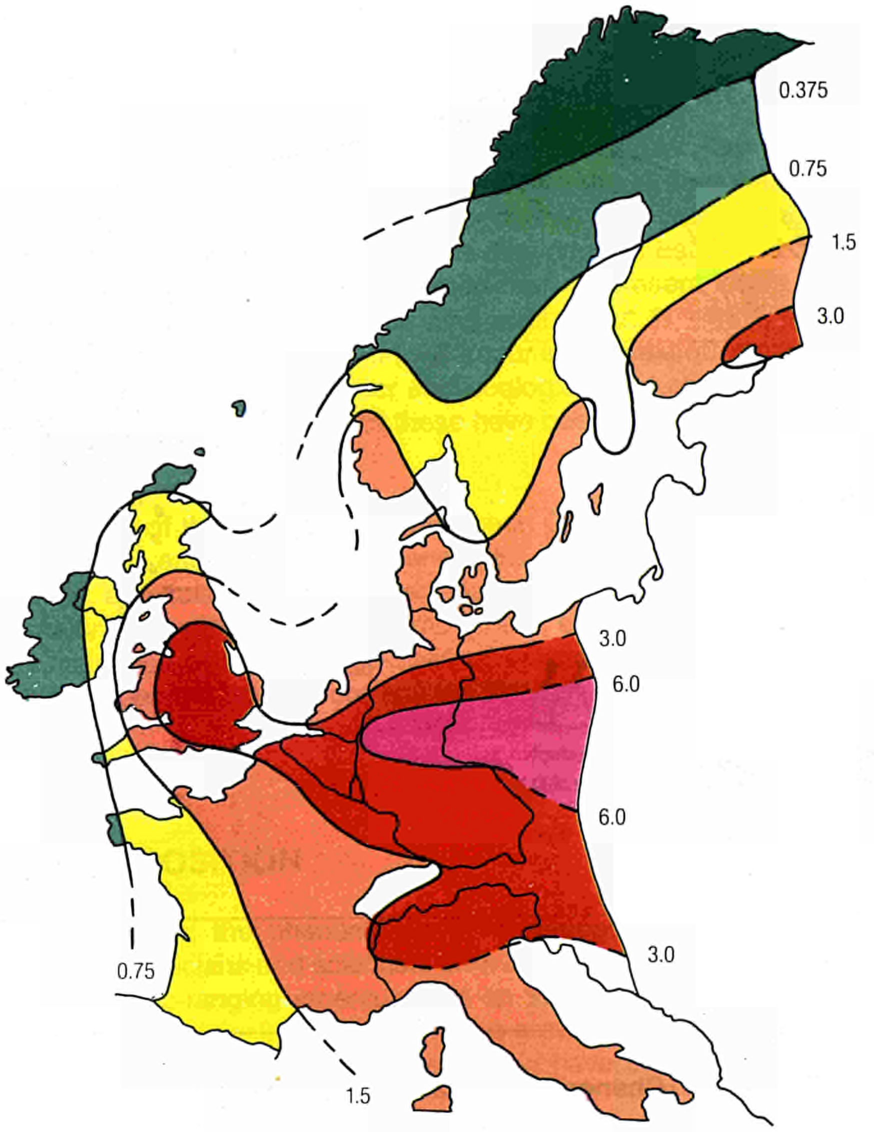


Figure 5.11 **Changes in rainfall acidity in Ireland**



Source: data from Cabot 1985

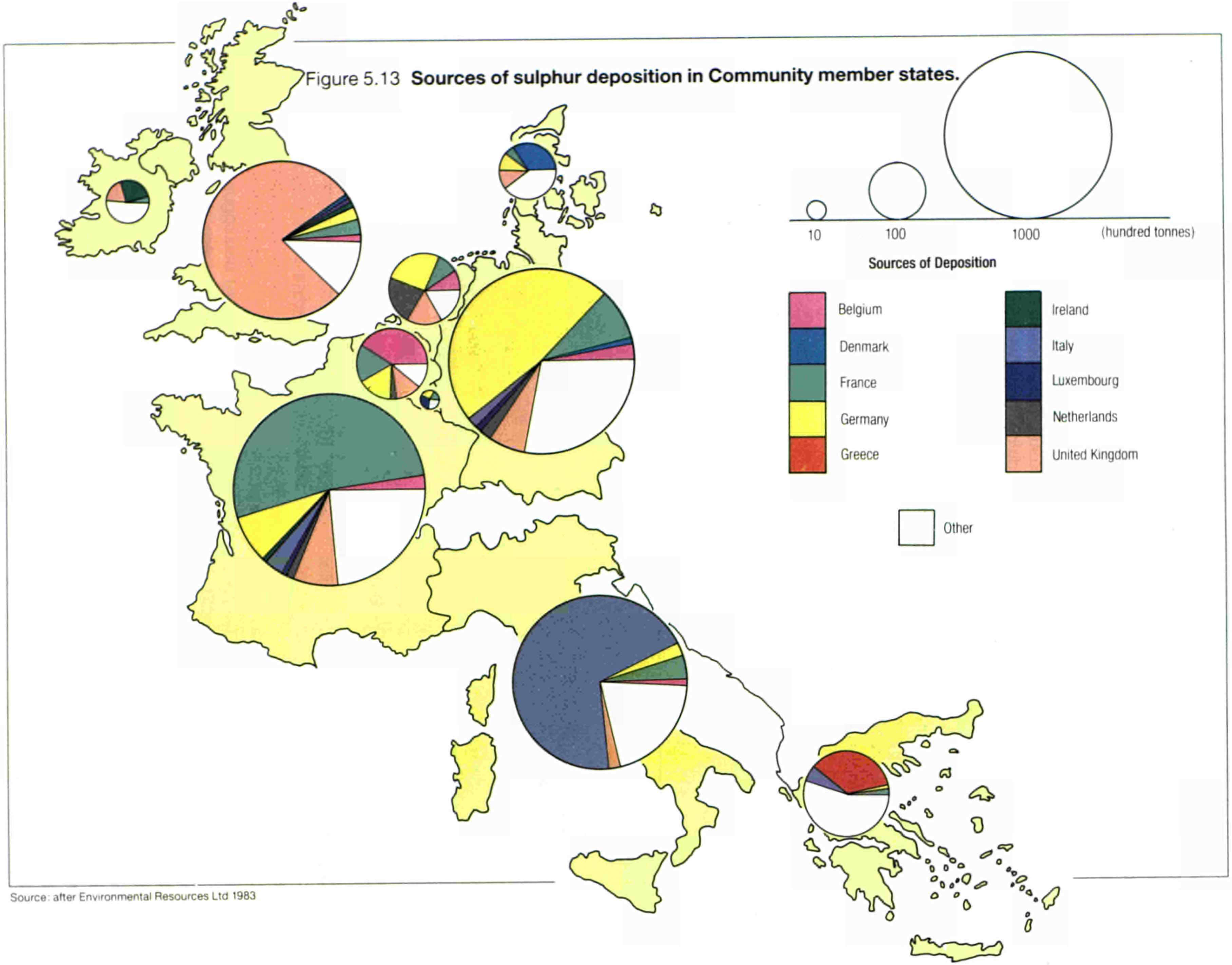
Figure 5.12 **Total sulphur deposition (g S/m²/yr) in the European Community.**



Source: after EMEP 1981

Since then many further investigations have been initiated, and several international conferences have considered the problem of acid precipitation, including the symposium organised by the European Commission at Karlsruhe in 1983. Out of all this work, a much clearer understanding of the causes and processes of rainfall acidity has emerged. Indeed it is now recognised that the problem is not simply one of acid rainfall, but also of the dry deposition of sulphur and other acidifying compounds in the environment. Thus the more general term 'acid deposition' has been adopted. The complex chemical reactions by which sulphur dioxide and nitrogen dioxide are converted to sulphuric and nitric acid and are then dissolved in cloud and rain

Figure 5.13 **Sources of sulphur deposition in Community member states.**



Source: after Environmental Resources Ltd 1983 droplets have also become known, at least in broad terms. Similarly, the main sources of these pollutants have been identified, and, as we have seen in previous sections, their emission rates calculated. It is now possible, therefore, to describe in general terms the cycle of emission, transport, reactions and deposition which is involved in acid deposition (Figure 5.10). What is less clear is the distribution of rainfall acidity in the European Community, the trends in the levels of acid deposition, and the real effects of the process on the environment.

The difficulty in describing these aspects relates to the lack of consistent data on acid deposition. Monitoring stations designed to measure the problem have been in operation for only a few years and are still few in number. In addition, large variations occur in measured rainfall acidity or sulphate deposition over short periods, so that average values or meaningful trends are often difficult to determine. In one study of 120 sites for which at least five years' data were available, for example, only 29 showed a statistically significant increase in rainfall acidity, while 5 indicated a decline. Similarly only 23 of the stations showed a significant increase in sulphate deposition. Claims of a generally increasing rainfall acidity must therefore be treated with caution, although examples of falling pH have been found. In Ireland, for example, the median pH of rainfall, sampled on a monthly basis, declined from 5.9 during the period 1960 - 1964, to 5.5 during 1975 - 1979 (Figure 5.11).

Table 5.4 **Estimated costs of damage by acid deposition in Community countries.**

LOCATION	LAND USE	COST PER YEAR (million ECUs)	SOURCE
Germany	Forestry	1100	U.B.A.
E.C.	Buildings	550 - 2800	E.R.L.
Belgium and Luxembourg	Buildings	830	OECD
Denmark	Buildings	475	OECD
Netherlands	Buildings	900	OECD
U.K.	Buildings	4500	OECD
France	Buildings	325	OECD
Germany	Buildings	7250	OECD

Notes: E.R.L. - Environmental Resources Ltd. (1983)
OECD - OECD (1985)
U.B.A. - Umweltsbundesamt Berichte 7/86

The distribution of acid deposition across the Comunity is also difficult to define in detail. Based on EMEP data and models, however, a broad pattern can be distinguished in the trends of sulphur deposition with highest values occurring in a belt across northern Germany, the Benelux countries, northern France and the eastern United Kingdom (Figure 5.12). To some extent, this pattern reflects the distribution of sulphur dioxide sources, but it is clear that much of the sulphur deposited in these areas is derived from further afield. Estimates derived from the EMEP model, for example, suggest that up to 77% of sulphur deposited in the Netherlands has its source in other countries, while about 64% of that in Denmark is of outside origin (Figure 5.13). The main emitters of this material are apparently the United Kingdom, Germany and states outside the European Community (e.g. East Germany and Czechoslovakia).

Plate 5.3 **Nuclear reprocessing plants, such as Sellafield in the United Kingdom, provide one of the main sources of 'man-made' releases of radioactivity into the atmosphere.**

Photo: D. J. Briggs

Given the problems of mapping and monitoring acid deposition, it is clearly difficult to assess in any detail its environmental and economic effects. Impacts on forest growth, agricultural crops, lakes, fish populations and buildings have all been claimed, and some of these are considered in later chapters. Table 5.4, however, quotes estimates of some of the costs attributed to acid deposition suggested for different parts of the European Community. Even allowing for likely errors in these assessments, the values are remarkable.

Not suprisingly, therefore, current environmental policies in the Community are concerned with reducing the levels of acid deposition, by reducing sulphur dioxide and NO_x emissions to the atmosphere. These actions are based on the fact that SO_2 and NO_x are directly implicated in the phenomenon of acid deposition. Nonetheless, it is not entirely clear that such actions alone will succeed in dealing with the acid deposition problem. In view of the complex processes involved in the atmosphere, and the role of other substances in the formation of acid deposition, other actions may well be necessary. In any event, acid deposition is clearly a problem which will continue to command justifiable attention in the foreseeable future.

5.8 RADIOACTIVITY

The atmosphere represents an important pathway for the flow of radioactive substances through the environment and a major source of human exposure to radioactivity. Not only natural sources, but also nuclear weapons, power stations and reprocessing plants, release radioactive particulates and gases into the atmosphere. Here, they may be transported over large distances before being removed by dry deposition, rainwash or inhalation. In these ways, the radioactivity enters other sectors of the environment and, through these processes, humans are also exposed to radioactivity.

5.8.1 Emissions

Artificial releases of radioactive substances into the atmosphere derive from three main sources: from nuclear weapons-testing, from nuclear power stations and from nuclear fuel reprocessing plants. Prior to the late 1960s, nuclear weapons were by far the most important of these sources, and the legacy of these tests still acounts for a large proportion of atmospheric radionuclides. With the ban on atmospheric testing of nuclear weapons, however, emissions from these sources have declined, and today the main artificial inputs are from the nuclear energy sector, in particular from reprocessing plants.

These emit radioactivity in a wide range of forms: as noble gases such as krypton-85 and argon-41, as radioactive halogens (e.g. iodine-131), as radioactive particulates, and as tritium and carbon-14. The quantity and composition of these emissions vary both from plant to plant and over time. In the case of nuclear power stations, the over-riding factor is the level of energy production, and emissions broadly fluctuate in proportion to production. In addition, the reactor type is important, and the quantities of gaseous effluents released vary according to the delay time between gas production and emission. In modern installations they are much reduced where charcoal beds and delay systems are incorporated.

Over recent years, improvements in nuclear technology have resulted in a decline in unit emissions (Bq per unit of electricity generated) from power stations of most of these radionuclides. In some cases, this has led to major reductions in total emissions from individual power stations. On the other hand, nuclear energy production has increased markedly (see Figure 3.11) and several new power stations have been brought into service. Overall, therefore, atmospheric emissions of radioactivity from power stations have probably remained more-or-less constant, or even risen slightly. In the United Kingdom, for example, releases from thirteen power stations increased by 25% between 1980 and 1983 after several years of declining emissions (Figure 5.14).

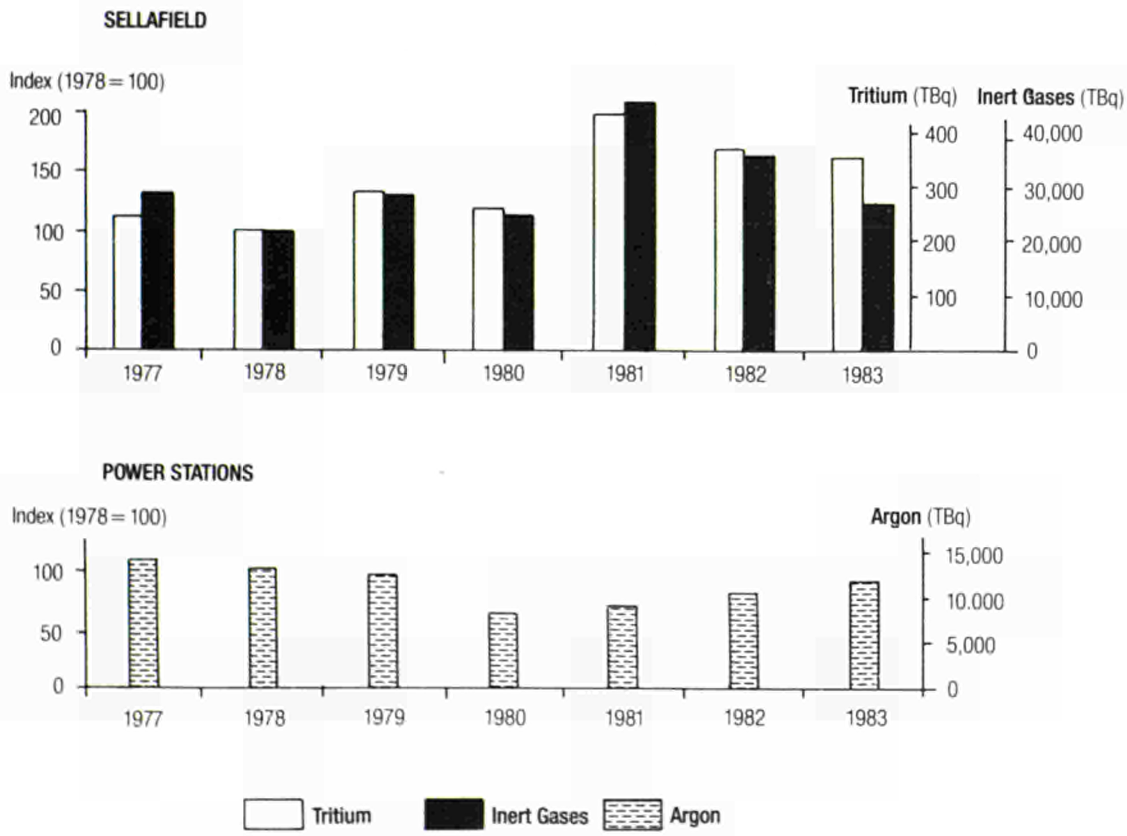
All these releases from power stations are small compared to the atmospheric emissions from nuclear fuel reprocessing plants. Sellafield and La Hague each release more krypton-85 than all the nuclear power stations in the Community in combination. Similarly tritium emissions from reprocessing plants are generally an order of magnitude greater than those from power stations. These emissions also vary over time, largely in response to levels of activity and technology. Releases of tritium and the noble gases (krypton-85 and argon-41) from Sellafield between 1977 and 1983 are shown in Figure 5.14. As can be seen, emissions rose until 1981, but have since fallen.

It is important to put all these emissions into a broader perspective. The main pathways by which atmospheric radioactivity enters humans are external exposure, inhalation and consumption of contaminated materials (especially milk). Except in areas close to the emission sources, all these inputs are negligible, and in the Community as a whole, natural sources of radiation account for 90% of the total dose received by the public. For critical groups (such as young children) living in close proximity to the sources, however, artifical sources may be significant, although small. Around nuclear power stations, doses of radioactivity from these sources generally average about 0.5% of the internationally agreed recommended limit, but may reach 2% or more in exceptional circumstances. The total dose for inhabitants close to reprocessing plants tends to be higher. Around Sellafield it may reach 4-5% of the recommended limit for people in critical groups.

5.8.2 Levels of Radioactivity in the Atmosphere

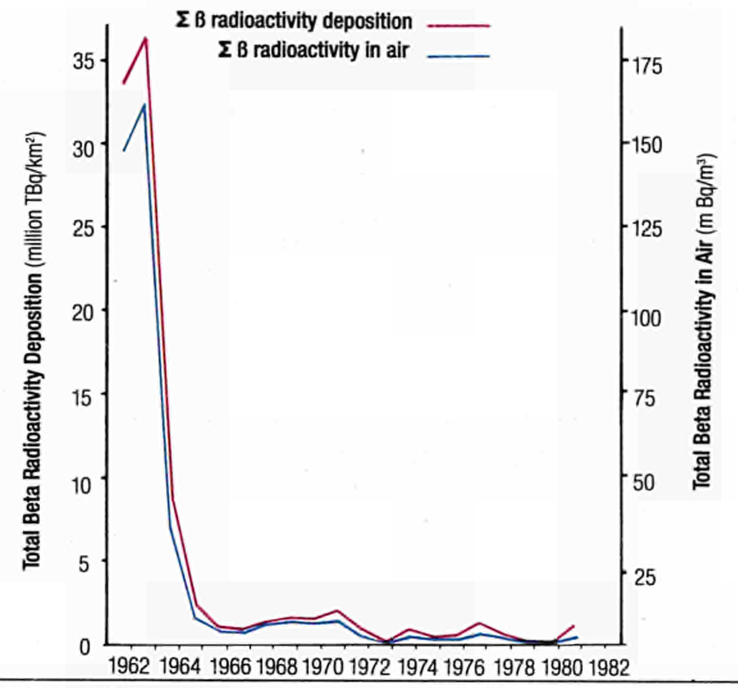
Ambient levels of radioactivity in the atmosphere depend upon the balance between inputs of radioactive substances (from natural and artificial sources) and removals by decay, rainwash, dry deposition and impaction (collectively referred to as fallout). Rates of decay depend primarily upon the half-life of the radionuclide, varying from a few hours in the case of radon and argon-41 to many thousands or even millions of years in the cases of carbon-14 and thorium, respectively. Radionuclides with a long half-life therefore tend to persist in the atmosphere longer than do short-lived substances.

Figure 5.14 **Annual emissions of radioactivity from Sellafield nuclear fuel reprocessing plant and from power stations in the UK, 1977-83.**



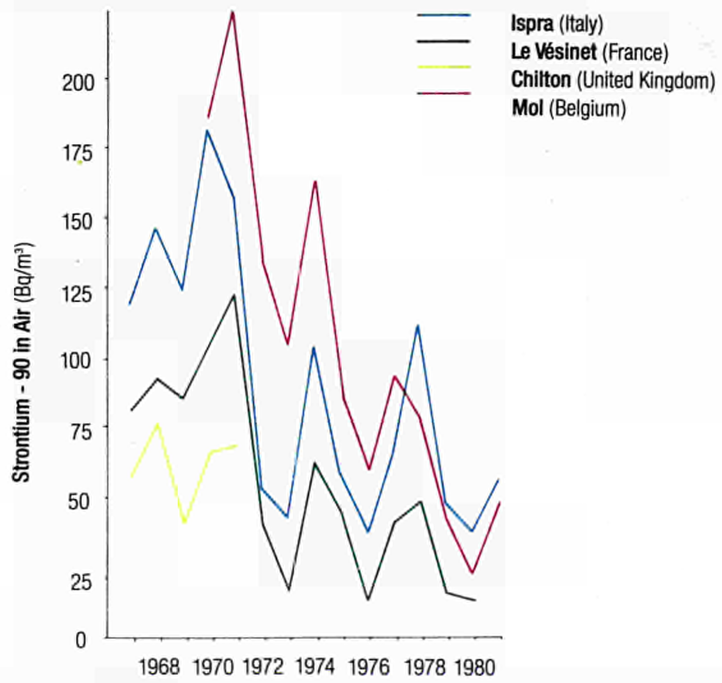
Source: data from Department of the Environment 1985

Figure 5.15 **Average levels of beta radioactivity in the atmosphere and in fallout in the European Community, 1962-1981.**



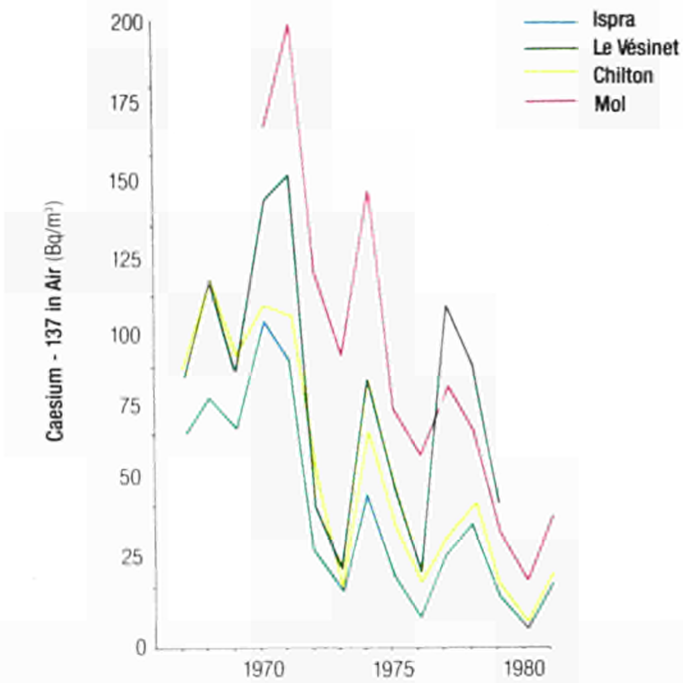
Source: data from Commission of the European Communities 1983

Figure 5.16 **Strontium-90 concentrations in the atmosphere at selected sites in the European Community, 1967-1981.**



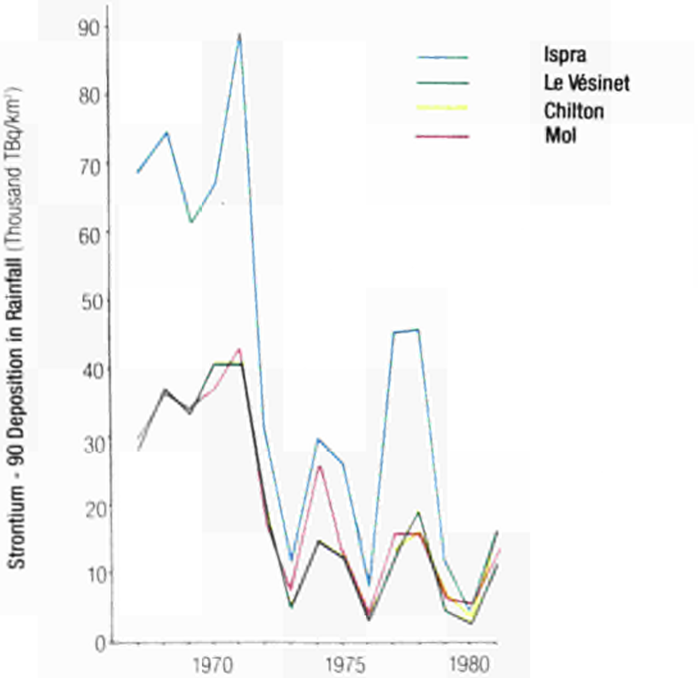
Source: data from Commission of the European Communities 1983

Figure 5.17 **Caesium-137 concentrations in the atmosphere at selected sites in the European Community, 1967-1981.**



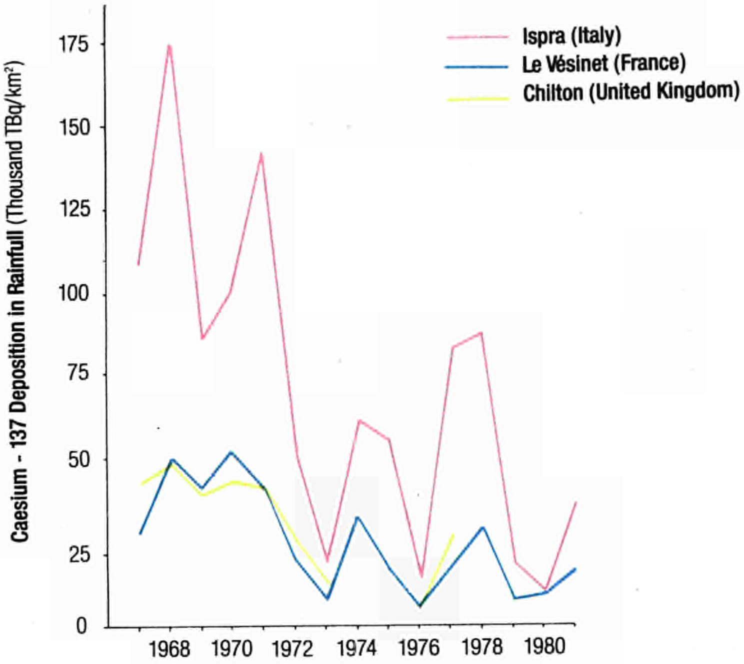
Source: data from Commission of the European Communities 1983

Figure 5.18 **Strontium-90 deposition in rainfall at selected sites in the European Community, 1967-1981.**



Source: data from Commission of the European Communities 1983

Figure 5.19 **Caesium-137 deposition in rainfall at selected sites in the European Community, 1967-1981.**



Source: data from Commission of the European Communities 1983

Rates of removal by fallout similarly vary between different radionuclides and according to climatic conditions. Dry deposition is most effective in the case of larger particles (>10 micrometres diameter) and under dry, stable atmospheric conditions. Rainwash, in contrast, affects mainly smaller particles, and is favoured by high rainfall amounts and high levels of humidity. Overall it is probably the main mechanism of deposition, accounting for up to 90% of the total fallout.

Because of the differences in behaviour of the various radionuclides, it is not easy to summarise in simple terms the state of radioactivity. Figure 5.15, however, shows levels of beta radioactivity in the atmosphere and in fallout since 1962 for the whole Community. The trend is clear. Over the last 20-25 years, levels of beta radioactivity have fallen markedly, and indeed at many sites are now below the threshold of the monitoring instruments. The most rapid decline took place between 1962 and 1965, since which time levels of beta radioactivity have tended to fall slowly. Data on strontium-90 and caesium-137 are not available for such a long period, but activity levels of these have also clearly declined since the late 1960s and early 1970s, though with great year-to-year variability (Figures 5.16-5.19).

A number of factors have contributed to these changes. In recent years developments in nuclear technology and improvements in emission control have undoubtedly played a part, more than off-setting in many cases the increase in nuclear production. Far more important, however, has been the cessation of testing nuclear weapons in the atmosphere. During the 1950s and early 1960s, these tests were by far the major sources of artificial radiation in the atmosphere. With the ban on atmospheric testing, levels of radioactivity have been greatly reduced.

5.9 CONCLUSIONS

5.9.1 Issues of Concern

Although several of the traditional causes of air pollution, such as smoke and particulates, are now under control in the European Community, the capacity of man to damage the atmosphere remains. Today, however, the concern is not so much with local air pollution close to the emission source, as with long- distance pollutants which have more subtle, but no less important, impacts upon human populations and their environment.

Chief amongst these concerns are the problems of sulphur dioxide, nitrogen oxides and acid deposition. Their effects are far-reaching. Individually or together they act to acidify the soil and lakes, inhibit plant growth and damage buildings. Costs of these effects are difficult to calculate but, according to estimates by Environmental Resources Ltd (1983), may average as much as 2-3,000 million ECUs per year across the Community as a whole. Understandably, therefore, these problems have recently attracted considerable attention, and the Community is already taking steps to reduce sulphur dioxide and NO_x emissions from their major sources.

These, however, are not the only issues of concern. Lead pollution from vehicle exhausts continues to be a major problem in many urban areas, and controls on lead levels in petrol are being re-inforced. Evidence is also accruing to suggest that changes in ozone concentrations may pose even greater threats. Destruction of ozone in the stratosphere as a result of emissions of chlorofluorocarbons and other volatile organic compounds, for example, may increase ultra-violet radiation at the earth's surface and raise the likelihood of skin cancers in human populations. Increased UV radiation may also inhibit plant growth. At the same time, increased ozone concentrations are being observed in the lower atmosphere, seemingly a response to reactions between nitrogen oxides and hydrocarbons. Again, the effects include damage to vegetation and diminished crop yields. The problems are clearly complex, and much yet has to be learned. Most recently of all, the Chernobyl incident has focused attention on the problems of atmospheric radioactivity.

5.9.2 The Need for Data

It is also apparent that in many areas considerably more data are needed if the effects of atmospheric pollution are to be monitored and its causes fully understood. Despite efforts by both member states and the Community, a relatively thinly scattered network of measurement stations currently serves the Community. Moreover, these stations monitor only a restricted range of compounds, and frequently use different sampling and analytical techniques. As a consequence, their results are rarely directly comparable. Some steps have been taken to combat this problem by setting up inter-calibration projects and establishing a system for the exchange of information on sulphur dioxide and smoke pollution. Substantial benefits are still possible, however, by extending this system to more stations, especially in more remote areas, and additional pollutants (especially NO_x and rainfall acidity). There is also a need co-ordinate the copious research into these problems in order to pool resources and minimise duplication of research effort. Similarly, further data are needed on the inputs of pollutants to the atmosphere so that emission trends can be monitored and potential pollution problems identified. For the same reason, progress is required in modelling long-distance atmospheric transport in order to allow better predictions of pollution hazards.

None of these requirements can be achieved instantly, nor without cost. To ignore them, however, will inevitably blunt attempts to develop sensitive and appropriate policies for air pollution control. The costs then - both in terms of environmental damage and economic losses - are likely to be much greater.

FOREST DAMAGE

Examples of forest damage in Germany

The importance of forests

Forests do not only have economic value in terms of timber production and tourism, but are also important and fundamental components of the natural environment. They protect the soil from erosion and help to stabilise slopes; they play a vital role in nutrient cycling and in maintaining soil fertility; they have a positive effect both on the air and global climate, and are important in relation to water resources; and they provide a wide range of habitats for plants and animals. For all these reasons, protection of forests is of particular importance in the European Community.

The forests of the Community, however, are under attack from two main sources: from air pollution, especially in the north, and from damage by forest fires, which predominates in the south. Over recent years, damage from both these effects has commanded increasing attention.

Damage from air pollution

The problem of forest damage by air pollution on any large scale was first recognised in Germany. Early in the 1970s, reports from Bavaria remarked on the high incidence of die-back amongst silver fir, and by the mid 1970s similar symptoms had been noted in Baden-Wurttemberg. Since then, the extent of damage and range of species considered to be affected have increased dramatically. Between 1980 and 1982, for example, the percentage of fir trees examined in Baden-Wurttemberg which were classified as healthy fell from 62% to less than 5%, while damage to spruce trees in that *land* increased from 6% in 1981 to 94% in 1983. By 1982, extensive dieback and foliar damage had been identified not only in fir and spruce, but also in hardwood species such as beech.

In the light of the growing concern about the problem, the Federal Ministry of Food, Agriculture and Forestry initiated national surveys of forest damage in 1982, and these have been repeated annually since then, using a subjective classification of damage on a I to IV scale. The general trend is clear (see upper Figure, overleaf). The area of damaged forest rose from 8% in 1982 to 34% in 1983 and 50% in 1984, mainly as a result of an increase in the extent of damage classes I and II.

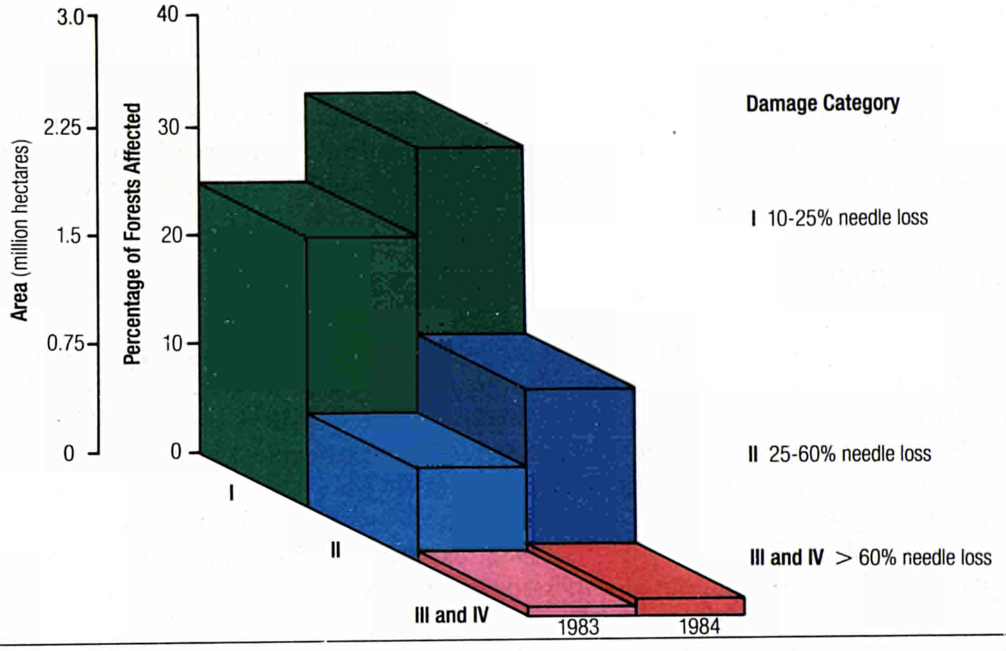
These surveys have also shown the wide range of species and areas affected in Germany. Fir is by far the most severely damaged species, with up to 75% of the area affected. But over 40% of pine and spruce, 26% of beech and almost 15% of oak were also identified as damaged in 1983. Similarly, the percentage of damaged forests ranged from 11% in Saarland to almost 50% in Baden-Wurttemberg (see lower Figure, overleaf).

The extent of damage elsewhere in the Community is less certain. Similar effects have been noted in the eastern Netherlands, and damage is apparent in the Vosges in France. In the United Kingdom, too, there is now increasing concern about the potential effects of forest damage, especially in upland areas. Both here and in other member states, however, firm evidence of a general problem of forest damage (as opposed to local damage close to emission sources) is lacking, and dramatic increases in dieback like those in Germany have not been reported. Whether this reflects differences in the perception of the problem, or real differences in environmental conditions, is not clear. The processes by which trees are damaged are also open to different scientific explanations. Many theories stress the role of long-range air pollution, causing dry and wet acid deposition and affecting forest productivity and development. Additionally, recent research has shown that ozone may be instrumental in causing forest damage, and variations in the extent of damage may reflect differences in the incidence of high ozone concentrations due to climatic factors.

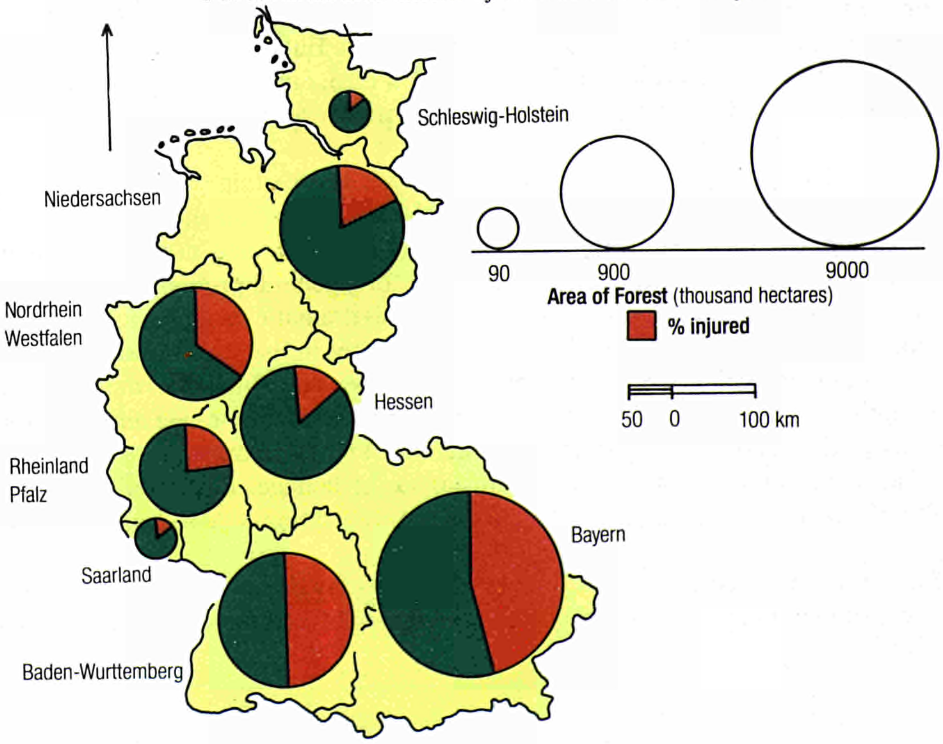
One of the other main contributors to forest damage may be heavy metal pollution. Forests are particularly susceptible to heavy metal toxicity, and damaging effects have been widely observed in central Europe.

Heavy metals are released from industrial sources, traffic and housing mainly in the form of particulates (aerosols). In the atmosphere, these are subject to transport and, as a consequence, may be

The extent of forest dieback in Germany, 1983-1984.



Forest area and extent of dieback in Germany, 1983.



carried long distances, even far into remote parts of the Community. They are removed from the atmosphere by two main processes: in precipitation (wet deposition) and by the filtering effects of the vegetation (interception deposition), especially by forests. As a result of these processes, a large proportion of the atmospheric load is deposited in the vegetation canopy. From there, they are cycled via rainwash and litter fall to the soil and thence either taken up by the plants or removed by leaching and erosion.

The nature of these flows in forest systems are shown for lead and cadmium in the figure opposite. The data are based on measurements in a rural beech forest in central Germany.

The two heavy metals show a number of differences. Lead is a relatively immobile element. About 20% of the atmospheric input is retained in the canopy and does not reach the forest floor. High concentrations in the bark show that much of the lead is bound there, and the content in the bark can be used as an indicator of more general lead levels in the environment. Almost all the lead reaching the floor accumulates in the soil, especially in the humus. The output in seepage waters is small under most soil conditions, and the majority of the lead is thus available for plant uptake. Within the plants most is retained in the roots. The cycle of lead is therefore slow, and only small proportions are lost from the forest.

In contrast, cadmium is more mobile. All the cadmium from atmospheric inputs penetrates the canopy and reaches the forest floor, mainly in throughfall: little is retained. Similarly, accumulation in the soil is limited. A large proportion is leached from the root zone, and about 20% is taken up by the trees. The rate of cycling is therefore rapid and considerable losses occur from the forest into the outside environment.

The impacts of these heavy metals in the forest ecosystem may be severe. High concentrations of the metals may affect soil organisms and disrupt the natural processes of organic matter decomposition and nutrient cycling. As a result, plant nutrition may be affected and the forest system can be destabilised. The effects are particularly acute under acid conditions, for in acid soils the heavy metals are considerably more soluble and are thus taken up more readily by the soil fauna and vegetation.

Together, heavy metals, acid deposition and ozone are having important effects on forests throughout the European Community - and particularly in northern areas. As the extent of forest damage becomes appreciated, however, it is also becoming apparent that the causes are far less simple than once proposed. Almost certainly, damage is a result of complex interactions within forest ecosystems, within which the effects of acid deposition provide an important catalyst.

Damage by forest fires

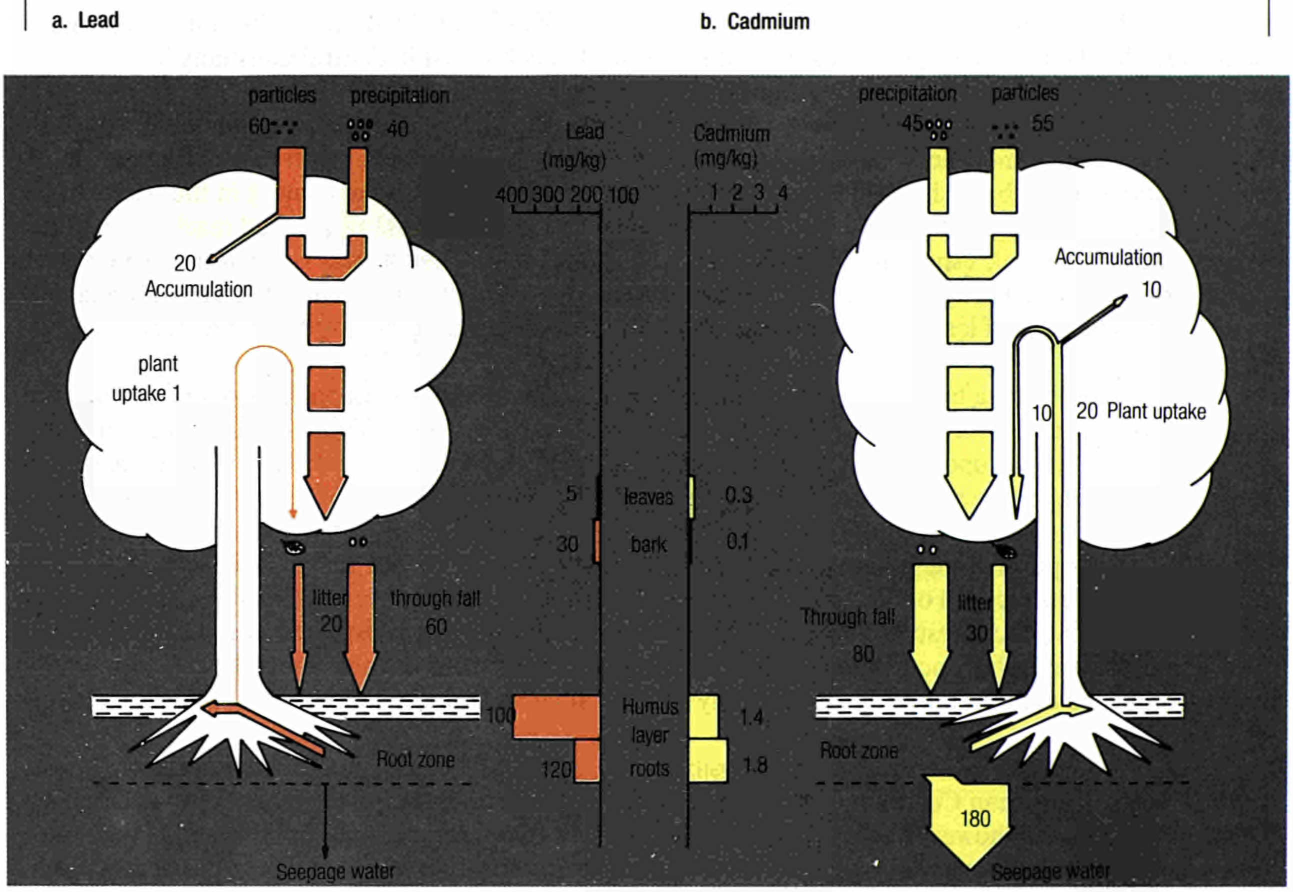
While problems of forest damage by air pollution undoubtedly predominate in northern parts of the Community, in the south the main concern relates to the effects of forest fires. Each year fires occur which damage large areas of forest land, amounting to an average of 120,000 ha/y in the whole Community. The incidence of these fires varies greatly from year to year, as a result of climatic differences and other, random effects, as the data in the figure below indicate. Nevertheless, it is also clear that the problem is a serious and persistent one (see Table, below).

Fires may be caused by a wide variety of factors. By far the major causes, however, are human negligence and criminal activies (e.g. arson). Statistics for 1978 for 20 European countries, for example, show that 89% of forest fires were a result of these factors.

Policy responses

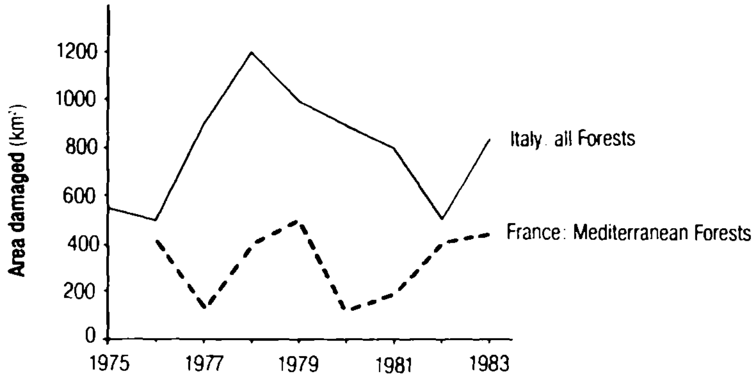
Whatever the specific mechanisms by which forest damage occurs, it is clear that the problem is a crucial one. Large areas of the Community are certainly affected, and the spectre of widespread damage to forests has caught public as well as political attention. A wide range of efforts

The flow of (a) lead and (b) cadmium through a forest ecosystem.



are therefore being undertaken by the Community to resolve the problem. One of the main thrusts of this action is directed at the control of air pollution by large power stations and motor vehicles. A further step was taken with the adoption by the Council on 17 November 1986 of regulations aimed specifically at promoting protection of forests against acid deposition and fires. Actions concerning acid deposition are aimed particularly at the establishment of a regular inventory of forest damage and a network of observation posts for measurement of the state of health of forests. Measures to improve protection against fire damage involve, on the one hand, preventive action such as removing of undergrowth and improved fire detection. On the other hand, action is also being taken to co-ordinate fire-fighting by the member states, as well as training of personnel in charge of fire control operations.

Extent of forest damage by fires in the Mediterranean region, 1975-1983.



Numbers and extent of forest fires in Community member states, 1985

Member state of fires	Number	Area affected by fire(ha)		Total area
		Forest	Farmland or natural land	(ha)
Italy	16,903	62,515	98,420	160,935
France	5,596	35,050	24,800	59,850
Greece	727	37,511	34,354	71,865
Spain	9,770	147,235	208,763	355,998
Portugal	5,459	81,475	54,095	135,570
Total	38,455	363,786	420,432	784,218

Note: data refer to the nine months to 30/9/1985 and are provisional estimates.

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NOTES AND SOURCES

Data availability

Measurements of atmospheric emissions in Community member states are carried out for specific emission sources such as individual factories or industrial installations. Many of these data are confidential, however, and in any case they tend to be unrepresentative of the wider situation. The main published data therefore derive from calculations based on factors such as combustion process, rate of fuel use, fuel consumption, method of emission control etc. These are calibrated against measured data and laboratory tests of emission equipment, but are clearly open to error and tend to vary from one member state to another because of different calculation procedures and formulae.

Published measurements of atmospheric concentrations are more plentiful, but still suffer from a number of limitations. In particular, measurement sites are often located in areas of known high pollution levels, and generally close to emission sources. More remote or low pollution areas are under-represented in the monitoring networks. Moreover, differences in measurement procedures between different sites and member states (or even at individual sites over time) make comparisons difficult, while problems such as equipment failure, changes in site location and administrative interruptions mean that measurement records are often incomplete. For all these reasons, data in this chapter must be treated with care, though discrepancies as a result of differences in measurement techniques are likely to be small in most cases compared to the broader spatial and temporal trends in emissions and atmospheric concentrations of pollutants.

Notes on Figures

Figure 5.3 'Black smoke' refers to measurement of suspended solids by reflectrometric anaylsis of filtered stains; 'suspended particulates' are measured by gravimetric methods. Sites included in this diagram are not intended to be representative of regional or national conditions.

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CHAPTER 6.

THE LAND

6.1 INTRODUCTION

"Land: an area of the earth's surface, the characteristics of which embrace all reasonably stable, or predictably cyclic, attributes of the biosphere vertically above and below this area including those of the atmosphere, the soil and underlying geology, the hydrology, the plant and animal populations, and the results of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man."

(FAO 1976, p.67).

6.1.1 The Importance of Land Resources

Since man has occupied this earth, he has been closely and inextricably dependent upon the land. It has provided him with territory on which to settle, materials with which to build and, most fundamentally of all, a basis for food production. The state of the land is therefore vital to his existence and crucial to his well-being. It is also, itself, intricately sensitive to the activities he performs and the pressures he exerts upon it.

Nowhere is the relationship between man and the land more intimate than in the realm of agriculture. Crop yields are directly linked to the ability of the land to supply the energy, water, nutrients and stability required for growth. Wherever any of these needs is not adequately met, crop growth will be inhibited. Where water is lacking - for example because of low rainfall, high rates of evapotranspiration, limited moisture storage capacity of the soil, or some combination of these - crops suffer from moisture stress and yields decline. Where water is in excess - due to high rainfall amounts or poor soil drainage - yields are similarly depressed. A short growing season - as a result of low levels of solar radiation, late frosts, or heavy and wet soils which warm up only slowly in spring - also reduces crop growth. Similarly, lack of nutrients - resulting from the presence of acid, nutrient-deficient rocks and soils, or high rates of leaching - impairs crop performance.

Through these effects, variations in the character of the land greatly contribute to variations in agricultural yields and thus to differences in productivity. Yet these effects do not operate only in a direct fashion; they also act more indirectly through their influence on agricultural practices. Indeed, a fundamental function of farming is to mitigate the constraints of the environment on crop performance by the application of appropriate farming techniques. Thus practices such as drainage, tillage, irrigation and crop protection are undertaken partly in response to land conditions. Crops are chosen and cropping systems are selected on the same basis. Livestock and grazing systems also are chosen in the light of the environmental constraints. As a consequence, a broad relationship exists between the character of the land and farming types in the European Community.

This relationship, however, is not confined to agriculture alone. Similar influences are exerted on forestry, on engineering and on recreational activities. The suitability of the land for commercial tree production, for example, is controlled in part by factors such as climate, soil conditions and topography. Soil depth and bearing capacity influence the costs of road and urban construction. Soil conditions and topography play an important role in determining the best routes for pipelines and other underground installations. Sportsfields, camp-sites and parks are all dependent to a great extent on land conditions.

In the same way the land influences many natural processes. It helps to govern the routing of water through the environment, determining what proportion soaks into the ground eventually to replenish groundwaters, and what proportion escapes as runoff to streams. Thereby it affects river discharge, rates of erosion and pathways of pollutants. It is a major determinant of local climate. It also plays a fundamental role in biogeochemical cycles (e.g. nitrogen, carbon), and affects the character of the natural vegetation and fauna they support.

Thus, the land is a central component of the environment, influencing many different aspects of land use, and related to many other elements of the physical world.

6.1.2 Pressures on the Land

Like all resources, the potential of the land can only be realised if the land is exploited. As with all resources, however, the land is not immutable, but is susceptible to the pressures exerted on it. We have seen in previous chapters where these pressures derive from: the major source is from agriculture. The very processes of management which are employed to overcome the limitations imposed by the land, or to exploit its potential, may - if carelessly undertaken - damage the land itself. Soil erosion, for example, may occur because of overgrazing; because of loss of structural stability as a result of repeated removal of organic matter in the harvested crop; or because the land is left bare and unprotected during periods when wind or rainfall forces are strong . Soil compaction may occur due to excessive trampling by livestock or the untimely use of machinery. Salinisation may take place due to poor irrigation practices; pollution may be caused by the excessive use of pesticides or fertilisers; acidification may develop because of insufficient use of lime.

Many of these pressures are a direct result of agricultural intensification - of the attempt to maximise yields from the land. We might expect from what we discussed in Chapter 4, therefore, that these pressures are increasing. Agriculture, however, is not the only source of pressure on the land. Industrial and domestic wastes and effluents may contaminate soils. Atmospheric emissions may change the near-ground climate, directly attack crop plants and animals, or be washed into the soil where they may act as a pollutant: the effects of acid precipitation are an all too well-known example. Similarly, vandalism to crops, trampling by tourists and worrying of animals by household pets may all reduce the agricultural potential of the land in urban fringe areas. And again, as we saw in Chapter 3, many of these pressures have increased in recent decades (although, in the last few years, reduced industrial activity and improved pollution control may have led to a decline in some aspects of pollution).

All these pressures impair the agricultural potential of land resources, but that is not their only effect. In some cases they may also reduce the suitability of the land for other uses - forestry or recreation, for example. In addition they have significant impacts on water resources and wildlife. Soil erosion leads to high sediment concentrations and increased turbidity in streams and lakes, making them unsuitable for insect, fish or amphibian species. It also results in increased siltation of reservoirs, reducing their storage capacity. Accumulation of agricultural or industrial pollutants in soils may result in contamination of drainage and runoff waters and the transfer of toxic residues through food chains to predatory birds and mammals. Structural damage of the soil may inhibit infiltration and encourage overland flow, thereby making streams more sensitive to rainfall events.

The land, therefore, is a sensitive as well as a valuable resource. Within the Community as a whole, pressures on it are growing. The immediate need is consequently to monitor closely the state of land resources, to specify areas of particularly high quality land which need protection, and to identify situations where remedial action is needed to reduce the threats to the land. The longer term need must be to develop policies of land use and conservation which ensure the most rational and beneficial use of this resource not only for the present population of the Community but also for future generations.

6.2 LAND QUALITY

The land resources in the European Community are finite and non-renewable. They are also subject to a wide range of conflicting interests. Agriculture, forestry, housing, industry, mining, recreation, transport and conservation are all in competition for the land. To use land resources to their optimum, therefore, we need to select between these various land uses, and, where possible, to encourage multiple uses of the land. To achieve this we need to match each area of land to its best possible and most compatible range of uses.

In part, such decisions are economic and social. They depend upon factors such as costs, prices and benefits; social needs and priorities. They are also, however, partly a question of physical resource evaluation, for the potential of the land for any use depends upon its physical characteristics - its climate, topography, soil, hydrology and vegetation. Consequently, to make these decisions, we need information on land quality.

6.2.1 Land Capability and Suitability

One of the primary concerns of planning and environmental policy in the European Community is the wise use of land resources. The need is clear: to ensure that each area of land is used for the best use, so as to maximise the benefits to the people of the Community. This, however, raises questions, for how do we decide the "best" use of any area of land? And how do we decide how good the land is for a particular use?

These are questions which have already been tackled to a greater or lesser extent by most member states of the Community: each has developed methods of assessing land quality for agriculture or other uses. The approaches, however, vary widely, as the information in Table 6.1 shows. In the United Kingdom, for example, relatively broad capability classes are defined according to the 'degree of limitation' imposed by soil, climatic and topographic factors. In the Netherlands and Ireland rather more detailed evaluations are made for individual land uses. In Germany, France and - for some crops - Belgium, more rigorous, parametric approaches are used to assess the yield potential for specific crops.

Given this wide variety of approaches to assessing land capability or land suitability for agriculture and forestry in the member states, it is clear that we cannot yet obtain a general picture of conditions across the whole Community. What is needed is a common method of land evaluation which can be applied to the whole Community territory. A broad framework for such a method has, in fact, been defined by the F.A.O.

Currently, therefore, the European Commission is carrying out a programme to develop a Community-wide system of crop suitability assessment. This is several years from completion, but already the main factors to be included in the assessment have been agreed and data on these are being collected. At the same time, draft maps of grassland suitability are being prepared. In addition, the European Commission is currently undertaking a project to identify areas of high land quality in the Mediterranean region as part of the CORINE programme.

Table 6.1 **National systems of land capability and land suitability assessment in the European Community.**

Member State	Objective	Method	Scale	Coverage
Belgium	Suitability for principal crops	5 classes, defined on the basis of field oservations and interviews	1:20,000	~100%
Denmark	None	-	-	-
France	Suitability for agricultural crops and forestry	6 classes based on numerical rating of soil conditions	varied	~50%
Germany	Soil quality for agriculture	8 yield index classes based on numerical rating of soil conditions affecting productivity	1:1,000,000	~100%
Greece	None	-	-	-
Ireland	Suitability for grassland and cultivation	5 classes for each use defined according to degree of limitation of soil and climatic factors	1:126,000	~40%
Italy	Suitability for maize (to be extended to other crops)	4 classes based on numerical rating of soil, slope and climatic factors	1:2,000,000	100%
Luxembourg	None	-	-	-
Netherlands	Suitability for major land uses	3 classes defined according to combination of specific assessment factors	1:25,000 and 1:50,000	-
U.K.	Capability for agriculture (MAFF: Agricultural Land Classification)	5 grades defined according to degree of limitation on yield and cropping flexibility of soil, climatic and topographic conditions	1:63,360	England and Wales
	Capability for agriculture, forestry and recreation (SSEW)	7 classes defined as above	1:25,000	~30% of England and Wales

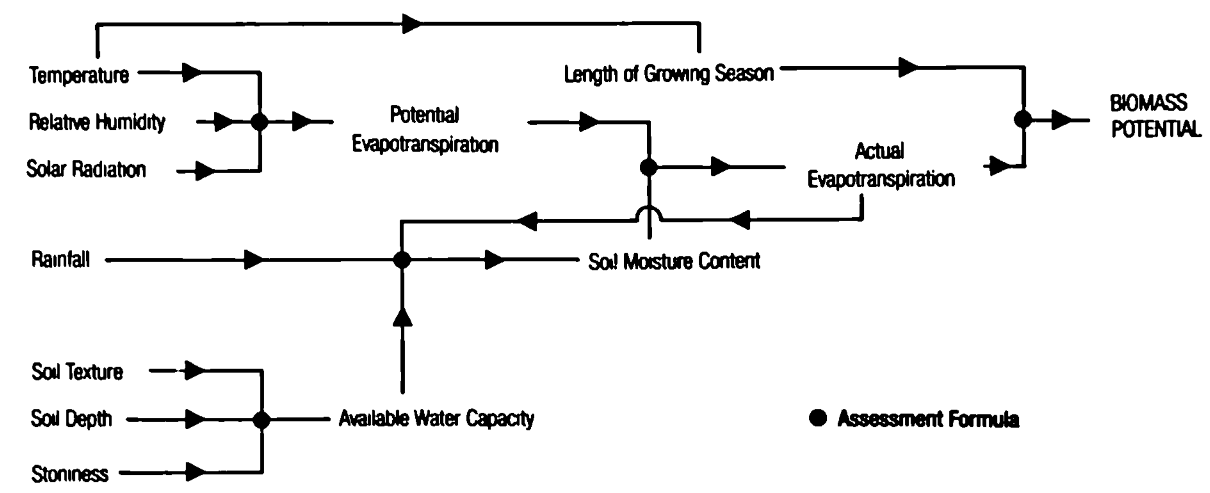
6.2.2 Biomass Potential

The ability of the land to produce biomass is primarily a function of the ability of the vegetation to convert energy into plant material. The energy is derived mainly from solar radiation, but the ability of plants to exploit this radiation (through photosynthesis) depends on a number of factors, including the area of green leaves and the availability of water and nutrients. Under a crop such as grass, the area of green leaf remains reasonably constant throughout the year. In addition, under high levels of management, the necessary plant nutrients can generally be supplied by fertilisers or manures. The main constraint on photosynthetic conversion of the radiant energy to plant material, therefore, is the plant's ability to take up water. Without irrigation, this in turn depends on three main factors: the potential rate of evapotranspiration (which is primarily a function of energy availability), rainfall, and the ability of the soil to store water (the available water capacity). In consequence, a broad relationship tends to exist between the rate of water use by the vegetation (its actual evapotranspiration rate) and the rate of biomass production.

This relationship was used in the two studies quoted here to assess the biomass potential (i.e. the capacity of the land to produce above-ground green biomass) across the whole of the Community. The model employed in these studies is outlined in a simplified form in Figure 6.1. To apply this model, two sets of data are required: average monthly climatic data including rainfall, temperature, relative humidity and solar radiation; and soil available water capacity. Data on climate were therefore collected from some 250 stations from climatic atlases and from national meteorological records; estimates of soil available water capacity were made from data on soils supplied for each member state by national soil scientists. The data were then entered into a computer program and the biomass potential calculated for a reference crop of mixed species grassland.

The results are plotted as a grid map in Figure 6.2. The general pattern is clear: high biomass potentials tend to occur mainly in the south west of the Community where energy and rainfall are plentiful. In addition, small areas of high potential occur in estuarine and valley floor areas (such as the Po valley in Italy and the Bordeaux region of France) where rainfall inputs to the soil are supplemented by groundwaters. In south-eastern areas, in contrast, biomass potential is limited by the lack of rainfall, while in northern regions the main limitation is the short growing season and low levels of solar radiation.

Figure 6.1 **The assessment of biomass potential.**



Source after Briggs and Coleman 1984

THE SOIL MAP OF THE EUROPEAN COMMUNITY

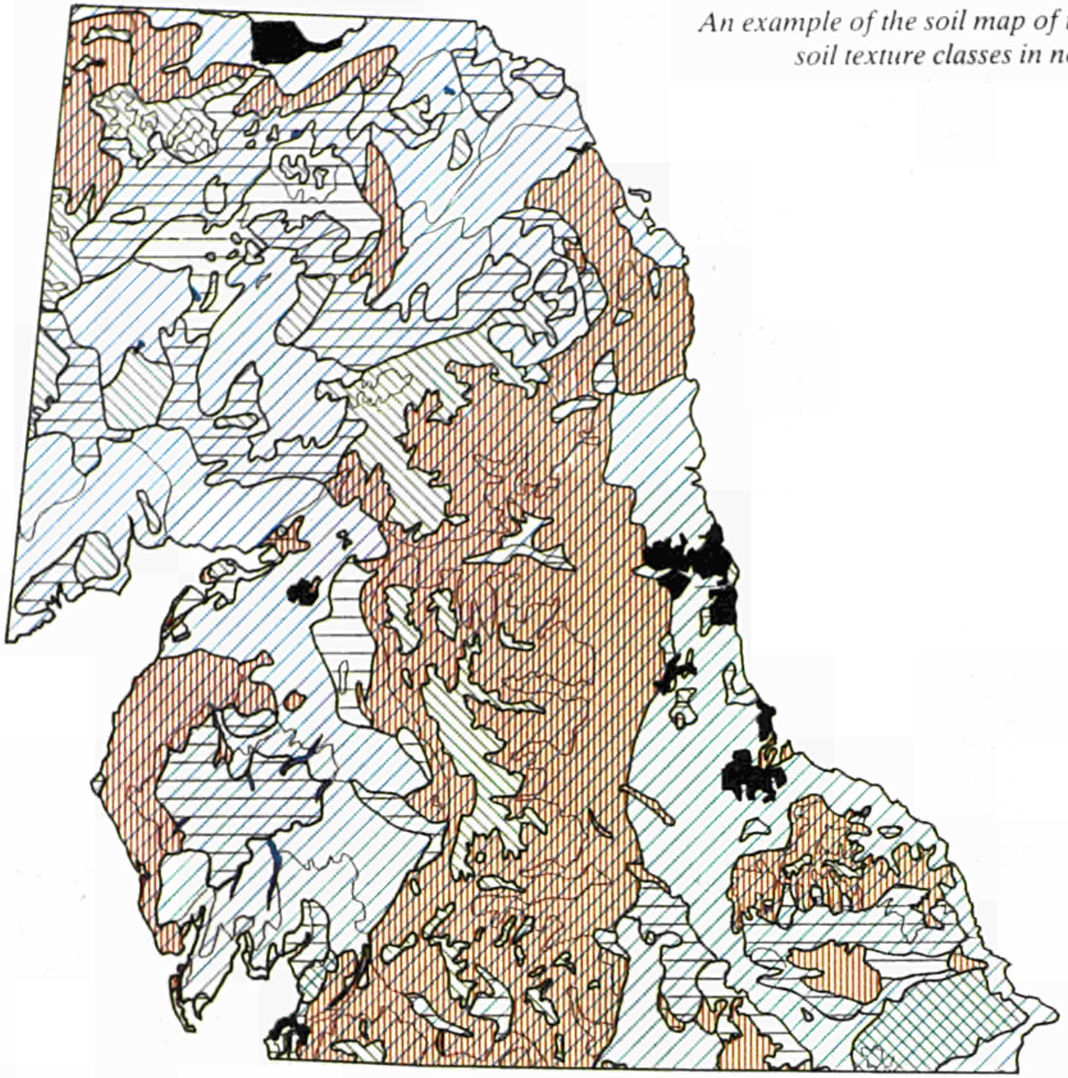
One of the basic requirements for any evaluation of land resources is comprehensive picture of the soils within the area of concern. For an area as large and diverse as the European Community, this poses major problems. Admittedly, most member states have produced soil maps, but the methods to describe and classify the various soil types, the scale of mapping, and the systems of presentation all vary markedly. It is far from easy, therefore, to collate these into a single, consistent form covering the whole Community.

In 1978, however, the Directorate General for Agriculture established a working party under the chairmanship of Prof. Tavernier to produce a soil map of the Community. It was a lengthy and complex operation. Firstly, an acceptable and practicable system of soil classification had to be agreed: no easy task given soil scientists' strong empathy for their national systems. Moreover, the classification could not be a simple amalgam of all the existing methods, because it had to ensure consistency between member states, reduce the range of soil classes recognised to the smallest practical number, and be based upon soil properties which were of significance for those who might use the map. Secondly, this classification had to be applied to the whole Community. This was achieved by asking each national delegate to collate archives on the soils in their own member states so that the national maps could be redrawn according to the agreed classification. The draft version of the Community soil map was then vetted by the national delegates and necessary adjustments made.

The result is a soil map of the Community, at a scale of 1:1 million, which was published in 1986. It is, of course, not without imperfections. Due to the different qualities of the source material available in each member state, the amount of information varies from one country to another: in Greece, for example, the soils are relatively generalised, whereas in countries such as Belgium and the United Kingdom, with a well-established soil survey, mapping is much more detailed. Nevertheless, the map is a major achievement. In practical terms, it shows how co-operation can be achieved between scientists in different member states - even on such a controversial issue as soil classification. It portrays the distribution of some 350 soil classes throughout the Community, each described according to its soil depth, texture, stoniness, drainage status and slope angle. Already it is being digitised (Figure opposite) and is providing the basis for a number of analyses of the Community's land and water resources. In the future, it is likely to form an integral part of the Community's policy development procedures on the land.

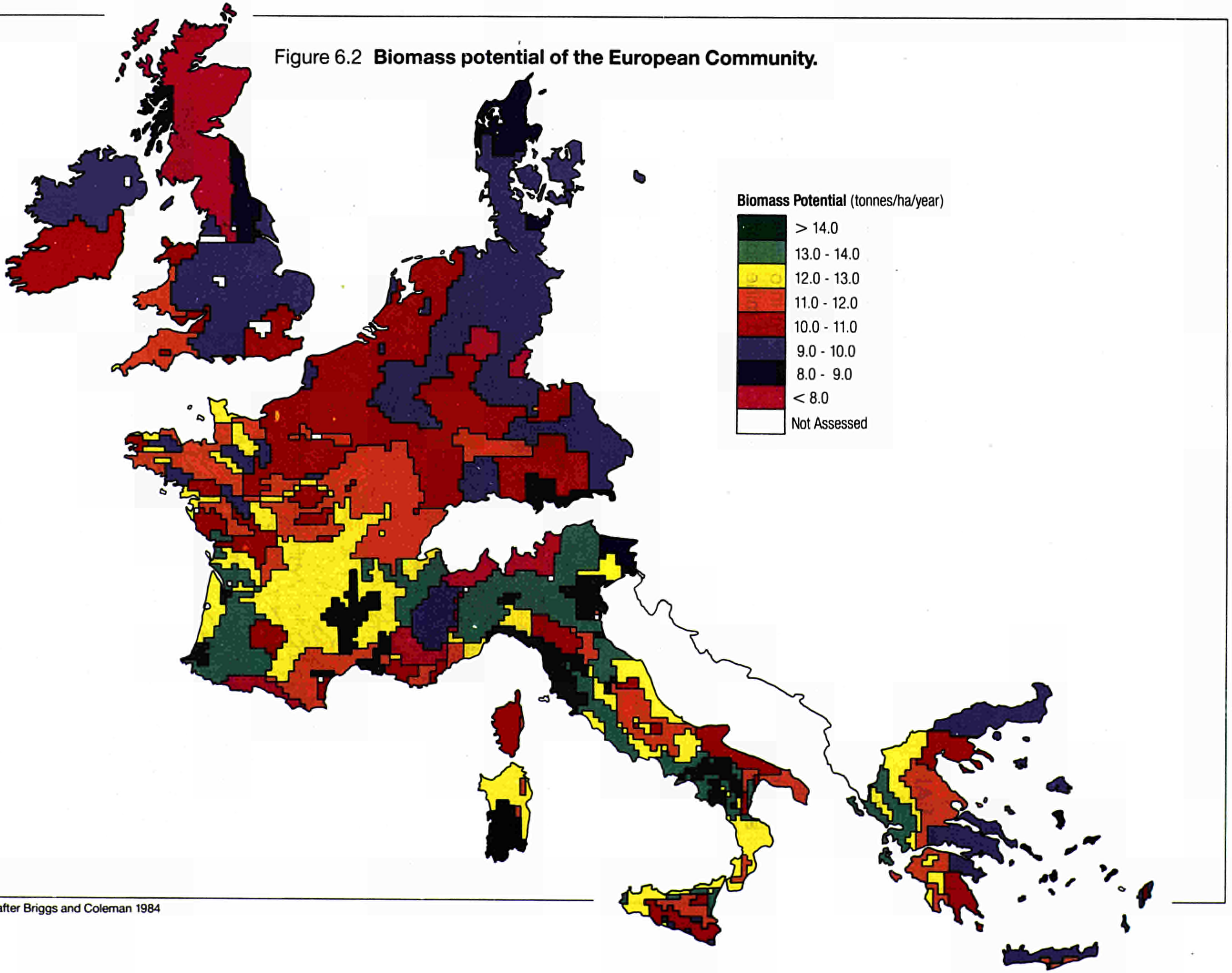
Nevertheless, it must be stressed that the Soil Map of the European Community gives a highly generalised picture of the soil resources. Many of problems facing the use of these resources are much more localised in character - problems such as soil erosion, land loss and pollution. To tackle these issues effectively, the need is for much more detailed information on soil distribution. This cannot be provided by the Community itself, but must come from the member states. It highlights, therefore, the need for the continued existence, operation and updating of land use and soil classification systems in all member states. As the pressures on land resources grow, the need for detailed soil survey information will grow apace.

An example of the soil map of the European Community: soil texture classes in north-west England.



Source: from the soil Map of the European Community

Figure 6.2 **Biomass potential of the European Community.**



Source: after Briggs and Coleman 1984

At the scale of mapping used in this study, these results can only show the general distribution of biomass potential in the Community, though the approach is equally suitable for more detailed evaluations where data exist. Even at this scale, however, it is clear that the extent of high quality land (with no serious restrictions on crop growth) is extremely limited in the Community. The need to protect these areas from adverse development (e.g. urban expansion or tourism) is therefore a vital one. Nowhere is this need more acute than in the Mediterranean region for here the extent of high quality land is at its most limited, while the pressures from other land uses are growing. Further studies being conducted by the Community will therefore concentrate on identifying in more detail the extent of these areas in the Mediterranean region as a basis for integrating the protection of these crucial land resources into the Community's policy on the region.

6.3 LAND LOSS

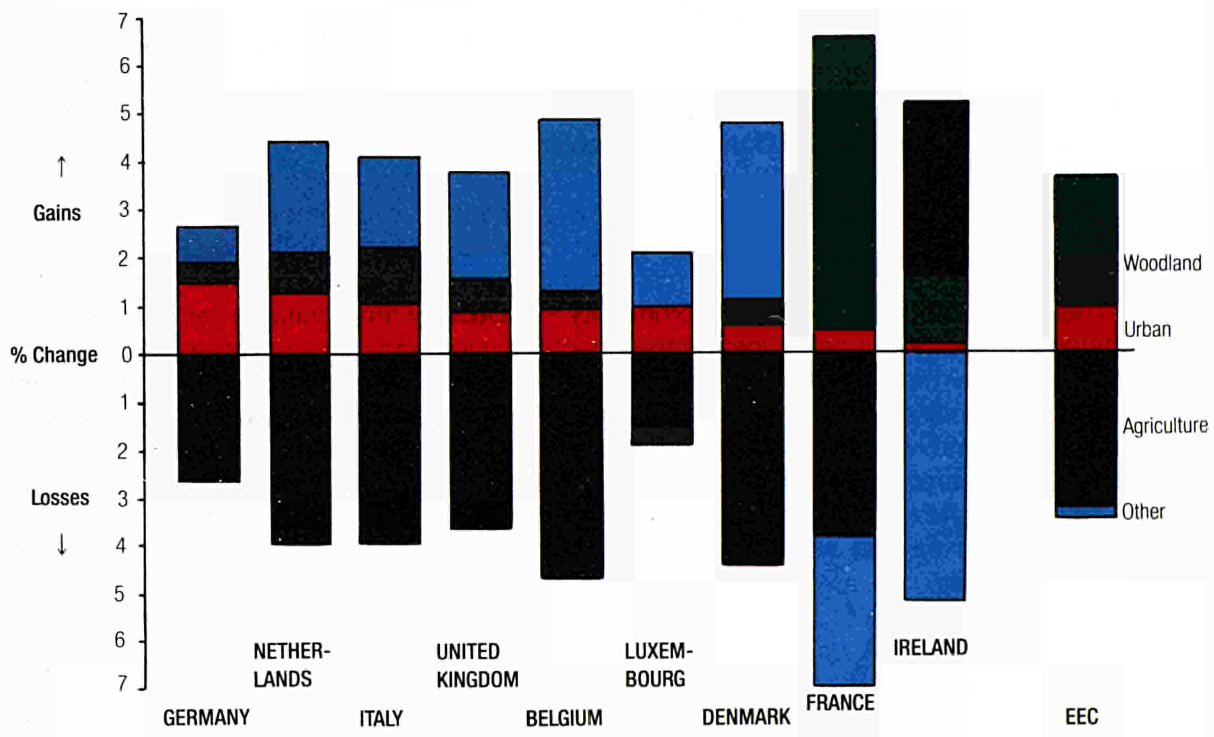
The total stock of land in the Community - especially land suitable for agriculture - is under constant attack. Soil is being lost by the effects of wind and rainfall erosion. Coastal lands are being removed by the sea. Urbanisation and other forms of construction are extending onto farmland. It is not wholly a one-way process, because land is also being reclaimed from the North Sea; salt marshes and wetlands are being drained and taken into cultivaton; moorlands and maquis are being cleared for agriculture; urban wasteland and mine spoil are being returned to farmland. Overall, however, the rate of agricultural land generation is less than the rate of land loss, so that, as we saw in section 4.3.2, the total area of utilised agricultural land in the Community is declining.

6.3.1 Changes in Land Use

Over the last 20 years, for example, the area of utilised agricultural land has declined at an average rate of about 0.4% per year. This represents the net effect of complex and often contradictory transfers of land between agriculture, industrial and urban uses and semi-natural vegetation. Data are not available on all these transfers, but the main cause of loss seems to be to afforestation and urban extension or through abandonment of marginal land. In Italy between 1961 and 1970, for example, an estimated 1.5 million ha of agricultural land were abandoned, and in 1977 a total of 2.1 million ha of so-called 'reverted' land was believed to exist in the country. In France, in 1978, reverted land was calculated as totalling about 1.5 million ha, while in Germany about 300,000 ha of reverted land could be distinguished. In other member states no significant quantities of reverted land were known to exist. Most of this abandonment has taken place in upland areas. In Italy, for example, the main zone of reverted land includes much of the Apennines and Alpine foothills, while in the United Kingdom extensive abandonment of moorlands occurred between 1904 and 1950 in Scotland, the Pennines, the North York Moors, Wales and Dartmoor. As studies in the United Kingdom also show, however, many of these marginal areas may be repeatedly abandoned and reclaimed, so that the boundary between cultivated and uncultivated land in these marginal areas fluctuates over time in response to economic forces.

Losses to urbanisation are, suprisingly, more difficult to estimate, due to the lack of information on the extent of built-up land. Data for 1961-1971 are presented in Figure 6.3, while more recent estimates are also shown in Table 6.2. These indicate the importance of transfers from agriculture into urban land, especially in the more densely populated countries such as Germany and the Netherlands. What makes the effect all the more serious is that - because of the historical location of settlement in more fertile areas, and because of the constructional advantages - urban expansion often impinges on the better farmland. Even so, the impact of urbanisation should not be over-stated. As Table 6.2 shows, the rate of urbanisation is generally declining. Moreover, the data in Figure 6.3 suggest that afforestation is often equally important,

Figure 6.3 **Changes in land use in Community member states, 1960-1971.**



Source: data from Best 1981

and between 1960 and 1975 in the United Kingdom transfers of farmland to forestry averaged about 25,000 hectares per year, compared with an annual loss of about 18,000 hectares per year to urban uses. In general, it may be expected that these broad trends are continuing, but all these data are clearly dated now, and there is a great need for more rigorous monitoring of changes in land use throughout the Community.

Table 6.2 **Urbanisation of agricultural land in selected member states.**

MEMBER STATE	Land transferred (% of cultivated area) 1960-70	1970-80
Denmark	3.0	1.5
France	1.8	1.1
Germany	2.5	2.4
Italy	—	2.5
Netherlands	4.3	3.6
United Kingdom	1.8	0.6

Source: data from OECD 1985

6.3.2 Soil Erosion

The importance of soil erosion at a local scale in the European Community is often apparent: it is evidenced by the presence of deep and ramifying networks of gullies, by extensive spreads of sediment covering agricultural footslopes, or by stinging clouds of wind-blown dust. At a wider scale, however, the effects are generally less obvious. Compared to the problems of semi-arid regions elsewhere in the world, soil erosion in the Community is slight. Nevertheless it is an insidious and probably costly process. It not only removes soil, but preferentially carries away the more fertile components, including the clay, organic matter and fertilisers. It removes also seeds and buries or damages standing crops. It causes siltation of streams and reservoirs and may block ditches and tracks. No estimates of the costs of such effects are available for the whole Community but some regional examples can be quoted. The cost of simply clearing up sediment washed into urban streets during two weeks of storms at Lewes in England in 1983 amounted to 20,000 ECUs. Costs of damage by wind erosion in the Netherlands are put at about 10 million ECUs per year. In southern areas of the Community, the costs must be an order of magnitude higher.

Soil erosion is encouraged by a wide variety of factors. Not only are natural processes such as rainfall and wind action important, but also the effects of land use. Vegetation clearance, harvesting and overgrazing leave the soil surface bare and exposed to wind and rain. Soil compaction by machinery or animals reduces the rate of rainfall infiltration and encourages surface runoff and erosion. Repeated tillage and crop removal reduce the soil organic matter contents and diminish the structural stability of the soil. Drainage encourages oxidation of organic matter and wastage of peat soils. All these effects are undoubtedly increasing as agriculture becomes more intensive, and thus we might anticipate that rates of soil erosion are rising in the Community.

Data on actual rates of erosion are scarce, and in any case must be interpreted with caution. It is not the absolute rate of erosion which is important so much as the rate of loss relative to the rate of soil renewal by natural soil forming processes. This varies greatly from one soil type to another. Simple definitions of an 'acceptable' rate of soil loss - such as the figure of 12 tonnes per hectare quoted by the United States Department of Agriculture - therefore have little practical significance. What is clear, as the data in Table 6.3 show, is that rates of soil erosion vary markedly in relation to locality, soil type and cropping system. Because of the vastly different conditions under which these data were collected, it is not easy to generalise, but it seems that the highest rates of erosion are associated with silty or peat soils, and with land either under fallow or row crops such as vines and sugar beet.

These interpretations are borne out by estimates of the extent of land at risk of soil erosion in individual member states. They indicate that erosion is a threat in many parts of the Community, most notably in Italy and Greece, mountain areas of southern France and in the sandlands and loessial soils of northern Europe. Vineyards are frequently identified as having particularly high risks of erosion, and in the Piedmont area of Italy, for example, it is suggested that over a quarter of the land is therefore subject to excessive rates of soil loss. According to OECD data, a total of 49,000 km^2 of land Greece, representing over 37% of the land area, is affected by erosion. About 45,000 km^2 (8% of the land area) is susceptible in France, and 25,000 km^2 (10% of the land area) in the UK. Conclusions based on these data are inevitably tenuous, but the implication is that soil erosion remains a significant threat over a considerable part of the Community, and nowhere moreso than in the Mediterranean region.

Figure 6.4 provides some indication of where these risks are greatest. This shows estimates of rainfall erosivity for some 236 climatic stations across the Community, based upon the modified Fournier index.

$$R = \Sigma p_i^2/p$$

where R is the rainfall erosivity, p_i is the mean monthly rainfall in each month and p is the mean annual rainfall.

Plates 6.1-6.2 **Examples of soil erosion in the European Community.**
Plate 6.1 **Wind erosion in the Vale of York, England.**
Plate 6.2 **Badland topography in Quaternary sediments, near Pescara Italy.**

Photo: D. J. Briggs

Photo: D. J. Briggs

Plates 6.3-6.4 **Despite attempts to reclaim derelict land in the European Community, dereliction remains a major process of land loss.**

Plate 6.3 **China clay spoil on the edges of Dartmoor National Park, England.**

Plate 6.4 **Derelict land may become an almost permanent feature of the local environment: an impression of environmental problems by a child from a mining area.**

Photo: D. J. Briggs

Picture by Daniel Savill (age 10)

Table 6.3 **Measured rates of soil erosion in the European Community.**

Location	Soil type	Crop/land use	Erosion rate (t/ha/y)
United Kingdom			
Silsoe	Sandy loam	Bare	10-45
	Sandy loam	Vegetated	0.6-24
East Anglia	Peat	Bare	<3
S. Pennines	Peat	Bare	0.2-0.3
England	Various	Various	1-18
Germany			
Trier	Various	Barley	0.2-2.0
Mosel Valley	Over shale	Various	0.5-2.0
Rhine/Mosel	?	Vines	0.7
Belgium and Luxembourg			
Ardennes	Over shale	Forest	0.13
	Loam	Fallow	82.2
	Loam	Sugar beet	30.1
	Loam	Winter wheat	4.3
Central Belgium	Silty clay	Wheat	10-25
Luxembourg	Over marl	?	0.7-1.8
Hesbaye	Loam	Wheat	14-27
Italy			
Piedmont	Clayey silt	Vines	33
	Sandy clay	Vines	70

Sources: see Notes and Sources, page 206.

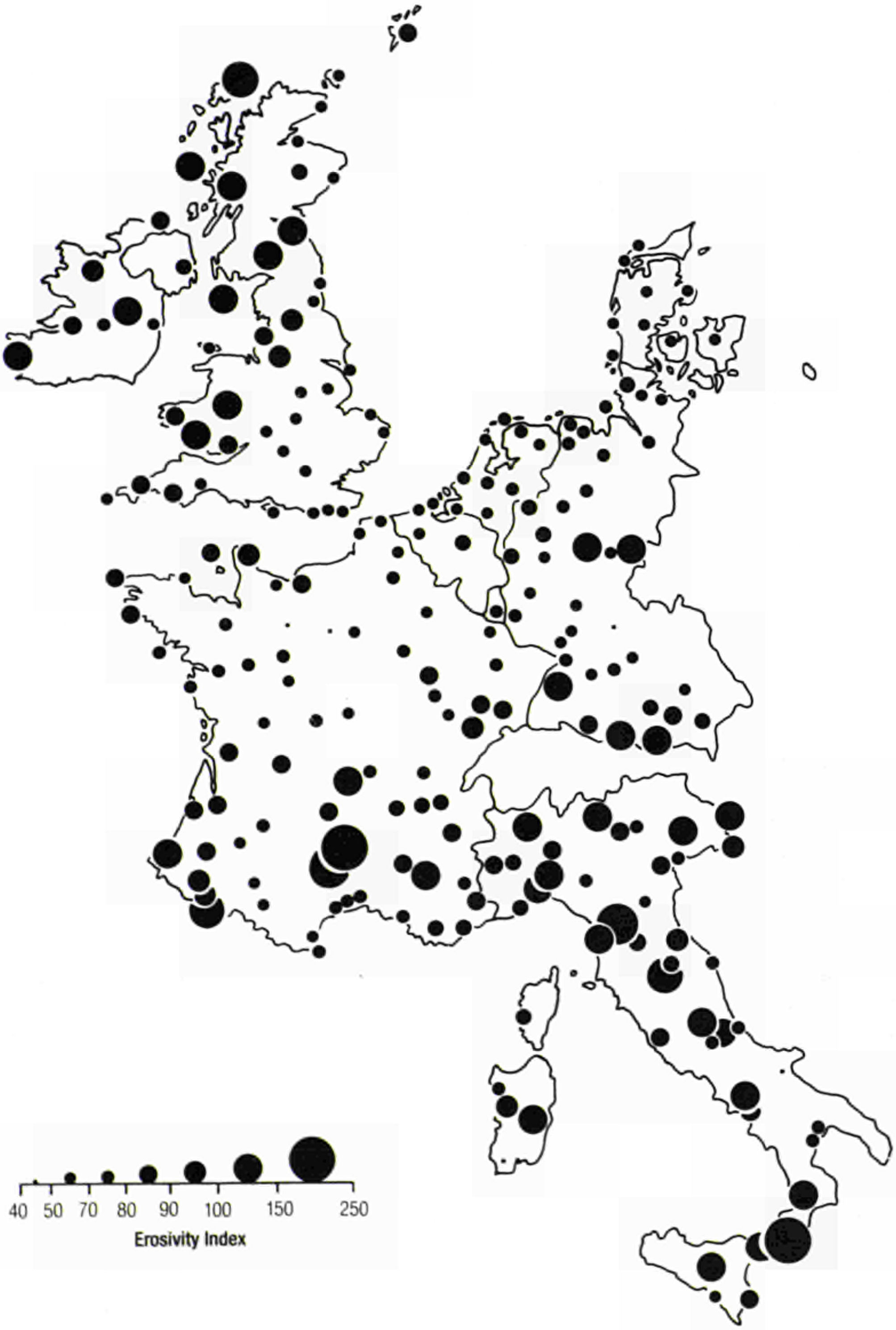
Highest erosivity indices occur in the Mediterranean, in the mountain regions of the Alps, Pyrenees and Massif Central and in the maritime uplands of the United Kingdom. Significantly, some of these areas are those which, in the past, have been protected by forest cover. Due to deforestation and the impact of forest damage, however, the protective vegetation cover is now in danger of being reduced. In that event, soil erosion problems are liable to become more acute.

Without doubt, all these data need to be treated with caution. We still do not know enough about the distribution of erosion to specify with certainty the most vulnerable areas of the Community. What is clear, however, is that erosion is a problem which may have serious impacts upon land resources, and for that reason should be viewed with concern. The need therefore exists to collect more reliable data on soil erosion throughout the Community.

6.3.3 Dereliction

Changes in land use do not always occur simply and efficiently. Often, before the land can be converted to a new use, it lies derelict and abandoned for a period. In all member states of the Community, therefore, derelict land constitutes a small but significant proportion of the total area.

Figure 6.4 **Rainfall erosivity in the European Community.**



Source: data from CORINE data base

In recent years, the stock of derelict land in the European Community has been subject to two, contradictory developments. On the one hand, increasing public awareness of dereliction has led to increased efforts at restoration. On the other hand, economic stagnation and structural adjustments in industry have tended to generate more derelict land, especially in urban areas. Thus, at best, the extent of derelict land is probably declining only slowly, and in some member states may actually be increasing.

Unfortunately, it is difficult to assess the magnitude of dereliction in the Community, due to the lack of consistent data. To a large degree this reflects the varied character of derelict land. Dereliction results from a wide range of processes, including abandonment of industrial infrastructure, demolition, dumping of wastes, and excavations. Thus derelict land may be taken to include unrestored mine spoil, disused quarry sites, abandoned railway land, disused urban and military areas, abandoned agricultural land and many other forms. Not surprisingly, the definition of all these classes of land tends to vary from one member state to another, and even in one area over time. Consequently, care is needed in making comparisons, even when data do seem to be available.

Some indication of recent developments, however, is provided by the data in Figure 6.5. This shows changes in derelict land in England between 1974 and 1982. Over this period, a total of 17,000 ha of derelict land was restored, 53% of it from spoil tips, excavations and tips and about a quarter from urban land. But at the same time more than 19,000 ha of new derelict land were created, mainly as a result of urban decay and abandonment. As a result, the stock of derelict land rose from 43,273 ha to 45,683 ha. The limitations of these data must nevertheless be stressed: at least part of this apparent increase is likely to be due to changing perceptions of derelict land in response to changing public awareness of the problem.

How typical these data are of other areas in the Community is therefore difficult to say. What is clear is that dereliction remains a problem, but that far better data are needed in order to show the distribution of dereliction and to monitor changes in its extent.

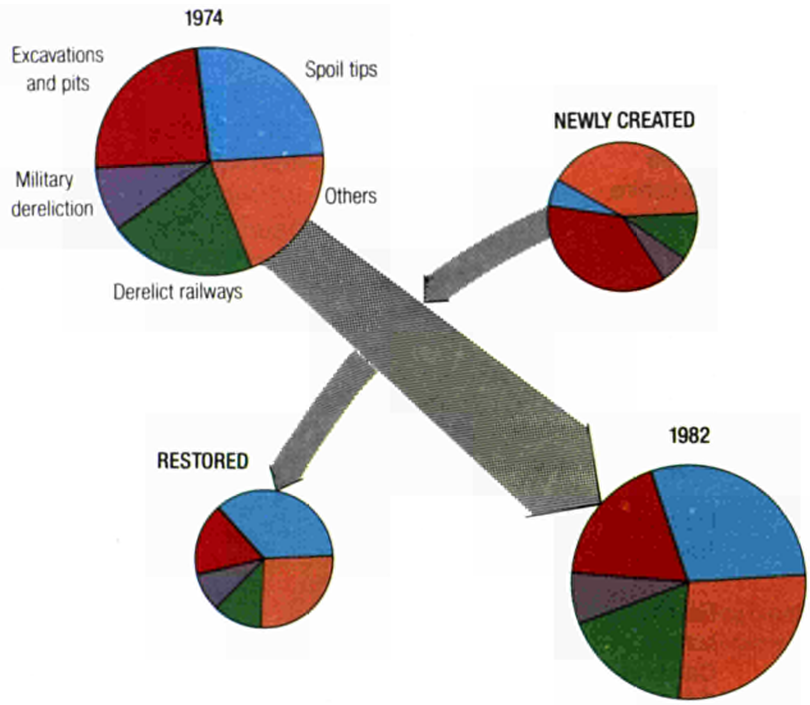
6.3.4 Coastal Erosion

Although data on the extent of coastal erosion in the European Community are generally lacking, the seriousness of the problem should not be underestimated. In many areas of the Community, loss of coastal land to the sea is causing considerable concern. The conditions favouring erosion are well-known. Soft coastal rocks, open exposure and strong longshore currents all encourage erosion. In addition, the problem is often exacerbated by human activities: in particular by the quarrying of beaches for sand and gravel or by the removal of the protective vegetation cover. Even activities far-removed from the beach may have a detrimental effect. Construction of reservoirs, or attempts to control erosion on agricultural land, for example, reduce the supply of sediment to the coast and destabilise the coastal system. As a consequence, coastal erosion may be increased.

Rates of erosion at specific sites and more general coastal zones are shown in Table 6.4. Although all these data are subject to considerable uncertainty, they indicate that rates of land loss may locally be severe. In particular, erosion is most active along exposed, soft sediment coasts such as those in southern Italy, south-west France and eastern England. Based on these data, it is therefore possible to identify regions which may be under the greatest threat from erosion. These are shown in Figure 6.6, though far more data are necessary if the real problems of coastal erosion are to be tackled.

Nor is erosion easy to control once it is initiated. In the past, emphasis has generally been placed on engineering responses, such as the construction of groynes and sea walls. In a number of cases, however, these have been applied in response to short-term erosion events, which although

Figure 6.5 **Changes in the extent of derelict land in England, 1974-1982.**



Source: data from Department of the Environment 1975, 1985

dramatic would normally be reversed by natural depositon. In addition, many attempts at coastal protection have been applied only on a piecemeal basis. As a consequence, erosion may be reduced locally, but the effect is to disrupt the existing system of sediment erosion and deposition along the coast as a whole. This results in the problem simply being transferred elsewhere. Like so many environmental problems, therefore, coastal erosion needs to be tackled at a much broader scale and in an integrated manner: actions should consider the whole environmental system implicated in the problem, and should embrace not only engineering methods but also more wide-ranging adjustments in land use.

6.4 SOIL POLLUTION

The soil is suceptible to pollution from a wide range of sources and by a wide range of substances. Heavy metals such as cadmium, mercury, lead and copper may seep from industrial plants, from tankers or mine spoil, or may accumulate as a result of spreading sewage sludge on the land. Pesticide and fertiliser residues and trace elements in fertilisers (e.g. cadmium) may build up to toxic levels as a result of repeated applications. In addition, atmospheric pollutants are washed from the air or deposited as dust, even thousands of kilometres from their source.

Table 6.4 **Rates of coastal erosion in the European Community.**

Member state	Locality	Geology	Erosion rate (m/y)
United Kingdom	Humberside	Glacial drift	0.3-3.3
	Norfolk	Glacial drift	0.2-5.7
	Suffolk	Glacial drift	0.6-5.1
	Kent	London Clay	0.7-3.4
	South Coast	Chalk	0.05-1.0
	Wales	Lias shale	0.008-0-10
	Yorkshire	Lias shale	0.02-0.04
	N. Ireland	Glacial drift	0.2-0.8
France	Somme	Chalk	0.08-0.37
	Seine Maritime	Chalk	0-0.4
	Camargues	—	1.5-4.0
	Landes	—	1-3
	Manche	—	1.0
	Aquitaine	—	~ 5.0
	Charente-Maritime	—	0.5-2.0
Germany	Helgoland	Sandstone	~ 1.0
	Baltic Coast	Glacial clay	0.6-2.0
Italy	Romagna	Dune sands	< 9
	Latium	Dune sands and marls	2.5
	Calabria	Alluvium	1.2-3.3
	Calabria	Sands and gravel	8-11
	Golfo di Tarento	—	4

Sources: see Notes and Sources, page 206.

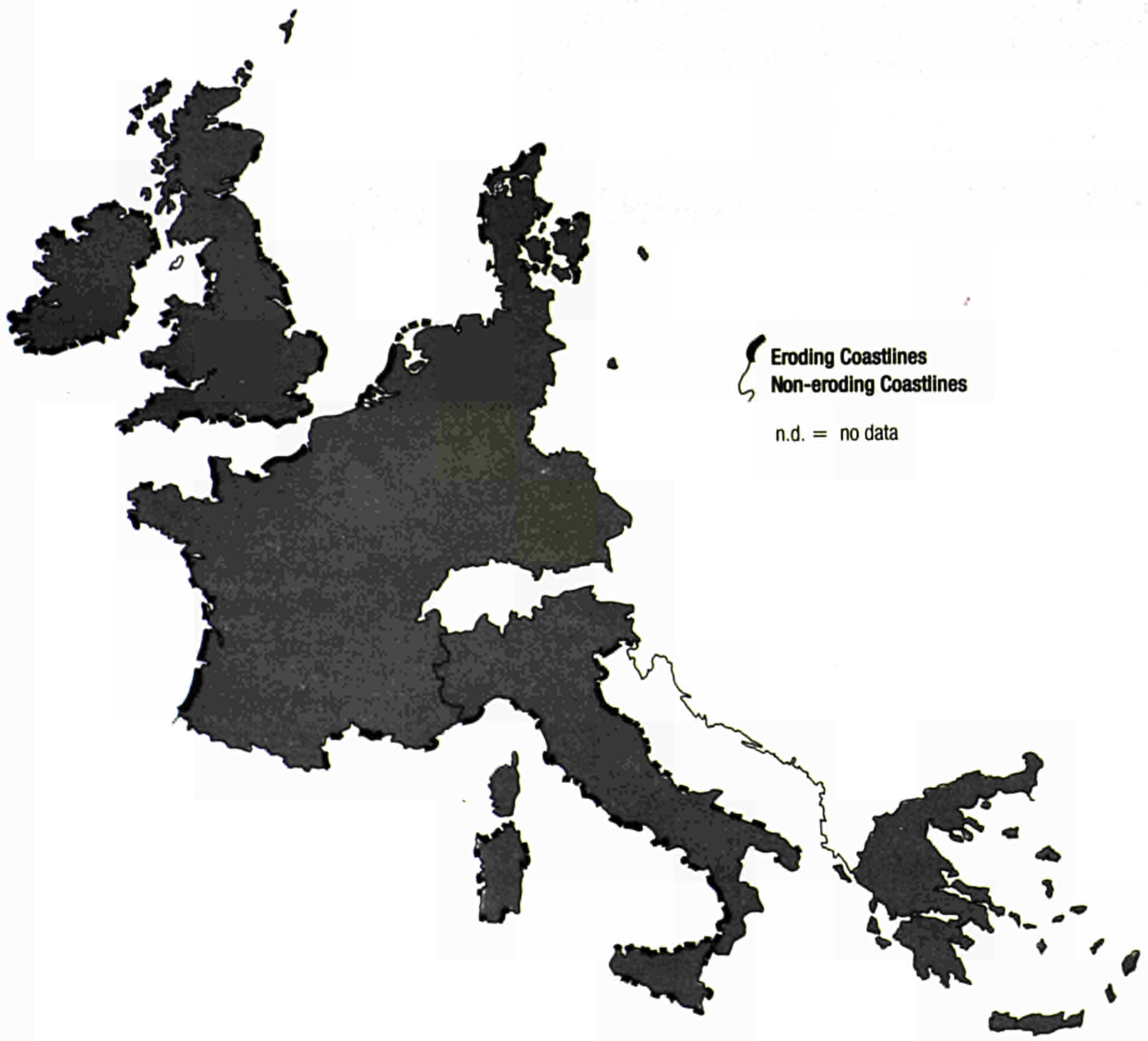
All these pollutants may have serious effects on land resources. The soil itself may be contaminated by metals and other compounds, or may be acidified and deficient in nutrients due to excessive leaching. As a result the growth of agricultural or forest crops may be impaired. In addition, direct damage may be done to the vegetation as a result of the accumulation of dusts or acids on the leaves. This inhibits photosynthesis and may cause die-back of the foliage.

These effects, however, are not always obvious. Acute problems of soil pollution or vegetation damage are normally localised - for example, in the immediate vicinity of a pollution source - and may therefore be missed by general surveys. More widespread effects of pollution, such as those arising from atmospheric pollutants, are often subtle and not easily detected; especially as the surrounding areas may be equally affected so that there is no unpolluted 'standard' to act as a comparison. Nevertheless, it is becoming increasingly clear that the effects may be economically as well as ecologically significant. Overall, the costs - in terms of lost production, remedial measures and compensation - may be considerable.

6.4.1 Soil Acidification

The lack of data on long term changes in soil acidity means that we have no clear picture of the problem of soil acidification in the European Community. It is, however, apparent that significant changes in acidity may greatly affect soil fertility and crop growth. The solubility of most

Figure 6.6 **Coastal erosion in the European Community: zones with high rates of erosion.**



Sources: see notes and sources, page 206

Plate 6.5 **One of the main sources of soil pollution is the spreading of sewage sludge derived from urban areas (especially areas including metal manufacturing and related industries) may contain significant quantities of heavy metals which accumulate in the soil and are washed into ground and surface waters.**

Photo: D. J. Briggs

plant nutrients and the activity of soil organisms are both dependent upon soil pH, and if soil acidity increases too much (i.e. if soil pH falls below about 4.5) then serious problems of nutrient deficiency and toxicity may develop.

These problems are not necessarily produced by human activity. Soil acidification is, in fact, a natural process which takes place in all temperate environments. It involves the gradual removal (leaching) of bases such as calcium, magnesium, potassium and sodium from the soil and their replacement by hydrogen or aluminium ions. The process depends upon a number of factors but is generally most active under conditions of high rainfall, and nutrient deficient (acidic) vegetation (e.g. heathland, pine forest).

In agricultural soils, however, various other factors are involved. Organic manures supply acids which enhance the removal of nutrients. More importantly, inorganic fertilisers release anions which encourage leaching, while improvements in drainage and irrigation increase the throughput of water. Afforestation may have similar effects, for most coniferous trees produce organic acids which take part in chelation, while the uptake of bases from the soil (and thus their return to the surface in litter fall) is limited. As a result, rates of leaching and acidification tend to be markedly higher under agricultural and forestry crops than under natural vegetation. To counteract this effect on agricultural soils, lime has traditionally been applied, but in recent years rates of application appear to have declined in many countries, and soils are probably becoming more acidic.

In recent years, too, another source of acidification has become apparent. Emissions of sulphur dioxide and nitrogen oxides from industry, domestic fuels and traffic are increasing the availability of atmospheric acids. These are either washed from the atmosphere by rain or deposited in dust and by impact with vegetation. The effect is to provide acids to the soil which accelerate rates of leaching and chelation and reduce soil pH. Acid deposition is therefore seen as an important contributor to soil acidification.

However it is caused, soil acidification may have important effects on soil fertility. Nutrients are lost by leaching. The activity of soil organisms is inhibited so that the processes of organic matter breakdown and nutrient cycling are impaired. Iron, manganese and aluminium may reach toxic concentrations. Root enzymes may be suppressed. Plants therefore suffer from a combination of macro-nutrient deficiencies and micro-nutrient toxicity. Yields of agricultural crops fall; forest growth is retarded.

The effects at a Community level are difficult to determine. The main areas where acidification has been reported are in the United Kingdom and Germany. Some of the most thorough studies have been in Germany and Figure 6.7 shows an example. It illustrates the distribution of soil pH values for samples of forest soils from the period 1953-1970 and in 1981. The general differences between the two distributions are clear. There was a decline in the frequencies of samples in pH classes above 3.7-3.8, but an increase in classes below this level. Thus, the average pH fell from about 3.95 in 1953-70 to 3.79 in 1981.

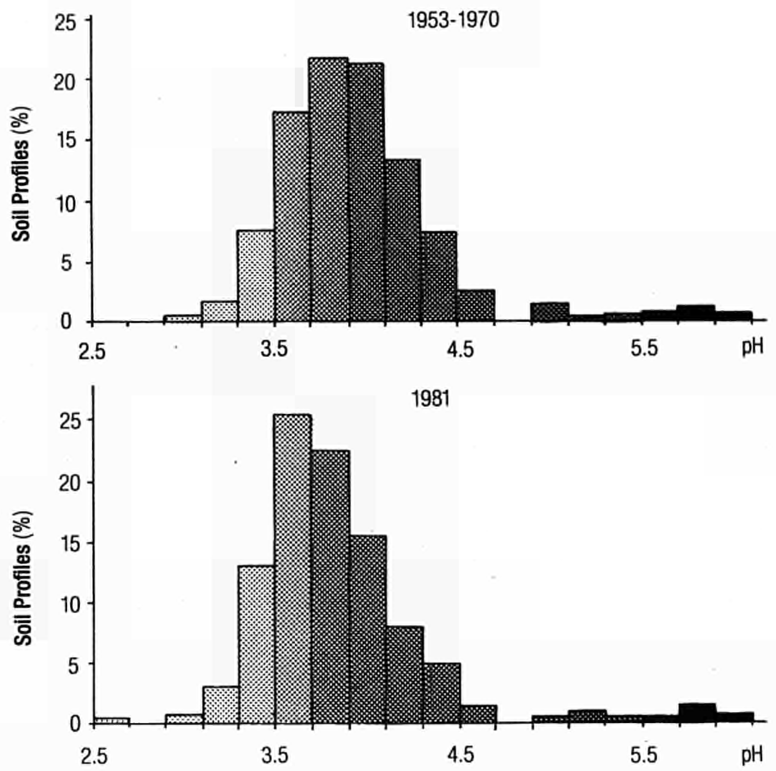
Table 6.5 **Sources of soil acidification: percentages of total acid input from different sources under different crop and vegetation types.**

	CROP/VEGETATION			
Source of acidity	Agricultural crops	Peat bog	Spruce forest	Pine forest
Nitrification of fertiliser	65-80	—	—	—
Plant growth	—	—	20-40	5-10
Harvesting	—	—	10-15	0-10
Organic matter decomposition	—	70-90	20-40	10-15
Soil respiration	10-20	—	—	0-5
Acid deposition	5-20	10-30	25-50	60-80

Source: after Environmental Resources Ltd 1983

This change is clearly small but, in soils which are relatively acid to start with, is likely to be significant if generally valid. The implication of this study is that the fall in pH is due to the effects of acid deposition though, because of the short time period of the second survey, other factors (such as random climatic fluctuations) could be important. Certainly, acid deposition can have an effect on soil pH, but equally certainly it is not necessarily the major effect. In agricultural soils for example, nitrification of fertilisers is generally much more important, often accounting for 60-80% of the input of acidity to the soil (Table 6.5). In this context, the increased use of nitrogenous fertilisers and associated decline in the use of lime are undoubtedly significant. Surveys in England in 1969-1970 and 1974-1975, for example, showed that soil pH had declined significantly in grassland soils, but had remained stable in arable land (Table 6.6). This was attributed to lack of lime applications; since the early 1970s, rates of application nationally have been below those needed to replenish calcium losses due to leaching and nitrification. Almost certainly this effect is widespread in a number of member states.

Figure 6.7 **The pH of soils in Germany, 1953-1970 and 1981.**



Source: data from Umweltbundesamt 1984

6.4.2 Radioactivity

A considerable proportion of the atmospheric emissions of radioactivity find their way back to the ground. They do so by a variety of processes, including rainwash, dry deposition and impaction. In addition, small quantities of radioactive materials may be spread on the land in contaminated slurries and composts (e.g. seaweed) or may seep into soils from wastes. In these ways, they collect in or on the vegetation, may be ingested by livestock, and enter the human body in foodstuffs.

Table 6.6 **Changes in soil pH in England, 1969-1970 to 1974-1975.**

	Percentage of soils in pH range			
	Grassland soils		Arable soils	
	< 5.5	5.5-6.0	< 5.5	5.5-6.0
1969-70	8	27	2	4
1974-75	13	31	2	6

Source: after G.W. Cooke 1983

Milk provides the most important pathway for this intake, for cattle consume large quantities of herbage and concentrate the radioactive materials in their milk. Levels of radioactivity in milk therefore give a good indication of intake in foodstuffs, and data on radioactivity in selected member states are shown in Figures 6.8 and 6.9. The two radionuclides considered both show clear trends, with a marked decline in levels in milk since the early 1960s. Over this time, strontium-90 levels have fallen to about 10-20% of their peak values, while caesium-137 activities are now less than 10% of the 1963-1965 level.

The reason for this decline is well-established. It reflects the reduction in emissions from nuclear weapons testing - historically the dominant artificial source of these radionuclides. Because the data are average values, however, taken from stations scattered throughout the Community, they do not show the locally high levels of radioactivity which still occur close to emission sources. Of particular significance in this context are nuclear fuel reprocessing plants, such as Sellafield in the United Kingdom and La Hague in France. Clearly these areas remain a matter of concern, and regular and detailed monitoring needs to be continued at these localities to ensure that adverse human health effects are avoided.

6.5 CONCLUSIONS

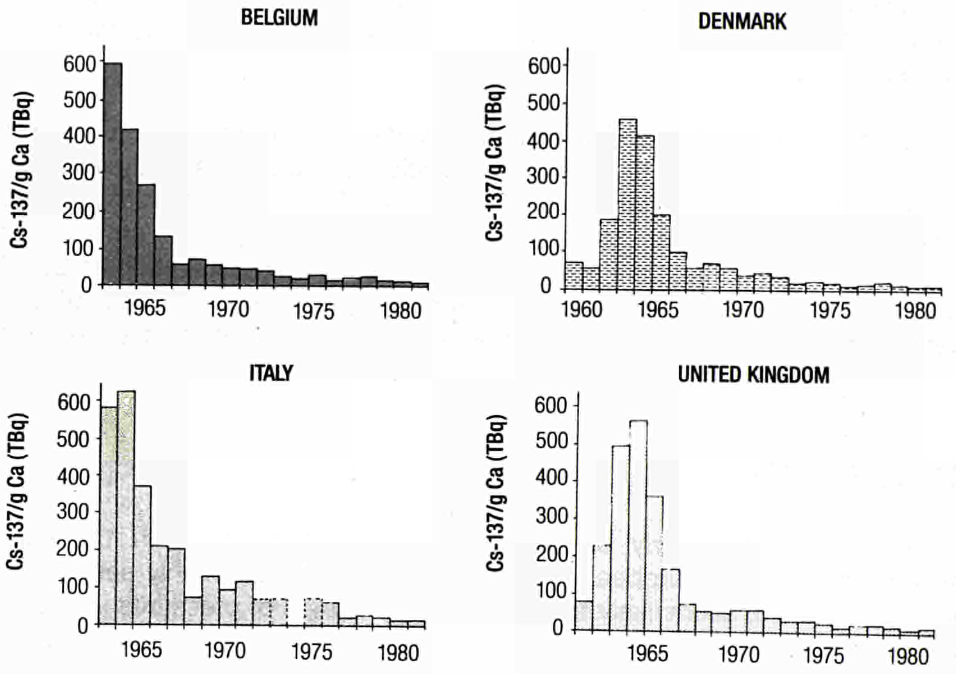
Land resources are clearly of fundamental importance to both the economy and environmental well-being of the European Community. They are also highly sensitive and, under present methods of land use, seem likely to be subject to a range of pressures including losses to non-agricultural uses, soil erosion, pollution (by agrochemicals, radioactivity, heavy metals, and acid deposition) and coastal erosion. Many of these problems stem from the release of industrial and urban wastes into the environment. Yet other problems may exist (such as the impacts of tourism, soil structural deterioration and salinisation) about which little is known at present.

The need for Community action on these problems is clear. To date, concern has mainly been with evaluative studies of particular areas (e.g. mountain zones, forests, coastal areas) rather than the development of broader, integrated policies to protect land resources. In the future, more direct action, and more detailed recommendations for general policy development, may be necessary. Already the need is becoming apparent in the case of forest damage, but other problems such as soil erosion, coastal erosion and soil acidification may well be equally severe.

To make credible and specific proposals for action and policy development, however, more information is clearly needed on land resources. It is all too obvious that present data on the land are scanty, fragmented and often inconsistent. As a result we simply do not know enough about the real extent of problems, whether they are getting worse over time, or whether current measures to combat them are being successful. Put simply, more baseline data are required, and more monitoring of land resources is needed.

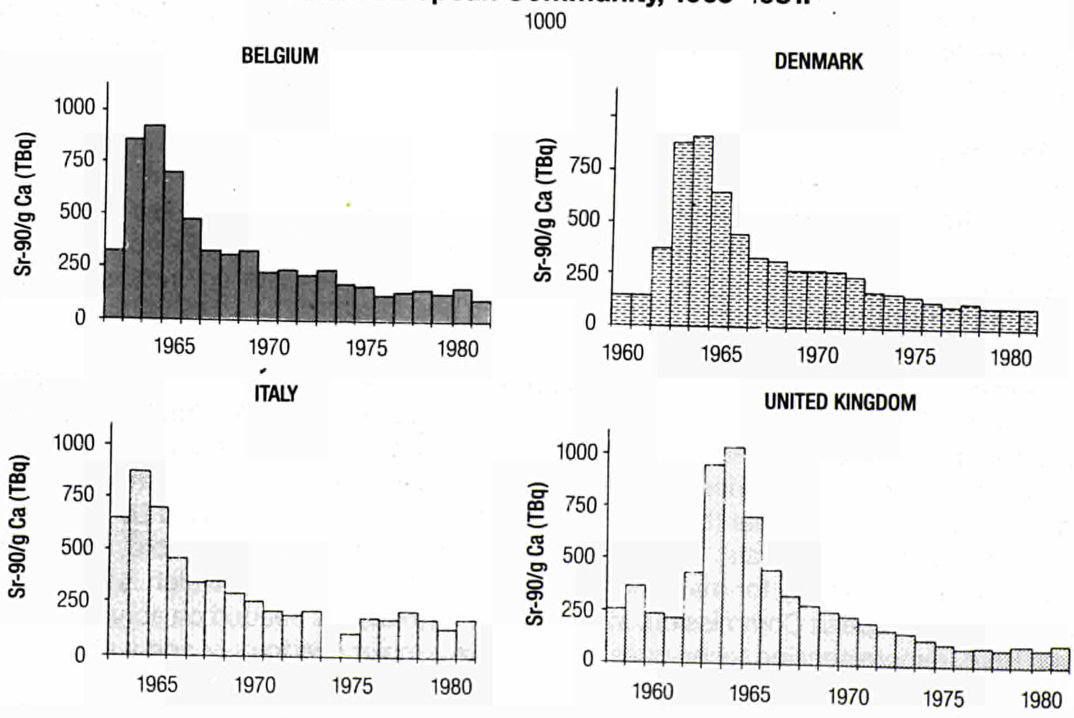
A first and crucial step in this direction has already been taken with the compilation and publication of the Soil Map of the European Community. This will provide vital basic data on soil resources. It is, however, only a means to an end. What are also needed are methods to evaluate the quality of land resources for agriculture. This can be achieved in general terms by improving assessments of biomass potential (by the use of the Community Soil Map and by collecting data from a greater number of climatic stations). In more detail, it requires reliable and consistent assessments of land suitability for major crops and livestock - an exercise which is currently being undertaken by the European Commission. In addition, information is needed on actual land use and land cover. Here, remote sensing techniques clearly have a major role to play, and a study is already under way to develop and apply a consistent land cover classification based on satellite imagery across the whole Community, as part of the CORINE programme (see Inset, pages 28-29). Similarly, the CORINE programme includes projects to compile provisional maps of of the extent of land

Figure 6.8 **Annual mean concentrations of caesium-137 in milk in the European Community, 1963-1981.**



Source: data from Commission of the European Communities 1983

Figure 6.9 **Annual mean concentrations of strontium-90 in milk in the European Community, 1963- 1981.**



Source: data from Commission of the European Communities 1983

susceptible to soil erosion, and the distribution of important land resources, for the Mediterranean region. Another urgent need is for data on derelict land and the extent of coastal erosion. These, too, may be obtainable from remotely sensed imagery. One thing is clear. Only if better data on land resources are available will it be possible to ensure that sensitive and relevant policies are adopted which tackle the real problems of the land before they become irreparable.

THE LLOBREGAT: A TYPICAL MEDITERRANEAN STREAM

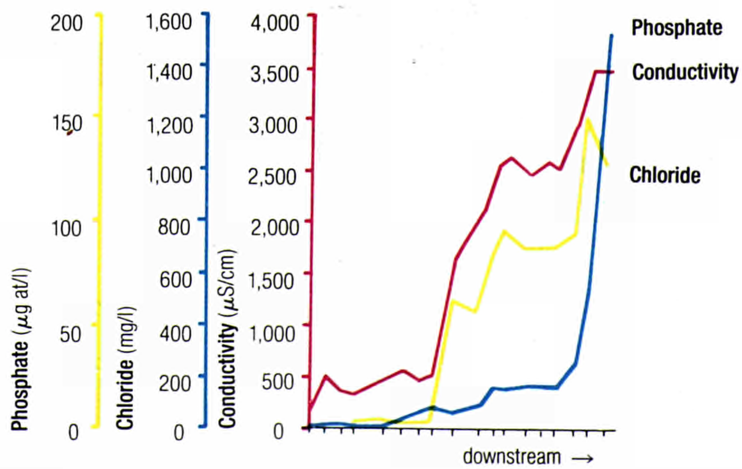
The Llobregat, in north-east Spain, is not a large or spectacular stream. It has a length of only 145 km, and drains a river basin of no more than 5000 square kilometres. Compared to the mighty Rhine or the Meuse, therefore, its problems are small. Yet in many ways it is typical of a large number of Mediterranean streams.

It rises at a spectacular and beautiful spring in the Cadi Mountains of the Pre-Pyrenees then flows south-east, across Catalonia to the Mediterranean. In its upper reaches, it passes through forest and sparse pastureland; the pressures on the stream are few. In its middle zone, however, agriculture becomes more intensive, and there are numerous reservoirs and dams storing water for local industry and for village water supplies. Its lower reaches are heavily urbanised and industrialised, and especially in the tributary valleys of the Anoia and Riera de Rubi, there are numerous textile factories and paper mills. These produce large volumes of toxic wastes.

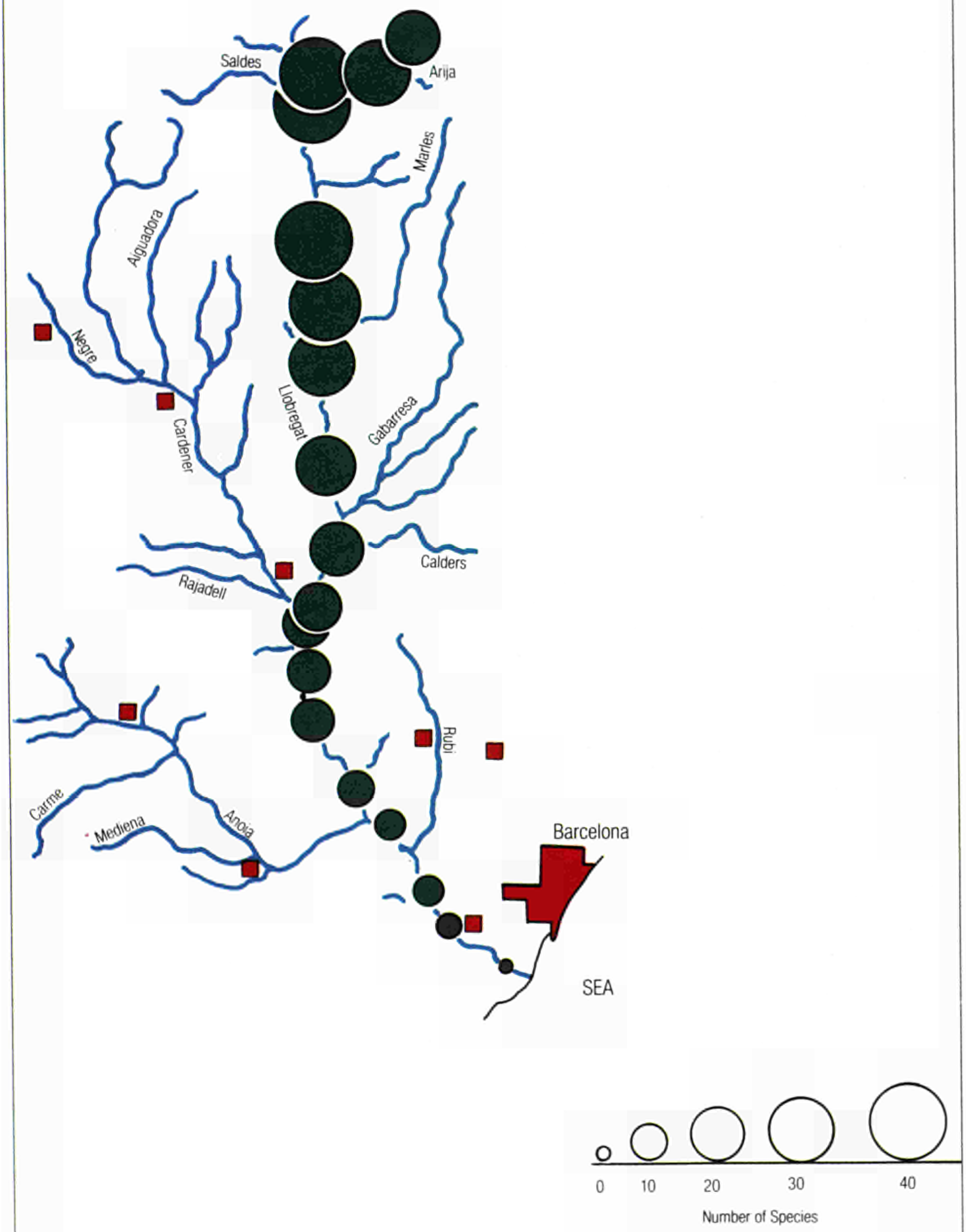
At the same time, the population density of the river basin is high, with an average population density of about 116 persons per square kilometre. Yet there are almost no sewage treatment plants in the river basin, so the wastes - both from the villages and from industry - are discharged directly into the stream. In addition, considerable quantities of water are abstracted for irrigation and public water supply. Together with the marked seasonality of rainfall, this results in a highly variable discharge: during the summer, when the flow is at its lowest, pollution concentrations are often excessive.

The pattern of pollution and some of its ecological consequences are shown in the figures below and opposite. Downstream, phosphorus concentrations, BOD, COD and conductivity all increase markedly. The dissolved oxygen content falls slightly. As a result, the character of the fauna changes also. In the upstream areas it is abundant and diverse. In the lower half of the river basin, however, the fauna becomes much more restricted. Filter-feeding species occur, in response to inputs of sewage and increased organic pollution loads. Ultimately, these too disappear as the river becomes deeper, as oxygen levels decline and as the concentration of urban pollutants increases.

Trends in chemical parameters down the Llobregat.



The ecology of the Llobregat.



Source: Whitton, B.A. (ed.) 1984 *Ecology of European rivers*. *London*: Blackwell

NOTES AND SOURCES

Data availability

Despite the crucial importance of land resources to the economy and ecological stability of the European Community, data on the state of the land remain inadequate. Soil survey and land capability or suitability information, for example, is available for many countries, but the classification systems used vary markedly and make comparisons or cross-border interpretations difficult. Similarly, although many detailed research studies have been carried out of problems such as soil erosion, coastal erosion and soil pollution, Community-wide information is generally lacking. Consequently, this chapter relies to a great extent on results from individual and often disparate research investigations of doubtful comparability. The data therefore provide no more than local or regional pictures of the state of, or trend in, land resources in the Community.

Notes on Figures

Figure 6.5 Data used to compile this figure derive from many different sources and are thus likely to be highly variable in quality and reliability. For this reason, no attempt can be made to quantify rates of coastal erosion. In general, however, all the areas indicated are likely to experience erosion rates of 0.1 m/y, at least over significant lengths of the coastline, and often rates are likely to reach 0.5 - 1.0 m/y. No data are available for Greece or northern Germany.

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CHAPTER 7.

INLAND WATERS

7.1 INTRODUCTION

7.1.1 The Importance of Inland Waters

Streams, lakes, canals, reservoirs and groundwaters are important components of the environment for a wide variety of reasons. First and foremost, they are a crucial natural resource, supplying water not only for domestic consumption but also for industrial, agricultural and other uses. Domestic sewage, industrial effluents and agricultural wastes are often released into streams, where natural processes of dilution, decomposition, transport and deposition reduce their potency and remove them from their source. Surface waters also act as routeways for commercial traffic and are widely used for boating, fishing, bathing, water sports and other forms of recreation. Moreover, they are rich natural habitats, feeding and breeding grounds for a large range of mammals, birds, amphibians, fish, insects, crustaceans and some reptiles.

The very diversity of these functions inevitably creates problems. Few of the activities are compatible with each other, so that exploitation of inland waters for one use almost invariably constrains their use for other purposes. Waste disposal and sewage release, for example, reduce the suitability of the waters for consumption and their quality as habitats or recreational features. Water sports and boating disturb wildlife. Transport produces pollutants and restricts recreational activities. Conservation of aquatic habitats for ecological reasons imposes limitations on other uses of the water (e.g. for waste disposal, transport and recreation).

7.1.2 Pressures on Inland Waters

As this implies many of the pressures on inland waters are a direct product of their use. Removal of water for consumption, release of effluents into the water and changes to the physical configuration of streams and lakes are all carried out as part of the process of exploitation. The effects are to modify both the flow and quality of the water.

In addition, however, many pressures on inland water arise as side-effects of other activities, often far-removed from the streams or lakes themselves. Fertilisers, pesticides, organic wastes and sediments, for example, may be washed from agricultural lands by surface runoff or drainage waters or may percolate into aquifers. Chemical pollutants, oil, heavy metals and other residues may seep into streams and groundwaters from industrial waste tips, or be washed from roadways.

Significant quantities of pollutants may also enter inland waters from the atmosphere either in rainfall or through processes of interception and dry deposition. Furthermore, natural processes of erosion, deposition, vegetation succession and climatic change may all alter the quality and flow of stream and lake waters.

In recent decades, the impact of these processes has become increasingly apparent, with the recognition in many cases of high levels of aquatic pollution and widespread problems of eutrophication. Particular problems have arisen in large, international rivers such as the Rhine and in intensively used, enclosed lakes such as the Norfolk Broads in England, the Bodensee in Germany and Lake Magiore in Italy. Additionally, concern has grown in the last few years about the effects of acid deposition on inland waters (especially lakes, reservoirs and canals), and about the problems of groundwater pollution by nitrates and hydrocarbons.

7.1.3 Community Policies and Inland Waters

Because of the importance of inland waters, and because of their sensitivity to damage, much attention has been directed to the development of Community policies aimed at protecting these waters from the adverse impacts of human activities. Some of the more significant actions are listed in Table 7.1.

Possibly the most far-reaching action has been the so-called 'Dangerous Substances' Directive which was adopted in 1976 with the intention of reducing or eliminating water pollution by listed substances. This identified two lists of substances: List I included all those considered, by definition, to be toxic, persistent and bioaccumulable, and therefore requiring the most stringent control; List II included substances considered to be less dangerous, levels of which nevertheless need to be reduced. Two different strategies of control were to be applied. List I substances were to be subject to strict emission limit values and quality objectives; List II substances were to be subject to quality objectives, defining the maximum permissible levels in the environment.

In the event, some difficulties were encountered in adopting the Directive, with the United Kingdom resisting the limit value approach. Consequently, a compromise was reached, permitting the member states which wished to do so to control List I substances by quality objectives instead. Moreover, the definition of limit values for List I substances was recognised as being a lengthy process, requiring the adoption of 'daughter' Directives for each specific group of listed substances. Thus, until the necessary daughter Directives were passed, all List I substances were to be treated as List II substances.

Since 1976, five daughter Directives, dealing with six substances, have been adopted: namely mercury, cadmium, HCH (lindane), DDT, pentochlorphenol and carbon tetrachloride. In addition, 129 substances have been identified for urgent consideration as List I substances. These include pesticides such as aldrin, dieldrin and endrin.

Other actions relevant to inland waters include Directives defining quality objectives for surface waters intended for bathing, for abstraction for drinking and for waters needing protection or improvement in order to support fish life. In addition, two Directives have been agreed which limit waste emissions from the titanium dioxide industry and a proposal for a third Directive on this subject is pending. Moreover, in recognition of the severe problems in obtaining consistent data on the quality of surface waters, a Decision was adopted in 1977 establishing a common system of monitoring within an agreed network of measurement stations throughout the Community. As will be seen in the next section, this has already provided a great number of data on stream water quality.

7.2 TRENDS IN WATER QUALITY

Many substances pollute stream waters. Pesticides enter the waters from adjacent farmland. Nitrates and phosphates come from fertilisers, animal wastes, urban slurries and sewage. Metals such as cadmium, nickel, mercury, copper and zinc are derived from industrial effluents, slurries and agricultural wastes. Detergents are discharged from industry and households. Sediment

Table 7.1 **Community actions on inland waters.**

DATE	ACTION	ABBREVIATED TITLE	OBJECTIVE
1975	Directive (75/440)	Quality of surface waters intended for drinking	Defines quality of freshwater intended for human consumption
1976	Directive (76/160)	Quality of bathing waters	Defines quality and measuring procedures
1976	Directive (76/464)	Dangerous substances discharged into aquatic environments	Provides system of listing dangerous substances and framework for defining limit values and quality objectives
1977	Decision (77/795)	Exchange of information on the quality of surface freshwater	Sets up network of monitoring stations and defines procedures
1977	Decision (77/586)	Protection of the Rhine against chemical pollution	Concludes international convention on protection of the Rhine
1978	Directive (78/176)	Waste from the titanium oxide industry	Defines measures for handling wastes in order to reduce pollution and encourage recycling
1978	Directive (78/659)	Quality of freshwaters for fish	Defines quality of freshwaters intended to support fish life and lays down monitoring procedures
1979	Directive (79/869)	Measurement and analysis of surface waters intended for drinking	Defines monitoring procedures
1980	Directive (80/68)	Protection of groundwater against pollution	Prevents or limits discharge of dangerous substances into groundwaters
1980	Directive (80/778)	Quality of water for human consumption	Lays down water quality standards and defines monitoring procedures
1982	Directive (82/883)	Monitoring of wastes from the titanium oxide industry	Defines monitoring procedures
1982	Directive (82/176)	Mercury discharges by the chlor-alkali industry	Defines limit values and quality objectives
1983	Directive (83/513)	Cadmium discharges	Defines limit values and quality objectives
1984	Directive (84/)	Mercury discharges by sectors other than the chlor-alkali industry	Defines limit values and quality objectives
1984	Directive	Discharges of HCH and lindane	Sets limit values and quality objectives
Proposed	2 Directives	Discharges of aldrin, dieldrin and endrin	To set limit values and quality standards for discharges
Proposed	Directive	Harmonisation of actions on titanium oxide wastes	Defines procedures for co-ordinating actions
Proposed	Directive	Discharges of List I substances (DDT,PCBs)	Sets limit values and quality objectives
Proposed	Directive	Quality objectives for chromium	Sets quality objectives

Source: Commission of the European Communities 1984

is produced by urban and industrial discharges and by soil erosion, both from farmland and urban land. Thermal pollution occurs as a result of hot brine discharges from power stations and industrial plants.

All these pollutants alter the quality of the water and they thus effect the biological activity which takes place in the streams. Under extreme conditions, the populations of aquatic organisms may even be killed off and the waters become sterile. This has considerable significance, not only in ecological terms but also because of its impact on self-purification and waste disposal processes. The organisms in the inland waters play a major role in breaking down many of the pollutants, fixing others in their bodies, and immobilising the residues in the sediments when they die. If organic activity declines, so does the ability of the stream or lake to cope with pollutants.

Nor are the effects of chemical and thermal pollution confined to the streams themselves. Inland waters provide routeways through which substances are carried to the sea. The less decompositon and immobilisation that occur in the stream, the greater the quantity of pollutants reaching the sea. In addition, of course, the organisms which inhabit inland waters are but part of wider ecosystems; effects on their populations may have more extensive impacts on species higher up the food chain. Heavy metals or pesticide residues absorbed by fresh-water plants and insects, for example, may accumulate in fish and thence in birds of prey. As the classic studies in the U.S.A. have shown, ultimately the pollutants may reach toxic levels in the predatory waterfowl.

Over recent decades inputs of pollutants to inland waters have undoubtedly risen, and in many parts of the Community, the quality of inland waters have deteriorated. But is this trend still continuing? Or have the changes in economic circumstances, which have led to a decline in industrial activities in some areas, reduced the pressure on inland waters and allowed water quality to recover? Have, also, the environmental actions taken by the Community and its member states started to reduce pollution? Have the improvements in effluent and sewage treatment facilities led to better water quality? Or has the continued growth in levels of fertiliser application increased damage to inland waters? These questions will be considered in this section.

7.2.1 The 'Exchange of Information' on Surface Freshwater Quality

In the realm of stream water quality, as elsewhere, a major need is for data. Most member states do, in fact, monitor water quality, but the sampling methods, analytical techniques, sampling frequencies and, to a lesser extent, the parameters considered vary markedly from one country to another (and between individual measurement stations). This has considerable significance, for many streams cross national boundaries and are thus of international concern.

It was with these issues in mind that the European Council adopted a Decision, in December 1977, to set up a system for the exchange of information on fresh water quality. This had the objectives of characterising levels of stream pollution as a basis for orienting Community policy on prevention of water pollution; monitoring the long term trends in water quality and improvements due to national and Community actions; and providing a means of comparing results from the selected measurement stations. For this purpose, member states nominated measurement stations according to the following criteria:

i. they should be representative of general conditions in the streams and should not be directly influenced by pollution sources;

ii. they should in general be no more than 100 km apart, and on the principal rivers (excluding tributaries);

iii. they should be situated upstream of confluences and should not be under any marine influence;

iv. they should have the capacity to measure the selected parameters.

On this basis, a total of 92 measurement stations were defined, in the then nine member states (i.e. excluding Greece) (Figure 7.1). Since then, amendments to the Decision, adopted in 1981, have extended the network to Greece, although as yet no results have been reported.

Each of these agreed to provide information on fifteen water quality parameters, while a further three parameters were to be measured where possible. These are listed in Table 7.2. Measurement techniques were not prescribed, but guidelines were established for reporting results, including the description of sampling and measurement procedures.

Data within the Exchange of Information have been available since 1976 but have not yet been analysed beyond 1981. It is, therefore, too early to identify significant long term trends, although in the following sections of this report some of the data from the system will be presented to show recent changes in water quality. But, in addition, caution is needed in interpreting the results for a number of reasons.

Most obviously, data are in some cases incomplete. Administrative problems, delays in installing equipment, and instrumental failure amongst other things cause gaps in the record. In the case of the heavy metals, also, observed values are often below the minimum threshold of the measurement technique. And, to date, Italy has transmitted few data for any of its sixteen measurement stations.

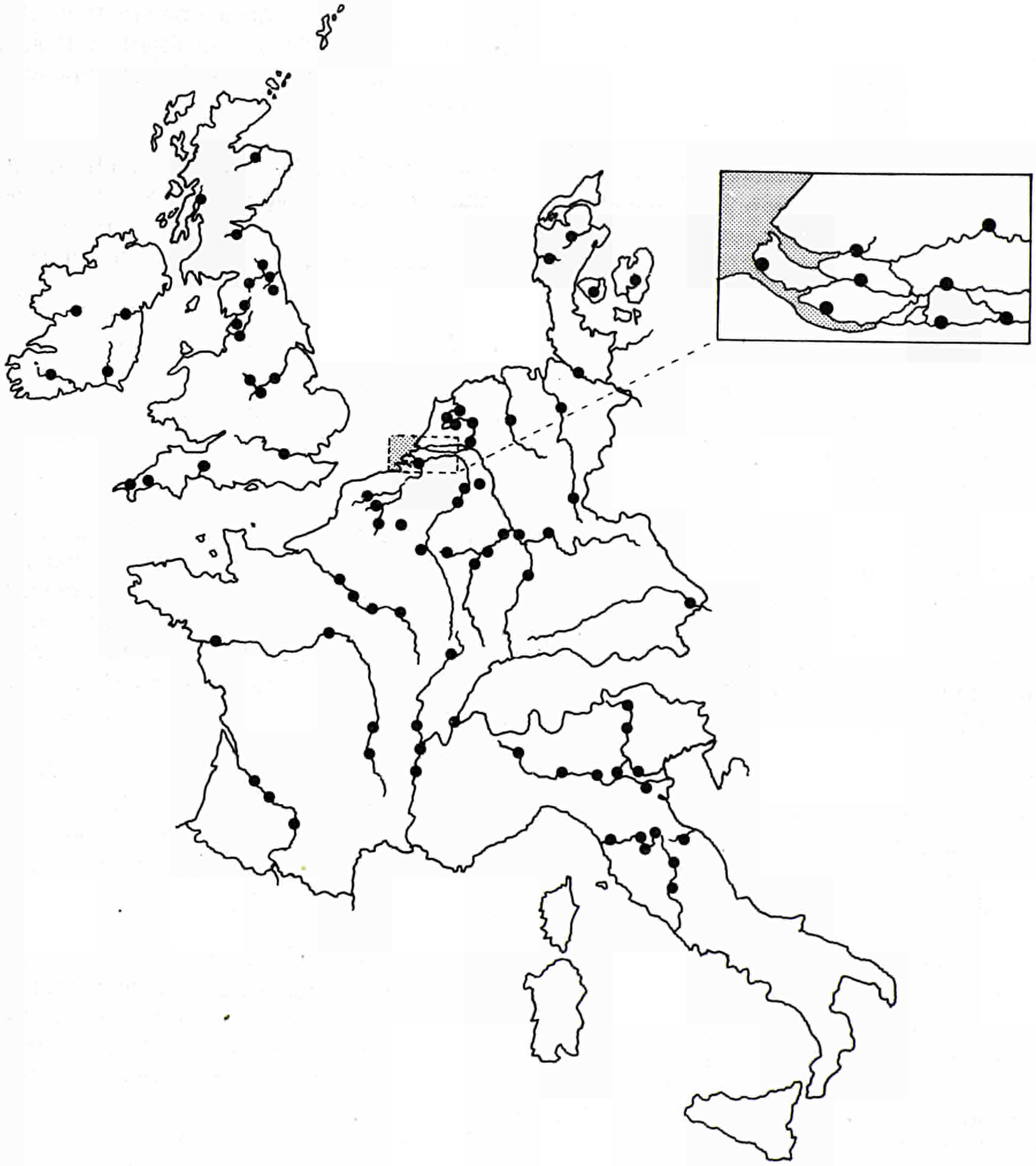
Less apparent, but also important, are the differences in measurement and sampling methods and frequencies. Sampling frequencies, for example, vary from as few as two per year at some sites in Belgium, to weekly at some sites in the Netherlands and United Kingdom. How representative the less frequent measurements are of annual conditions is uncertain. Moreover, despite the criteria set out in the Community Decision, it is not clear that the sites themselves are representative of the reach in which they lie. In Belgium, most stations lie downstream of urban areas; in Germany and the United Kingdom in contrast, they tend to be upstream of towns.

Notwithstanding these problems, the data do give a broad indication of the state of the stream water quality in the Community. Results are summarised in Figure 7.2, which shows for six parameters for which there is sufficient information, the quality status of each measurement station. As can be seen, the parameters vary in broad sympathy with each other, so that distinct differences can be discerned in overall water quality from one area to another.

Although it is early days to start deciphering long term trends, these data also give an indication of changes in stream water quality over recent years. Results are summarised in Table 7.2, which shows for each station for which there is sufficient data the trend in the measured quality parameters (whether improving or deteriorating). Overall the pattern is clear. At almost all stations the quality of the water is improving. The main improvements are in conductivity, chloride, ammonium, dissolved oxygen, BOD5, COD, phosphorus and detergents. The only parameter generally to be deteriorating is nitrate content. Improvements are most extensive in the Netherlands, reflecting perhaps the efforts made in the last ten years to clean up the Rhine and its distributaries. Less improvement (or even a tendency for declining quality) is seen in several French and British rivers, notably the Seine, Garonne, Soane, Tyne and Thames. These are, in any case, relatively clean.

The reasons for these trends will be discussed in more detail later, but crucial factors are undoubtedly improvements in sewage treatment and reduced discharges from industry.

Figure 7.1 **Major streams and sampling stations included in the Community's Exchange of Information on freshwater quality.**



Source: data from Commission of the European Communities 1986

Table 7.2 **Trends in water quality parameters in Community rivers.**

LOCATION	Temp	pH	Cond	Cl	NO_3	NH_4	O_2	BOD5	COD	P	Dets	Cd	Hg	FC	TC
Lanaye, Meuse					−	+	+			+	+		−	−	−
Maxay, Rhine			+			+	+								
Mainz, Rhine						+	+		+						
Koblenz, Rhine						+	+		+						
Palzem, Moselle			+	+		+			+						
Kleve, Rhine			+	+		+	+			+		+			
Goch, Niers			+	+	−	+		+		+					
Herbrum, Ems			−	−				+	+						
Hemeln, Weser			+	+	−	+				+					
Intschade, Weser			+	+	−	+									
Geesthacht, Elbe				+		+	+			+		+			
Montereau, Seine	−				−										
Melum, Seine	−				−										
Paris, Seine	−				−		+								
St. Rambert, Loire					−	+	+			−	+			+	
Nantes, Loire					−	+									
Roanne, Loire							+				+				
Orleans, Loire						+	+				+				
Toulouse, Garonne						+		+	+					+	+
Auxonne, Saone					−					−	−				
Mulatiere, Saone			+	+											
Pont-Carnot, Rhone							+			−	+				
Lyon, Rhone			+	+			+	+	+		+				
St. Vallier, Rhone			+	+			+				+				
Wasserbillig, Sure					−	+									
Lobith, Bovenrijn	+	+	+	+		+	+	+	+	+	+	+	+	+	+
Kampen, Ijssel	+	+	+	+		+	+	+	+	+	+	+	+	+	+
Gorkum, B. Merwede	+	+	+	+		+	+	+	+	+	+	+	+	+	+
Vreeswijk, Lek			+	+		+	+	+	+		+		+		
OM-42, Oude Maas						+	+			+	+		+		
HM-34, Nieuwe, Maas			+	+	+	+	+	+		+	+	+			
Eijsden, Maas	+	+	+	+		+	+	+		+	+	+	+	−	+
Lith, Maas				+		+	+	+		+	+				
Keizersveer, Bergse			+	+		+	+			+	+		+		
N10-H9, Haringvliet				+	+	+		+			+		+		
N11-H12, Haringvliet				+	+	+	−	+			+				
N12-IJ12, Ketelmeer	+	+	+	+	+	+	+		+	+	+	+	+		
N13-IJ23, Ijsselmeer				+	−					−	+				
Derwenthaugh, Derwent				+	+	+									
Tregony, Fal						+	+	+							
Halton, Lune			−			−	+								
St. Michaels, Wyre				+	+										
Salmesbury, Ribble									−						
Chetwynd, Tame			+	+	+	+		+							
Nottingham, Trent			+	+	+	+	+	+			+				
Yoxal, Trent			+	+	+	+		+			+				
Craigiehall, Almond									+						
Renton, Leven								+							

Notes: Temp - temperature; Cond - conductivity; Cl - chloride; NO_3 - nitrate; NH_4 - ammonium; O_2 - dissolved oxygen; BOD5 - biochemical oxygen demand. COD - chemical oxygen demand; P - total phosphorus or orthophosphate; Dets - detergents; Cd - cadmium; Hg - mercury; FC - faecal coliforms, TC - total coliforms.

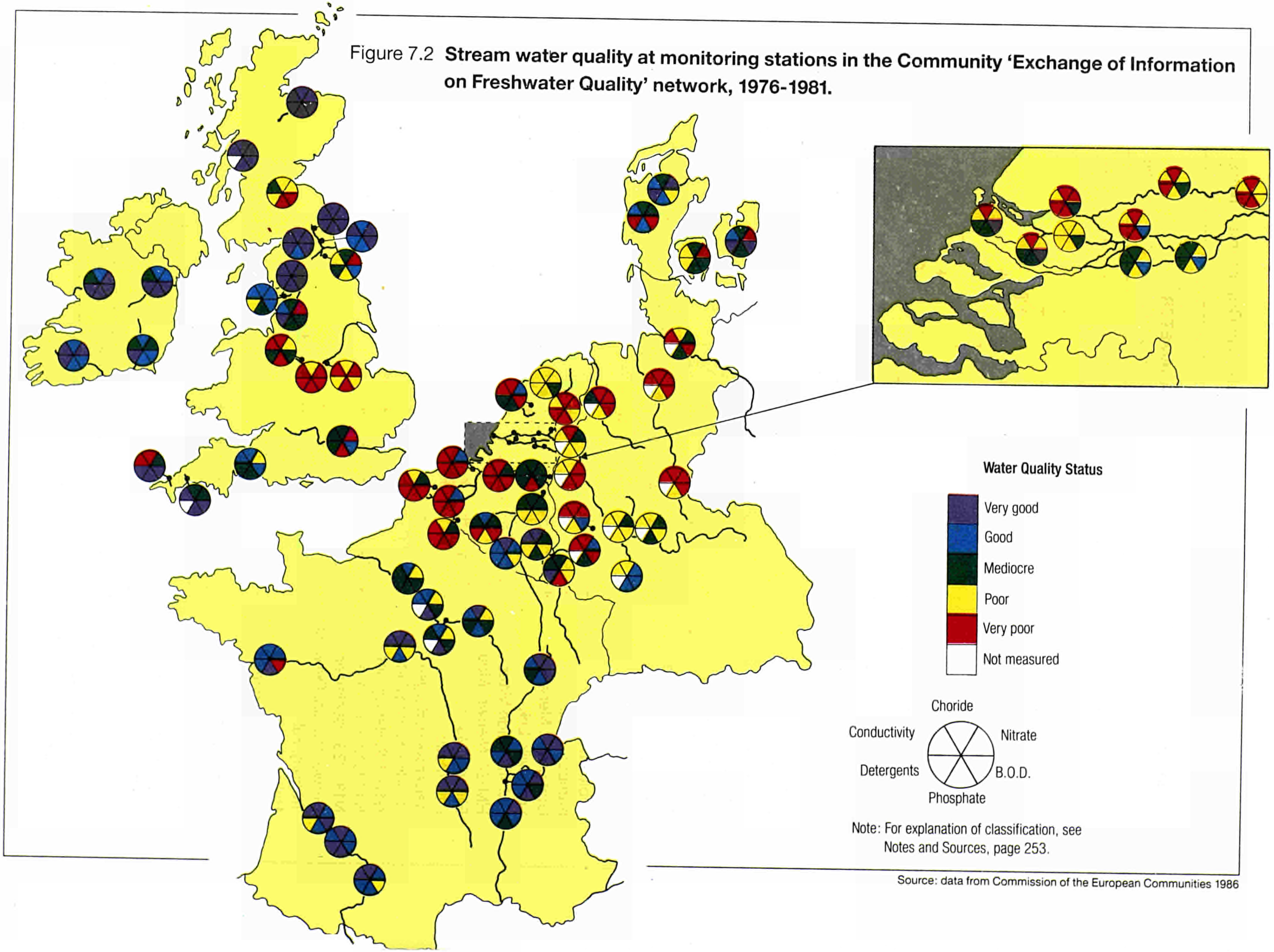
(N B. discharge, faecal streptococh and salmonella also measured at some sites, but no trends distinguishable.)

'+' improvement, '− deterioration; ' ' no change or not measured.

Sites showing no trends in any parameters not included.

Source: data from Commission of the European Communities 1986

Figure 7.2 **Stream water quality at monitoring stations in the Community 'Exchange of Information on Freshwater Quality' network, 1976-1981.**



Source: data from Commission of the European Communities 1986

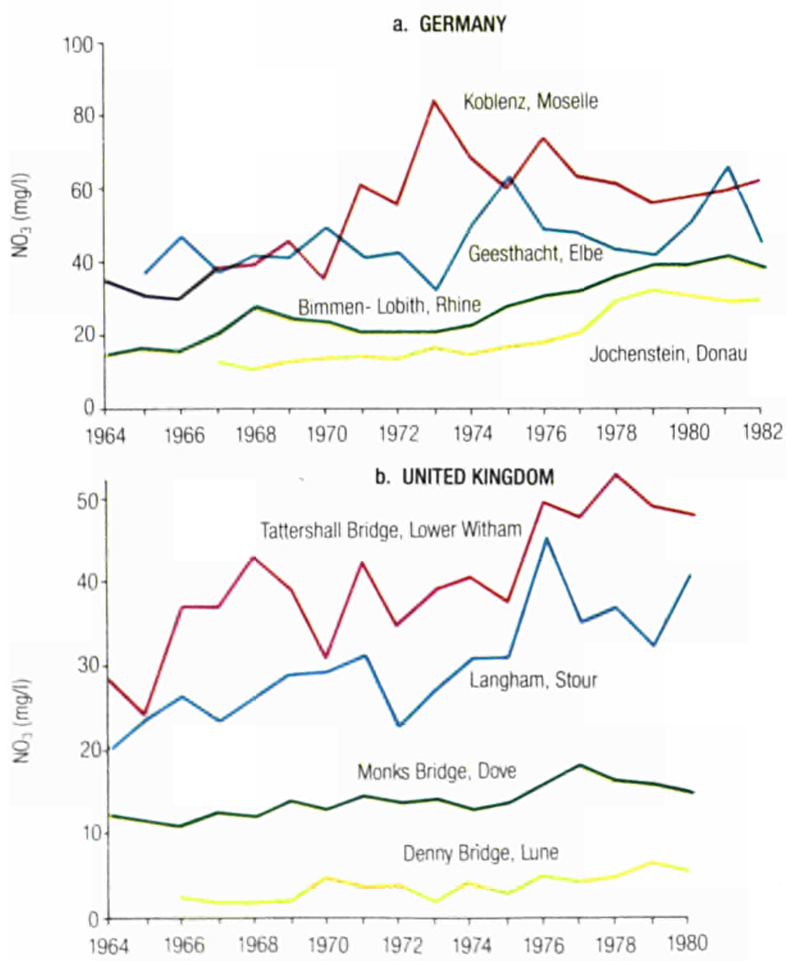
7.2.2 Nitrogen and Phosphorus

Nitrates and phosphates undoubtedly represent some of the more important pollution problems affecting inland waters. Not only can they affect organic activity and ultimately lead to eutrophication, but they may also pose a threat to human health. High levels of nitrate, for example, may lead to methaemoglobinaemia, especially in children, and the World Health Organisation (WHO) recommend a 'safe' limit of 10.0 mg per litre of nitrate-nitrogen in drinking water. In accordance with this, a limit of 50 mg/l NO_3 (equivalent to 11.3 mg/l NO_3-N) has been adopted by the Community in its legislation on water for human consumption.

There is, however, widespread evidence that nitrate levels in many inland waters are increasing. Figure 7.3 presents long term data for a range of sites in Germany and the United Kingdom, while Figure 7.4 summarises results from stations in the 'Exchange of Information'. Although they may not be wholly representative, they probably reflect the range of situations found within member states.

On the whole the trends for nitrate are consistent. At many sites, nitrate concentrations have risen progressively over the last 10-20 years, although in some cases there has been a slight decline or a period of stability since the late 1970s. This trend appears to occur irrespective of the

Figure 7.3 **Long-term trends in nitrate-nitrogen levels in selected streams in Germany and the United Kingdom.**



Sources: data from Umweltbundesamt 1984; Department of the Environment 1985 station locality (e.g. whether urban or rural), but proportionally the rate of increase in nitrate levels is slightly greater in rural sites. The pattern generally reflects increasing inputs from fertilisers and animal wastes. Inputs from industrial and domestic sources conversely may have fallen in several instances due to the combined effects of reduced economic activity and improved sewage treatment.

Total phosphorus and orthophosphate concentrations are somewhat less consistent (Figure 7.5). Many stations show a significant decline in phosphate concentrations in recent years, following a general rise during the 1960s and early 1970s. The cause of this pattern cannot be identified with certainty, but it possibly reflects the combined effects of reduced industrial activity in some areas, improved sewage treatment, and changes in detergent formulations over the last 5-10 years. Counteracting this to some extent, however, has been a continued rise in inputs from fertilisers.

7.2.3 Heavy Metals

Because of their persistence and toxicity, heavy metals present particular problems of pollution, and the Community is therefore taking action under the 'Dangerous Substances' Directive to control their release into stream waters. Numerous heavy metals occur as pollutants in the environment, but amongst the most important are cadmium, lead, mercury, zinc and copper. These are all harmful even at low concentrations, are readily absorbed by organisms, and are thus accumulated in food chains. The main sources of these are industrial activities such as metal processing, mining and chemical industries, and - to a lesser extent - agricultural chemicals such as fertilisers and pesticides. In addition, significant quantities of heavy metals are released by motor vehicles (see Table 5.2).

Changes in the intensity of some of these activities were outlined in Chapters 3 and 4. Data are scarce on actual discharges to streams, but in general it seems likely that inputs are currently declining following a long period in the 1950s to 1970s when they increased. In the Netherlands, for example, estimated discharges of cadmium fell from 30 tonnes in 1976 to 14 tonnes in 1979, while chromium discharges declined from 282 tonnes in 1977 to 129 tonnes in 1979. On the other hand, release of some heavy metals increased: lead rose from 113 tonnes to 163 tonnes between 1976 and 1979, while zinc rose from 782 tonnes to 919 tonnes over the same period.

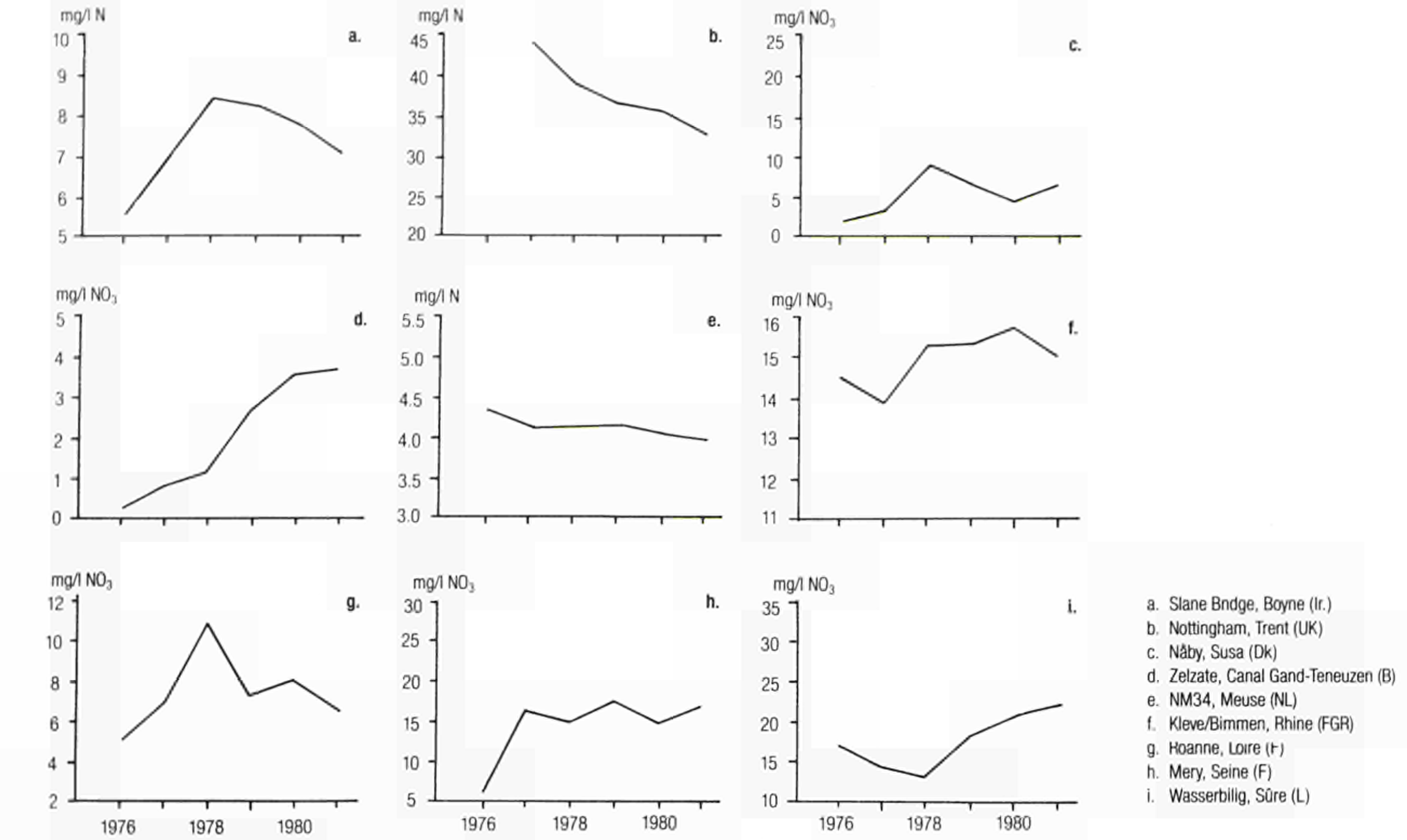
How representative these changes are of other areas is difficult to say. Changes in heavy metal concentrations in stream waters, however, are shown in Figure 7.6. Insofar as general trends can be distinguished it seems that concentrations of most heavy metals are falling. At Bimmen-Lobith on the Rhine, for example, lead concentrations declined from almost 60 μg/l in 1974 to about 13 μg/l in 1982. At the same site, cadmium levels fell from about 3.4 μg/l to about 0.7 μg/l between 1976 and 1982, while mercury levels were reduced from 0.75 μg/l to 0.15 μg/l. Similar changes are seen in many other rivers, including the Trent, Meuse, Rhone and Loire.

The causes of the improvements cannot be defined with certainty. In addition to the greater precision (and therefore lower thresholds) of analysis, three factors are probably involved: reductions in industrial activity, especially in metal-processing and related sectors; improved emission controls at source, partly at least due to the regulations already introduced or planned by the Community and member states; and improved effluent and sewage treatment prior to their release into streams. As ever, the relative importance of these different factors cannot easily be determined.

7.2.4 Biochemical Oxygen Demand and Dissolved Oxygen

Biochemical oxygen demand (BOD5) is defined as the quantity of oxygen consumed under constant conditions (incubation over five days at 20°C in darkness) by certain materials present in the water, principally as a result of degradation by biological processes. In other words,

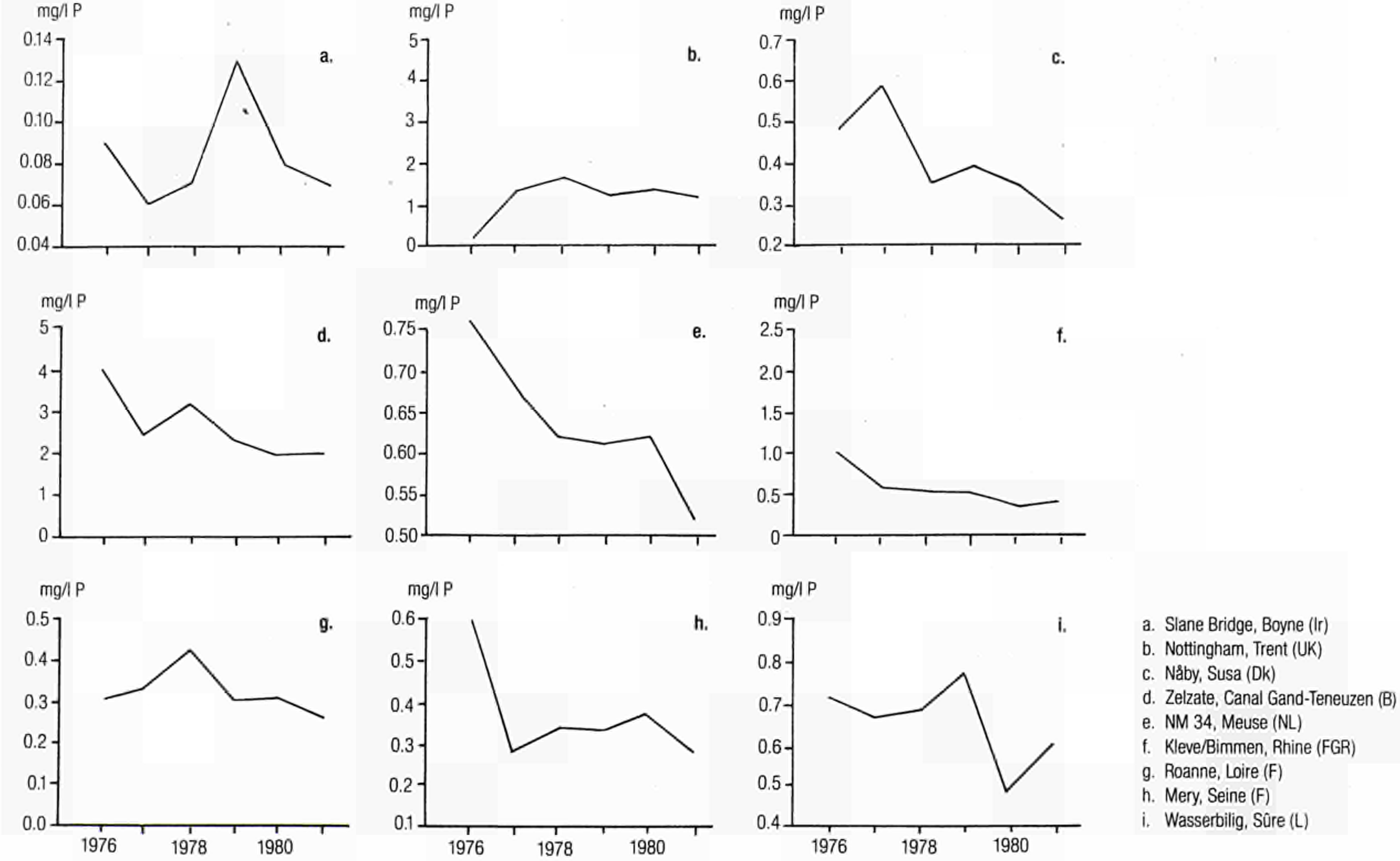
Figure 7.4 **Trends in nitrate-nitrogen concentrations in selected major streams in the European Community, 1976-1981.**



Note: Total organic nitrogen measured at Slane Bridge, Nottingham aznd NM34.

Source: data from the Commission of the European Communities 1986

Figure 7.5 **Trends in phosphorus concentrations in selected major streams, 1976-1981.**



Source: data from Commission of the European Communities 1986

the BOD5 is a conventional test which allows the estimation of the level of water pollution due to organic wastes capable of aerobic decomposition. As the quantity of these substances in the water rises, so does the value of BOD5.

In most streams and lakes, the main source of oxidisable materials is sewage or animal wastes. Thus, measurement of the biochemical oxygen demand gives a broad indication of the load of these substances in the water. As was noted in Chapters 3 and 4, inputs of these materials in the Community have been undergoing considerable and often contradictory changes in recent years. On the one hand, controls on dumping of animal wastes have become more stringent, while sewage treatment techniques and facilities have been improved. Changes in the actual load of oxidisable materials in inland waters - and thus in BOD5 levels - therefore depend on the balance between these developments.

Examples of recent changes in biochemical oxygen demand are indicated in Figure 7.7. As has already been noted, the general trend is towards reduced BOD5 levels, partly perhaps as a result of better sewage treatment and declining industrial activity. Partly, also, these improvements are likely to be a reflection of the actions taken to control water pollution, both at national and Community level. Interestingly, several of the stations which do not show this trend are in more rural, less heavily polluted sites, where the main inputs are probably from agricultural sources: these have not declined to the same extent.

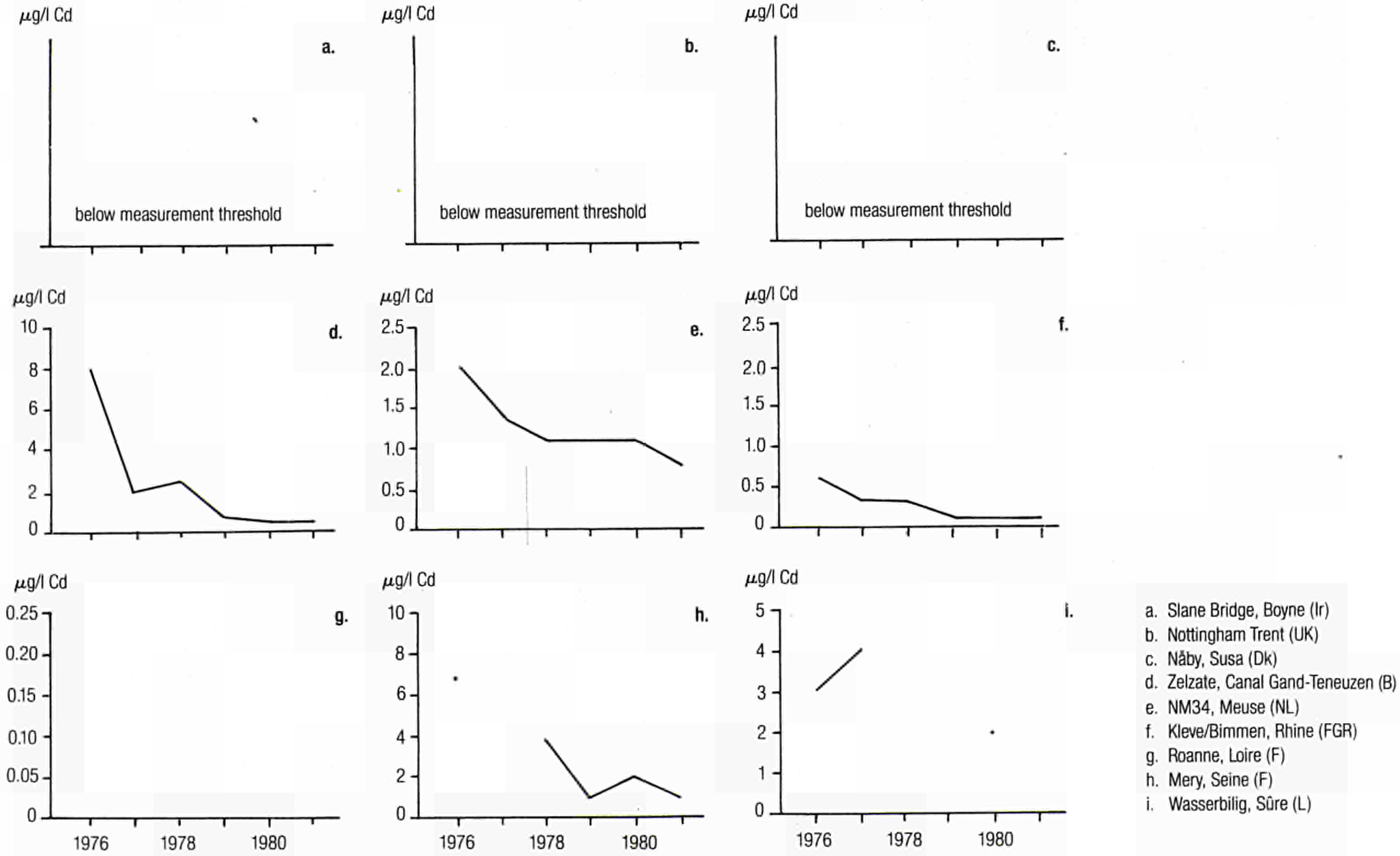
7.2.5 Water Quality Classifications

Although detailed measurements of individual substances provide an invaluable indication of the level of pollution of inland waters, they are often difficult to interpret and they do not give, in a single statement, a picture of overall water quality. For this reason, most member states have developed systems of water quality classifications based on rather more general criteria. The criteria used vary markedly from one country to another, but generally indicate the biochemical status of the waters. In Germany, for example, four quality classes (plus intergrades) are recognised, based essentially on a saprobic index and a measure of biochemical oxygen demand. In the United Kingdom, five classes are defined based, in much the same way, on biological and biochemical criteria. In France, a broadly similar classification is used.

In several member states, repeated surveys have been conducted using these classifications. These allow a general picture to be obtained of trends in water quality. Examples are shown in Figure 7.8, which suggests a general trend towards improved water quality, with a reduction in the proportion of measurement sites, or the length of rivers, in the poorest quality classes.

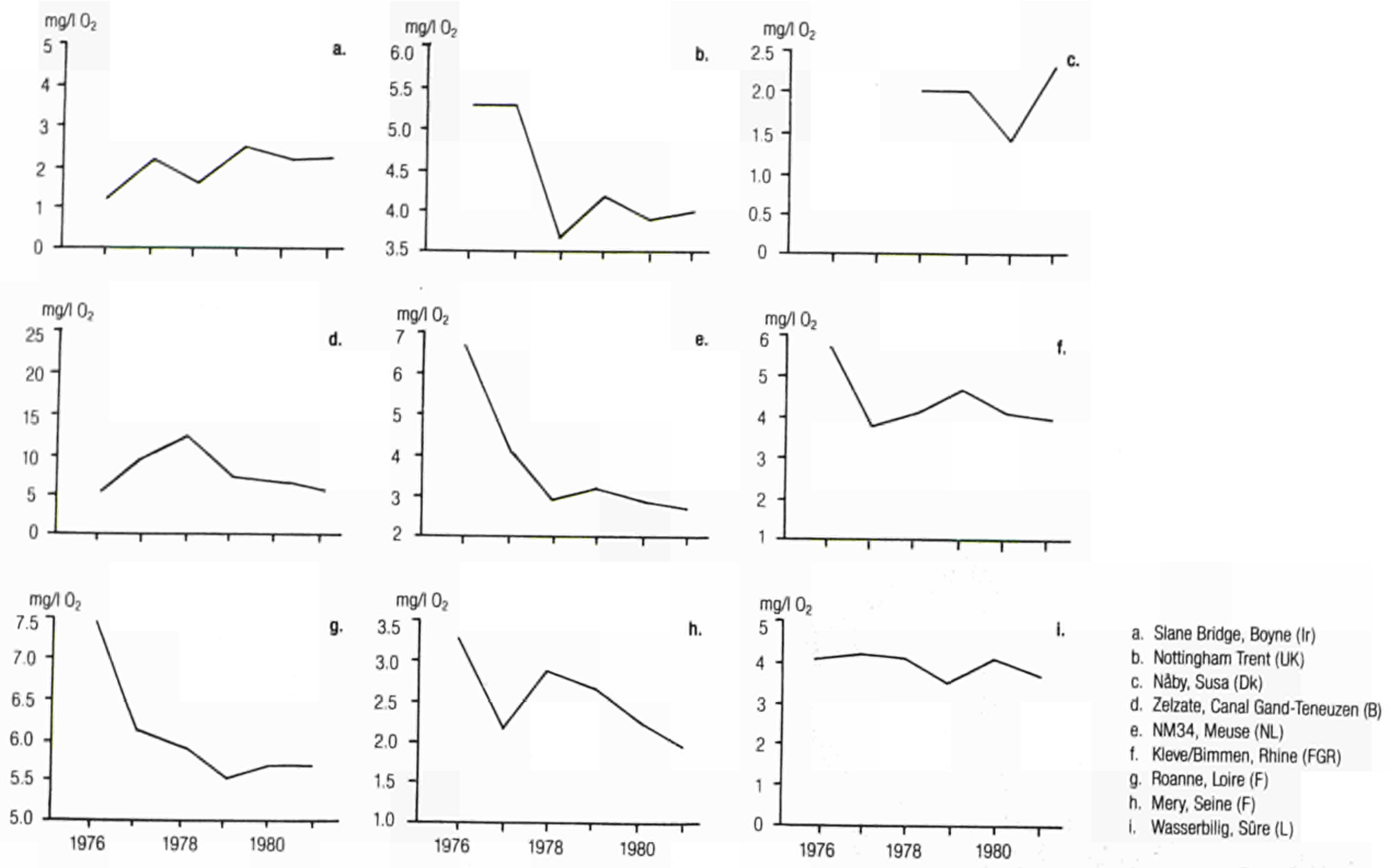
Reasons for these improvements cannot be adduced with certainty, but are likely to be varied. Not all the changes visible in the data are necessarily a result of actual changes in water quality - some are due to variations in measurement procedures. The apparantly marked improvement in France, between 1981 and 1982, for example, coincides with the inclusion in the survey of an extra 72 measurement stations, bringing the total to 205 sites. Nevertheless the reduced inputs of pollutants due to declining economic activity have almost certainly made a contribution, as have improvements in sewage treatment. In a number of cases (such as the Thames and Rhine) this has allowed fish to be reintroduced to what were previously polluted and almost sterile rivers. Environmental policies, both at national and Community level, have undoubtedly provided a force for pollution control and encouraged these improvements. On the other hand, inputs of fertilisers are probably still growing, as the trends in nitrate concentrations have indicated (Figure 7.3). The question for the future is whether this trend for improved water quality will continue.

Figure 7.6 **Trends in cadmium concentrations in selected major streams in the European Community, 1976-1981**



Source: data from Commission of the European Communities 1986

Figure 7.7 **Trends in biochemical oxygen demand (BOD5) in selected major streams in the European Community, 1976-1981**



Source: data from Commission of the European Communities 1986

Plate 7.1 **Eutrophication as a result of excess runoff of animal wastes in a small, enclosed river basin: Loch Ascog in Scotland.**

Photo: D. J. Briggs

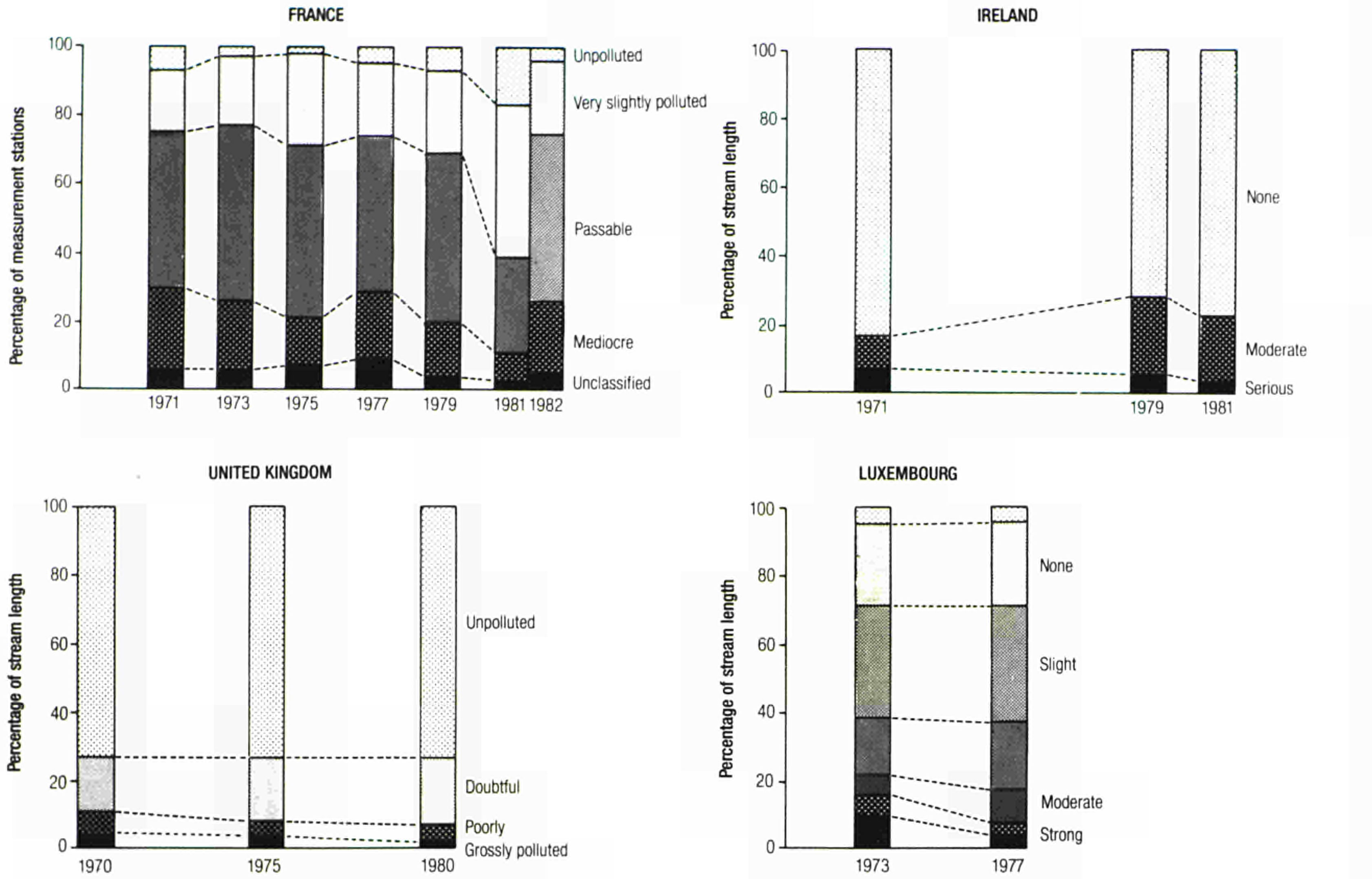
It is not an entirely optimistic view, for while further improvements in sewage control are likely to occur more slowly, inputs of agricultural wastes may well continue to increase. Renewed growth in economic activity may similarly lead to higher discharges from industrial sources. In these events water quality may again start to fall.

It should also be mentioned that in recent years a more flexible approach to water quality classification has been adopted in the Community. This focuses attention on the use to which the water is to be put. It is clearly a sensible approach because each use demands different quality objectives, and is affected to varying degrees by different polluting substances. To apply blanket controls on water quality, irrespective of its use, is consequently either costly (if the highest necessary objectives are set) or ineffective for some uses (if lower objectives are set). Instead, the Community has established classifications of water resources based on their use: different quality objectives are prescribed for drinking waters, waters supporting freshwater fish and bathing waters (see Inset, page 245). In the future, this approach is likely to be extended to other water resources.

7.3 CASE STUDIES OF MAJOR RIVERS

It is often said that nature knows no frontiers. Without doubt this is true of rivers, and in the case of the pollutants they contain it poses severe political as well as environmental problems, for the streams act as arteries through which the waste products from sources upstream are transported into lower reaches. *En route*, numerous processes of decomposition, dilution and deposition take place, but these rarely, if ever, remove the whole pollutant load. Moreover, while dilution reduces the concentration of polluting substances in the waters, it does not reduce the quantity transported downstream. And similarly, while decomposition may convert the original substances into new forms, it does not necessarily reduce their toxicity. Thus, the effluents from one site become the unwanted inputs to sites downstream.

Figure 7.8 **Changes in water quality in selected member states according to national quality classifications**



Sources: data from Ministère de l'Environnement 1984; Cabot 1985; Department of the Environment 1985; STATEC 1985

IMPROVING THE COMPARABILITY OF WATER QUALITY CLASSIFICATIONS IN THE COMMUNITY

The varied systems of stream water quality classification used in member states (and the lack of any classification in others) makes it difficult to obtain a comprehensive picture of the state of inland waters in the Community. Since the rivers themselves respect no political boundaries, this creates grave difficulties for management and policy development. An agreed and practicable method of water quality evaluation which can be applied across the whole Community would therefore be a useful tool. This would make it easier to define where the most urgent problems lie, and where the most appropriate point for action occurs. It would also help to show whether actions being taken are operating with equal success throughout the Community (or even throughout individual cross-border river basins).

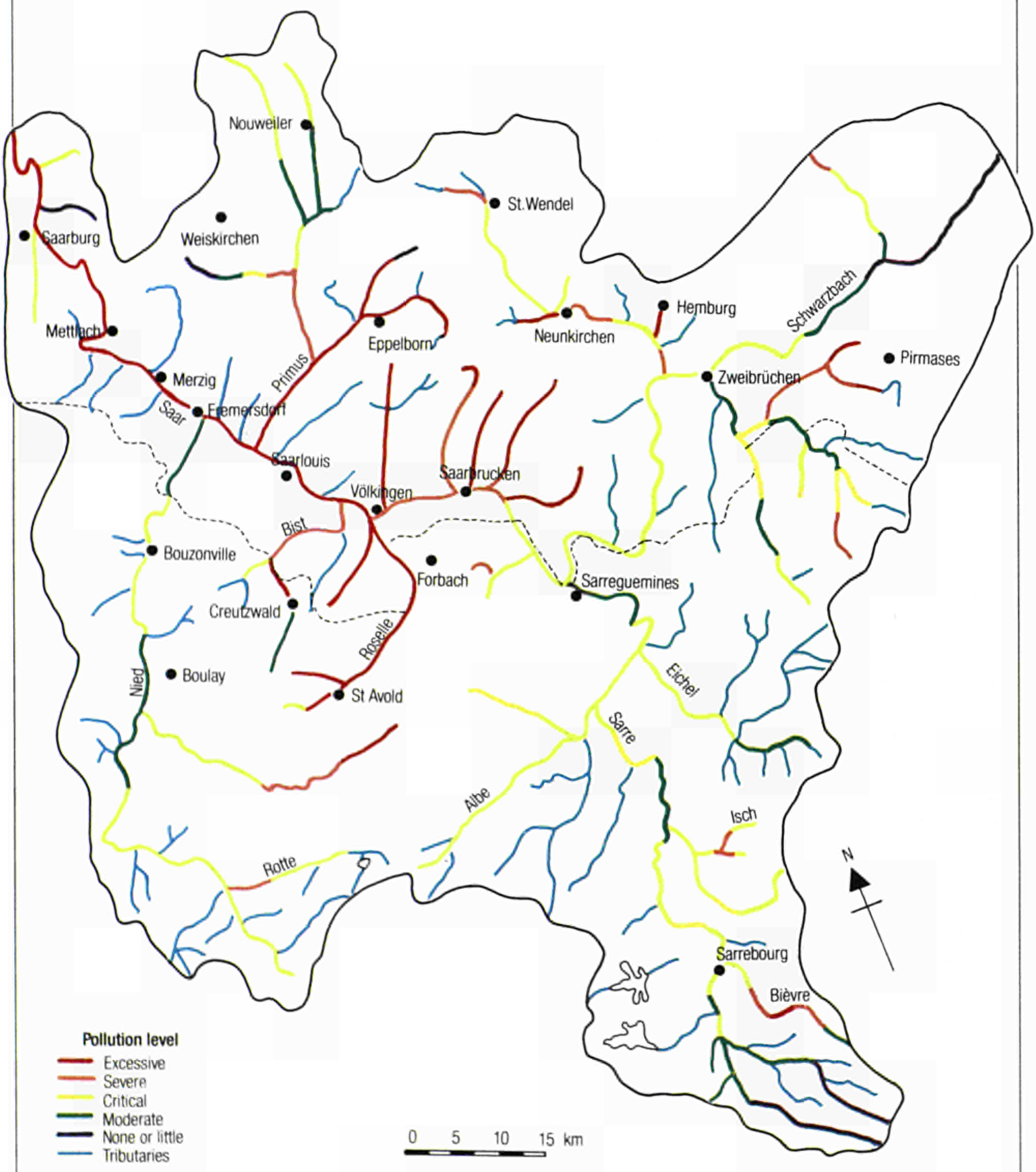
That such a system can be devised is shown by a recent Community project in the Saar-Roselle basin. This was conducted by the Agence de l'Eau Rhin-Meuse in France and the Institut für Wasser-, Boden- und Lufthygiene in Germany. By reference to existing Community quality standards for surface waters, criteria were identified for eight critical parameters to give a five-class classification of general water quality (see Table, below). On this basis, the whole of the Saar-Roselle river system was evaluated and a map of water quality produced (Figure opposite). This shows clearly the concentration of excessively polluted streams in the St. Avold to Saarburg region and provides a basis for co-ordinated action to control pollution problems in the area.

The water quality classification used in the Saar-Roselle project.

	QUALITY CLASS				
PARAMETER	0	1	2	3	4
Temperature (°C)	< 20	< 22	< 25	< 30	> 30
Dissolved oxygen (mg/l)	> 7	> 5	> 3	> 1	< 1
(% saturation)	> 90	> 70	> 50	> 10	< 10
BOD5 (mg/l)	< 3	< 5	< 8	< 25	> 25
COD (mg/l)	< 20	< 25	< 40	< 80	> 80
Ammonium (mg/l)	< 0.1	< 0.5	< 2.0	< 8.0	> 8.0
Anionic detergents (mg/l)	(< 0.2)	< 0.2	< 0.5	< 1.0	> 1.0
Phenols (μg/l)	(< 5)	< 10	< 40	< 500	> 500
Total cyanides (μg/l)	(< 10)	< 10	< 20	< 50	> 50

Key to criteria-quality classes:
0 - unpolluted
1 - moderate pollution
2 - critical pollution
3 - very important pollution
4 - excessive pollution

Water quality classification of the Saar-Roselle basin, 1981.



Source: data from Langenfeld, F., Weingertner, P., Irmer, H., Schreiner, H. and Schumann, H. 1984 *Pollution des eaux du bassin Sarre - Roselle. Rapport de synthese.* Maulin-les-Metz: Agence de l'Eau Rhin-Meuse and Institut für Wasser-, Boden- und Lufthygiene des Bundesgesundheitsamtes

The conflicts of interest and responsibility which this invokes have considerable importance within the European Community. Many of the most heavily exploited rivers cross national as well as regional boundaries. As a result, rivers such as the Rhine, Saar, Meuse and Moselle raise the need for close international co-operation if the problems of water pollution are to be resolved. In this section, therefore, we consider examples of major rivers in the Community and examine the patterns and problems of pollution along their courses.

7.3.1 The Rhine

The Rhine presents one of the most serious and internationally important environmental problems in the Community. Rising in the Alps in Switzerland, its waters collect in the Bodensee on the German border, before flowing some 850 km northwards to the Dutch frontier at Bimmen (Figure 7.9). On its way, it gathers tributaries from France, Luxembourg and Germany and expands in volume until, as it enters the Netherlands, it has a mean annual discharge of about 3000 m^3/s. Here it splits into three distributary streams, the Waal, Neder-Rijn and Ijssel.

During all its lengthy course, the Rhine is subject to a wide range of industrial and agricultural effects. Water is abstracted for domestic, industrial and agricultural purposes. It is used for cooling, washing, processing and irrigation. When the water returns to the river its temperature and composition are often different. In addition, sewage, effluents and mine-wastes are discharged into the river, while leakages of oil and cargo materials escape from the traffic which uses the Rhine. All these substances add to the pollution load of the river; and it is a mighty load, for the Rhine and its major tributaries - the Moselle, Main, Ruhr and Lippe - drain some of the most heavily industrialised land in the Community. Pollution of the Rhine is therefore a major, international concern, and it was for that reason that the Commission for the Protection of the Rhine against Pollution was established in 1963. This had the objective of co-ordinating data collection on the river and proposing remedial action to the riparian states.

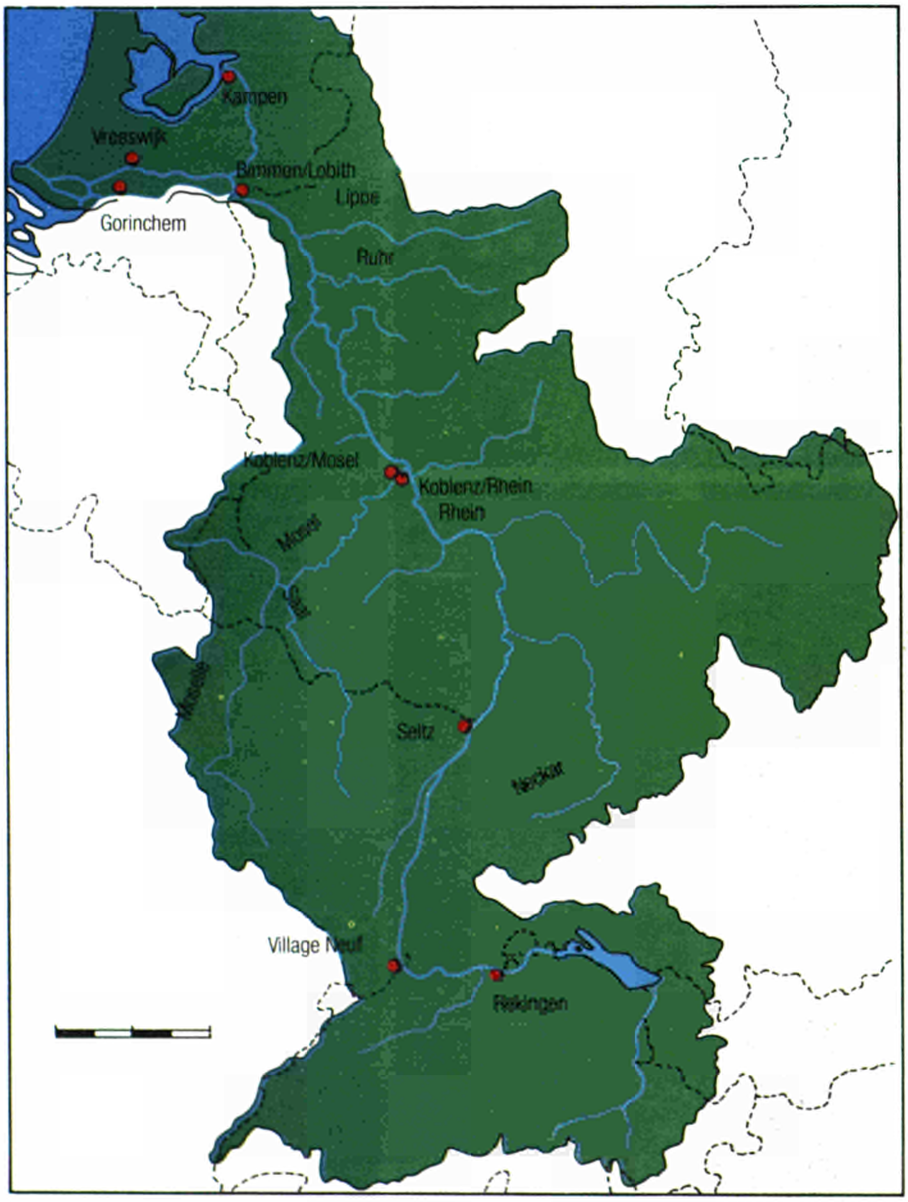
Some of the results of this work are shown in Figures 7.10 and 7.11. In general, the trends are highly consistent. Pollution concentrations rise progressively down the Rhine at least as far as Bimmen-Lobith (this station is recorded as the average of results from sites either side of the border). Thereafter, the pattern varies. In the case of nutrient ions (sulphate, orthophosphate and nitrate) concentrations tend to continue increasing in the three distributary streams; in the case of the heavy metals (mercury, cadmium and zinc) concentrations tend to decline in the distributaries.

These patterns tell only part of the story. If the total load (rather than the concentration) of these pollutants is considered, the downstream increase becomes even more marked, for the discharge of the Rhine increases approximately three-fold between Village-Neuf and Bimmen. Thus the load of nitrate, for example, rises from about 55,000 tonnes/year at Village-Neuf to 300,000 tonnes at the Dutch border. Similarly, the load of orthophosphate increases from 630 tonnes/year at Rekingen to about 22,000 tonnes at Bimmen-Lobith (Figure 7.12).

The main implication of these data is that a major net downstream transfer of pollutants occurs, placing a heavy burden on the Lower Rhine. In addition, the Rhine exports a massive quantity of pollutants into the North Sea. In total, in 1982, it discharged about 23,000 tonnes of orthophosphate, 350,000 tonnes of nitrate, 5.6 million tonnes of sulphate and over 11 million tonnes of chloride into the coastal waters of the Netherlands. Present data are inadequate to show the precise sources of the pollutants, but it is apparent that the main inputs occur upstream of Bimmen, either by direct discharge into the Rhine, or via the major tributaries (at Koblenz, for example, the Moselle introduces about 1 million tonnes of sulphate per year into the Rhine). Reduction of pollution in the lower reaches of the valley, and of the Dutch coastal waters, can only be achieved by controlling these inputs in the middle and upper Rhine.

Also important is the deposition of pollutants - especially heavy metals - in the channel sediments. This helps to remove the substances from the waters but it may not totally immobilise them, for the bottom-dwelling stream organisms may absorb the residues and pass them into food chains. It is also likely that a degree of exchange occurs between the sediments and stream waters, so that concentrations of pollutants in the two media are in a state of dynamic equilibrium. If this is so, then a considerable delay may be encountered between reducing inputs of effluents to the stream and eliminating the pollutants from the water, as residues are released from the sediments.

Figure 7.9 **The River Rhine.**



Source: Commission Internationale pour la Protection du Rhin contre la Pollution 1982

Plate 7.2 **Views of the River Rhine.**

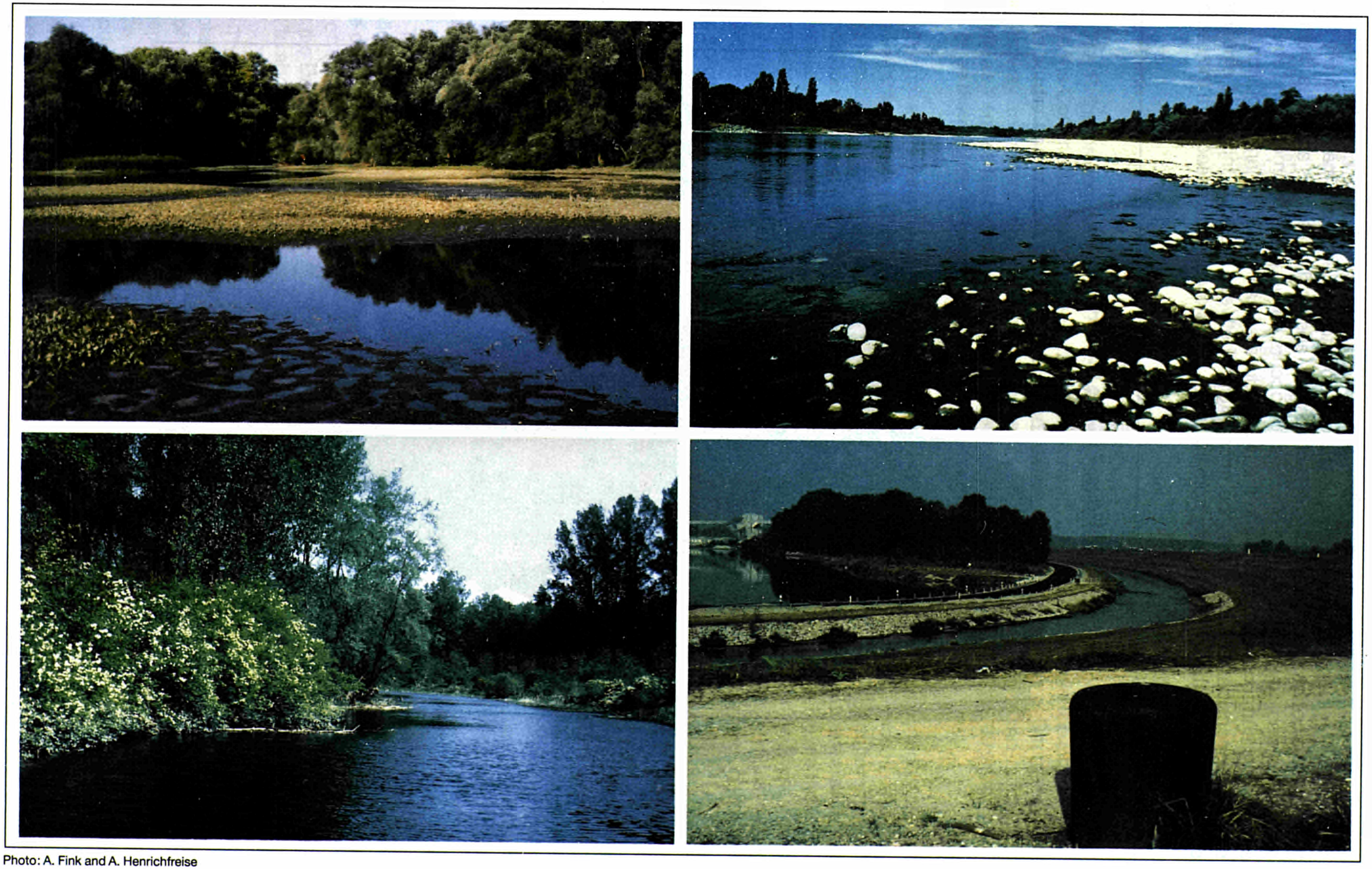
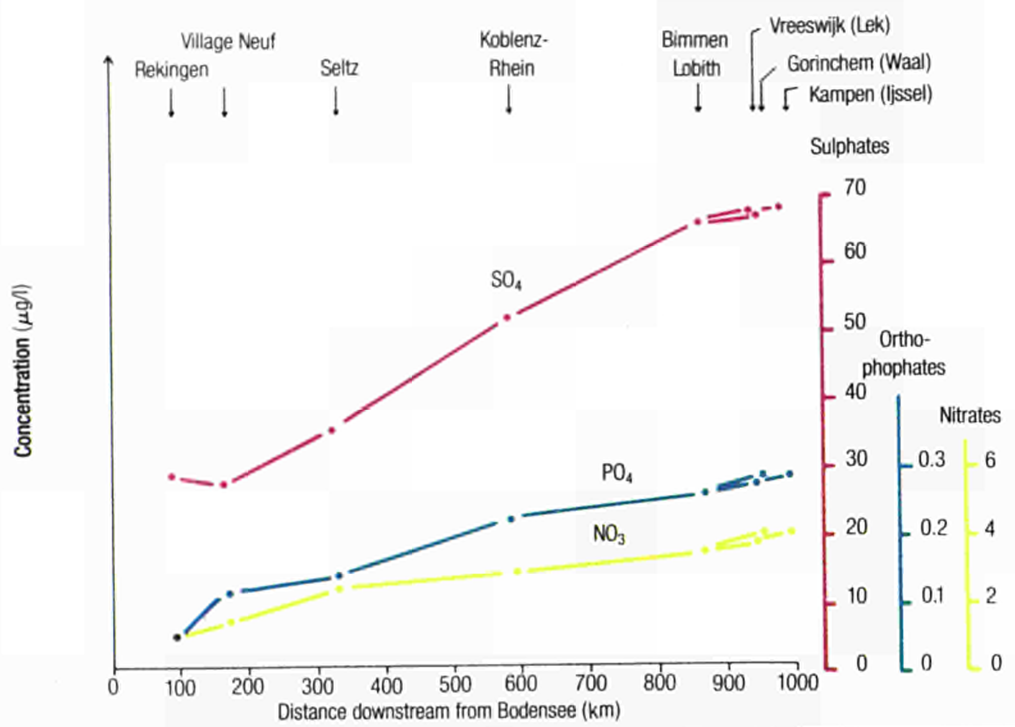


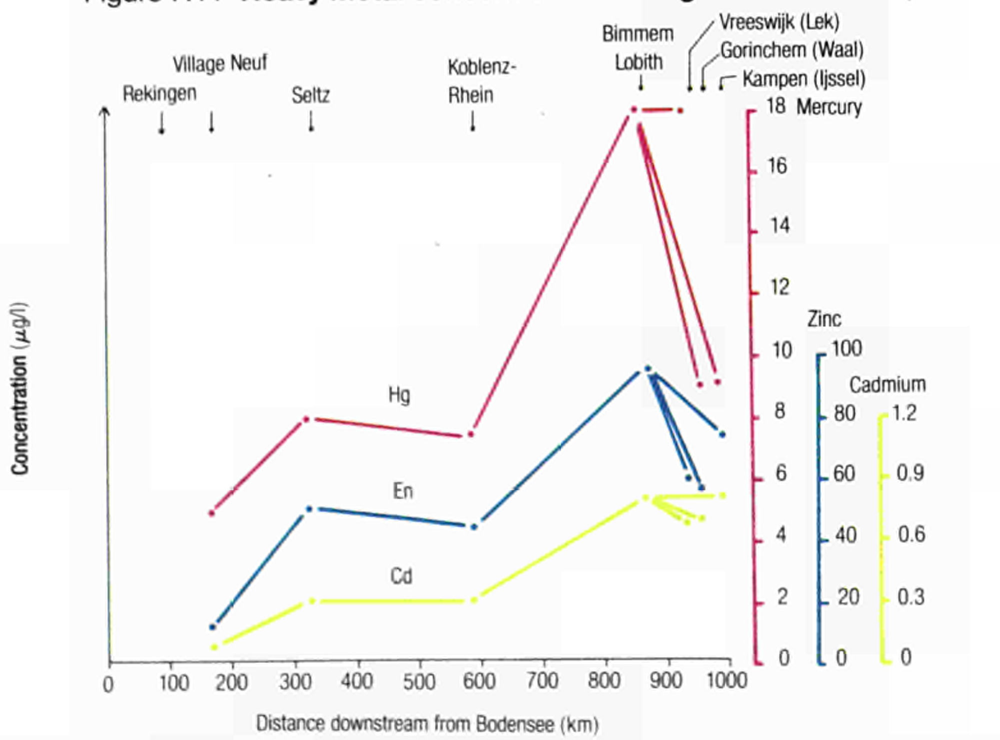
Photo: A. Fink and A. Henrichfreise

Figure 7.10 **Nutrient concentrations along the River Rhine, 1982.**



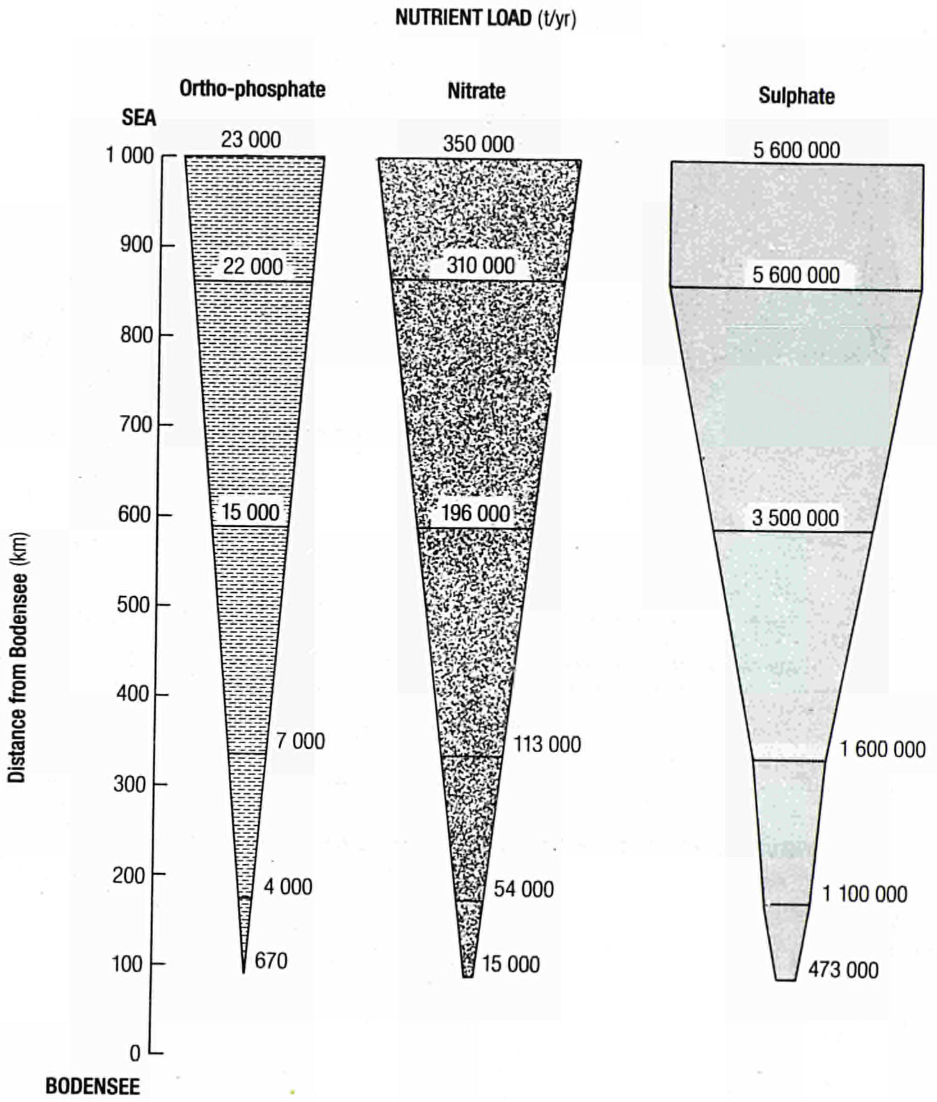
Source: data from Commission Internationale pour la Protection du Rhin contre la Pollution 1982

Figure 7.11 **Heavy metal concentrations along the River Rhine, 1982.**



Source: data from Commission Internationale pour la Protection du Rhin contre la Pollution 1982

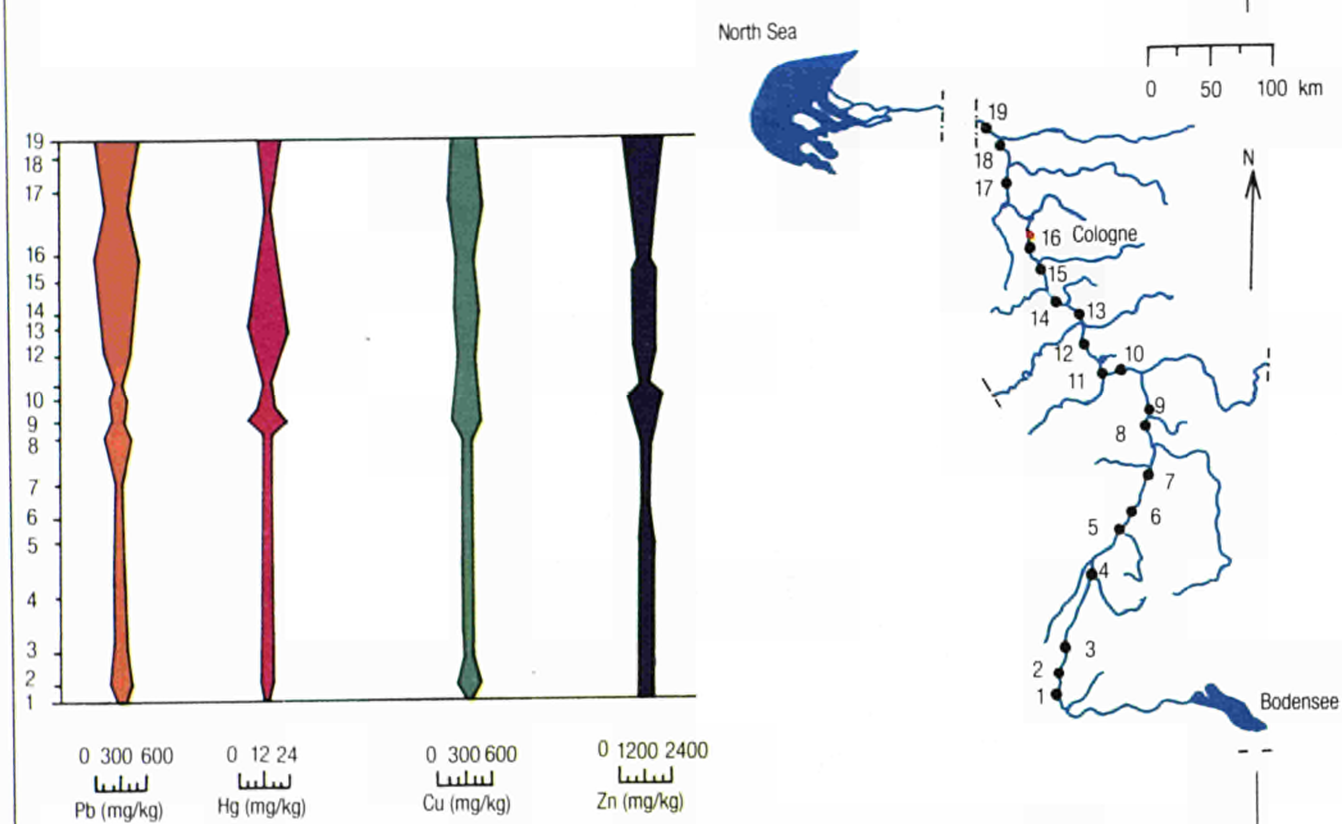
Figure 7.12 **The nutrient load of the River Rhine, 1982.**



Source: data from Commission Internationale pour la Protection du Rhin contre la Pollution 1982

Recent data on heavy metal concentrations in the sediments of the Rhine are not available, but studies during the early 1970s provide an indication of downstream variations in pollution levels between Basel and Bimmen. The patterns for lead, mercury, copper and zinc are shown in Figure 7.13. Though dated, it is unlikely that the patterns have changed greatly. Moreover, because the sedimentary fractions are relatively immobile, they show much more clearly than the water analyses where the main, long term inputs occur. Prior to the date of these samples, it is clear for example that major inputs of mercury occurred at the confluence of the Weschnitz, and again where the Moselle and Lahn join the Rhine. Lead, on the other hand, increases progressively between Koblenz and Cologne, an indication either of its mobility, or, more likely, the presence of multiple sources in this stretch of the river.

Figure 7.13 **Heavy metal concentrations in the sediments of the Rhine, 1971.**



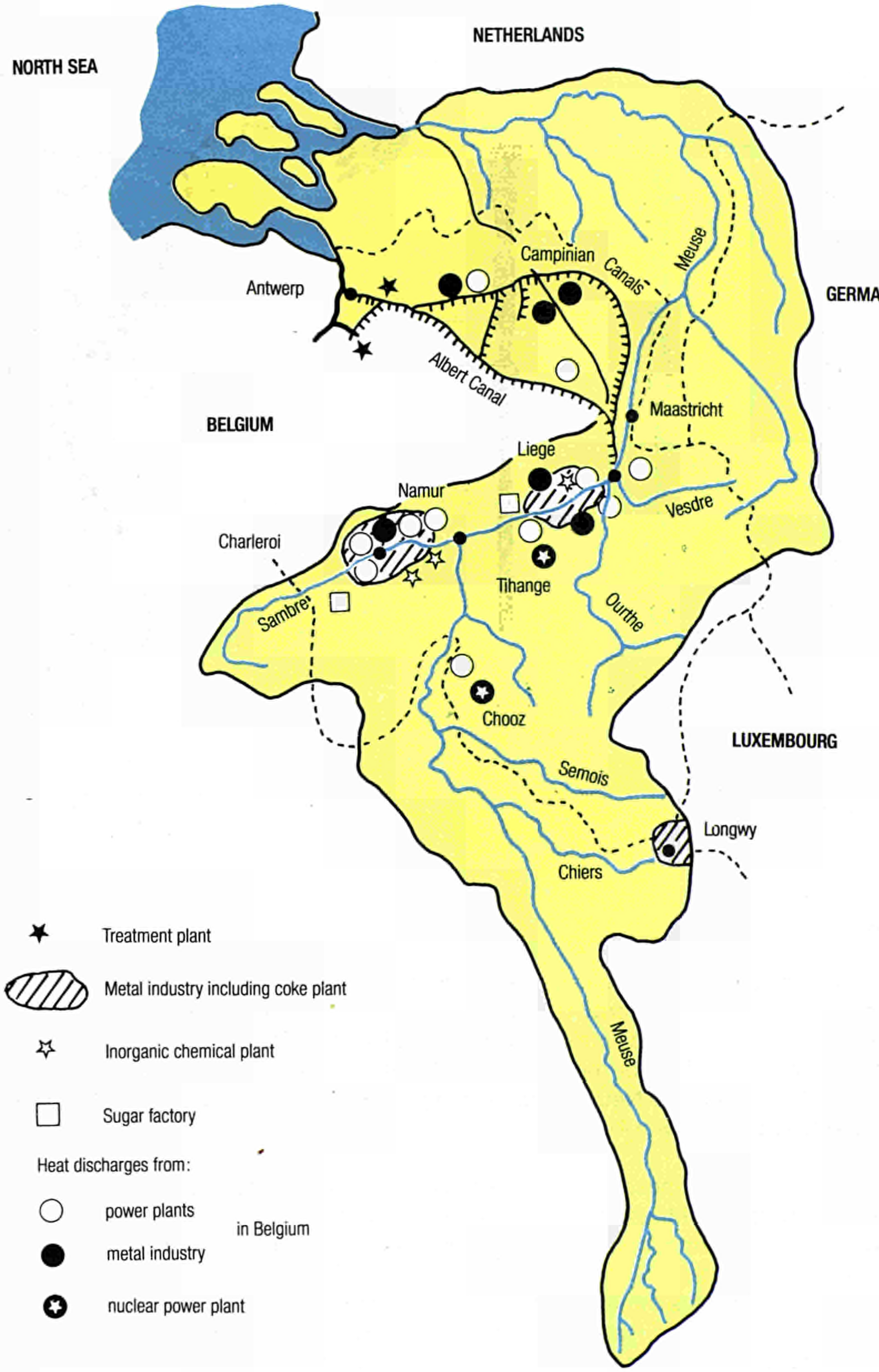
Source: after Deutsche Forschungsgemeinschaft 1982

7.3.2 The Meuse

The Meuse has its source in the Langres region of France. From there it flows northwards through the dissected hills of the Lorraine and Ardennes, across Belgium and through the Netherlands, where it curves westwards into the Haringvliet. During this course of some 900 km, it collects waters from a number of major tributaries: the Chiers in France, the Sambre, Ourthe and Vesdre in Belgium and the Roer in the Netherlands. At Liege, part of its waters are fed into the Albert Canal which runs westward to link with Antwerp.

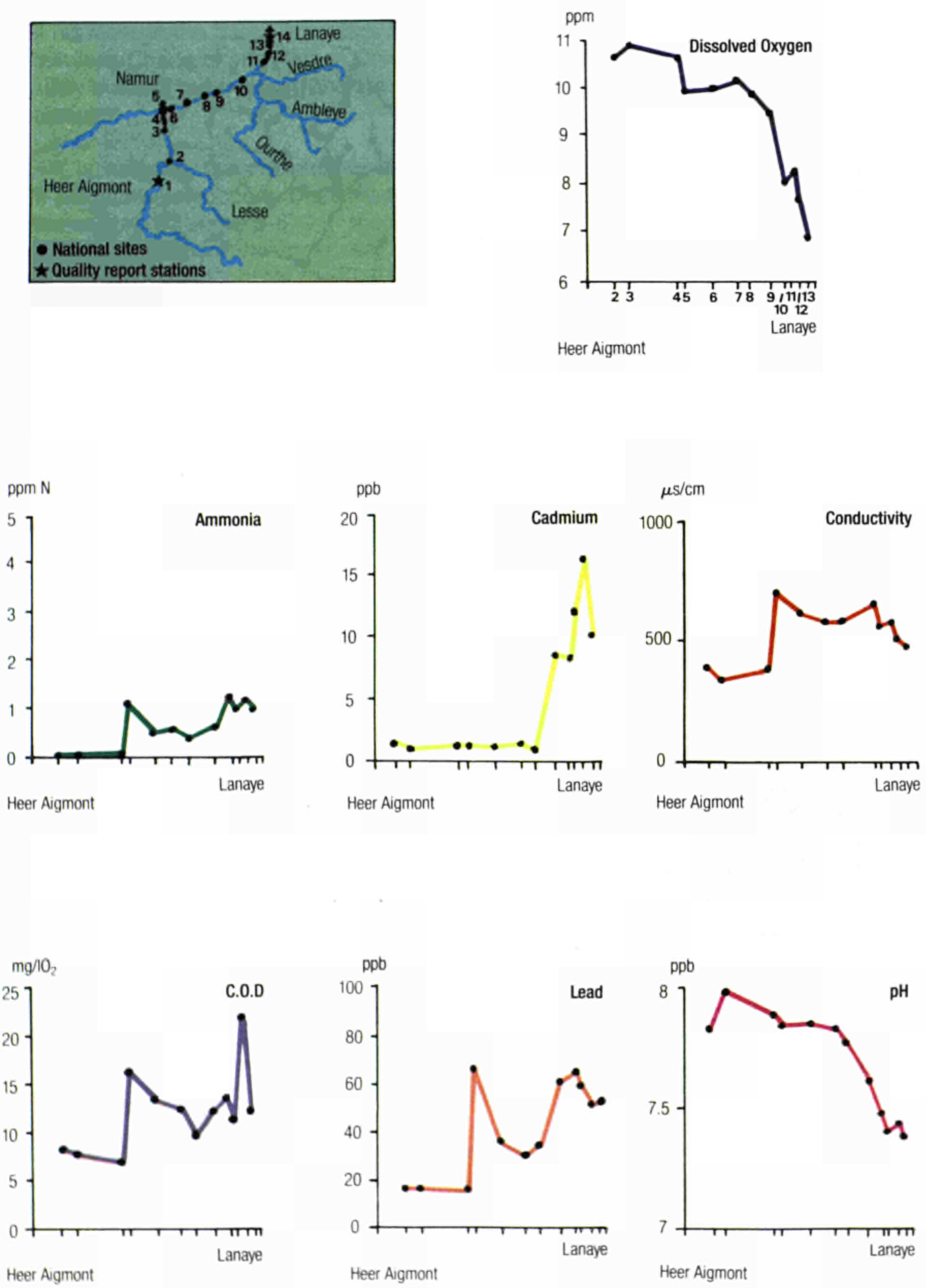
Throughout their length, these streams are subject to a wide range of conflicting pressures and uses. Between Charleroi and Maastricht, for example, the waters of the Sambre and Meuse are used to cool power stations, and both in this region and around Longing there is extensive metalworking, chemical manufacture and coke processing (Figure 7.14). All these activities discharge industrial wastes into the stream. In addition, this part of the valley is densely populated, so that discharges of sewage are considerable. Even so, the waters of the Albert Canal are a vital source of drinking water, supplying some 120 million m^3 to the 1 million inhabitants of Antwerp, while the main river of the Meuse is also used for drinking water in Belgium and the Netherlands. And at the same time, the Meuse and its tributaries are important aquatic habitats, the quality of which is directly affected by levels of pollution. Clearly, as in the Rhine, pollution is a major problem in the Meuse catchment.

Figure 7.14 **The River Meuse.**



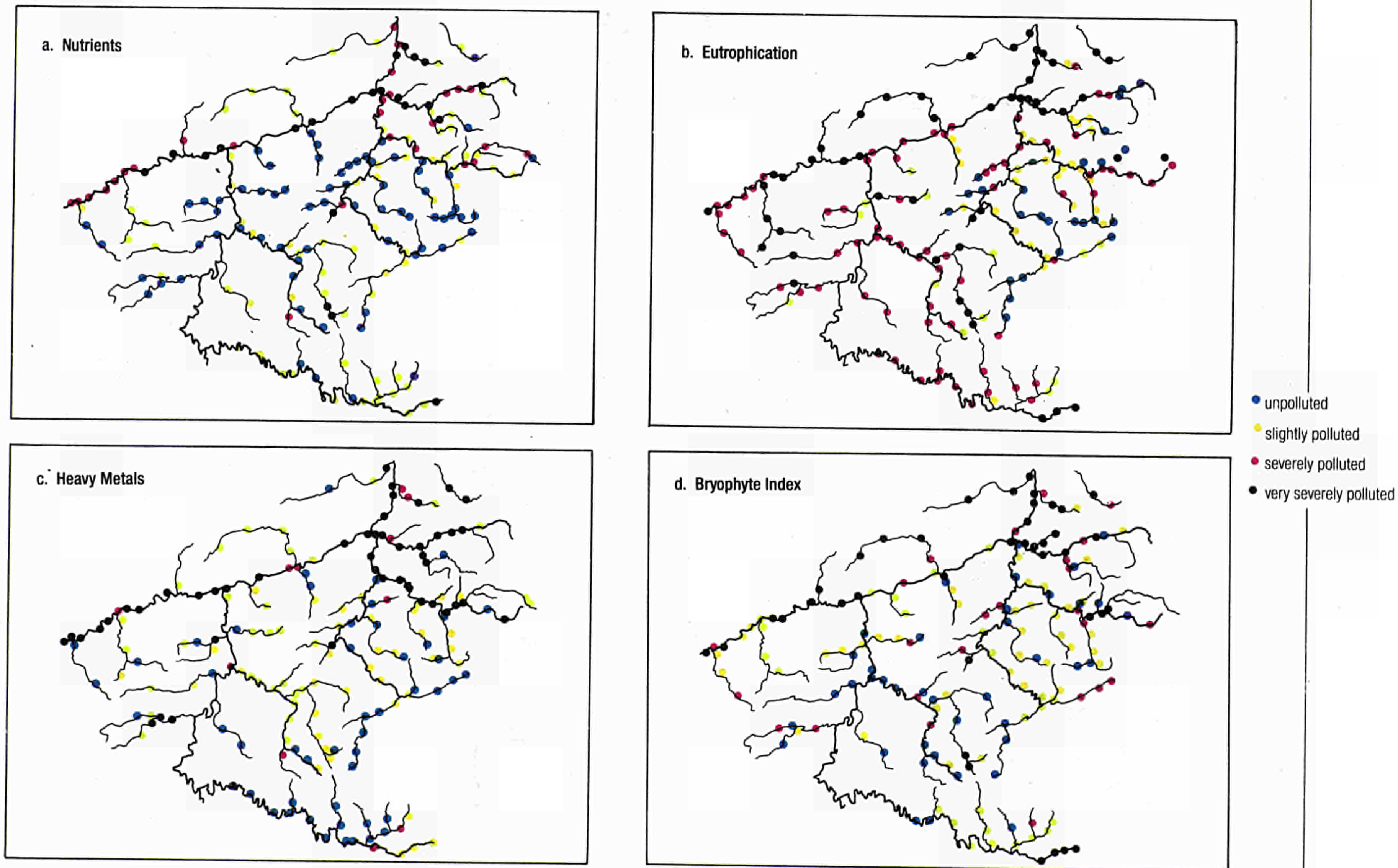
Source: van Craenenbroeck 1982

Figure 7.15 **Variations in water quality parameters down the Belgian Meuse, 1973-74.**



Source: after Institut pour une Politique Européenne de l'Environnement 1983

Figure 7.16 **Pollution levels in the River Meuse.**



Source: data from Institut pour une Politique Européenne de l'Environnement

The distribution of this problem, and the effects of different sources of pollution, are shown for the Belgian Meuse in Figure 7.15. In its upper reaches in Belgium, the Meuse is relatively clean and unpolluted. Where it is joined by the Sambre, however, levels of pollution rise markedly. Dissolved oxygen contents fall and COD increases, reflecting in part the large, though seasonal, discharges of carbohydrates into the Sambre from sugar beet factories around Charleroi (at least in the past). Ammonia and lead contents also rise due to inputs of industrial wastes between Charleroi and Namur. Downstream of the Sambre confluence, some recovery of water quality occurs, but beyond Tihange, as the river enters the Liege industrial area, pollution again increases.

It is not only the chemical composition of the river which is affected. Thermal and sediment pollution also occurs. Discharges of power station coolant into the Sambre raises the water temperature by some 5-8°C in the Charleroi area, and this water flowing into the Meuse raises the temperature of the main river by 3-5°C at Namur. The significance of this can be profound, for the heated waters may harbour pathogenic amoebas which, on occasions, have resulted in fatal infections of humans. Similarly, turbulence caused by boat traffic and dredging operations increases the concentration of suspended sediments in the Meuse and, more especially, the Albert Canal.

These pollutants clearly have important implications for the use of the Meuse as a source of drinking water, and increase the need for extensive filtering and purification. These are not the only effects, however; equally severe are the ecological impacts. Some indication of the problem is illustrated by the data in Figure 7.16 which show the distribution of eutrophication, heavy metals, nutrients and levels of pollution in bryophytes in the Belgian catchment area of the Meuse. The bryophyte index is particularly significant, because mosses are sensitive not only to long-term chemical pollution, but also to physical disturbance and short-term pollution. The particularly severe pollution in the Sambre, lower Meuse, Vesdre, Amblève and upper Semois are clear. This pattern is also reflected by studies of fish. Even more than bryophytes, these are susceptible to short-term pollution events and disturbance and surveys have led to the state of fish populations in the Meuse being described as 'catastrophic'. Without doubt, the effects of pollution in the Meuse are a cause for continuing concern.

7.4 GROUNDWATERS

Groundwater provides an important resource in the European Community. Over about half of the territory, rates of precipitation are low relative to evapotranspiration, so surface water supplies are limited and often unreliable; in these areas groundwaters are a vital source of water not only for drinking, but also for irrigation and industry. Elsewhere, the pressures upon streams from industry, transport and agriculture mean that, despite their abundance, surface waters are often unsuitable for human consumption. As a result, in these countries also groundwaters provide an important source of drinking water. Estimates from different sources vary, but, in Denmark, groundwaters supply about 99% of drinking water, in Italy 88%, Belgium 76%, Germany 73%, Luxembourg 70%, France 68%, the Netherlands 67%, the United Kingdom 32% and Ireland 15%.

The use of groundwater, however, is not without its problems. Excessive abstraction may lead to the lowering of the water table, depletion of aquifers and, in coastal areas, the influx of saline marine waters. At the same time, percolation of pollutants from industry and agriculture may reduce groundwater quality and make waters unsuitable for human consumption. Moreover, because groundwaters are often replenished only slowly, and have a low rate of turnover, it may take many hundreds or even thousands of years before pollutants are removed or groundwater reserves are fully replenished. Clearly, groundwaters are sensitive as well as vital resources.

7.4.1 Groundwater Quality and Vulnerability

The drought of 1975-76 revealed the vulnerability of the Community's water supply systems and the advantages of groundwaters, especially as a source of drinking water. Data on groundwaters, however, were recognisably limited, and the European Commission therefore embarked on a project to assess the groundwater resources of the Community, under the leadership of Prof. J. Fried of the Institute of Fluid Mechanics, Louis Pasteur University. This survey was to include an assessment of their vulnerability and present quality, in order to provide water management and planning authorities and decision-makers with data on a consistent scale and in a compatible form, thus allowing comparisons between member states. Due to financial and time constraints, no fieldwork was undertaken, and all assesements were based on existing information. The study covered six factors, as shown in Table 7.3.

The assessments of these factors involved the compilation of a wide range of data from many different sources. To achieve this, nine national consultants (subsequently ten, with the inclusion of Greece) were brought together in Brussels. Under the supervision of Prof. Fried, these worked out common definitions, harmonised scientific concepts, decided on a common set of symbols for representing the data, and assessed the problems and limitations of the data. They then carried out assessments for their own national territory, using an agreed basic grid for each cell of which hydrogeological and water management data were collated.

It was not an easy task, but the results were successful and show what can be achieved by co-operation of experts from different member states. Amongst the problems they had to overcome were:

i. scientific difficulties, stemming from the semi-empirical knowledge of dynamic parameters (e.g. transmissivity), the assessment of which often depends on the expertise of the hydrogeologist.

ii. differences in the type and quality of information available (a serious problem in some areas but causing no difficulties in others).

iii. difficulties of accessibility of data, which are often scattered among several different authorities of independent or overlapping competence.

iv. problems of scale which needed to be large enough to ensure acceptable representation of the smaller member states, but not too large for the spatial resolution of the data. The reference scale selected was 1:500,000.

Data on resource availability (items 1 to 4 in Table 7.3) are presented as sets of maps, one set for each factor. These are supported by eleven reports (one for each member state plus a synthesis report). Data on vulnerability and quality are being published separately, with separate national reports.

Overall, the results show the quantity, quality and vulnerability of groundwater reserves across the European Community, and allow realistic comparisons to be made between different regions or member states. They also show the zones where data are lacking, and give an estimate of the range of uncertainty for the data collected. An example of the results on groundwater quantity, for eastern central England, is shown in Figure 7.17.

The study confirms that groundwater is a regionally localised resource, and emphasises the danger of simplistic generalisations about groundwater availability and quality. Similarly, it stresses the need for careful and concerted management of groundwater in member states; this applies not only to countries such as Denmark which depend almost entirely upon groundwater, but

Table 7.3 **Information collected in the EC survey of groundwater resources.**

FACTOR	DESCRIPTION
1. Inventory of aquifers	Geographical location Geometry Geology Lithology Stratigraphy Type (confined or unconfined) Permeability (intergranular, fissured or karst)
2. Hydrogeology of aquifers	Transmissivity Piezometric data Flow direction Exchanges with surface water or other aquifers Specific problems (e.g. marine intrusion)
3. Groundwater abstraction	Geographical distribution and rate Location of major pumping stations (> 1-10 m^3/year)
4. Potential resources	Balance between rate of exploitation and replenishment
5. Vulnerability	Time taken for rainwater to infiltrate vertically from the surface to the groundwater body
6. Groundwater quality	Dissolved solid content Chloride content Nitrate content Sulphate content Content of dangerous substances (where significant) (+ land use)

Source: Commission of the European Communities 1982

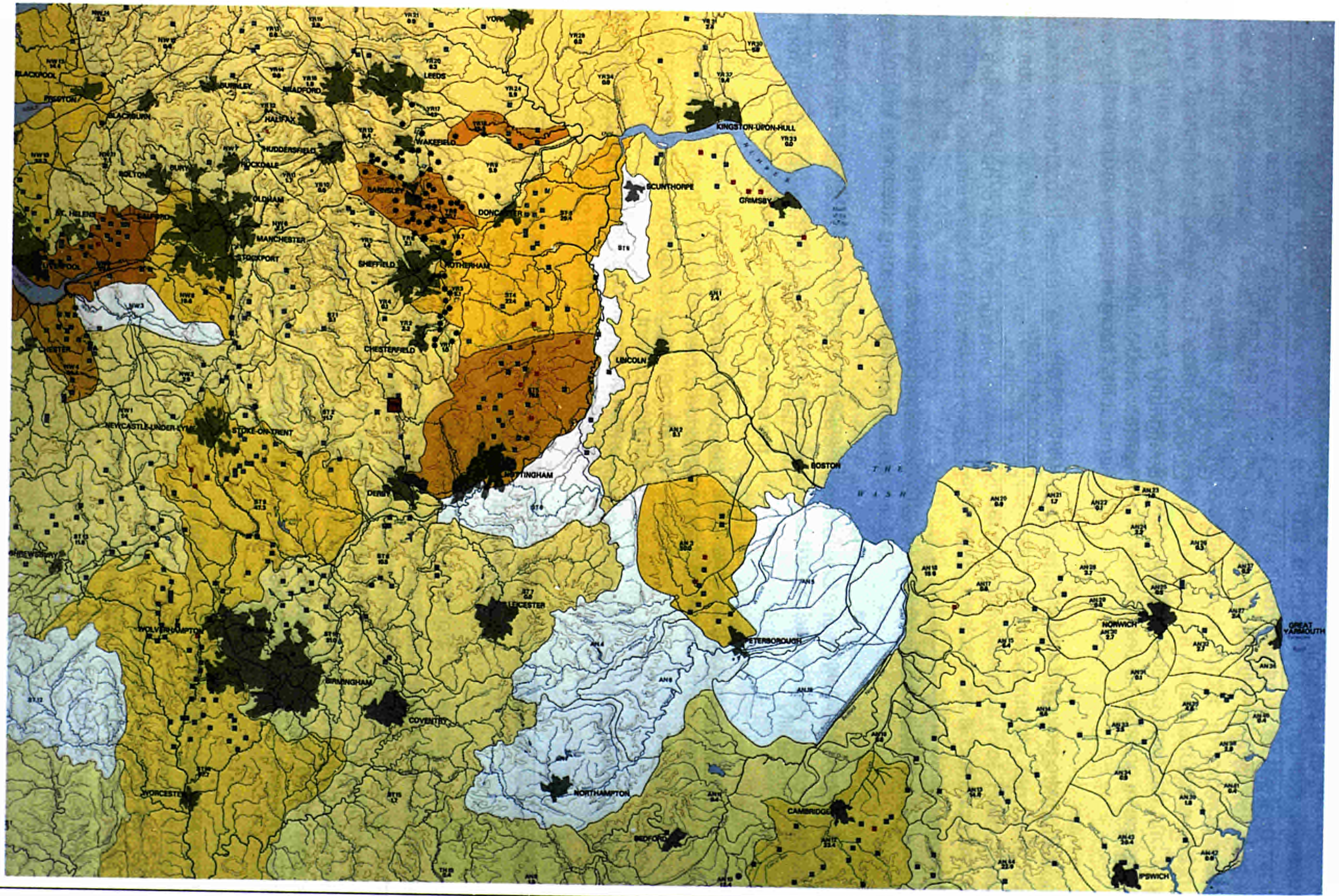
also those like Ireland where groundwaters are locally important. Management of these resources must be based on a policy of protection against quality degradation. For this purpose, the data on vulnerability provided by this study are clearly of particular value. Policies must also aim to combat wastage by improving the abstraction systems, while areas of over-exploitation (as defined in this study) need specific attention. Finally, by revealing gaps in our present understanding of groundwaters, this study shows where future research should be focused.

7.4.2 Nitrate Pollution of Groundwaters

Concern about the levels of nitrate in groundwater has been growing in a number of states in recent years, although firm evidence of a widespread problem is lacking. Most of the severe nitrate problems have occurred at a local level, and where incidences of excessive NO_3 concentrations have developed, consumption of the waters has in some cases been temporarily banned.

The problem arises because nitrates are highly soluble and extensively used. As a result, nitrates applied at the surface or formed by oxidation are readily washed into groundwaters, where rates of decomposition are low and the risk of NO_3 accumulation is significant. A major source of the

Figure 7.17 **Groundwater resources of the European Community: reserves in eastern England.**



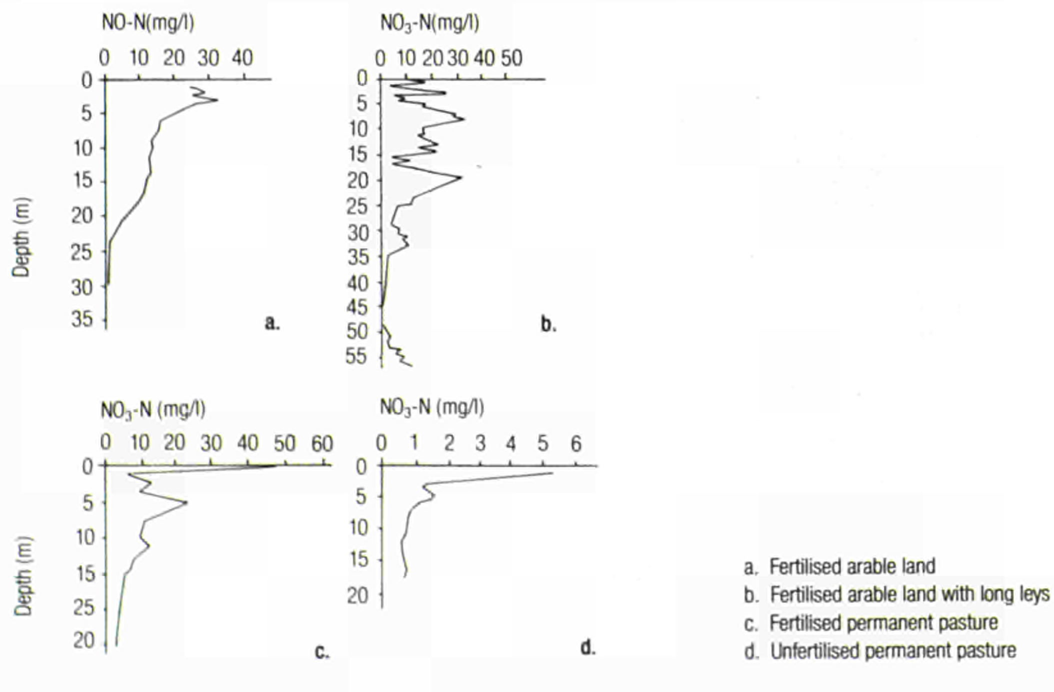
Source: Commission of the European Communities, 1982 nitrogen is agricultural activity: in particular, the use of nitrogen fertilisers and farmyard manures, dung and urine from livestock, and nitrogen losses from the ploughing up of grass and leguminous crops. In addition, local inputs of nitrate may come from industrial and urban sources, either by direct release onto the land or via discharges to the atmosphere.

The magnitude of all these pressures has been changing in recent years. Due to economic recession, direct discharges from many industrial sources have declined, although, as we saw in Chapter 5, atmospheric discharges of nitrogen oxides from power stations and traffic have risen in some cases. Releases of nitrogen from domestic sources may also have fallen, as more areas have been connected up to public sewerage networks. Together, these have probably led to a decline in total inputs of nitrogen from industrial and urban activities.

The threat from agriculture, on the other hand, has increased considerably. The main reason is agricultural intensification - itself to a large extent a function of Community policies - which has resulted in greatly increased uses of nitrogenous fertilisers and sewage sludge and livestock densities. These changes have more than compensated for any decline in nitrogen discharges from other sources and caused a marked increase in nitrate levels in many groundwaters.

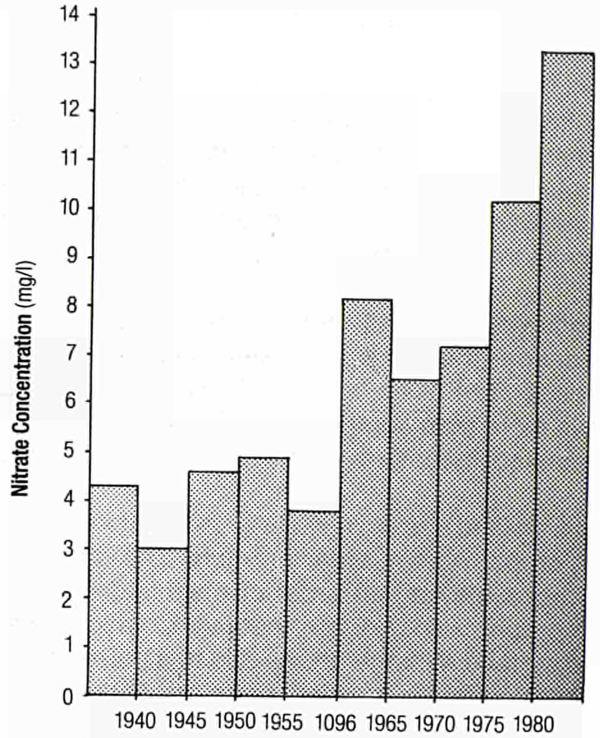
The problem varies with land use. It is greatest under intensive feedlots or heavily fertilised pastureland, cereals or root crops. As the data in Figure 7.18 show, therefore, nitrate-nitrogen concentrations under these crops may be an order of magnitude greater than under unfertilised permanent grassland. These graphs also indicate the way in which nitrate levels under farmland typically increase towards the surface. Whether this is due to a pulse of more polluted water moving downwards as a result of increasing fertiliser usage, or an equilibrium between rates of input at the surface and rates of breakdown at depth, has been disputed. If it is the former, then serious problems of nitrate pollution are likely to ensue in the future.

Figure 7.18 **Nitrate-nitrogen levels in groundwaters in England.**



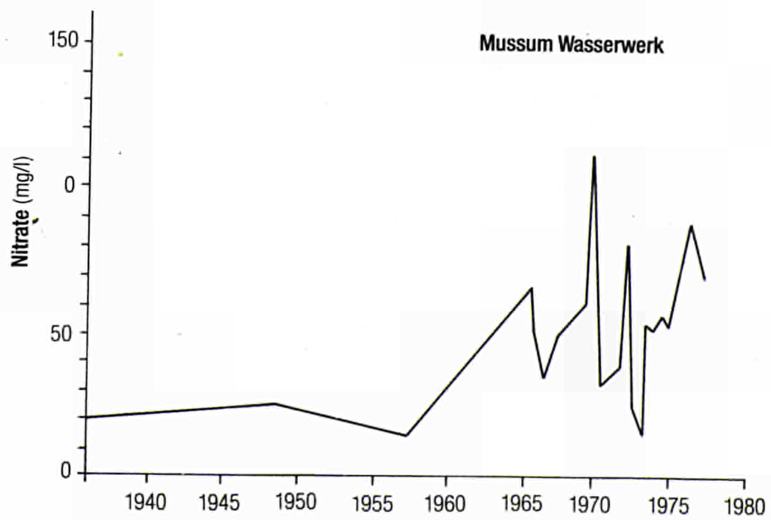
Source: after Young and Gray 1978

Figure 7.19 **Nitrate concentrations in groundwater in Denmark, 1940-1980.**



Source: data from Fried 1984

Figure 7.20 **Nitrate concentrations in the water at Mussem Waterworks, Germany, 1911-1976.**



Source: after Deutsche Forschungsgemeinschaft 1982

Certainly, there is widespread evidence of a growing problem, and concern has been expressed in Denmark, France, Germany, the Netherlands, the United Kingdom and Italy. In Denmark, for example, the average nitrate level of groundwaters has more than tripled over the last thirty years (Figure 7.19). As a consequence, 8% of Danish waterworks are now producing water with a nitrate concentration above the admissable limit of 50 mg/l, and 18% are producing water with concentrations above 25 mg/l. Overall, nitrate levels are increasing at a rate of about 3.3 mg/l/y.

A similar problem exists in France. Here, it is estimated that almost 20% of the population is dependent on water with nitrate concentrations above 25 mg/l, while some million people (2%) are drinking water with levels above 50 mg/l. Almost 90% of this water is from groundwater sources. In Germany, also, nitrate concentrations have risen dramatically. At Mussum Waterworks, nitrate levels rose from about 11.6 mg/l in 1911, to over 65 mg/l in 1976 (Figure 7.20). As all these examples indicate, nitrate pollution of groundwaters is likely to remain a major concern in the foreseeable future, and careful monitoring of groundwater conditions need to be undertaken.

7.5 CONCLUSIONS

7.5.1 Trends in Water Quality

At first sight, the trends identified in water quality in this chapter are hopeful. In the last few years especially, many of the indices of surface water quality measured in the Community appear to be showing improvements. Heavy metal concentrations at most locations are falling, phosphorus loads are declining, biochemical oxygen demand is either remaining steady or diminishing slightly. Ammonium and dissolved oxygen levels are similarly showing signs of improvement.

The causes of these improvements cannot be precisely defined, but some possible factors have been mentioned. They include the reductions in discharges to streams due to reduced industrial activity (especially in the mining and manufacturing sectors), and better effluent control at source. In addition, extension of the sewerage system and improvements in treatment procedures (e.g. conversion from mechanical to biological systems) have undoubtedly made a contribution. Community and national environmental policies have almost certainly stimulated much of this action, for even in advance of legislation many firms and authorities introduce improvements in the anticipation of statutory controls.

Despite these measures, a number of problems remain, and in several parts of the Community levels of water pollution are still unacceptably high. Nitrate concentrations, in particular, are rising as a result of the continued increase in rates of nitrogen fertiliser application. In many streams and groundwaters, pollution by pesticides, detergents, heavy metals and other dangerous substances continue to give concern. It has also been suggested that some of the improvements seen over recent years will soon start to slow down: it seems, for example, that further extension of the sewerage system is likely to be limited in some regions for only remote areas now remain to be connected. The prospect for the future, therefore, is by no means entirely good, and renewed action will be necessary if the progress already made is to be maintained. Moreover, as the recent accident at the Swiss chemical works in Basle indicates, the problem of water pollution is to a great extent a trans-frontier one. Future efforts may thus need to be directed much more specifically at international co-operation to control pollution.

7.5.2 The Need for Data

In view of this prospect, it is apparent that continued monitoring of water quality is essential. Only in that way can potential problems be identified in time to take preventive action, and only in that way can the effectiveness of current actions be evaluated. It is also clear, however, that the availability and quality of data at present are in many cases limited. Few data, for example are available for Italy or Greece, and it is likely to be some time before comprehensive data are available for Spain and Portugal. Similarly it has been stressed that many of the data which are available are inconsistent in terms of their sampling and measurement methods. Steps are being taken to resolve this through the programme on the 'Exchange of Information' but even so discrepancies remain, and more effort needs to be devoted to the location of stations so that a clearer picture emerges of sources of pollutants and of the regional pattern of water quality. Yet it must also be borne in mind that the acquisition of data costs money. Data collection, like other aspects of environmental policy, must therefore be seen to be cost effective. The need is to acquire data which will make a positive and worthwhile contribution to the management of water resources in the Community.

Two other points may also be noted. Flow data have not been discussed at any length in this chapter and they are difficult to cope with at this scale of analysis. It is apparent, however, that abundant data exist nationally on stream discharges, but that these vary considerably in their format and system of recording. Such data are vital for planning of water use, for prediction of flood and other hazards, and for pollution modelling and monitoring. Without doubt an exercise to collate and co-ordinate these data would have considerable benefits. Secondly, whilst quality monitoring of streams is well established, various aspects are less satisfactory. In particular, few data yet exist in an available form on the quantities and quality of effluent discharges to streams; and regular monitoring of lakes seems rarely to be conducted or reported. As with all other aspects of inland water resources, the more information that is available on these aspects, the more sensitive and effective will be planning and policy development for inland waters.

QUALITY OF COMMUNITY BATHING WATERS

Bathing is a widespread and traditional leisure activity in almost all parts of the Community; each year millions of people spend their holidays in resorts with natural bathing facilities. The quality of the bathing waters therefore affects greatly the level of enjoyment - and even the health - of holiday makers at these locations. But the quality of the bathing waters is also under threat, not only from the pollution caused by the holiday makers themselves but also from industrial effluents, urban sewage, agricultural wastes and discharges from shipping.

For these reasons, in December 1975, the European Council adopted a Directive on the quality of bathing waters. This set out procedures for designating important bathing beaches, and for monitoring and reporting on the quality of the waters. Nineteen parameters were defined, which were to be measured according to specified procedures and sampling frequencies. For each parameter two quality levels were defined: a mandatory (I) value with which all designated bathing waters had to conform by 1985, and a guide (G) value which every effort should be made to achieve by that date. Data on water quality at each of the selected sites was to be transmitted to the European Commission annually, from 1980.

On this basis, member states identified bathing waters according to the criteria prescribed by the Directive: namely that they should include all fresh or sea waters explicitly authorised for bathing by the State, or where bathing is not prohibited but is traditionally practised by large numbers of people. In the event, these criteria were applied rather differently in different member states, with the result that very different numbers of bathing areas were designated in the various countries (over and above variations due to climate, coastal topography or national bathing patterns). These are listed in the Table below.

Given the discrepancies in interpretation of bathing waters, it is not surprising that the data reported on them also vary markedly from one member state to another. At one extreme, Belgium, Germany and the United Kingdom provide only summary statistics on water quality at each site. At the other extreme, maps are made publically available in Denmark each year showing the status of the bathing waters (see Figure, overleaf).

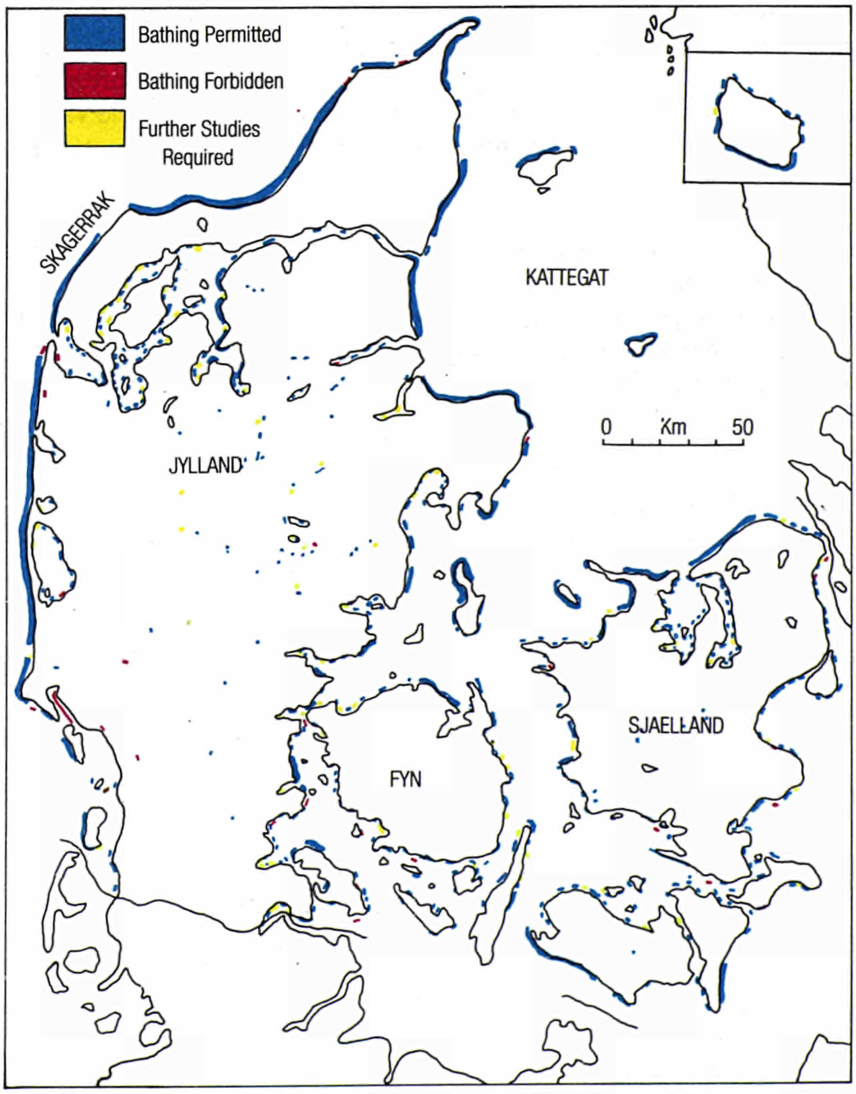
Designated bathing waters in the Community.

Member State	Number of waters designated
Belgium	15 (zones)
Denmark	1323
France	3470
Germany	95
Greece	74
Ireland	6
Italy	1907
Luxembourg	32
Netherlands	360
United Kingdom	27 (beaches)

In general, however, the data which are available show a gradual improvement in bathing water quality towards (or even beyond) the standards set in the Directive. In France between 1978 and 1982, for example, the percentage of sampled sea waters in the highest quality class (A) rose from 8.8% to 28%, while those classed as polluted (C-D) declined from 29.6% to 24.9%. In the United Kingdom, over the same period, the number of sampled beaches failing to conform with the mandatory quality classes fell from 8 to 6.

Nevertheless, progress in many cases is slow, and the 1985 targets have not been met in a number of cases. At some localities large capital investments are considered necessary to remove the existing pollution problems and raise water quality to the specified standards. But it is also clear that the approach adopted in Denmark and France to the open publicity of bathing water quality information is a great incentive to improvement and an important public service, for it encourages all areas (not only the designated beaches) to meet the quality criteria in order to maintain their attraction to holdaymakers. It is an approach which should certainly be encouraged elsewhere.

Bathing water quality in Denmark, 1984.



Source: Commission of the European Communities 1985 *Quality of bathing water.* Brussels: Commission of the European Communities.

NOTES AND SOURCES

Data availability

Although the availability of data on the quality of surface waters has been greatly improved by the Community programme on the Exchange of Information, serious weaknesses still occur in a number of areas. In particular, the location of monitoring stations, sampling designs and measurement techniques all vary significantly from one station to another (even in the case of those stations included in the Exchange of Information). Moreover, because of instrumental failures and administrative problems, many records are incomplete. It should also be remembered that data on levels of pollutants in stream waters provide only part of the picture: equally important in many cases are the concentrations in the sediments and aquatic organisms, but measurements of these are generally lacking. For all these reasons, care is needed in comparing results from different sites in the Community.

The same is true of groundwaters. While the Commission's study of Community groundwater resources has increased data availability, very limited information exists on pollution levels in many areas of Europe.

Notes on Figures

Figure 7.2 The classifications used to define water quality status in this figure are as follows:

Parameter	Very Good	Good	Moderate	Poor	Very Poor
Conductivity (μS/cm)	< 280	280-430	430-600	600-860	> 860
Chloride (mg/l)	< 15	15-20	25-60	60-150	> 150
Nitrate (mg/l)	< 7.5	7.5-10.6	10.6-15.9	15.9-18.0	> 18.0
BOD5 (mg/l O_2)	< 2.2	2.2-2.9	2.9-3.7	3.7-4.5	> 4.5
Phosphate (mg/l)	< 0.009	0.009-0.020	0.20-0.45	0.45-0.60	> 0.6
Detergents (mg/l)	< 0.025	0.025-0.039	0.039-0.05	0.05-0.069	> 0.0

These scales are those used in the original report and do not represent a generally agreed classification.

Figure 7.19 Data in this figure are derived from 11,000 samples from depths of greater than 10 metres.

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CHAPTER 8.

THE SEAS

8.1 INTRODUCTION

8.1.1 The Importance of the Seas

Historically, culturally and economically, the sea is a vital and integral part of the European Community. Over the centuries, many member states have been important trading nations, dependent upon the sea for communications and power, as well as for defence. Along the lengthy seaboard of the Community, fishing has always been a major source of food and livelihood, and its legacy is still visible in the culture and landscape of these societies. In recent years, the sea has provided yet more valuable mineral resources and energy, and a focus for recreation and leisure.

How important the varied resources of the seas are to the Community can be seen by the contribution they make to its economy. In 1981, about 5 million tonnes of fish were landed by the Community's fishing fleet, while about 90% of its oil production and the majority of its natural gas production came from its territorial waters. Large quantities of gravel and sand are also extracted from the sea floor, while over 1,000 million tonnes of international freight were carried by sea to the Community in 1981. In addition, the sea plays a vital role in waste disposal, receiving effluents both directly from coastal industries and households, and, via streams, from the whole inland area of Europe.

The sea, however, is not only an economic and cultural resource. Equally, it is a fundamental component of the ecosystem. As well as the numberless populations of fish, crustacea and lower species which live in these waters, the seas also act as breeding grounds, food sources and habitats for a wide range of birds and mammals.

8.1.2 Pressures on the Seas

The range of uses to which man puts the sea inevitably places pressure upon its waters. Fishing, has had a major impact, for in several instances excessive catches have depleted fish and whale stocks and disrupted natural food chains. Gravel and sand extraction may disturb the balance of sediment deposition and removal and destabilise coastal beaches and sandbars. In addition, human activities both on land and at sea may cause marine pollution.

The nature and sources of these pollutants are immensely variable. The wastes themselves include domestic sewage; industrial effluents containing minerals such as cadmium, zinc, nickel and mercury; heated waste water from power stations; radioactive discharges from nuclear processing plants; pesticides, fertilisers and livestock wastes from farmland; and vast quantities of sediment. They enter the sea in all manner of ways. Some are discharged directly from coastal settlements and factories. Some are dumped at sea as part of deliberate waste disposal policies. A significant quantity escapes from ships either during passage or loading and unloading. Not a little enters the sea as atmospheric fallout and rainwash. But often the largest proportion reach the sea via streams and rivers draining the adjacent land masses. Thus the seas of the European Community collect the wastes not only of the entire continent, but also from other seaboard areas such as north Africa, the Near East and southern Scandinavia.

To some extent, the seas provide a vital medium for the decomposition, deposition, dispersal and dilution of these wastes. Biological and chemical processes act to break down many of the substances, while, in estuarine areas especially, large quantities of materials are adsorbed onto solid particles or flocculated and removed by sedimentation on the sea floor. In addition, exchanges between the seas mean that residues may be widely dispersed and diluted. Nevertheless, not all pollutants are removed in these ways, and the seas act as huge sinks for many of man's waste products. Nowhere is this more true than in the Mediterranean which, because of its slow rate of turnover, traps the vast majority of the wastes it receives.

8.1.3 Community Policies and the Seas

In adopting the First Action Programme on the Environment in 1973, the European Community acknowledged the economic and ecological importance of the seas around it. It noted, also, that the seas were already subject to high levels of pollution, and thus that a primary aim of the Community policy must be to reduce or prevent marine pollution. This commitment has subsequently been re-emphasised in the Second and Third Action Programmes and has given rise to a number of specific actions (Table 8.1).

Pressures on the seas, however, do not derive only from within the Community and its member states; many derive from outside the Community boundaries. As a result,the Community has taken part in several international initiatives aimed at combatting marine pollution, such as the Paris Convention on land-based pollution of the sea, and the Barcelona Convention on the Mediterranean.

Out of these forums have come broad commitments to protect marine resources and combat pollution. The implementation of these commitments, nevertheless, needs to be conducted through more specific and formal Directives, and in the last 10 years the Community has adopted a number of actions. One of the first, in 1976, was the Bathing Water Directive, which laid down quality standards for bathing areas in the Community (see pages 245-246). As has been noted, there are some discrepancies in the way the Directive has been interpreted and implemented at national level, but it has undoubtedly acted as a significant force in encouraging the cleaning-up of many of the main bathing beaches in the Community.

In 1979, a similar Directive was adopted for shellfish waters. Like the Bathing Water Directive, this sets out guide (G) and imperative (I) values for various water quality parameters considered to influence the suitability of waters as shellfish habitats - including pH, salinity, dissolved oxygen content, soluble metal concentration and numbers of faecal coliforms. All shellfish waters were to meet these criteria within six years of their designation, and member states have to monitor water quality at a minimum frequency specified by the Directive. In practice, considerable variations in the interpretation of the Directive have occurred and the extent of designation and enforcement have been somewhat uneven in the different member states.

In the case of chemical pollutants, Community policy is framed within the general Directive on Dangerous Substances, adopted in 1976. As we have seen in the previous chapters, this defines procedures for listing dangerous substances as a basis for setting limit values on emissions, or quality objectives on environmental concentrations. Thus far, daughter Directives have been adopted for mercury, cadmium, HCH (lindane), carbon tetrachloride, pentachlorophenol and DDT, while proposals are pending on a number of other substances including dieldrin, endrin, aldrin and chloroform.

Two other areas of concern are oil pollution and dumping of wastes. The problem of oil pollution is a truly international one, for it may derive not only from neighbouring land areas but also from shipping. As a consequence it is a difficult problem to solve. The Community, however, has adopted a number of actions aimed at collecting information on oil spillages and establishing contingency plans for dealing with spills. Similarly, in 1977 a Decision was adopted concluding the Barcelona Convention; amongst other things this calls upon member states to control dumping of wastes in the Mediterranean. Currently a Directive is also under discussion concerning the discharge of certain substances into the sea.

8.1.4 Availability of Data

The importance attached to marine pollution by many individual countries, the European Community and other international organisations has meant that a considerable volume of information has been collected in recent years. Within the territorial waters of the Community member states, much work has been carried out under the auspices of the Paris and Barcelona conventions. The Paris Commission was established in 1978 to monitor marine pollution from land-based sources. It deals with the sea area bordering western Europe, and thus includes the North Sea, Irish Sea, the Skagerrak and Kattegat (between Denmark, Norway and Sweden), the English Channel and eastern Atlantic including the Bay of Biscay. The Barcelona Convention deals with the whole of the Mediterranean Sea.

Reports of the Paris Commission supply a vital source of data on the marine environment, and are therefore extensively used here. In addition, much useful information comes from the so-called 'North Sea Conference' held in 1984, which was concerned mainly with the North Sea and its adjacent waters (the English Channel, Skagerrak and Kattegat). Similarly, data on the Baltic have been compiled by the Helsinki Commission, while UNEP have brought together extensive data on the Mediterranean.

Overall, these data provide a valuable overview of conditions in Community waters, but they are far from comprehensive, either in terms of their geographic extent or their timespan. This is a reflection mainly of the difficulties in obtaining information on the seas, for most studies depend on surveys by individual ships which are inevitably restricted and sporadic. In particular, data are still lacking on many aspects of the Mediterranean. As a consequence, there is an unavoidable bias towards North Sea waters in this chapter. This is not to suggest that conditions in the Mediterranean are less serious - far from it, indeed, for in many ways problems there are more severe than anywhere in the Community. It is simply a reflection of the scope and quality of available data.

8.2 OIL POLLUTION

The problem of oil pollution is one which occasionally thrusts itself into the public eye when major spillages occur. Over recent decades, a number of such incidents have taken place in European waters, including the *Torrey Canyon* accident in 1967 and the *Amoco Cadiz* in 1978 (Table 8.2). It has also been a growing problem as the density of shipping in the seas around the Community, and as the volumes of oil carried and extracted, have increased. Between 1980 and 1983, for example, the number of oil production installations in the waters of the Paris Commission rose from 28 to 43, while the total capacity of the Community's oil tanker fleet was over 45 million tonnes in 1981.

Table 8.1 **Community environmental actions concerned with the sea.**

DATE	ACTION	ABBREVIATED TITLE	OBJECTIVE
1975	Decision (75/437)	Prevention of marine pollution from land-based sources	Ratification of the Paris convention on land-based pollution of the sea
1976	Directive (76/160)	Quality of bathing water	Defines quality of bathing water for designated bathing beaches
1976	Directive (76/464)	Dangerous substances discharged into aquatic environments	Provides system of listing dangerous substances and framework for defining limit values and quality objectives
1977	Decision (77/585)	Protection of the Mediterranean Sea against pollution and prevention of dumping at sea	Concludes Barcelona Convention, aimed at protecting the Mediterranean against pollution
1977	Decision (77/586)	Protection of the Rhine against chemical pollution	Concludes Convention on Pollution of the Rhine which sets out objectives for controlling chemical pollution, partly in order to limit inputs to the North Sea
1978	Directive (78/176)	Waste from titanium dioxide industry	Sets out measures to control disposal of titanium dioxide wastes, including dumping at sea.
1978	Resolution	Pollution by hydrocarbons discharged at sea	Sets up action programme to control and reduce pollution by hydrocarbons discharged at sea
1979	Directive (79/923)	Quality of shellfish waters	Lays down quality standard for shellfish waters and defines monitoring procedures
1980	Decision (80/686)	Advisory Committee on hydrocarbon pollution at sea	Sets up an advisory committee on control and reduction of hydrocarbon pollution at sea
1981	Decision (81/420)	Pollution of the Mediterranean by oil and other harmful	Concludes protocol for dealing with oil and other substances harmful substances in cases of emergency

DATE	ACTION	ABBREVIATED TITLE	OBJECTIVE
1981	Decision (81/971)	Information systems on hydrocarbon discharges at sea	Establishes inventory of hydrocarbon discharges, national contingency plans and hydrocarbon properties
1982	Directive (82/176)	Mercury discharges from the chlor-alkali electrolysis industry	Defines limit values and quality objectives for mercury discharges including the seas
1982	Directive (82/883)	Monitoring of waste from titanium dioxide industry	Defines procedures for surveillance and monitoring of TiO_2 wastes in the environment, including seas
1983	Decision (83/101)	Protection of the Mediterranean against land-based pollution	Concludes Protocol for protection of the Mediterranean
1983	Directive (83/513)	Cadmium discharges	Sets limit values and quality objectives for Cd discharges
1984	Directive	Mercury discharges from other than the chlor-alkali electrolysis industry	Sets limit values and quality objectives
1984	Directive	HCH (lindane) discharges	Defines limit values and quality objectives for HCH discharges
1986	Directive	List I substance (pentachlorophenol, DDT carbon tetrachloride)	Sets limit values and quality objectives
Proposed	Directive	Dumping of wastes at sea	Prohibits the discharge of certain dangerous substance into the sea and sets up system of certification
Proposed	Decision	Information system on dangerous substances discharged at sea	Extends the scope of 1981 Decision
Proposed	Directive	Contingency plans to combat accidental oil spills at sea	Fixes minimum requirements for national emergency contingency plans
Proposed	Directive	Chromium	Sets quality objectives

Source: Commission of the European Communities 1984

Oil pollution has many effects. First and foremost, it can threaten marine organisms, especially fish, birds and mammals. Secondly, it may cause contamination of beaches and coastal resorts, and thus has important impacts on tourism and recreation. In addition, the operations involved in cleaning up oil pollution are costly and themselves often ecologically damaging. For all these reasons, there is a great need to minimise the occurrence of oil spillages and to maintain a close watch on levels of marine oil pollution.

Table 8.2 **Oil spills from major tanker acidents in European waters, 1972-83.**

YEAR	SHIP	QUANTITY SPILLED (tonnes)	AREA AFFECTED
1972	*Guisippe Giuletti*	26,000	Spain
	Trader	35,000	Greece
1976	*Urquiola*	101,000	Spain
	Boehlen	11,000	France
1978	*Amoco Cadiz*	228,000	France
	Eleni V	3,000	U.K.
	Christos Bitas	5,000	U.K.
	Esso Bernica	1,160	U.K.
	Andros Patria	47,000	Spain
1979	*Betelgeuse*	27,000	Ireland
	Antonia Gramsci	6,000	Baltic (Sweden)
	Messlaniki Frontis	6,000	Greece
	Gino	42,000	France
	Independenta	94,600	Mediterranean (Turkey)
1980	*Irenes Serenade*	102,020	Greece
	Tanio	6,000	France
1981	*Jose Marti*	6,000	Baltic (Sweden)
	Ondina	500	Germany
	Cavo Cambanos	18,000	France
1983	*Sivand*	6,000	U.K.

Source: data from OECD 1985

8.2.1 Inputs to European Waters

The problem of oil pollution in European seas was brought forcibly to the public eye in 1967, when the *Torrey Canyon* grounded off the south-west coast of the United Kingdom. Over 120,000 tonnes of oil spilled from the tanker, spreading into the English Channel and ultimately causing widespread pollution along the coasts of southern England and northern France.

As this indicates, spillages from oil tankers provide one of the major inputs of oil into the sea. These occur for a variety of reasons, both from ships in transit and in port. Causes include collisions, grounding, foundering, fires, explosions, structural failures, spillages during loading and unloading, and deliberate (although generally illegal) discharges of waste oil. The actual quantities involved and the specific causes of the spillages are not always known, however, for incidents are often not reported and many minor releases probably go undetected. In 1982, for example, one study identified a total of 37 oil slicks greater than 0.5 km in Community waters yet only 5 of these (13%) were reported and of known cause. Nevertheless, the most important spillages probably occur as a result of collisions or groundings involving oil tankers, and between 1970 and 1980 an estimated 400,000 tonnes of oil were released in these ways into north-west European waters. The distribution of these incidents is shown in Figure 8.1 and it is clear that the most vulnerable areas are those close to shore and in busy shipping lanes (e.g. in the English Channel). Annual quantities of oil discharged in these spills are indicated in Figure 8.2. No general trend is detectable due to the large variation from year to year, but it is clear that the main contribution comes from a few major incidents (e.g. the *Amoco Cadiz* in 1978, and the *Gino* in 1979).

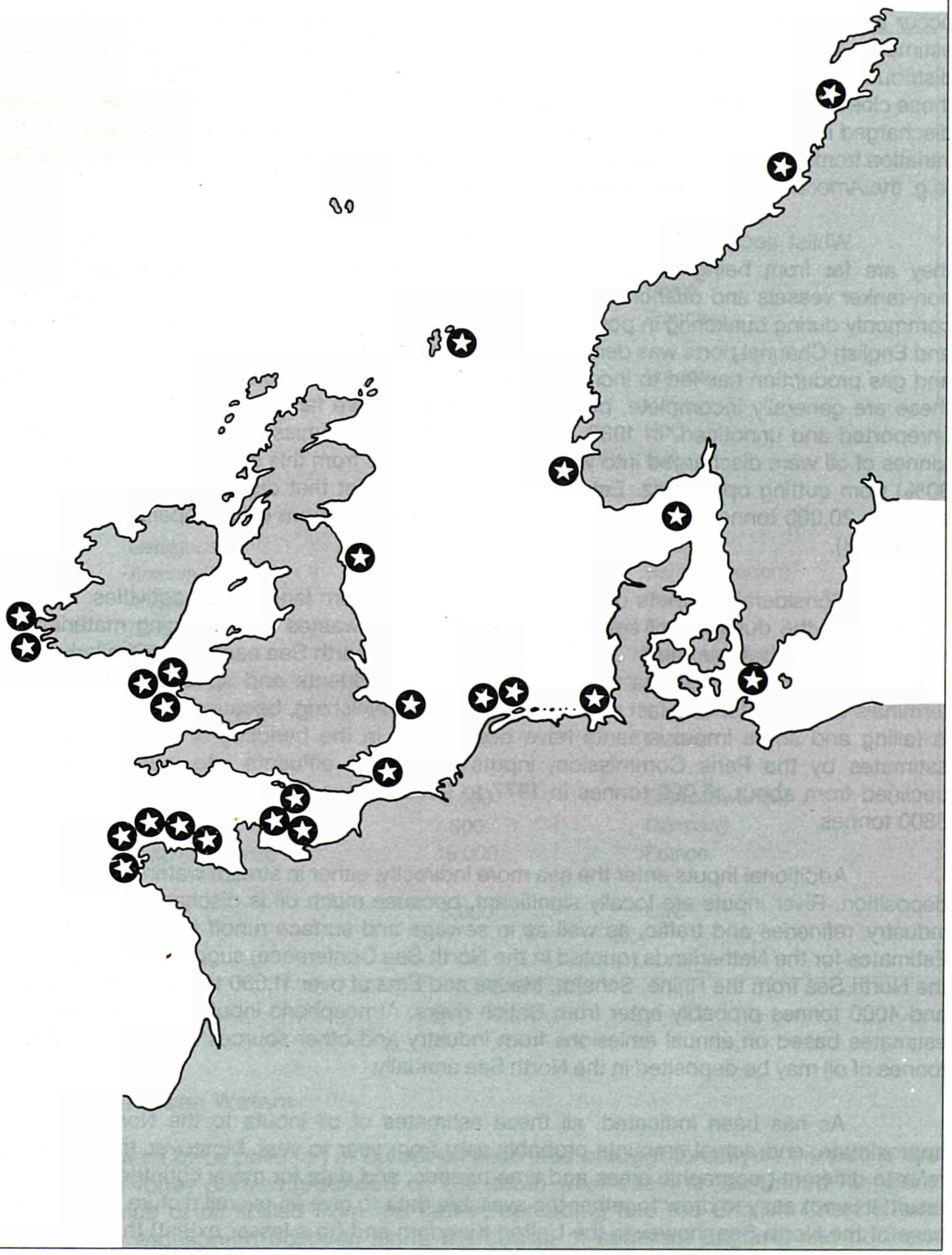
Whilst accidents involving tankers provide the most dramatic incidents of oil pollution, they are far from being the only source of discharges. Significant releases also occur from non-tanker vessels and offshore oil installations. Spillages from non-tanker ships take place most commonly during bunkering in port, and in 1981-2 about a quarter of the oil spilled in the North Sea and English Channel ports was derived from this source. In addition, the development of offshore oil and gas production has led to increasing discharges from wells, platforms and pipelines. Data on these are generally incomplete, because most oilfields are far from shore and spillages may go unreported and unnoticed. In 1982, however, the Paris Commission estimated that about 14,000 tonnes of oil were discharged into west European waters from this source, the vast majority (about 90%) from cutting operations. Estimates for 1983 suggest that discharges may have risen to as much as 20,000 tonnes, and it is generally clear that inputs from oilfield operations are increasing (Figure 8.3).

Considerable inputs of oil also enter the sea from land-based activities. A major input comes from the dumping of sewage sludge, industrial wastes and dredging materials. In total, these may contribute as much as 15,000 tonnes to the North Sea each year. Similarly, much oil is released directly into the sea in sewage, industrial effluents and spillages from oil refineries, terminals and depots. This last source is, perhaps, diminishing, because the number of refineries is falling and some improvements have been made in the handling of oil. Thus, according to estimates by the Paris Commission, inputs of refinery effluents into west European waters declined from about 16,000 tonnes in 1977 to 9500 tonnes in 1981, and may now be as low as 5800 tonnes.

Additional inputs enter the sea more indirectly, either in stream waters, or via atmospheric deposition. River inputs are locally significant, because much oil is discharged into streams from industry, refineries and traffic, as well as in sewage and surface runoff from roads and farmland. Estimates for the Netherlands (quoted in the North Sea Conference) suggest a total annual input to the North Sea from the Rhine, Scheldt, Meuse and Ems of over 11,000 tonnes, while between 2000 and 4000 tonnes probably enter from British rivers. Atmospheric inputs are less well known, but estimates based on annual emissions from industry and other sources indicate that 8000 - 9000 tonnes of oil may be deposited in the North Sea annually.

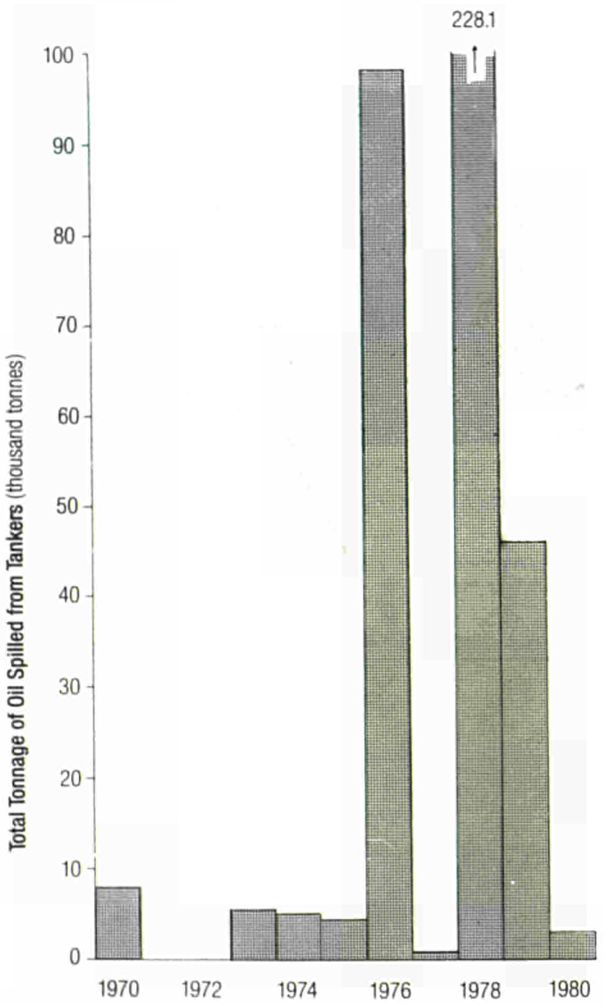
As has been indicated, all these estimates of oil inputs to the North Sea are highly approximate, and actual amounts probably vary from year to year. Moreover, the sources quoted refer to different geographic areas and time periods, and data for many countries are limited. As a result, it is not easy to draw together the available data to give an overall picture of oil inputs. In the case of the North Sea, however, the United Kingdom and (to a lesser extent) the Netherlands, are undoubtedly the main sources of oil pollution. Figure 8.4 shows the relative contributions from

Figure 8.1 **Major oil spillages from tankers in the North Sea and adjacent waters, 1970-1980.**



Source: data from Royal Commission on Environmental Pollution 1981

Figure 8.2 **Annual quantities of oil discharged from major spills in the North Sea and adjacent waters, 1970-1980.**

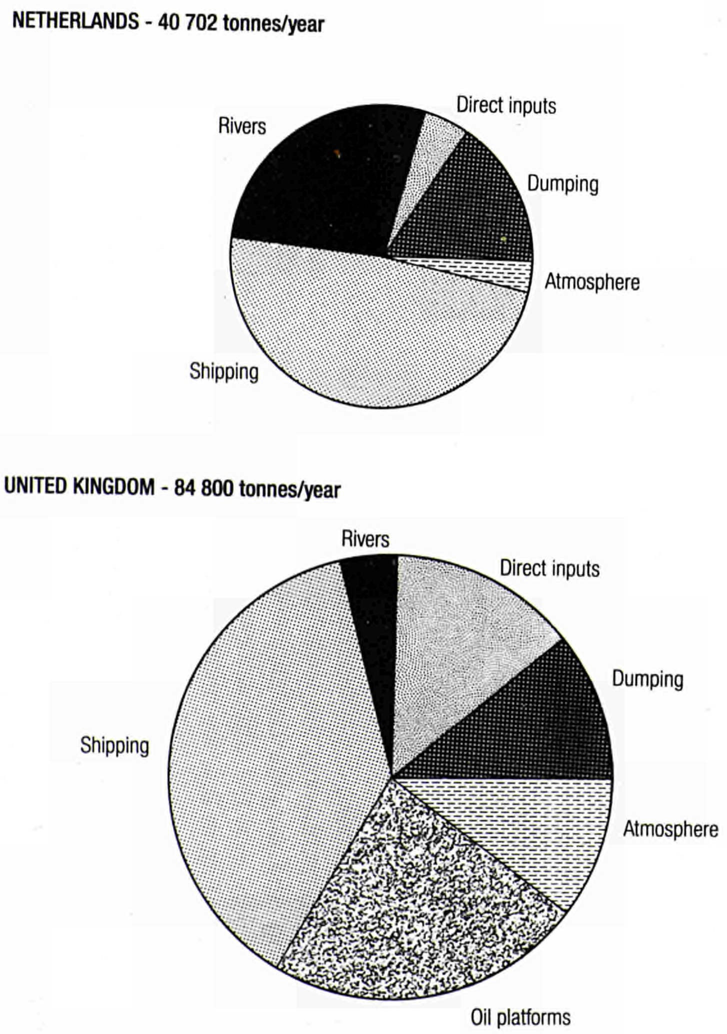


Source: data from Royal Commission on Environmental Pollution 1981

different sources in these countries (based on data from both the Paris Commission and North Sea Conference). Remembering the limitations of the data, we can nevertheless see that discharges from shipping and oilfields constitute the dominant source, while inputs from dumping, direct discharges, rivers and the atmosphere probably comprise about 40% of the total. Extrapolating from the data in Figure 8.4, we might anticipate an overall input of about 120,000 - 150,000 tonnes per year.

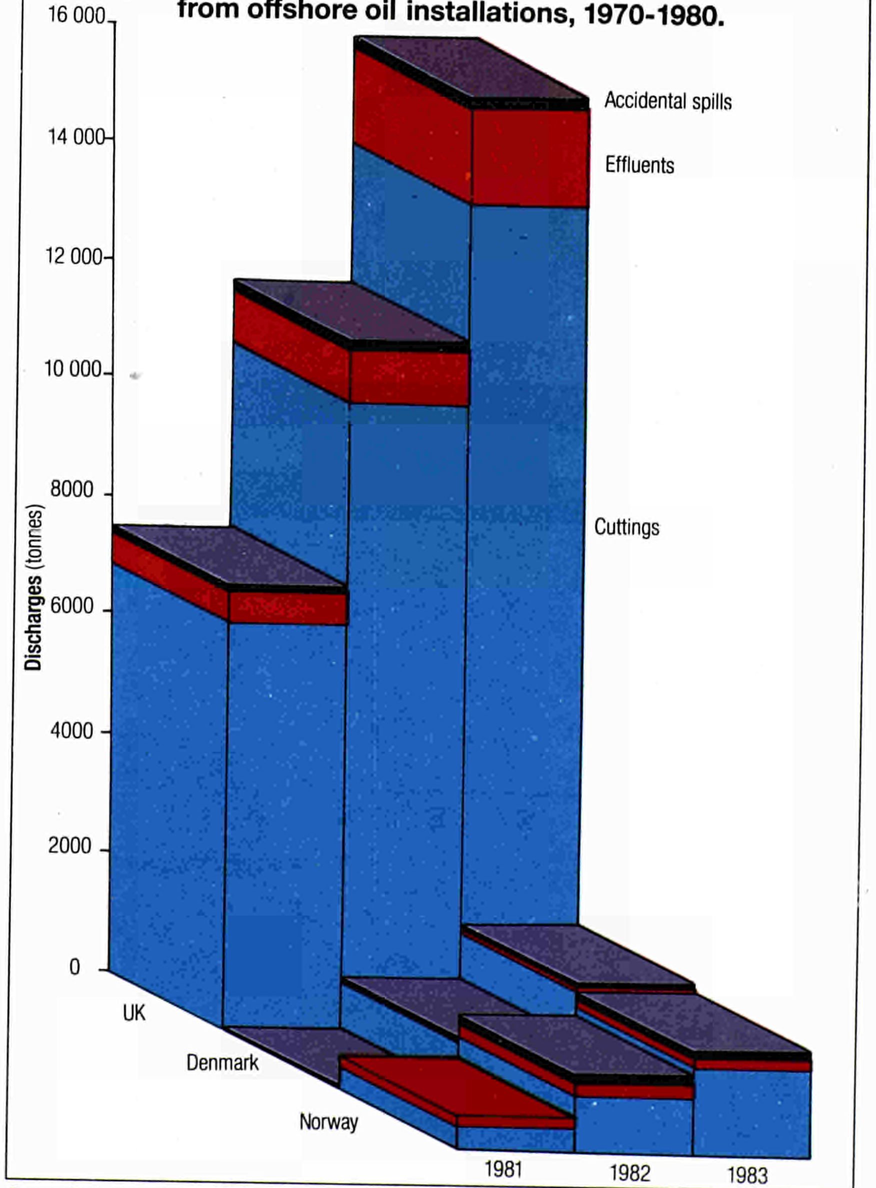
Data on oil inputs to the Mediterranean are far less comprehensive, but estimates for total inputs range from 0.1 to 1.0 million tonnes per year. A realistic value would appear to be about 800,000 tonnes, most of which comes from terrestrial runoff or release by shipping. The Mediterranean has over 60 refineries located along its coast, while about 35% of the world's tanker fleet, carrying over 350 million tonnes of crude oil, cross the Mediterranean each year. Together, these make the Mediterranean one of the most oil-polluted seas in the world.

Figure 8.4 **Oil inputs to the North Sea from Britain and the Netherlands.**



Source: data from International Conference on the Protection of the North Sea 1984

Figure 8.3 **Oil discharges to the North Sea and adjacent areas from offshore oil installations, 1970-1980.**



Source: Paris Commission 1984

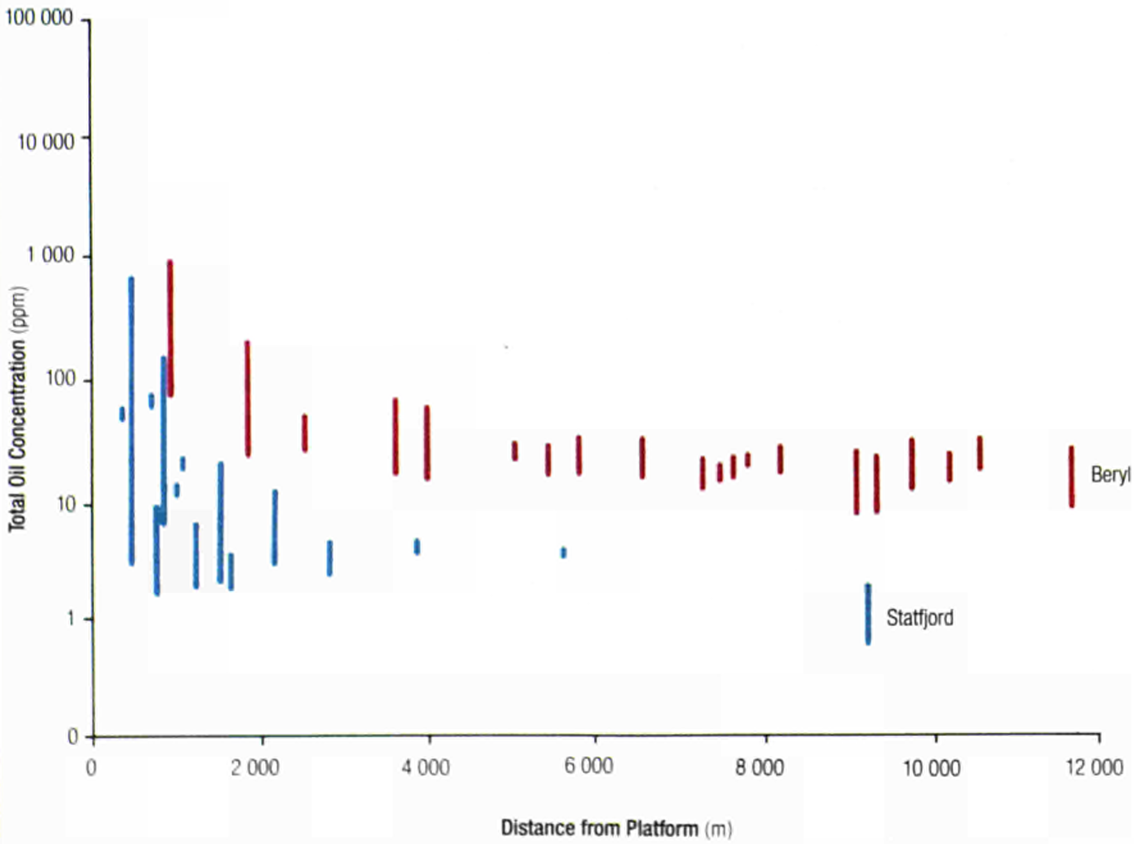
8.2.2 Oil Concentrations in European Waters

Concern about levels of oil pollution in the seas of the Community has grown mainly since the early-mid 1970s. The development of offshore oil production in the North Sea, and the occurrence of several major tanker accidents in Community waters, then led to a number of surveys being carried out by various member states. Few of these surveys are extensive or regular enough to show the detailed distribution of oil concentrations in the sea, but broad ranges can be identified for different types of marine environment: for example, open sea, oil field areas, coastal waters, industrial estuaries and oil-handling sites.

Measurements in open water provide an indication of baseline oil concentrations in the North Sea. Most studies indicate a background level of less than 2.5 μg/l, with an average of about 1.25-1.5 μg/l. Other areas tend to show values considerably higher than this baseline concentration. Highest concentrations tend to occur in industrial estuaries and close to oil platforms or terminals.

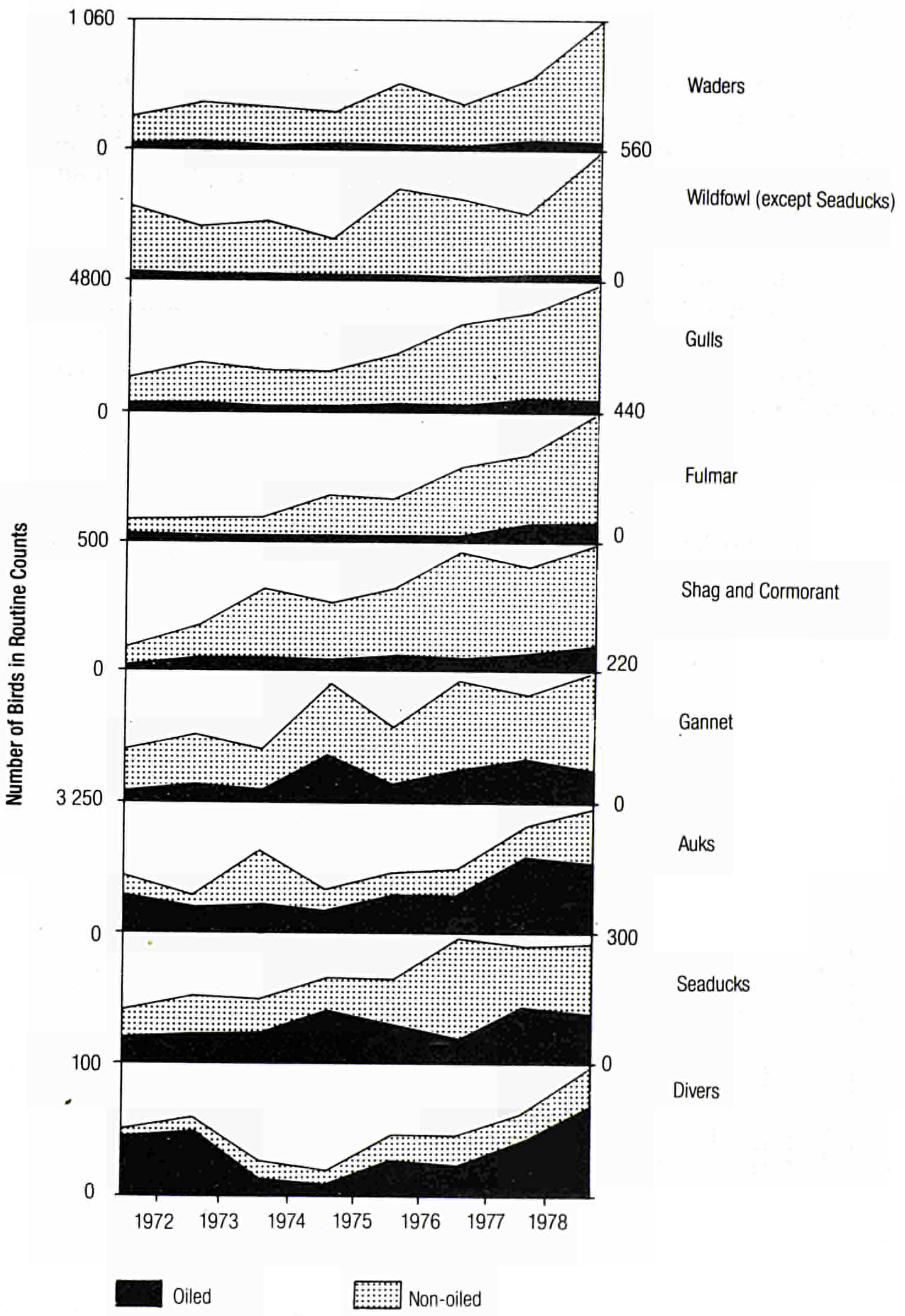
In the North Sea, for example, levels of oil pollution as high as 40 μg/l have been reported from inner estuary areas of the Forth and Northumbrian coast. Typically, however, concentrations decline seaward, and in the outer estuaries are generally below 10 μg/l. Similar, though less extreme, patterns are seen in the Elbe estuary in northern Germany, where petroleum hydrocarbon concentrations fall from 7 - 13 μg/l in the estuary itself to 0.4 - 0.6 μg/l in the open sea (1983 data).

Figure 8.5 **Levels of oil pollution around North Sea oil platforms.**



Source: after International Conference on the Protection of the North Sea 1984

Figure 8.6 **Mortality and oiling of selected groups of seabirds around the coast of the United Kingdom, 1971-1979.**



Source: data from Royal Society for the Protection of Birds 1979

High concentrations of oil have also been found around oil platforms in the North Sea, though they fall to background levels within a few thousand metres. Around the Beryl platform in the northern North Sea, for example, oil concentrations in the surface water fall from about 1000 p.p.m in the immediate vicinity of the platform to about 10 p.p.m at a distance of 5000 m. A similar pattern is also seen in the Statfjord field (Figure 8.5).

In general these data show that oil concentrations in the North Sea are low and, except in very localised areas, are well below the concentrations likely to have any significant effects on coastal or marine wildlife. Only in the immediate vicinity of platforms and highly industrialised estuaries do oil levels exceed 10 $\mu g/l$. On the basis of data from U.K. waters, it seems probably that these areas comprise no more than 0.02% of the whole North Sea basin. On the other hand, conditions in the Mediterranean are far less satisfactory. Background levels seem to be close to 5 $\mu g/l$ on average, while severe oil pollution occurs along shipping lanes, especially in eastern regions where discharges of oil from ships were permitted until recently: here concentrations of 50 $\mu g/l$ have been reported. The extent of pollution is also evidenced by the widespread occurrence of oil slicks and tar balls. Trapped by the almost closed circulation of the Mediterranean, these ultimately accumulate on the coast, where they contaminate tourist beaches and wildlife.

8.2.3 Ecological Effects

Oil pollution has a wide range of ecological impacts. In the long term, low-level inputs of oil undoubtedly have significant effects, especially in estuarine areas where they may inhibit the survival of sensitive plants, zooplankton and molluscs. Data on these effects are relatively rare, however, and the most obvious impacts are from shorter-term, higher concentration pollution incidents, such as those arising from spillages. In these cases, large slicks may develop which drift across the sea and ultimately collect on beaches and in sheltered bays and estuaries. In the process, considerable numbers of marine and littoral species may be contaminated.

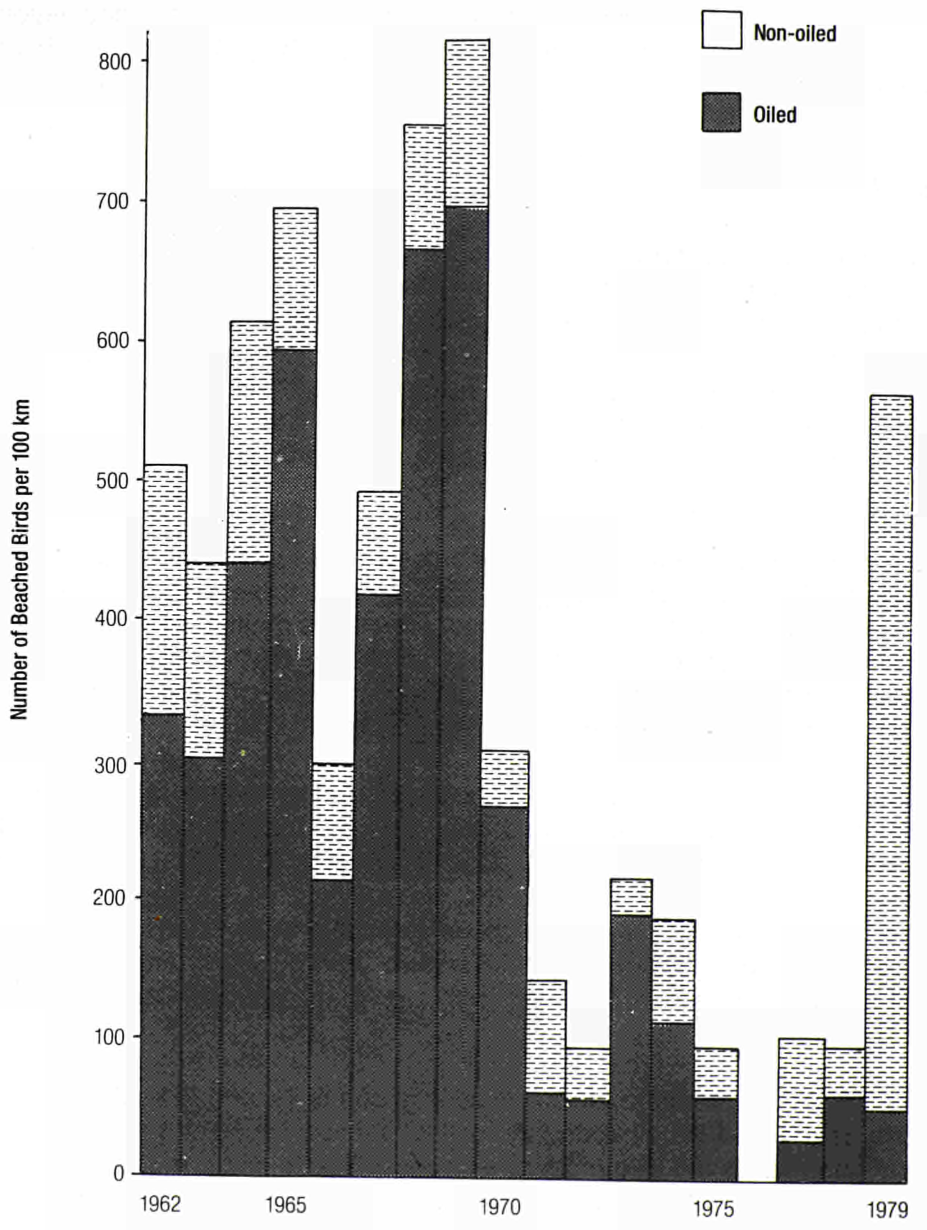
By far the most seriously affected group of organisms are birds. These suffer both directly, through physical oiling of their bodies and ingestion of oil residues, and indirectly through effects on their food supply and nesting grounds. The more direct effects are most readily seen, because they result in large numbers of dead and oiled birds almost immediately after the spillage. Indirect effects may have substantial long-term impacts on bird populations, however, by reducing survival rates of chicks and increasing mortality amongst older, less healthy birds.

Susceptibility to oiling varies between species. Numerous factors are involved, including the location of the spillage, the time of the year, and the population size and feeding, breeding and nesting habits of birds. Species most at risk tend to be those which are gregarious and spend much of their time on the water. Most oil spillages tend to occur in coastal areas, and oil slicks commonly build up on beaches, in estuaries and in quiet inlets. Species which frequent these localities are therefore particularly vulnerable. In addition, spillages are most abundant in winter time, so winter-residents are generally more at risk than summer-resident species.

As Figure 8.6 shows, therefore, divers, seaducks and auks tend to be the most vulnerable species in the North Sea. These are all abundant, collect in large flocks and are active swimmers. Gannets, shags and cormorants are also moderately susceptible to oiling, mainly because they are locally present in large numbers. Other seabirds, such as fulmers, gulls and skuas, which spend little time on the water, are least vulnerable, while waders and other essentially littoral species are rarely subject to oiling in large numbers, but may be affected by longer-term impacts of oil on their feeding grounds.

The data in Figure 8.6 show changes in numbers of beached and oiled birds found on surveys of the U.K. coastlines between 1971 and 1979. The general trend is clear: numbers of all species are rising, though in relative terms the percentage oiled is decreasing slightly. How representative these data are of wider conditions is uncertain. Surveys in both the United Kingdom and Helgoland show that the incidence of oiling has clearly increased in recent years; in Belgium on the other hand, both the number of beached birds and the number oiled declined between 1968 and 1978, before another large increase in 1979 (Figure 8.7).

Figure 8.7 **Numbers of beached and oiled birds recorded on the Belgian coast, 1962-1979.**



Source: data from Aquatic Biological Consultancy Services Ltd 1984

Plates 8.1-8.2 **Marine and littoral bird species differ in their suceptibility to oil pollution according to their nesting and feeding habits and the time they spend in polluted areas. Two of the more susceptible species are puffins and cormorants.**

Plate 8.1 **Puffin (*Fratercula arctica*)**

Plate 8.2 **Cormorant (*Phalacrocorax carbo*)**

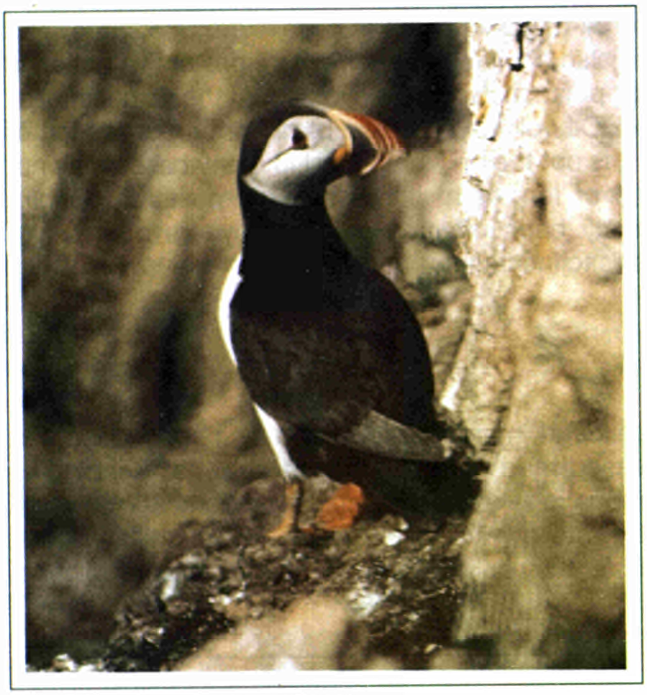


Photo: D. Moss, Nature Conservancy Council

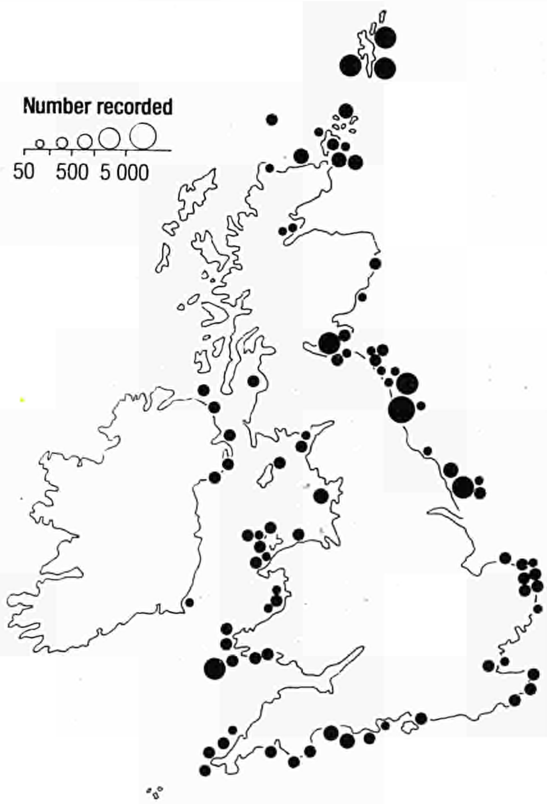
Photo: D. Moss, Nature Conservancy Council

The distribution of bird casualities during long-term surveys around the coast of the United Kingdom is shown in Figure 8.8. The patterns are to some extent predictable, in that the highest numbers of casualties are found close to oil-handling areas (e.g. Teeside, Shetlands) and where seabird populations are largest. This figure also shows, however, where protective action is most urgently needed if long term effects on bird populations are to be avoided. At the same time, all these data need to be placed into a wider context. Oil pollution is undoubtedly an important factor influencing bird populations in marine areas, but it is not the only one - and in many cases may not be the most crucial. Nor is there any evidence of long-term impacts of oil pollution on bird populations. Individual communities have certainly been affected for some years after major spillages, but overall the trend is for bird populations to increase.

8.3 HEAVY METALS

Heavy metals such as cadmium, copper, lead, mercury, nickel and zinc are widespread environmental pollutants. On land, they are released by a range of human activities - including smelting, metal manufacturing and fossil fuel combustion - and in industrial and domestic sewage. From these sources, they travel extensively, by stream, in the atmosphere, in solid wastes, ultimately to reach the sea. Being relatively insoluble, they collect there not in the seawaters, but in

Figure 8.8 **Bird casualties recorded in surveys in the U.K. and Ireland, 1971-79.**



Source: after Aquatic Biological Consultancy Services Ltd 1984 the sediments and marine organisms. So, over time, the heavy metals enter and pass through marine food chains until, in the animals at the top of the system, large and sometimes fatal concentrations accumulate.

8.3.1 Inputs to European Waters

Like most other marine pollutants, heavy metals enter the sea via a number of pathways. One of the major sources tends to be rivers, because streams are used to dispose of urban and industrial wastes, and these are collected and transported from extensive inland areas. Significant quantities are also discharged by man directly into the sea, either from coastal settlements and industries or by waste dumping. In addition, large amounts of heavy metals may be deposited from the atmosphere, while weathering of coastal rocks and sea-floor sediments may release minor quantities.

Data on all these inputs are inevitably limited, and estimates from different authorities tend to vary substantially. This is particularly so in the case of atmospheric inputs, as Table 8.3 shows. Estimates of the annual atmospheric input of zinc to the North Sea, for example, range from less than 1500 tonnes to 77,000 tonnes. Those for lead vary between 1730 tonnes and 13,000 tonnes. The same is true for the Mediterranean. Estimates for atmospheric deposition of lead range from 300 - 1800 ng/cm²/yr, while those for cadmium range from 10-50 ng/cm²/yr. In both cases the wide ranges are simply a reflection of the similar discrepancies in the estimates of rainfall over these sea areas. Even so, it is clear that levels of atmospheric deposition do vary markedly from one part of the sea to another. In the Mediterranean, for example, atmospheric concentrations of lead and cadmium are 5-10 times higher close to densely populated areas than they are over the open sea. Without doubt, these are reflected by the patterns of deposition.

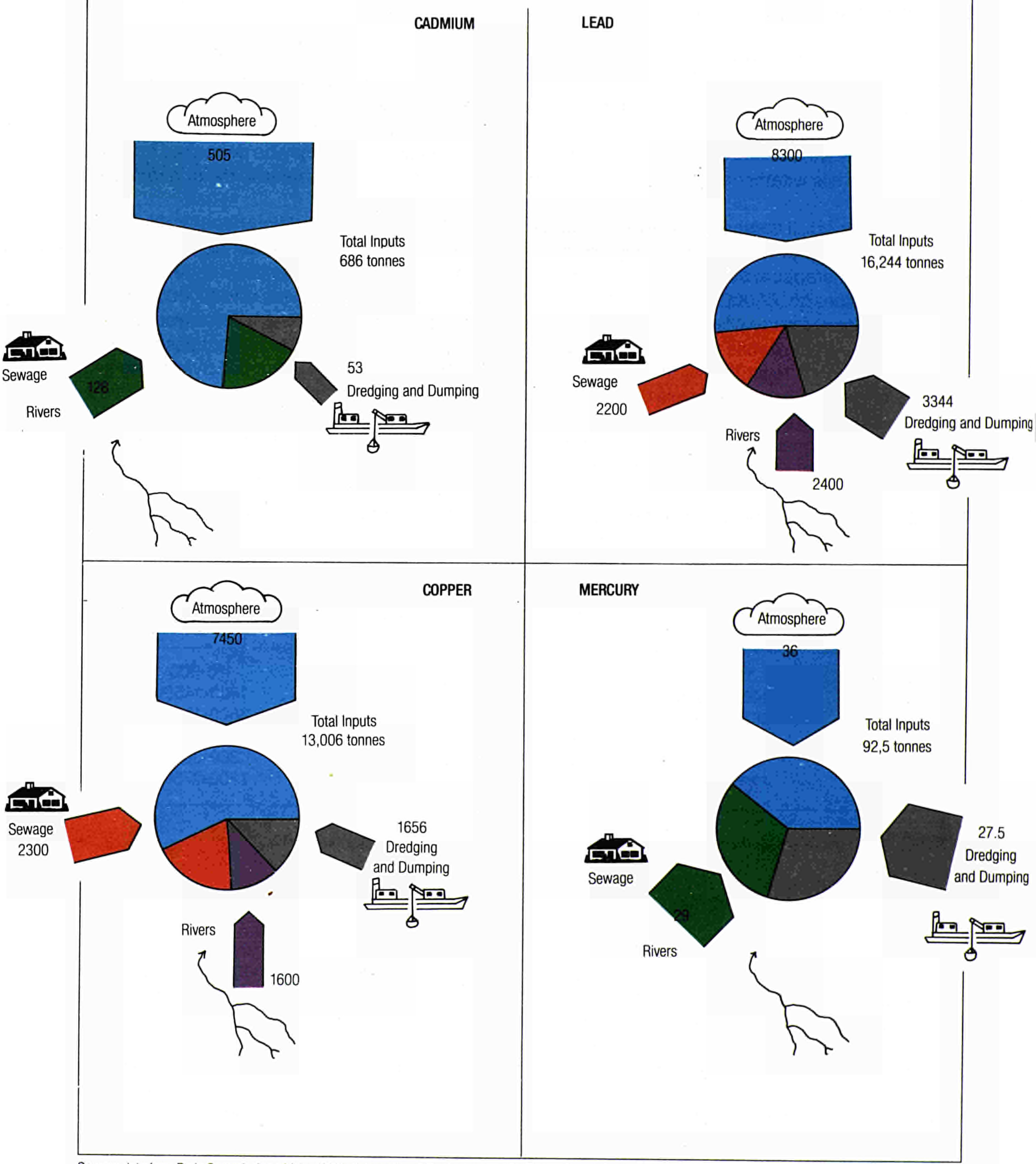
Table 8.33 **A comparison of the estimated atmospheric inputs of heavy metals to the North Sea.**

Heavy metal	Estimated input (t/y)				
	TNO (1)	ICES (2)	Cambray (3)	Hill et al. (4)	Paris Commission (5)
Cadmium	110-430	-	-	340-890	110-900
Copper	1400-10000	4900	5600	2310-6100	1400-14500
Lead	3600-13000	5600	5800	1730-4560	3600-13000
Mercury	<36	5.6	7	30-80	<36
Nickel	360-3600	1650	<1900	940-2470	360-3600
Zinc	7200-58000	1450	1600	4160-10960	7200-77500

Notes:
1: van Aalst *et al* (1983)
2: International Council for the Exploration of the Sea (1978)
3: Cambray *et al* (1979)
4: Hill *et al* (1984)
5: Paris Commission (1984b)

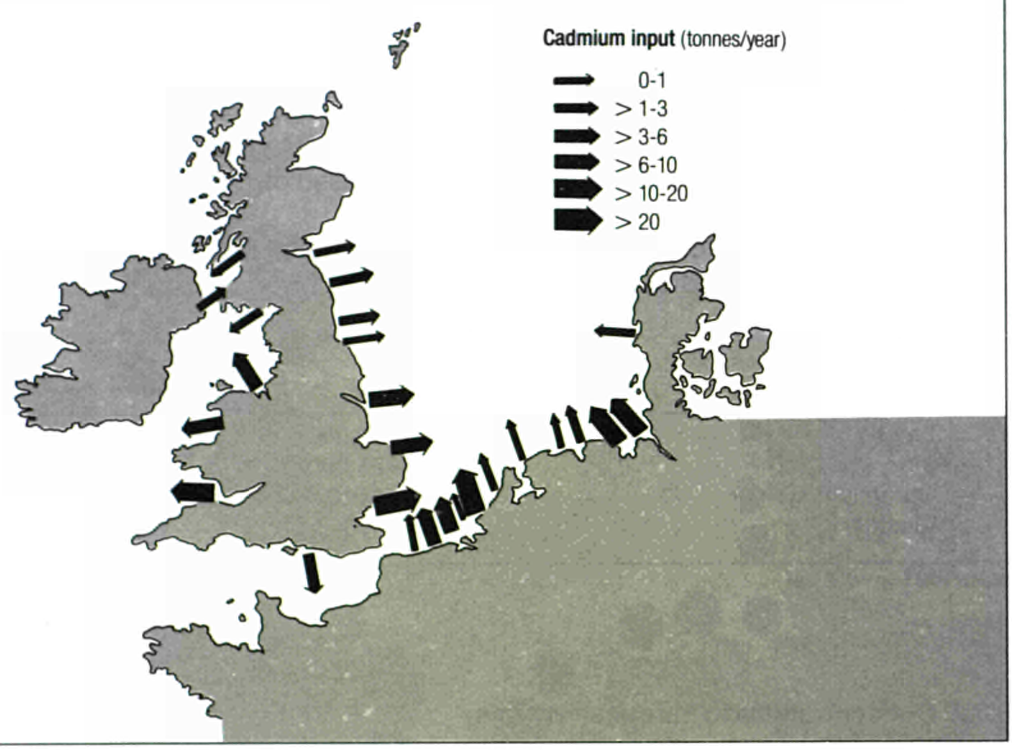
Since, in many cases, the atmosphere appears to provide the dominant source of heavy metals to the seas, the uncertainty surrounding these data makes any attempt at quantifying total inputs highly doubtful. This needs to be borne in mind in considering Figure 8.9, which shows inputs of selected heavy metals to the North Sea. Data used in this Figure are simply mid-points from ranges presented in the Paris Commission reports. In addition, estimates of inputs from dumping and dredging may give something of a false picture. Most of these inputs are from dredging (and these derive mainly from the United Kingdom) and, in strict terms, merely involve the redistribution of sea-bottom sediments from estuaries and harbour areas out to sea. Thus, they do not constitute a real input to the North Sea, but rather an internal transfer.

Figure 8.9 **Inputs of heavy metals to the North Sea: cadmium, lead, mercury and copper.**



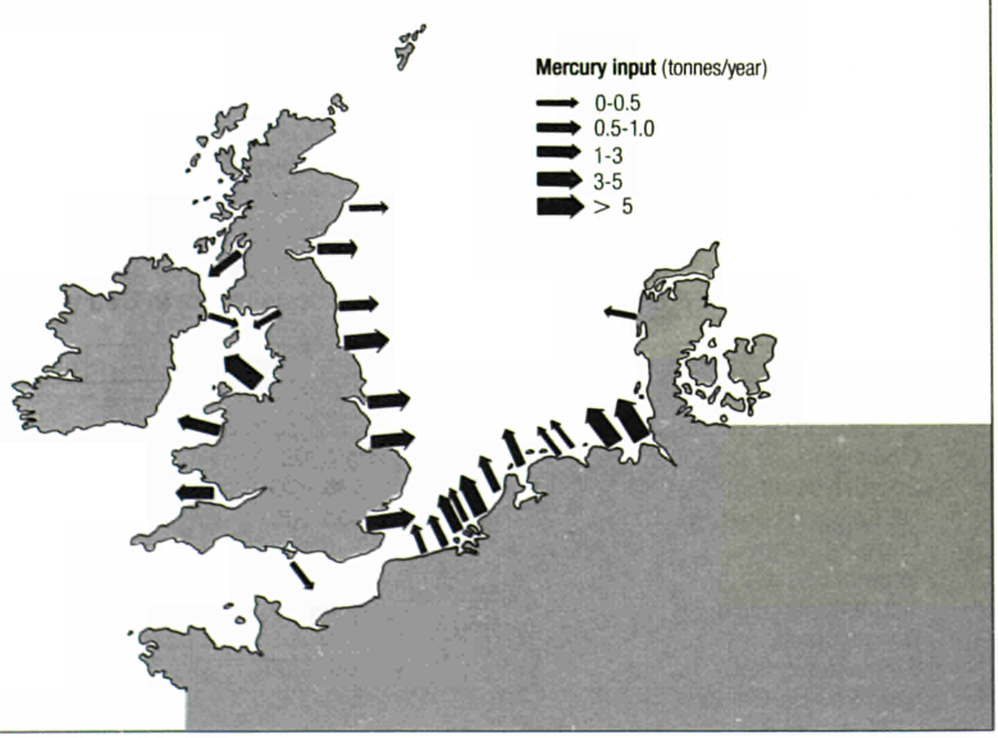
Source: data from Paris Commission 1984a, 1984b; International Conference on the Protection of the North Sea 1984

Figure 8.10 **Riverine inputs of cadmium to North Sea and adjacent waters.**



Source: data from Paris Commission 1984b

Figure 8.11 **Riverine inputs of mercury to North Sea and adjacent waters.**



Source: data from Paris Commission 1984b

Bearing in mind the limitations of the data, we can nevertheless, gain some impression of the major sources of heavy metals. According to the data in the Paris Commission and North Sea reports, the atmosphere provides the main inputs, normally accounting for over 50% of the total. Inputs from rivers typically comprise 10 - 30% of the total, though locally they may be much greater. Examples of inputs of riverine cadmium and mercury to north-west European waters are shown in Figures 8.10 and 8.11. The major influence of the Rhine and its distributaries, the Elbe and the Weser is clear. Between them, these drain some of the most intensively industrialised areas, not only in the Community, but also in East Germany. Data for the Mediterranean are scantier, but Table 8.4 summarises estimated inputs of four heavy metals based on data collected by UNEP.

Table 8.4 **Inputs of heavy metals to the Mediterranean Sea.**

Heavy metal	Atmospheric input (t/yr)	Riverine input (t/yr)
Lead	5,000 - 30,000	2,200 - 3,100
Zinc	4,000 - 25,000	11,000 - 17,000
Chromium	200 - 1,000	350 - 1,900
Mercury	20 - 100	30 - 150

Source: data from UNEP 1984

8.3.2 Concentrations in European Waters

Problems associated with the measurement of heavy metal concentrations in sea water mean that results of earlier surveys of Community waters must be treated with caution. As a result, reliable data on concentrations are scarce. Some of the more recent data for cadmium and copper in the North Sea, however, are presented in Table 8.5. As this shows, average copper concentrations in coastal waters are probably about 200-555 ng/l, while, in the open ocean, the background concentration is in the range of 10 - 100 ng/l. For cadmium, the average values are 20 - 100 and 5 - 10 ng/l respectively.

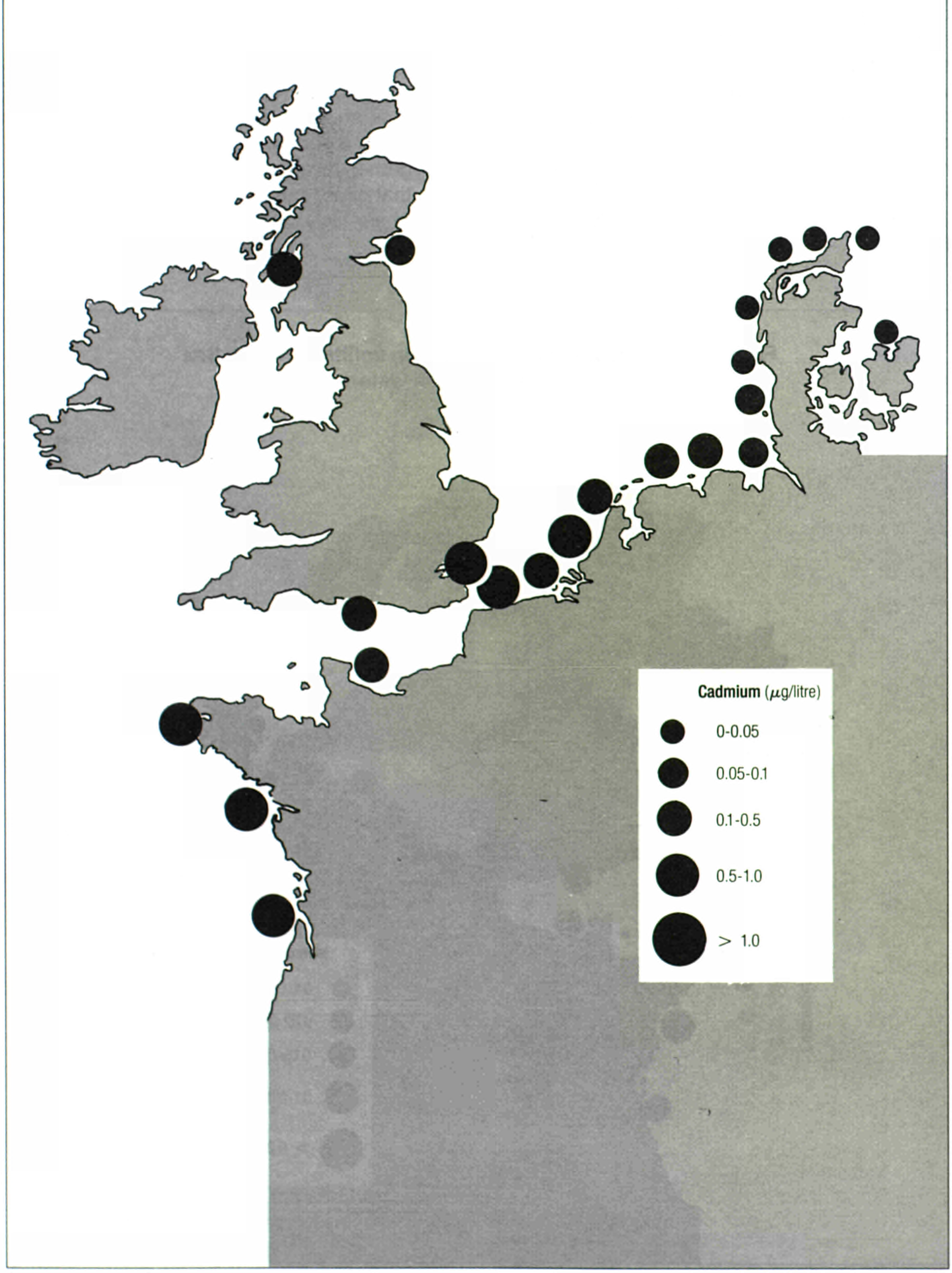
As these data indicate, highest concentrations of heavy metals tend to occur in coastal waters, and particularly close to major estuaries. This reflects the localised inputs of heavy metals from rivers. The consequences are seen in Figures 8.12 and 8.13, which show concentrations of cadmium and mercury in coastal waters in western Europe. Highest concentrations occur close inshore, mainly in estuaries fed by rivers draining industrial hinterlands, such as the Thames, the Scheldt-Rotterdam area, the German Bight, the Loire and the Gironde.

Table 8.5 **Heavy metal concentrations in North Sea waters.**

	Copper (ng/l)	Cadmium (ng/l)
Open sea	10-100	5-10
Scottish coast	100-400	10-60
NE England coast	400-800	50-100
English Channel	300	30
Scheldt Estuary	400-1500	40-180
Netherlands coast	200-300	20-30
Danish coast	450	25
S. Sweden coast	700-1200	40-130
Nord Pas-de-Calais	-	10-40

Source: data from International Conference on the Protection of the North Sea 1984

Figure 8.12 **Cadmium concentrations in unfiltered North Sea and adjacent coastal waters.**



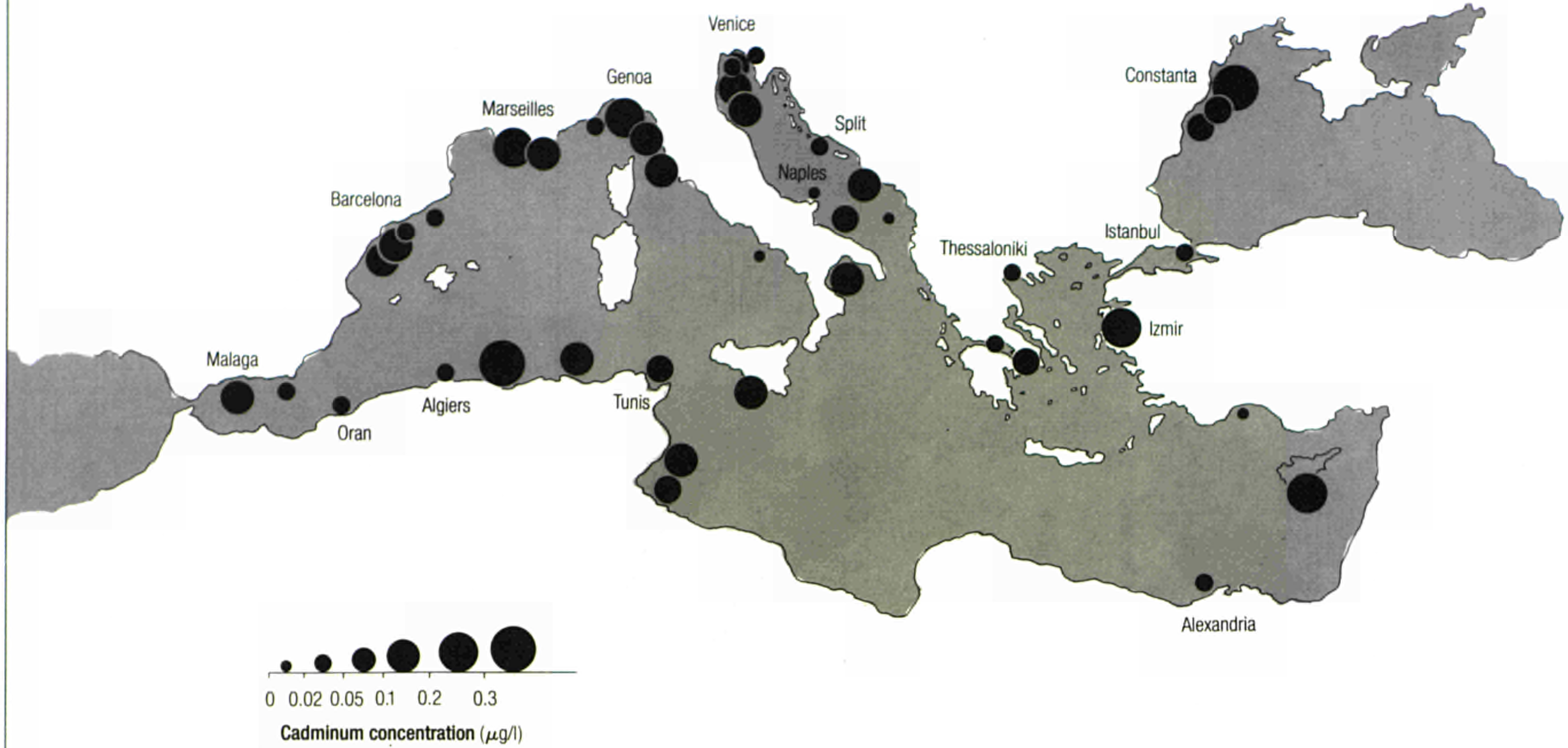
Source: data from Paris Commission 1984b

Data for the Mediterranean Sea are much more scarce. Estimates collated by UNEP, as part of the MED POL programme, however, indicate background mercury levels in the open sea of about 0.12 μg/l. Concentrations in coastal waters are apparently more variable, depending on the effect of local riverine inputs, but seem to range between 0.02 and 0.60 μg/l, highest concentrations occurring around heavily polluted estuaries such as the Rhone, lowest values being associated with areas where clean streams dilute the coastal waters. Information on other heavy metals is even more sparse, but in general cadmium, copper, zinc and lead show similar patterns. Cadmium levels in sea water, for example, range from about 0.004 μg/l in the least polluted regions to over 0.1 μg/l in the most polluted estuaries. Some indication of this pattern is shown by the data for mercury and cadmium in Figures 8.14 and 8.15. These present results from a survey of 126 coastal sites by the research ship *Calypso* in 1977. The data are not altogether reliable because of the analytical limitations which are now known to have existed at that time, but the existence of localised 'hot-spots' is apparent, most notably around Ravenna where high concentrations of mercury are found.

Figure 8.13 **Mercury concentrations in unfiltered North Sea and adjacent coastal waters.**

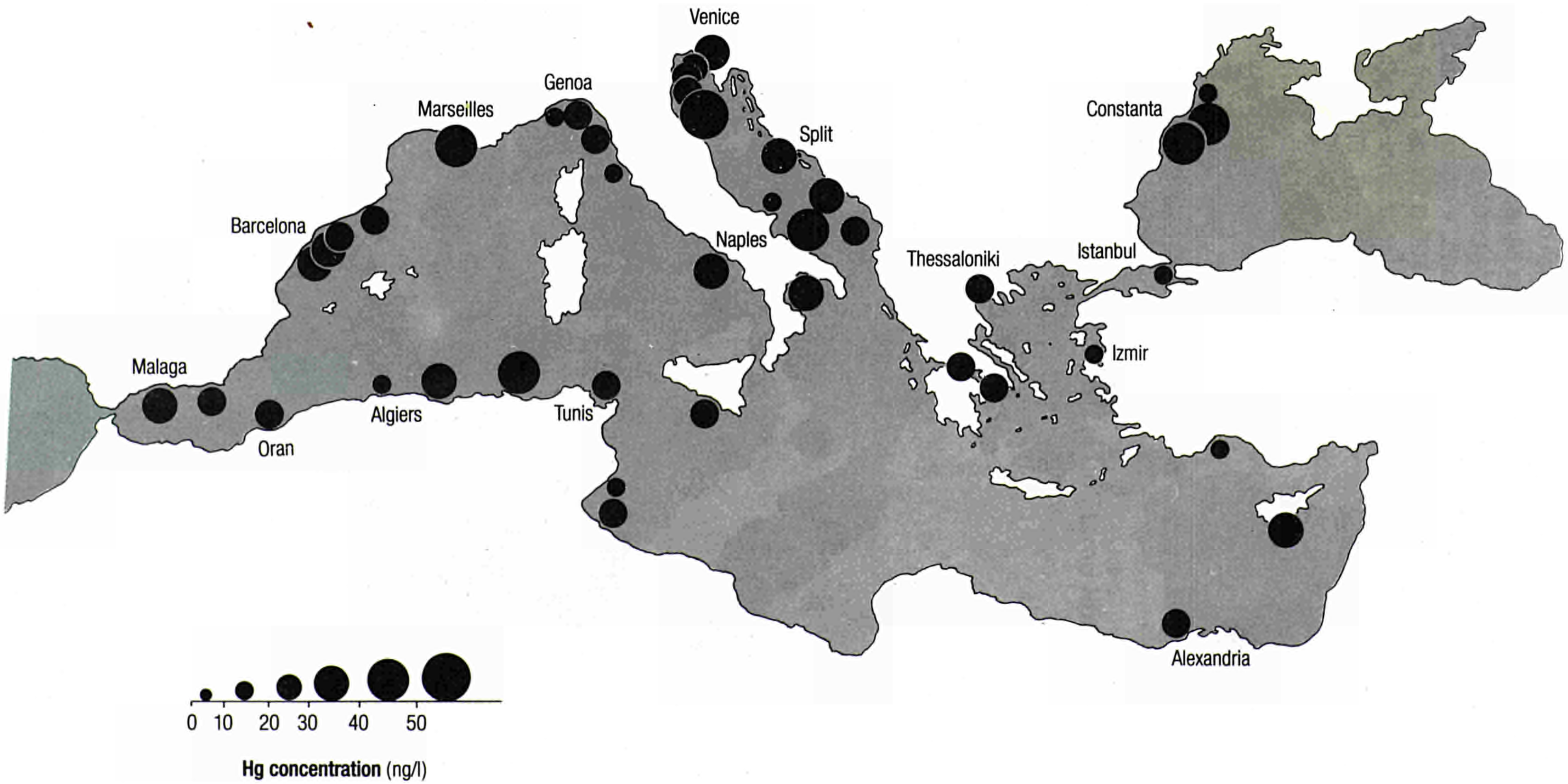
Source: data from Paris Commission 1984b

Figure 8.14 **Cadmium concentrations in coastal waters of the Mediterranean.**



Source: data from Commission Internationale pour l'Exploration de la mer Méditerranée 1979

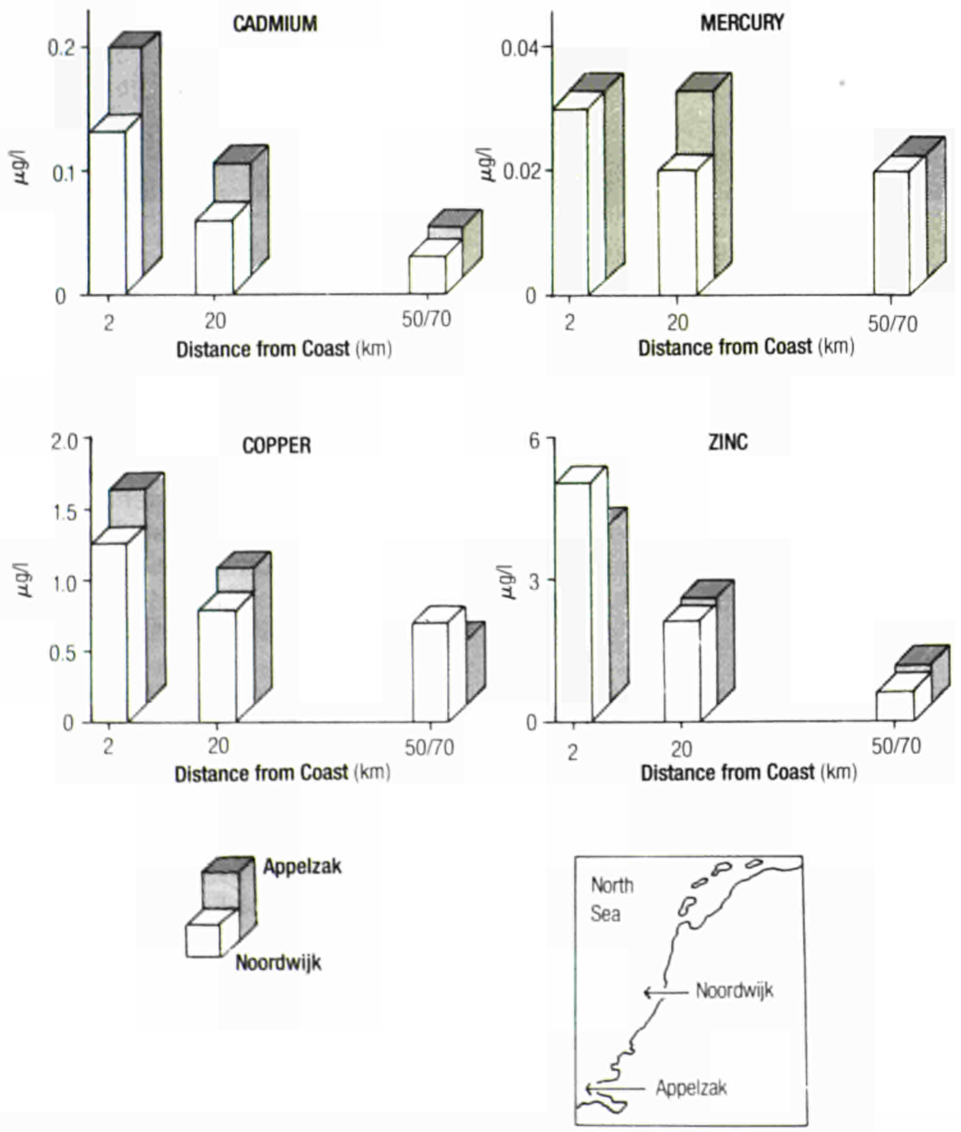
Figure 8.15 **Mercury concentrations in coastal waters of the Mediterranean.**



Source: data from Commission Internationale pour l'Exploration de la mer Méditerranée

These data are in some ways encouraging, because they suggest that significant heavy metal pollution is confined to relatively small areas of both the North Sea and Mediterranean, in the immediate vicinity of input sources. This is not altogether surprising, because heavy metals are often relatively insoluble and readily become adsorbed to organic and inorganic particles in the water. These settle out in the estuarine and inshore areas and thus limit the spread of heavy metal pollution into the open sea. As the data in Figure 8.16 show, therefore, steep concentration gradients occur away from the coast and heavy metal concentrations generally fall to background levels within 50 km of the coast, even in the most severely polluted areas. The corollary, however, is that high concentrations of these substances tend to accumulate in the coastal sediments. In the German Bight, for example, cadmium concentrations of over 2.5 mg/g are found close inshore, in the estuaries of the Ems and Weser. These decline to less than 1 mg/g within 2 km. Similarly, mercury levels fall from 0.8 mg/g to less than 0.1 mg/g, while comparable trends are also shown by copper and zinc.

Figure 8.16 **Heavy metal concentrations off the coast of the Netherlands.**



Source: data from International Conference on the Protection of the North Sea 1984

Plate 8.3 **Organic pollution of coastal waters, Denmark.**

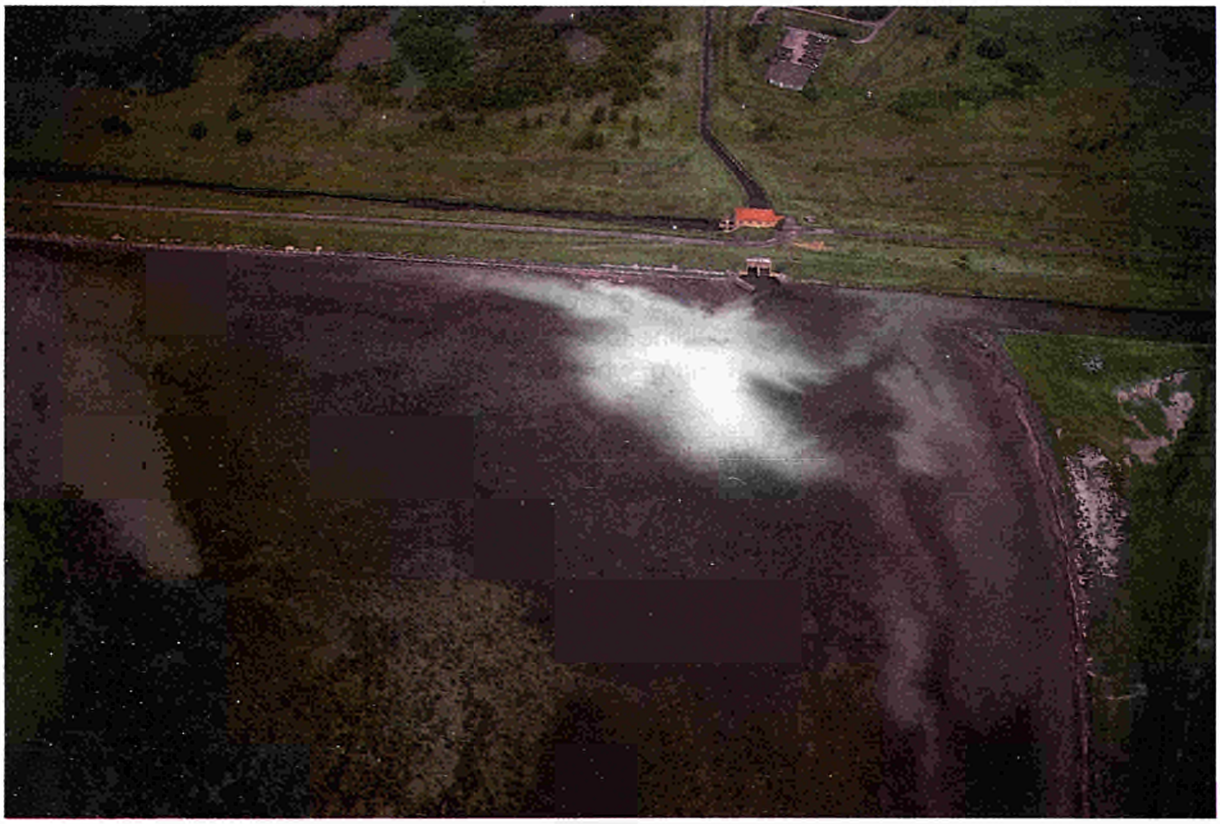


Photo: D. J. Briggs

Fixation of the heavy metals by sediments in this way clearly has important implications. On the one hand, it helps to remove pollutants from water and restricts high levels of contamination to the offshore zone. On the other hand, the process is a dynamic one, and these same metals may be released from sediments if seawater concentrations fall and the equilibrium is upset. Reductions in heavy metal inputs, therefore, may not lead to proportional improvements in water quality because of the release of the elements from the sea floor sediment. In addition, the sediments provide an important pathway by which the heavy metals enter foodchains, for bottom-dwelling organisms may absorb large quantities of pollutants which are subsequently passed to predatory fish and birds.

8.3.3 Ecological Effects

Because of their persistence, toxicity and widespread occurrence, heavy metals present particular threats to aquatic ecosystems. Marine organisms are exposed to these pollutants almost constantly - dissolved in the seawater around them, adsorbed onto suspended or seafloor sediments, or contained in their food materials. They take in the metals by a number of processes. Phytoplankton absorb the pollutants directly during photosynthesis. From these, they may be passed to zooplankton and fish by ingestion. Fish also absorb large quantities of heavy metals through their gills, while bottom-dwelling organisms take in the metals from the sediment during filter feeding. In turn, these primary and secondary consumers are eaten by organisms higher up the food chain so that the pollutants eventually accumulate in predatory birds and mammals.

The level of bioaccumulation depends on many factors, including the ambient quantities of the metal in the surrounding environment, the nature of the pollutant, and the character of the organism itself. In the case of aquatic organisms, it is this last factor which generally seems most important, and marked differences are found between different organisms living in the same environment. For this reason, most studies concentrate on those organisms which have the highest affinity for heavy metal uptake, and thus the most reliably measurable contents in their bodies. Recommended species include the flounder (*Platichthys flesus*), the edible mussel (*Mytilus edulis*) and the dabfish (*Limanda limanda*).

Results from surveys of these and other organisms in both the North Sea and Mediterranean are highly variable. Data for the Mediterranean, for example, show concentrations of lead in *Mytilus* flesh ranging from about 2.5 to over 100 μg/g (dry weight), while copper may reach over 150 μg/g (Table 8.6). With the exception of lead, these levels are not dissimilar to those reported from the North Sea and Atlantic, and appear to pose no specific health threat. On the other hand concentrations of mercury in certain other, pelagic species - notably tuna - appear to be anomolously high. The reasons are not entirely clear, for the concentrations do not appear to reflect particularly severe levels of pollution in the Mediterranean waters. To date, there is no evidence that these have led to any risk to human health, but some concern exists about the potential effects on high-risk groups, such as local fishermen, children and pregnant women, and close monitoring of the situation seems desirable.

Table 8.6 **Heavy metal concentrations in flesh of *Mytilus* species from different regions of the Mediterranean Sea.**

	Metal (μg/g dry weight)				
Region	Cadmium	Copper	Zinc	Lead	Mercury
Ligurian Sea	0.4-5.9	2.4-154	97-644	2.4-117	0.18-0.96
Gulf of Trieste	1.4-1.7	6.2-9.8	87-137	3.8-15	0.28-1.3
Turkish Aegean	6.6-12	36-64.5	336-452	83-110	0.89-1.1
S.W. Mediterranean	0.3-6.5		7.2-71		0.25-0.63

Source: data from Fowler 1985

8.4 NUTRIENTS AND ORGANOCHLORINES

Industry, urban activities and agriculture produce a wide range of pollutants, many of which find their way to the sea. In addition to the substances we have considered already, therefore, there are many others. Nutrients such as nitrates and phosphates, for example, are released from fertilisers, by industrial processes and in domestic sewage. Pesticide residues, such as DDT, dieldrin and aldrin - although no longer used in any quantity - are still washed from the soil and old industrial wastes. All these pollutants follow a variety of pathways to the sea - in streams, in the atmosphere, in sewage and solid wastes - but ultimately they may all accumulate in marine waters. And once there, they may have a wide range of ecological effects.

8.4.1 Nutrients

As with other pollutants, data on nutrients are more widely available for the waters of the North Sea than they are for the Mediterranean. It was also stated by the International Conference on the North Sea that the vast majority of nutrient inputs derive from the inflow of ocean waters from the

Atlantic. Estimates vary, but these may account for as much as 90% of the annual input of phosphorus and about 80% of the nitrogen. Quantitatively, therefore, it is apparent that man-made sources are of relatively minor importance. Many of these human inputs, however, are concentrated at specific point sources, so that locally nutrient concentrations may be considerably inflated.

Rivers provide one of the major sources of these man-made inputs to the North Sea. It has been calculated that these provide an annual input of over 750,000 tonnes of nitrogen and 75,000 tonnes of phosphorus. Most of these inputs come from the Netherlands and the United Kingdom. As we saw in Chapter 7, the Rhine alone discharges about 350,000 tonnes of nitrogen into the North Sea each year, and about 56,000 tonnes of phosphorus. Large quantities of both nutrients are also introduced by the Scheldt, Maas, Thames, Tyne, Tees and Forth, while smaller amounts are discharged by streams in Sweden, Norway, Germany and Belgium.

Small, but locally significant, quantities of nutrients are also provided by direct discharges and dumping. Unless chemical treatments are used, sewage effluents are particularly rich in phosphorus, and direct inputs from industry and coastal settlements in the United Kingdom annually add some 14,000 tonnes of phosphorus to North Sea waters. Direct discharges from the Netherlands are less, with an input of 5,000 tonnes of phosphorus per year. Dumping of sewage sludge and industrial wastes similarly adds significant quantities of nitrogen and phosphorus; data for the United Kingdom are incomplete, but as much as 17,000 tonnes of nitrogen and 14,000 tonnes of phosphorus are released in this way from the Netherlands each year.

A further source of importance is deposition from the atmosphere. Again, estimates are somewhat unreliable, and not available for the whole North Sea area. Data from the Netherlands sector, however, suggest an annual deposition rate of 1320 kg N/km^2 and 82 kg P/km^2. On the basis of a total sea area of 575,000 km^2, this implies inputs of 760,000 tonnes of nitrogen and 47,000 tonnes of phosphorus per year into the North Sea.

Comprehensive surveys of nutrient contents in the North Sea have not been carried out since the late 1960s, so present distributions of nitrogen and phosphorus are not known in detail. The pattern of inputs, however, may be expected to result in locally high nutrient concentrations around the main sources. Thus the Southern Bight, which receives about 80% of all nutrient inputs from land-based sources, and coastal areas adjacent to major estuaries or industrial towns, probably show the highest nutrient levels. Such patterns were, in fact, found in the early surveys and the limited data available for more recent years suggest that they have persisted to the present day; though since the 1960s phosphorus concentrations appear to have increased two- or three-fold.

The increase in nutrient inputs and concentrations observed in the North Sea in recent years has led to fears that eutrophication may be developing, which might result in dissolved oxygen deficiencies. Data on phytoplankton populations are available for a number of areas, and many do indeed show marked fluctuations over time. In the Southern Bight, especially, there appears to have been a progressive rise in phytoplankton levels, as evidenced by the increased greeness of the sea. Nevertheless, there is no convincing evidence to link this, or other plankton blooms, to eutrophication, and, except in highly polluted estuarine areas, seawaters are generally saturated with oxygen.

In the case of the Mediterranean Sea, the picture is even less clear. The Atlantic may provide one source of inputs of nutrients, though on the whole it seems that inflowing Atlantic waters have lower nutrient concentrations than outflowing Mediterranean waters. Major inflows also occur through the Dardanelles from the Black Sea and Sea of Marmara. Because the Black Sea receives waters from some of the largest rivers in Europe, this is likely to be a particularly important nutrient source in the Mediterranean.

More direct inputs from man-made sources occur via atmospheric deposition, river runoff into the Mediterranean and sewage discharge and dumping. Data on atmospheric inputs are generally lacking, but rivers undoubtedly provide the main land-based source, contributing a total of about 300 t/yr of phosphorus and 800 t/yr of nitrogen. The majority of this input comes from densely populated estuaries, and around these local oxygen deficiencies may develop, especially in summer when strong temperature gradients in the sea prevent mixing and keep the polluted waters close to the surface. In the north Adriatic Sea there have also been a number of plankton blooms - 'red tides' - in recent years. As these blooms decay they cause marked oxygen deficiencies in the deeper waters and have, in some cases, resulted in major fish kills.

8.4.2 Organochlorines

Organochlorines such as PCBs and PCTs are of particular concern because they are highly toxic and persistent pollutants. Typically, they are fat-soluble and therefore accumulate readily in marine organisms, building up through the food chain until they reach toxic levels in higher species. Mammals and seabirds are thus particularly susceptible to their effects, although evidence linking changes in wildlife populations to organochlorine pollution is limited. There is some evidence to suggest that the fertility of seals may be reduced by PCB and DDT accumulation, however, while DDT has also been shown to lead to eggshell thinning in some seabird species.

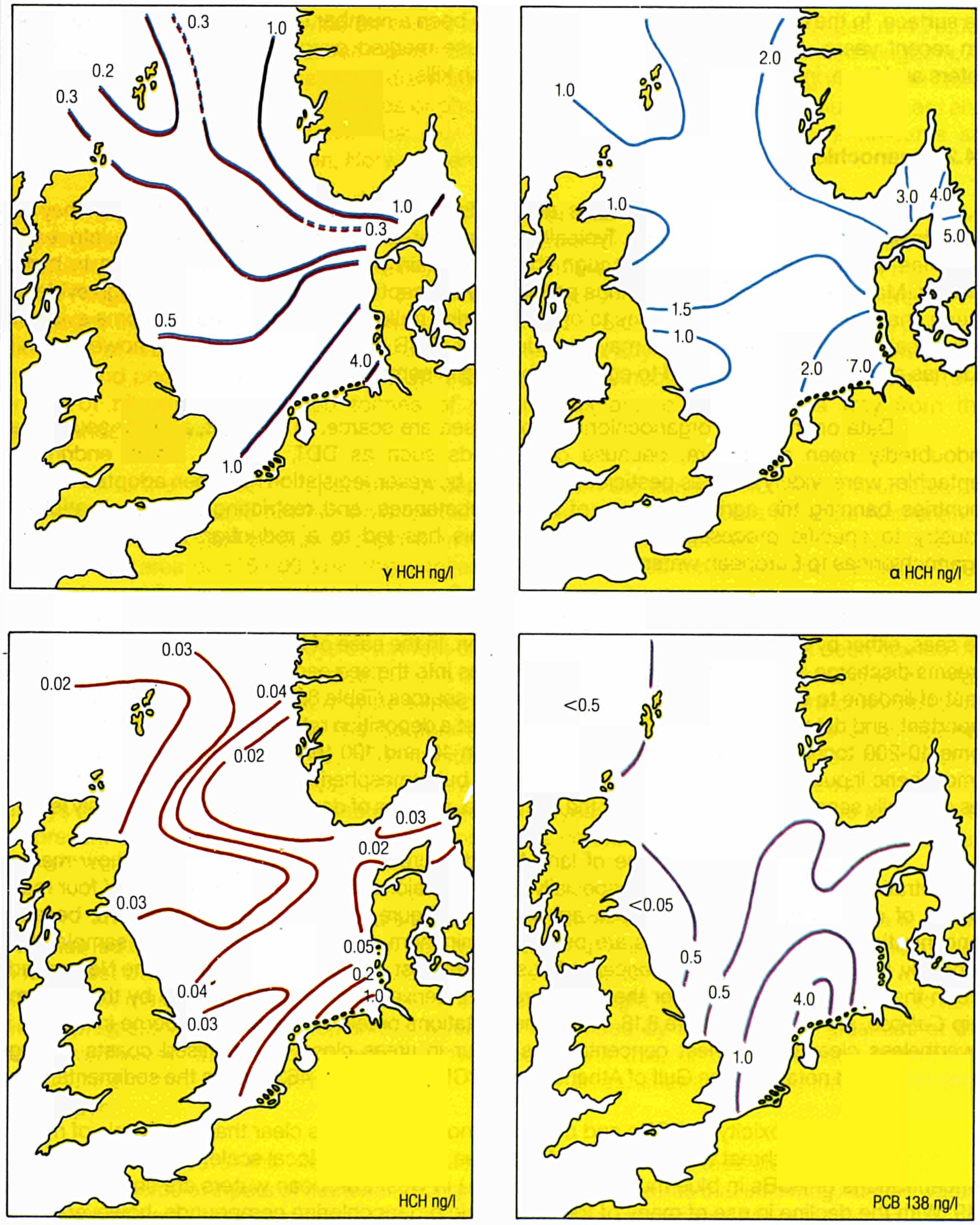
Data on inputs of organochlorines to the sea are scarce. In the past, a major source has undoubtedly been agriculture, because compounds such as DDT, dieldrin, aldrin, endrin and heptachlor were widely used as pesticides. Recently, however, legislation has been adopted in many countries banning the agricultural use of these substances, and restricting their applications in industry to specific processes. Without doubt, this has led to a reduction in inputs of many organochlorines to European waters.

Even so, land-based sources continue to supply significant quantities of organochlorines to the seas, either by runoff or via atmospheric deposition. In the case of the Mediterranean, for example, streams discharge about 90 tonnes of organochlorines into the sea each year, while about 80% of the input of lindane to the North Sea comes from riverine sources (Table 8.7). Atmospheric inputs are also important, and data from the Paris Commission suggest a deposition rate across the whole North Sea of some 10-200 tonnes of PCBs per year, and between 10 and 100 tonnes of HCH per year. Data for atmospheric inputs to the Mediterranean are lacking, but atmospheric concentrations of organochlorines generally seem to be lower than over the North Sea, so rates of deposition also are probably less.

Because of the importance of land-based sources, most organochlorines show marked concentrations in coastal areas, and especially close to major estuaries. The distribution of four major groups of compound in the North Sea are shown in Figure 8.17. Patterns are tentative, because concentrations of these substances are below the minimum detection levels at many sample sites. Generally, however, it is clear that concentrations are greatest along the north coast of the Netherlands and in the German Bight. Data for the Mediterranean, derived from the 1977 survey by the research ship *Calypso*, are shown in Figure 8.18. Whilst the limitations of this survey must be borne in mind, it is nevertheless clear that highest concentrations occur in areas close to urbanised coasts or large estuaries - most notably in the Gulf of Athens where PCB levels reach 463 ng/g in the sediments.

Given the toxicity of PCBs and other organochlorines, it is clear that high levels of marine pollution may pose a threat to wildlife in the North Sea, at least on a local scale. Data are scarce, but concentrations of PCBs in blue mussel (*Mytilus* spp.) in west European waters are shown in Figure 8.19. With the decline in use of many of the more toxic organochlorine compounds, however, it may be expected that levels of pollution and biological accumulation will fall. Such seems to be the case. As Table 8.8 shows, levels of DDT, HCH and PCBs in fish flesh have declined in many parts of the North Sea since 1979.

Figure 8.17 **Distribution of selected organochlorines in the surface waters of the North Sea.**



NB, units = ng/l

Source: data from International Conference on the Protection of the North Sea 1984

Table 8.7 **Inputs of organochlorine compounds to North Sea waters from the United Kingdom.**

Source	Lindane	Inputs (kg/yr) DDT	PCBs
Rivers	455-462	0-192	0-193
Sewage	64-93	94-142	55-74
Industry	0.7-1.3	0.1-0.2	0.6-2.6
Dumping	2-185	-	21-435
TOTAL	522-741	94-334	77-705

Source: data from International Conference on the Protection of the North Sea 1984

Table 8.8 **Levels of organochlorine compounds in fish flesh in the North Sea, 1979 - 1982.**

Year	Thames(1)	Southern Bight(2)	Ijmuiden(2)	Western Scheldt(2)
1. DT (mg/kg wet weight)				
1979	1.7	0.70	-	-
1980	0.78	0.60	0.57	0.41
1981	0.60	-	0.53	0.28
1982	0.31	1.10	0.19	0.20
2. HCH (mg/kg wet weight)				
1979	0.10	0.77	-	-
1980	0.13	-	0.18	0.11
1981	0.07	-	0.13	0.11
1982	0.03	0.15	0.06	0.07
3. PCBs (mg/kg wet weight)				
1979	3.2	1.9	-	-
1980	2.7	5.3	0.15	0.09
1981	3.9	-	0.10	0.09
1982	1.1	7.1	0.04	0.05

Notes: (1) Data for cod (2) Data for flounder

Source: data from International Conference on the Protection of the North Sea 1984

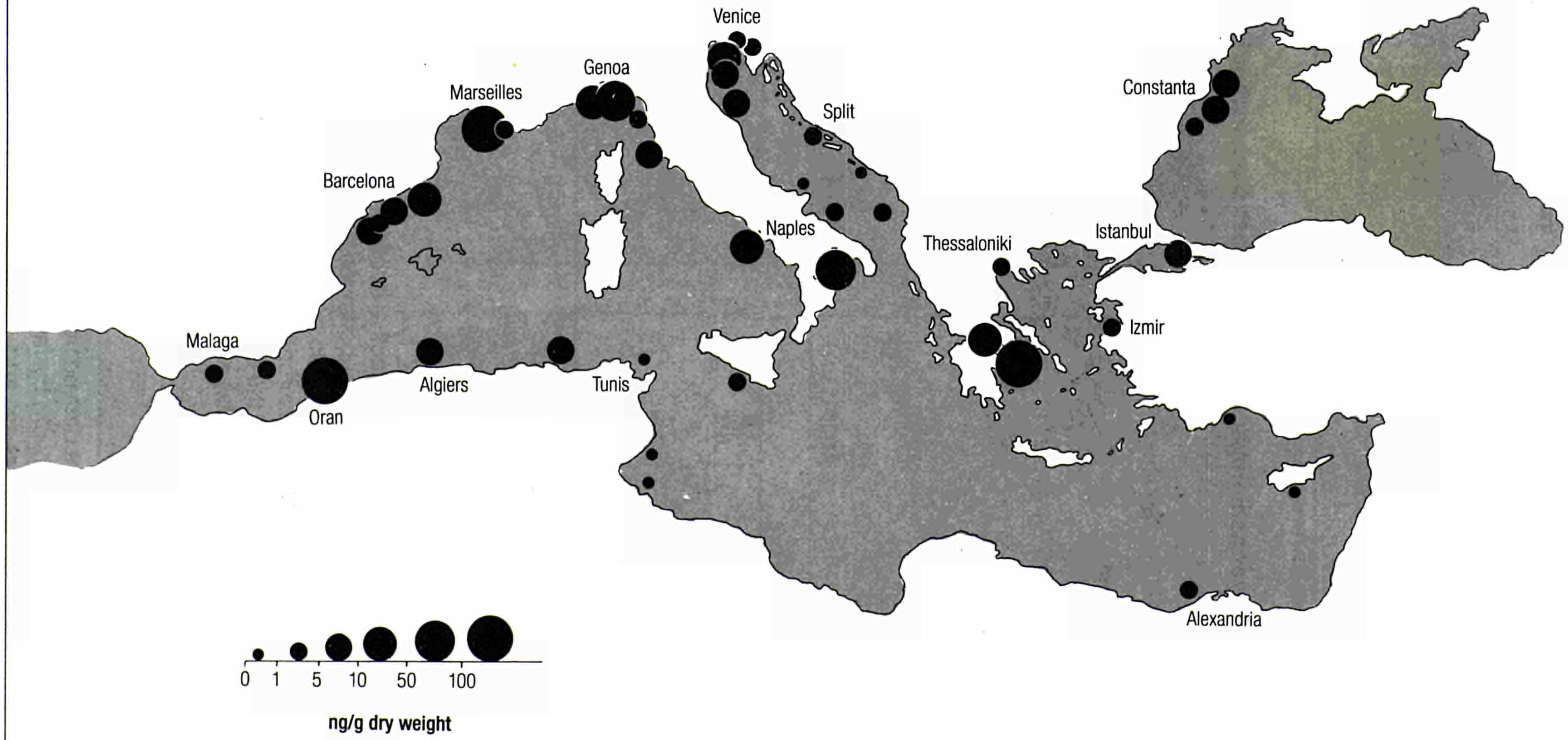
8.5 RADIONUCLIDES

Many of the pathways which radioactive substances follow through the environment lead ultimately to the sea; and once there, these substances have no easy escape. The sea therefore acts as a major sink for many radionuclides. It also acts as a significant source of human exposure to radioactivity especially through the consumption of contaminated seafoods. For these reasons, particular attention has been focused in the European Community on inputs of radioactivity to the sea and the concentrations of radionuclides in sea water and marine organisms.

8.5.1 Inputs to the North Sea

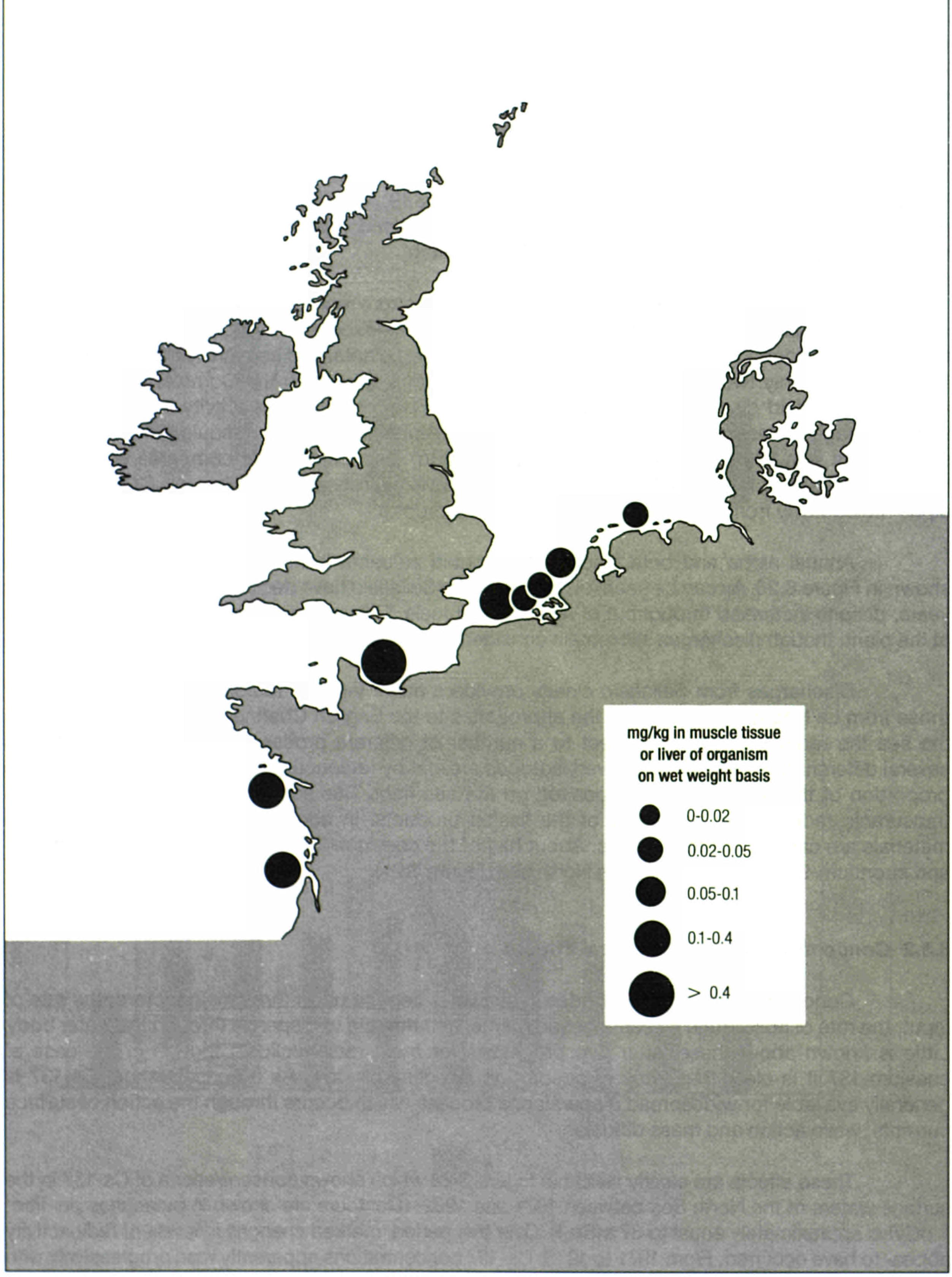
Radioactive substances are derived from a wide range of sources and they enter the sea in a variety of different ways. Quantitatively, by far the most important sources are cosmic. Together with natural processes of weathering and volcanic activity these account for more than

Figure 8.18 **PCB concentrations in coastal waters of the Mediterranean.**



Source: data from Commission Internationale pour l'Exploration de la mer Méditerranée

Figure 8.19 **Concentrations of PCBs in Blue Mussel (*Mytilus* spp.) in North Sea and adjacent waters.**



Source: data from Paris Commission 1984

three-quarters of the inputs of radioactivity to the seas in the European Community. Radioactivity from these sources enters the sea directly, from coastal or submarine rocks and magmas, or indirectly via streams and atmospheric deposition and rainwash.

By comparison, artificial sources of radioactivity are relatively small. They include releases from nuclear weapons, discharges from the nuclear energy sector, and the use and disposal of radioactive substances by industry, agriculture and research. Again, these reach the sea either through direct discharges or indirectly in atmospheric fallout and precipitation and runoff from land.

In the past, nuclear weapons provided the main source of this 'man-made' radioactivity. Between 1951 and 1962, a total of 356 atmospheric explosions were conducted, and those resulted in high rates of fallout (see for example, Figures 5.15 to 5.19). With the ban on atmospheric testing of nuclear weapons in the 1960s, however, releases declined rapidly, and this source is now of secondary importance for all radionuclides except tritium.

Discharges from the nuclear energy sector therefore represent the main artificial source of radioactive inputs to the sea at the present time. With the exception of accidents like Chernobyl, these derive predominantly from nuclear fuel reprocessing plants, and especially from Sellafield and La Hague, the only two large-scale industrial installations existing in the Community. In 1983, for example, Sellafield discharged over 67,000 Ci (2500 TBq) of beta radioactivity in liquid effluents, while La Hague released over 30,000 Ci (1200 TBq). Alpha radioactivity in liquid effluents from the same plants was 370 Ci (14 TBq) and 13.8 Ci (0.5 TBq) respectively. This compares with the total liquid discharges of less than 1500 (55 TBq) of beta radioactivity and a little over 1 Ci (0.04 BTq) of alpha radioactivity from all power stations in the Community.

Annual alpha and beta discharges in liquid effluents from Sellafield and La Hague are shown in Figure 8.20. As can be seen, discharges from Sellafield have declined considerably in recent years, despite increased throughput of reprocessed fuels. This reflects technological improvements at the plant, though discharges still remain considerably higher than those from La Hague.

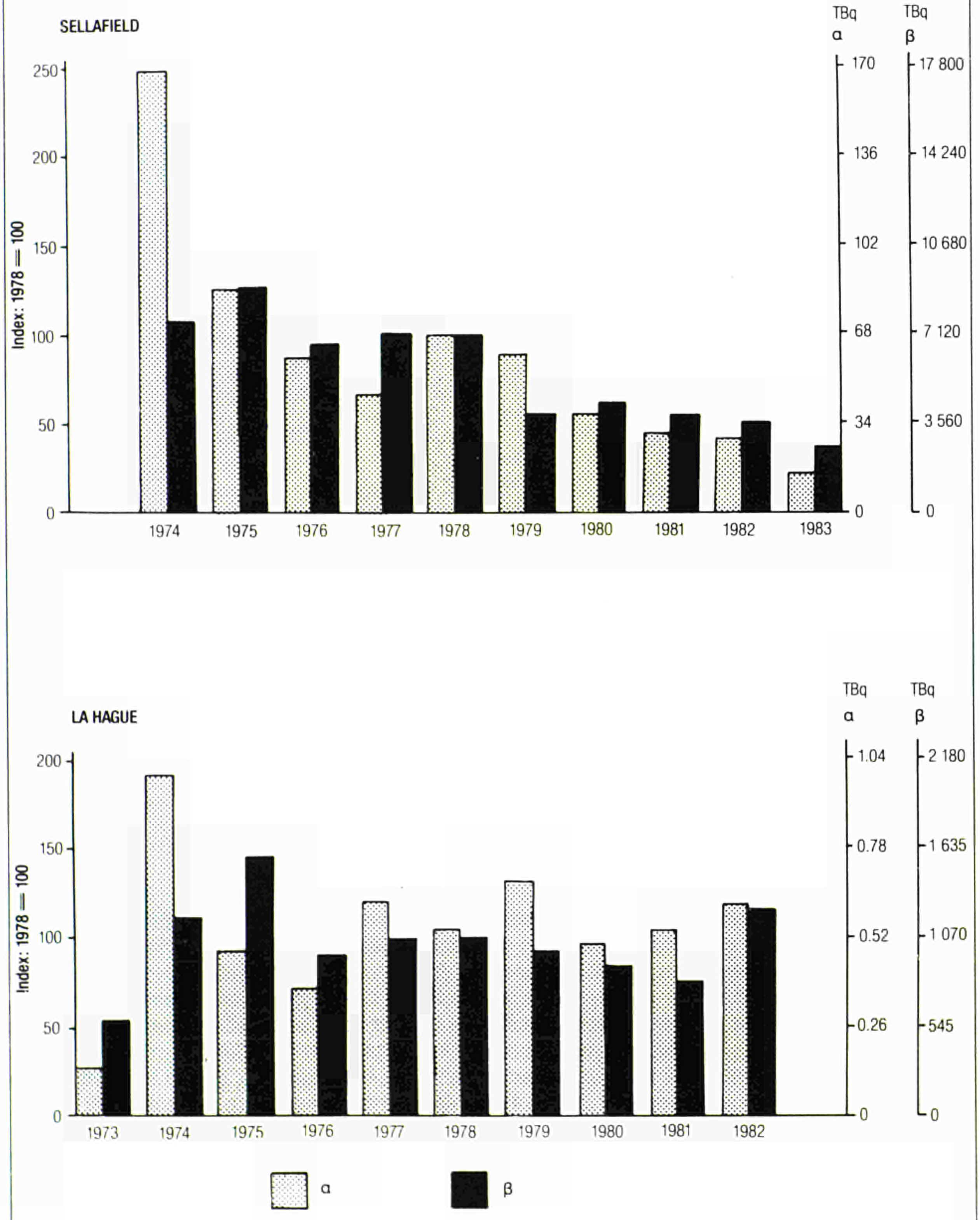
Discharges from Sellafield clearly provide a major input of radioactivity to the Irish Sea: those from La Hague similarly enter the approaches to the English Channel. In both cases, once in the sea the radionuclides are subject to a number of different processes and progress towards several different destinies. Shorter-lived isotopes are lost by radioactive decay, while a considerable proportion of the remainder are deposited on the sea floor. This accounts for the majority of the transuranic radioactivity and many of the fission products. In addition, some of the radioactive materials are carried into the Atlantic. About half of the caesium-134, and most of the caesium-137 and strontium-90, however, reach the North sea (Figure 8.21).

8.5.2 Concentrations and Biological Effects

Concentrations of radionuclides in seawater depend upon three main factors: the rate of input, the rate of adsorption by seafloor sediments, and the rate of dispersal through the water body. Little is known about these latter two processes for most radionuclides, though in the case of caesium-137 it is clear that rates of adsorption are generally low. As a consequence, Cs-137 is generally available for widespread dispersion, a process which occurs through the action of surface currents, wave action and mass diffusion.

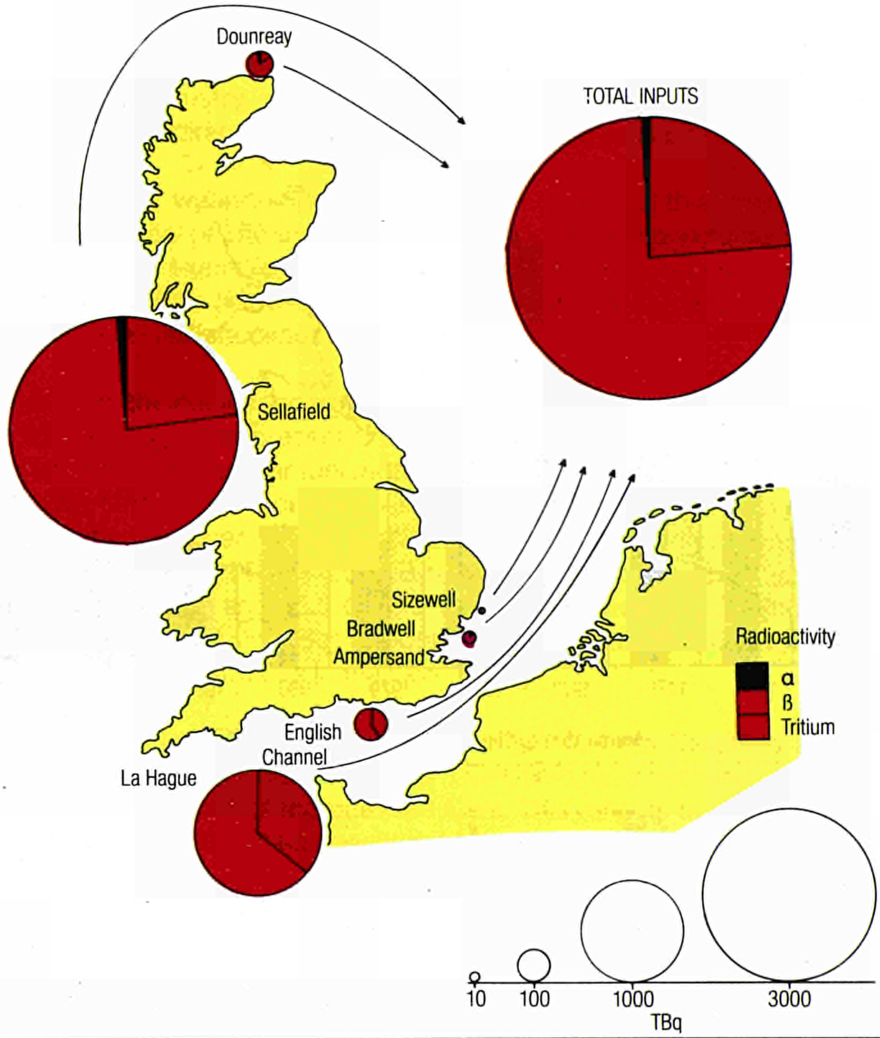
These effects are clearly visible in Figure 8.22 which shows concentrations of Cs-137 in the surface waters of the North Sea between 1971 and 1982. (Contours are shown in picocuries per litre: 1 pCi/l is approximately equal to 37 mBq/l). Over this period, marked changes in levels of radioactivity appear to have occurred. From 1971 to 1978, Cs-137 concentrations apparently rose progressively with levels in the open sea increasing from about 0.4 pCi/l (15 mBq/l) to 2.5 pCi/l (90 mBq/l). This increase

Figure 8.20 **Liquid discharges of alpha and beta radioactivity from Sellafield and La Hague nuclear reprocessing plants, 1973-1983.**



Source: data from International Conference on the Protection of the North Sea 1984, Department of the Environment 1985

Figure 8.21 **Inputs of radioactivity to the North Sea.**

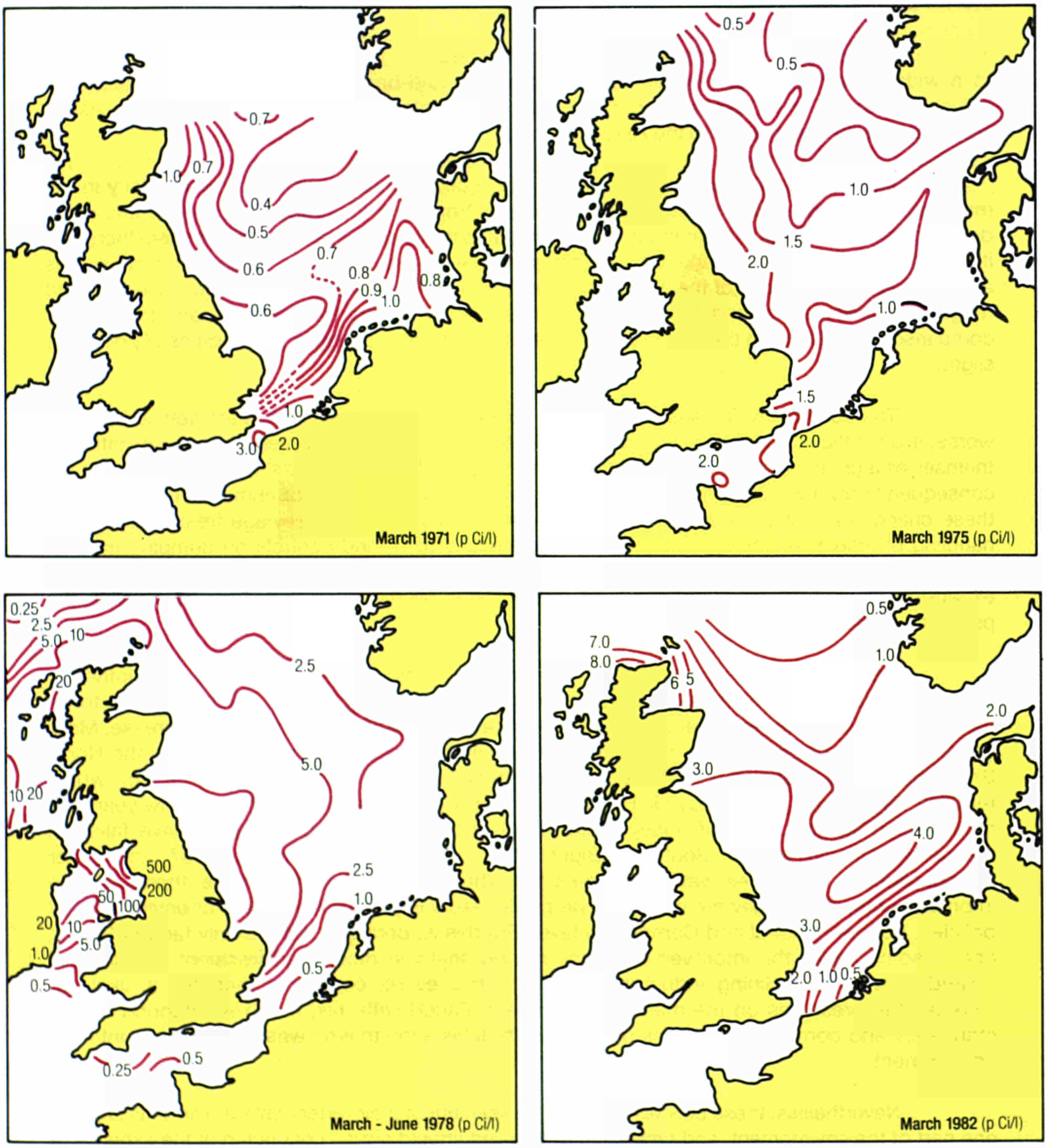


Source: data from International Conference on the Protection of the North Sea 1984

can be related to contaminated water moving into the northern reaches of the North Sea from the Irish Sea and Scottish coast, reflecting the transport of radionuclides from Sellafield and Dounreay. At the same time, radioactivity from the English Channel has spread out into the southern North Sea. Since 1978, however, the trend seems to have been reversed, and Cs-137 levels have generally declined, probably due to reduced discharges from Sellafield and other sources. Thus, in open sea, average activity levels measured by Deutsche Hydrographische Institut fell from 4.7 pCi/l (174 mBq/l) in 1978 to 2.2 pCi/l (81 mBq/l) in 1981. The zone of highest radioactivity, moreover, has shifted to the southern central North Sea. This region comprises a zone of variable water movement, with no clear vector of flow.

Although levels of radioactivity in the North Sea are falling, it is clear that relatively high activity concentrations remain in coastal waters near to nuclear plants. Close to the Dounreay reprocessing plant, mean annual Cs-137 concentrations of about 300 mBq/l (8.1 pCi/l) occur, while around Sellafield levels of over 1000 mBq/l (27 pCi/l) are found. These undoubtedly lead to increased levels of radioactivity in fish, but the effects are small and thus their implications for both fish stocks and human health are generally believed to be negligible. Concern has been expressed, however, about critical groups living close to these sources. For these, fish might constitute a significant proportion of their total radioactive intake.

Figure 8.22 **Changes in caesium-137 levels in North Sea waters, 1971-1982.**



Sources: data from Lee and Ramster 1981; International Conference on the Protection of the North Sea 1984

8.6 CONCLUSIONS

8.6.1 Patterns and Trends

As the data in this chapter have shown, the seas of the European Community are subject to a wide variety of pressures. Oil from tankers and land-based activities, heavy metals from industry, nutrients from fertilisers and sewage, organochlorines from pesticides and industrial sources - all add their burden to the seas.

Nowhere is this burden greater than in the coastal areas - and most particularly in the major river estuaries. For it is here that rivers deposit much of their load, that sewers and ships discharge their wastes, and that much deliberate dumping takes place. As we have seen, therefore, it is in the narrow zone of near-shore and estuarine waters that levels of pollution are highest. It is also in this zone that many of the effects are most acute: for it is here that the greatest numbers and range of organisms live; and it is this zone that is most important for recreation and tourism. By comparison, conditions in the open sea tend to be cause for less concern, and impacts of pollutants slight.

The question which arises is whether conditions in the coastal zone are getting better or worse. It is a difficult question to answer, because the data are scarce. Moreover, the seas gather to themselves a great variety of pollutants from a multitude of different sources. Pollution problems are consequently diverse, and influenced by changes in almost all sectors of human activity. Many of these changes are also complex and contradictory. Improvements in sewage treatment and the handling of industrial wastes, reductions in economic activity, and controls on dumping have all been acting to diminish inputs of pollutants. Increased uses of fertilisers and animal wastes and the expansion of offshore oil production and tanker traffic on the other hand, are intensifying the problems of marine pollution.

Trends seem to vary, therefore, from one area, and from one pollutant, to another. In the North Sea, for example, levels of phosphorus and nitrogen pollution generally seem to be rising; similarly, off the Netherlands coast, heavy metal concentrations are on the increase. More generally, levels of oil pollution from offshore oil-fields is becoming more serious in the North Sea, while accidental spillages from shipping remain a problem in the Mediterranean, which remains very heavily polluted by oil. But, in a number of areas, the signs of the last few years are more encouraging. Levels of heavy metal, PCB and pesticide contamination have fallen in marine organisms in the Southern Bight; the activity level of caesium-137 and other radionuclides in North Sea waters has declined. There is some room for hope, therefore. The improvements, where they are occurring probably testify in part to the effects of environmental policies, both at national and Community level. But this is, perhaps, not the only factor at work, and in some cases the improvements may not be anything more than transient fluctuations, related simply to declining industrial activity. In this event, economic recovery is likely to increase the pressures on the marine environment. Faced with this, much will depend on the stringency and comprehensiveness of Community legislation to limit waste discharges into the environment.

Nevertheless, these policies must not be seen out of their wider context. The seas are only one part of the environment, and protection of this part should not be conducted at the expense of others. Restrictions on waste disposal into the seas, for example, should take account of problems of disposal on land. Nor should actions in one area, or on the coast of one member state, be permitted to jeopardise environmental conditions elsewhere. In other words, environmental policies on the seas need to be integreted into wider policies on the environment. It is at this scale that Community policy is likely to be most crucial.

8.6.2 The Need for Data

In this discussion of the seas, as with other aspects of the environment, the scarcity of data has been apparent. This is less true of the North Sea than elsewhere, for international co-operation has encouraged the collection of a wide range of information in these waters. The Paris Commission, in particular, has played a vital role in bringing together data. Even so, gaps in our knowledge remain: most crucially in relation to nutrient trends in the North Sea waters, and in the inputs of almost all pollutants. More regular and rigorous monitoring is therefore desirable.

The problems in relation to the Mediterranean are even more acute. Despite the recent work of UNEP, as part of the MED POL programmes, data in this area remain limited and knowledge of both inputs and concentrations of pollutants is scanty in the extreme. Given the increasing pressures from industrial, tourist and agricultural development, and the low turnover rates of the Mediterranean Sea this is a situation which cannot be allowed to persist.

THE MONK SEAL: THE RAREST SEAL IN THE WORLD

The Mediterranean monk seal (*Monachus monachus*) has a total world population of less than 1000 individuals. About half of this population probably occurs in the European Community.

Monk seals are in many ways exceptional creatures. Compared to other seals they are large, and they occur in warm waters unlike most other species. In the past, they had a relatively wide range. They were found throughout the Mediterranean, as far as the Sea of Marmara and the Black Sea, and also along the Atlantic coast from 20°N in Africa to the Canary Islands and Azores. What the population size was historically is not known, but without doubt, during the course of the present century, it has declined to a fraction of its previous level. It has now disappeared entirely from mainland Spain and France, and much of Italy and Yugoslavia. Where it remains - both in the Community and outside - it is as scattered groups of low numbers. The main populations survive in Greece. How many servive is not clear: estimates vary from 150 to 600 (with a figure of 200-300 probably being nearer the truth). Whatever the population size, however, its numbers are clearly alarmingly low.

The reasons for the decline of the monk seal over the last fifty years are uncertain. Several different explanations have been put forward, including the effects of pollution by organochlorine compounds, loss of habitats, competition from man for food supplies, disturbance by tourists and scientists, and inbreeding as a result of the small surviving population. All of these may in fact operate to a small extent, but recent surveys show that the far more important causes are normally accidental or deliberate killing. Deliberate killing, particularly by fishermen, has certainly been a major factor in the past and, although it has now been banned, no doubt continues illegally: monk seals are trusting and docile creatures and are thus very easy prey. Accidental killing, however, is possibly the single greatest threat at present. Pups, especially, may become tangled in fishing gear and, with the rise in the number of fishing vessels in coastal regions of Greece, mortality may well have risen in recent years.

Whatever the exact causes of its decline, the monk seal is clearly in a critical state. If it is to survive, the pressures on its population will quickly need to be relieved. This will involve more rigorous enforcement of existing legislation and improved education of the public (especially tourists and fishermen) about the species. But preventive action alone will not be sufficient; it is probably too late for that. More direct remedial actions also need to be taken, with the establishment of further reserves in Greece and southern Corsica, and of breeding centres to help build up the population. Like many other species, the monk seal owes its plight to human interference. Now it depends upon human intervention for its survival.

The monk seal

Photo: courtesy of John Harwood, Sea Mammal Research Unit
Source: Harwood, J., Anderson, S.S. and Prime, J.H. 1982 *Special measures for the conservation of monk seals in the European Community.* Luxembourg: Commission of the European Communities

NOTES AND SOURCES

Data Availability

In addition to the comments made in Section 8.1.4, the following points should be noted about data availability.

1. Data on inputs are generally based on assumed relationships between industrial and other activities and discharges. Although these may be calibrated to some extent by actual measurements, such measurements are scarce, and the models used in the calculations vary from one case to another. Consequently, significant differences often exist in the estimates made by different authorities, and data quoted here are often simply values taken from widely divergent estimates.

2. Data on water quality are derived mainly from short-term studies carried out by survey ships. The representativeness of the results is therefore limited, both temporally and spatially. Moreover, in the case of heavy metal analyses, it is now known that significant errors were involved in early measurements (before the late 1970s) due to contamination from the survey ships. Comparisons of data over time must therefore be made with extreme care.

Notes on Figures

Figure 8.6 Data on oiling and mortality must be interpreted with caution because of the errors inherant in many surveys. In most cases, counts are based on the number of beached and oiled individuals, made at particular times of the year. Several sources of error therefore arise: i. individual corpses, or whole areas of the coast, may be missed during the survey; ii. because of short-term random effects, counts may not be representative of longer-term mortality rates; iii. not all oiled corpses may be washed ashore, and recovery rates range from 10-50% or more according to local coastal and sea conditions; iv. some birds may have been oiled after death from other causes.

Figure 8.7 As above.

Figure 8.8 As above.

Figure 8.9 Comparative data from the Paris Commission (1984b) indicate total inputs of cadmium and mercury for other countries as follows:

Belgium:	10.1 t/y Cd	0.8 t/y Hg
Denmark	3.1	0.4
Germany	15.8	6.9
Norway	20	1.5

Figure 8.20 Care is needed in interpreting these data because they involve summation of radioactivities for different radioisotopes of varied radiotoxic properties. Differences in the activities within each group do not therefore necessarily reflect differences in radiotoxicity.

Figure 8.21 As above.

Figure 8.22 Data for 1971, 1975, 1978 from Lee and Ramster; data for 1982 from International Conference on the Protection of the North Sea. Data for 1982 have been converted to pCi and contours interpolated from point data.

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CHAPTER 9.

WILDLIFE

9.1 INTRODUCTION

9.1.1 The Importance of Wildlife

The wide range of environmental conditions which is found in the European territories of the Community gives rise to a great diversity of natural habitats. Between the semi-arid areas of Greece and the cool, humid maritime regions of Ireland - between the wide lowland plains of northern Germany and Denmark and the high mountains of the Alps - there occurs a large variety of biotopes: maquis and garigue, saltmarsh and dune, mixed oak woodland and boreal forest, peat moorland and calcareous grassland. Each of these supports a considerable variety of wildlife species. Estimates are inevitably tentative, but in the Community as a whole, as many as 6,000 species of plants, 100,000 species of invertebrates, 580 species of birds, 110 species of reptiles and amphibians, and 120 species of mammals are thought to exist.

The importance of this great natural diversity cannot be underestimated. At the very least it contributes to the aesthetic quality of the environment, providing variety, interest and beauty within which people can relax and find peace. Thus, wildlife and its natural habitats are major elements in the Community's recreational and amenity value. More than that, however, it has great scientific, economic and social significance. Natural habitats supply baseline data against which ecological changes can be measured; they give a means of studying and understanding how the world works and how man affects it. Wildlife also represents a vital genetic resource which can be exploited for medical and agricultural purposes. Any major reduction in its diversity may restrict the scope for future discovery and development. In addition, the genetic variety of natural ecosystems provides the basis for biological adaptations, ensuring that they can change and adjust to future changes in the environment.

9.1.2 Pressures on Wildlife

The ecological diversity of wildlife in the European Community is clearly of major importance. Nevertheless, it is far from inviolate. Over recent centuries, it has been progressively diminished as industry, agriculture, tourism, transport, hunting and collecting have disturbed or destroyed habitats and reduced or eliminated species. As a result, the range of wildlife and natural ecosystems present in the Community now is less than it has been for thousands of years; and the rate of decline and loss is probably greater than it has ever been.

The causes of this disruption and loss are obviously matters of major concern. They operate, however, in many different ways. Some of the most direct effects are a product of deliberate attempts to control agricultural pests, for example by the use of pesticides. Similarly, collecting and shooting pose serious threats to some species - especially those which are rare and are most vulnerable to human interference.

More general impacts occur as a result of habitat destruction. This takes place for a variety of reasons. Urban expansion, quarrying, mining and waste disposal all swallow up land and destroy or fundamentally modify any natural habitats in their way. Agricultural expansion results in the cultivation of previously undisturbed areas, and the clearance of natural vegetation. Intensification of farming has seen the removal of hedgerows, the drainage of wetlands, the infilling of streams, and the replacement of varied plant communities by cereal or grass cultivars. Afforestation has encroached into natural habitats, especially in upland areas; tourism has disturbed and destroyed coastal habitats.

These processes have direct effects both on the habitats concerned and the species they support. Their impacts, however, do not stop there, for almost all these activities also create pollution which affects a much wider area. Pesticides, for example, have accumulated in natural food chains and caused major reductions in wildlife populations, particularly of raptors such as hawks and falcons. Fertilisers, livestock wastes and sewage have been washed into streams and lakes where they result in eutrophication and loss of fish and other animal species. Emissions of sulphur dioxide and nitrogen oxides from urban, industrial and traffic sources have contributed to the formation of acid deposition, leading to extensive damage to forests and lakes.

Together, these effects are having a widespread and, in some cases, irreversible effect on wildlife in the European Community. Data on species extinctions are scarce and unreliable but during the present century a number of plant and animal species have become extinct. According to IUCN/Council of Europe data, 7 plant species have become extinct in Belgium over the last fifty years, 7 in France, 8 in Germany, 8 in Greece, 2 in Italy, 3 in the Netherlands and 2 in the United Kingdom. Many of these are weed-species (crop-followers), but even so, over the Community as a whole probably twenty or more plant species have been lost. Countless invertebrates have also become extinct over the same period. Moreover, many habitats have declined considerably in extent. Wetlands, dunes and semi-natural lowland grasslands have been particularly severely affected, for these are in any case restricted in their distribution and tend to occur in areas which are under greatest pressure from agricultural, industrial and urban development.

9.1.3 Community Policy and Wildlife

In the face of the growing threats to wildlife and natural habitats, most member states have adopted national or regional policies to protect endangered species and biotopes. These policies, however, are far from comprehensive and vary considerably between different countries: in terms of both the administrative structures involved, and the extent of land and numbers of animal and plant species afforded protection (and the type of protection given).

These inconsistencies in wildlife protection by member states have a number of implications. In particular, they mean that species which are protected in one part of their range may remain under threat elsewhere: national policies may thus be rendered ineffective. This is especially the case with migratory species, such as birds.

In order to overcome these inconsistencies, it has long been recognised that the Community needs to adopt its own, co-ordinated policy on wildlife. In this way, it can be ensured that national or regional policies do not damage habitats or species of European significance. Such a policy is also necessary for the reverse reason: to avoid threats to national or regional wildlife resources by Community actions or by adverse actions occurring in other parts of the Community. This is a vital issue, for many of the main pressures for agricultural intensification and expansion, tourism, transport and industrial development come from the Community's own sectoral policies.

It was with these aspects in mind, therefore, that the European Community established a policy towards wildlife in the First Action Programme on the Environment, in 1973. The broad aims of this policy are to develop an integrated approach to the conservation of endangered species of flora and fauna and the protection of natural habitats. Subsequent action programmes have reaffirmed and developed this policy, and the Second Programme, for example, calls upon the Commission to direct its actions towards the protection of birds, the control and restriction of international trade in certain species of wildlife, the re-assessment of shooting and hunting laws, and protection of wetlands of international importance.

In pursuit of this policy, the Council has adopted a number of legislative instruments (Table 9.1). Without doubt one of the most important and far-reaching is the Directive for the Conservation of Wild Birds, agreed on April 2nd 1979. This noted the decline in populations of wild birds, emphasised the need for international action on bird protection and set out provisions for the protection, management and control of all species of naturally occurring birds in the wild state in the Community territory (see Inset, page 296).

More recently, on December 3rd 1981, the Council has adopted a Decision on the Berne Convention on the Conservation of European Wildlife and Natural Habitats. This calls upon all the contracting parties within the Community to take action to maintain wildlife populations, to promote sensitive national policies on wildlife conservation and to control pollution and other threats to wild fauna and flora. Specifically, it lists threatened species of plants, mammals, birds and amphibians and urges that the capture, hunting, killing, disturbance or trade of listed species be prohibited or limited.

On June 24 1982 a further Decision was adopted on the Bonn Convention on the Conservation of Migratory Species of Wild Animals. This lists endangered migratory species of mammals, birds, reptiles, fish and insects and obliges member states to take steps to protect listed species and control pressures upon them.

The implementation in the Community of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as of 1 January 1984, was decided by the Council on 3 December 1982. The Regulation concerned (3626/82) contains a number of measures which go beyond the provisions of the Convention. It aims at an effective control of trade in thousands of (in many cases endangered) animal and plant species at the external frontiers of the Community, and a prohibition of commercial activities involving endangered species and illegally imported wildlife.

In addition, on 28 June 1984, the Council adopted a Regulation on action by the Community relating to the environment. Amongst other things, this provides the possibility of granting Community financial support to certain environmental projects. Eligible projects include those aimed at re-establishing seriously threatened biotopes which are the habitats of endangered species (as defined by the Bird Directive), and up to 50% of the cost may be provided. Initially, the Regulation will be applied for three years and during that time about 50 projects will probably by supported; by mid-1986 Decisions concerning 30 were in force, representing a financial commitment of some 4.2 million ECUs. These projects are spread throughout the Community territory and cover a wide range of measures, including biotope management, land purchase and leasing, acquisition of capital equipment and improvements in public awareness. In all likelihood, it will be necessary to extend this programme beyond three years, and to other types of biotope of importance to the Community.

9.2 PLANT AND ANIMAL SPECIES

In order to conserve plant and animal species in the Community, a vital requirement is for reliable data on populations and geographic distribution. Only if these data are available can sensible conservation measures be taken, and directed towards problems and areas where action is most needed in an effective and cost-efficient manner. Only if regular surveys of plant and animal

THE BIRD DIRECTIVE

Adoption of the Directive for the Conservation of Wild Birds, on April 2nd 1979, marked a milestone in the Community's environmental policy. For it was the first Directive aimed specifically at the protection and management of wildlife.

The scope of the Directive is broad. It establishes a system of protection for all species of naturally occurring birds in the wild state in the European territory of the member states to which the Treaty of Rome applies. It covers the protection, management and control of these species and lays down rules for their exploitation; and it applies not only to the wild birds themselves but also to their eggs, nests and habitats.

As loss of habitats is becoming an increasingly acute problem, dwarfing all others involved in the conservation of wild birds, the Directive focuses above all on the preservation, maintenance and re-establishment of biotopes and habitats, including - as a first step - the creation of special protection areas for 144 bird species (listed in Annex I) in need of particular attention. The European Commission has the task of ensuring that these areas constitute a coherent network which meets the protection requirements of the species concerned, and in this context is at present working with scientists to draw up a preliminary inventory of areas of major importance for the conservation of wild birds in the Community. This will serve as a reference document for the creation of the network, and will help to make sure that important bird habitats are not adversely affected by developments encouraged by the Community.

Article 5 of the Directive sets out the obligations of the member states with regard to regulating the capture and disturbance of birds. Subject to their rights to derogate from this provision under certain conditions, member states must, in particular, prohibit:

- deliberate killing or capture of birds by any method;
- deliberate destruction of, or damage to, their nests and eggs or removal of their nests;
- taking their eggs in the wild and keeping these eggs even if empty;
- deliberate disturbance of these birds, particularly during periods of breeding and rearing, in so far as disturbance would be significant within the objectives of the Directive;
- keeping birds of species whose hunting and capture is prohibited.

Not all bird species are covered by all these provisions. Owing to their population level, geographical distribution and reproductive rate throughout the Community, twenty-four species (listed in Annex II/1 of the Directive) may be hunted under the national legislation of the member states. Forty-eight other species, listed in Annex II/2, may be hunted only in certain member states. None of these species, however, may be hunted during the rearing season, nor during the various stages of reproduction. In the case of migratory species, hunting is only permitted during their breeding period or during their return to their rearing grounds.

The Directive also controls the marketing of wild birds. The sale, transport for sale and the offering for sale of live or dead birds (or of any readily recognisable parts or derivatives of these birds) are all prohibited, with the exception of 26 species referred to in Annex III of the

Directive. In addition, the use of all means of large-scale or non-selective capture or killing of birds is banned, as is the hunting of birds from aircraft, motor vehicles, and boats driven at a speed of more than 5 km/hr.

The Bird Directive is clearly a wide-ranging and detailed piece of legislation. It reflects, however, the awareness that in order to safeguard wildlife species from the pressures of human activities, comprehensive action needs to be taken. Piecemeal efforts are unlikely to be effective or efficient. As such, it forms a model for similar actions to protect other wildlife groups in the Community.

*The goshawk (*Accipter gentilis*): a raptor which has been subject to severe persecution and pressure in many parts of the Community. As a result of habitat disturbance, hunting, egg collecting and pollution (especially by pesticides) it is now extinct in Britain, and reduced to very low numbers in the Benelux countries, France and Portugal. In recent years, however, reductions in these pressures have allowed numbers to increase again in some areas.*

Photo: copyright R. E. Kenward, Institute of Terrestrial Ecology

Table 9.1 **Community actions on wildlife and natural habitats.**

DATE	ACTION	ABBREVIATED TITLE	DESCRIPTION
1975	Recommendation (75/66)	Protection of birds and their habitats	Recommends accession to Ramsar Convention on Conservation of Wetlands and Paris Convention
1979	Directive (79/409)	Conservation of wild birds	Defines measures to maintain wild bird populations at an appropriate level; specifies conservation measures for threatened species; imposes a ban on marketing and hunting of wild birds (except for species listed in Annexes II and III)
1981	Regulation (348/81)	Imports of whales and other cetacean products	Specifies need for licence to import whales or other cetacean products
1981	Regulation (3786/81)	Common rules for import of whales and other cetacean products	Lays down conditions which must be satisfied for licences
1981	Decision (81/691)	Conservation of Antarctic marine living species	Concludes convention on conservation of Antarctic marine ecology
1982	Decision (82/72)	The Berne Convention	Concludes convention on conservation of wildlife and natural habitats in Europe
1982	Decision (82/461)	The Bonn Convention	Concludes convention on conservation of migratory wild animal species in Europe
1982	Regulation (3626/82)	CITES	Lays down conditions under which trade in endangered wildlife species can be carried out
1983	Directive (83/129)	Importation of skins of seal pups	Bans commercial importation of certain seal pup skins and derived products into the Community
1984	Decision	The Barcelona Convention (4th Protocol)	Approval of the Protocol concerning specially protected areas in the Mediterranean
1984	Regulation (1872/84)	Action by the Community relating to the environment (ACE)	Gives possibility for 3 years' financial support for projects relating to important biotopes

Source: Commission of the European Communities 1984

populations are carried out can the threats to species be identified and the success - or otherwise - of conservation actions be evaluated. For all these reasons, the identification and monitoring of the status of wildlife species are essential.

To assess the status of wildlife species, however, we need a means of classifying them according to the size and stability of their populations. Inevitably this is a highly subjective procedure in many cases, but some degree of consistency is possible by using the IUCN definitions. These recognise eight categories, as follows:

Extinct: species not definitely recorded in the wild during the past 50 years.

Endangered: taxa in danger of extinction, and whose survival is unlikely if the causal factors continue to operate.

Vulnerable: taxa believed likely to move into the endangered category in the near future if the causal factors continue operating.

Rare: taxa with small world populations that are not at present endangered or vulnerable but are at risk.

Indeterminate: taxa known to be extinct, endangered, vulnerable or rare but where there is not enough information to say which category is appropriate.

Out of danger: taxa formerly included in one of the above categories, but which are now considered relatively secure because of effective conservation measures or removal of the original threat.

Insufficiently known: taxa that are suspected but not definitely known to belong to any of the above categories because of the lack of information.

Not threatened: species which are neither rare nor threatened.

In the case of the European Community, recognition of these categories depends on the extent of the territory considered. As new member states enter the Community, the status of some species will inevitably change.

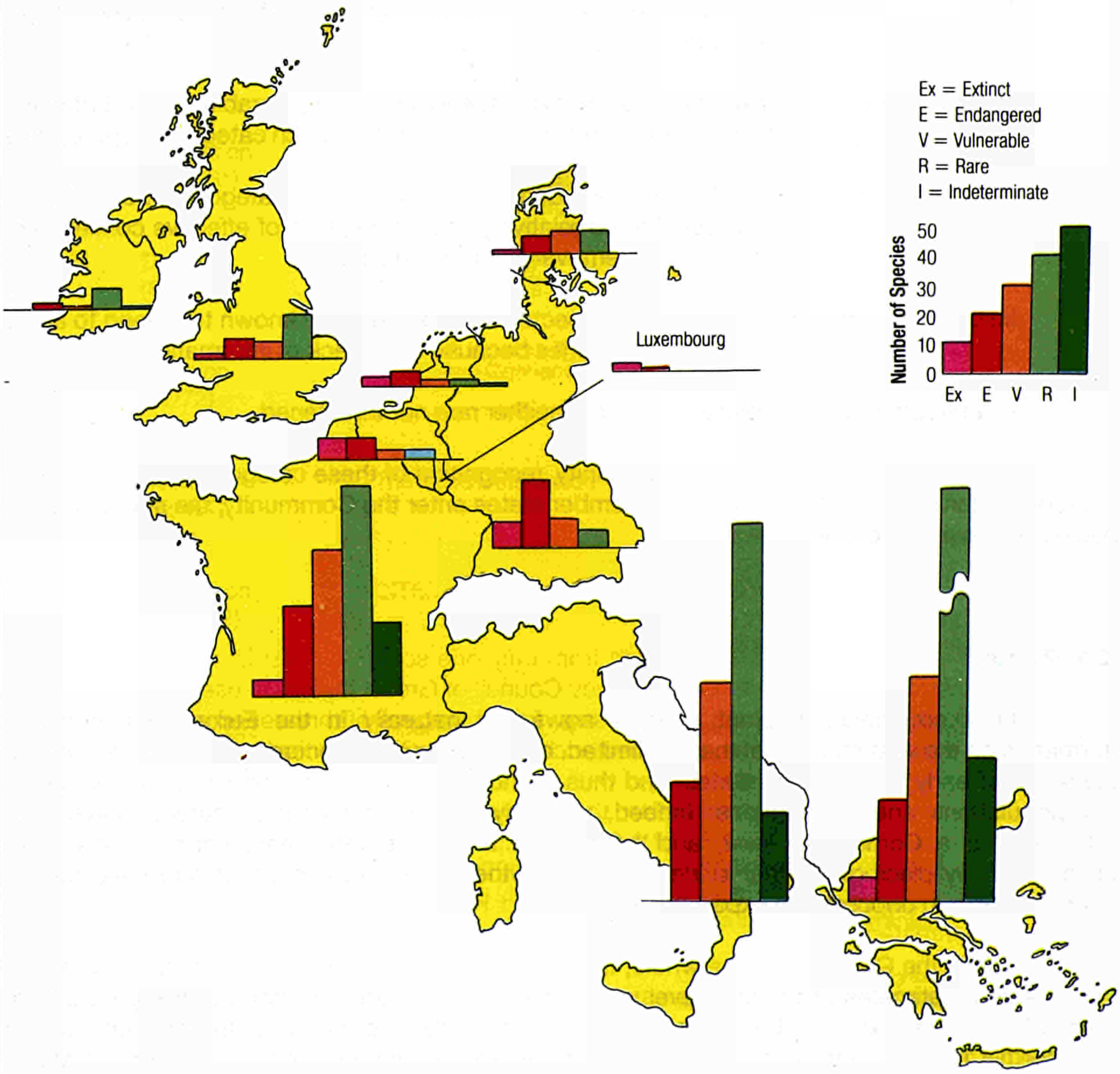
9.2.1 Plants

Over six thousand plant species are found naturally in the European Community. Information on the vast majority of these is limited, however, for many records date only from the late nineteenth of early twentieth centuries, and thus do not relate to recent conditions or changes in their populations and distributions. Indeed, relatively few, comprehensive surveys have been undertaken at a Community level, and information on threatened plants normally has to be accumulated by piecing together evidence from a wide and diverse range of published papers, regional floras and unpublished expert knowledge.

Within the Community as a whole, therefore, it is difficult to estimate exactly the status of plant species. Estimates at national level vary widely, and indeed are often so divergent that no meaningful comparisons can be made between them - reflecting, perhaps, the different ways in which the IUCN categories have been interpreted. Different authorities nevertheless agree that over a thousand species are under threat and somewhere in excess of 200 species are in danger of extinction.

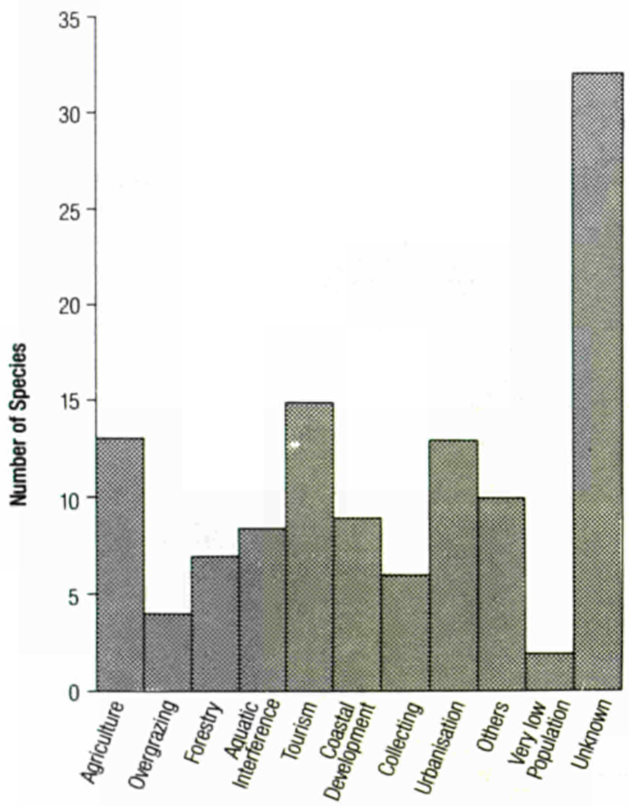
Figure 9.1 **Threatened and extinct plant species in Community member states.**

The species classified as threatened or extinct in this diagram occupy a wide range of habitats, including coastal cliffs, maritime sand dunes, water meadows, limestone grassland, lake margins, siliceous outcrops, volcanic waste and agricultural lands. Particular concern, however, is attached to those species regarded as 'narrowly endemic' in their range: that is plants which are restricted to a few very specific localities in the Community. Many species in this category occur only in coastal areas of France, Greece or Italy, most notably *Omphalodes littoralis, Cytisus aeolicus, Astragalus verrucosus, Ribes sardoum, Biscutella neustriaca, Limonium recurvum, Gypsophila papillosa, Astragalus maritimus, Stipa bavarica, Salicornia veneta, Hormathophylla pyrenaica, Brassica macrocarpa, Abies nebrodensis* and *Centaurea horrida*.



Source: data from Nature Conservancy Council 1982

Figure 9.2 **Threats to plant species in the European Community.**



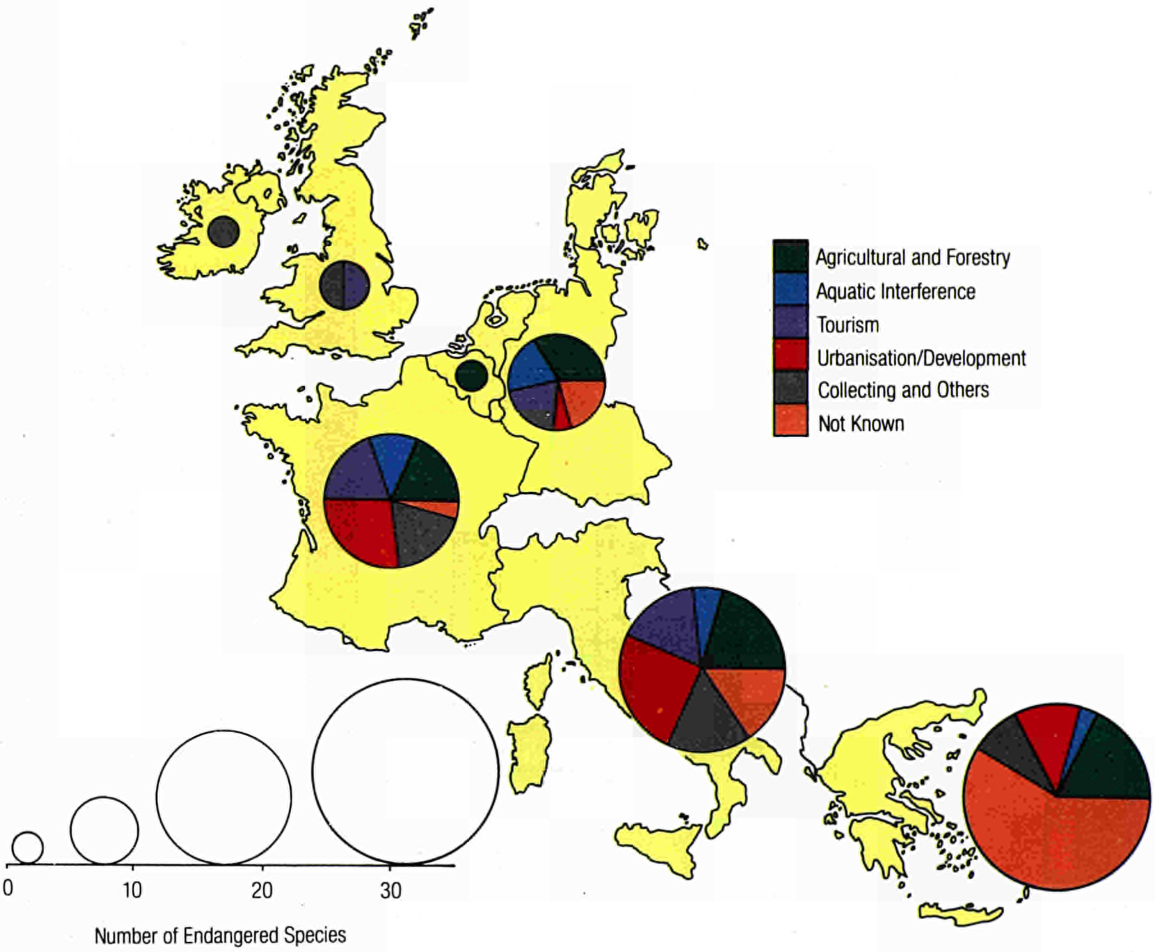
Source: data from Nature Conservancy Council 1982

For the purpose of consistency, data from only one source - a study conducted for the European Commission by the Nature Conservancy Council of Great Britain - is used here. Some of the results are summarised in Figure 9.1, which shows the numbers of threatened and extinct plant species in Community member states, classified according to IUCN definitions.

Whilst it is necessary to remember the possible limitations of these data, the general pattern is clear. There is a preponderance of threatened species in the Mediterranean area, with over 500 species in the rare category and a further 104 in the vulnerable and endangered classes in Greece alone. This contrasts markedly with the United Kingdom, which although larger in area contains only 25 threatened species.

This pattern seems to be an expression of a number of related influences. Undoubtedly the basic pattern reflects the natural distribution of species across the Community. Species diversity is far lower in northern areas due to the relatively adverse climate at the present and the effects of glaciation and climatic deterioration during the Quaternary period; it is higher in southern areas which escaped the most severe impacts of Quaternary glaciation and, today, have a comparatively benign climate.

Figure 9.3 **Distribution of threats to plant species in Community member states.**



Source: data from Nature Conservancy Council 1982

Superimposed upon this basic pattern, however, are the effects of human activities. In northern areas, forest clearance, the spread of intensive cultivation and extensive industrial development have combined to cause the extinction of large numbers of plant species over the last 200 years: stated simply, there are relatively few now left to be threatened. In contrast, pressures in southern regions have only recently begun to intensify, with the result that increased numbers of species are now under threat. One important implication of this, of course, is that continued increases in pressure in these southern regions (e.g. from tourist development, industrial expansion or agricultural intensification) may have a major impact on plant populations unless conservation measures are introduced.

The nature of the threats to plant species in the European Community is shown in Figure 9.2. This relates to the 82 plant species identified by the Nature Conservancy Council as 'endangered' in the European Community. (The total in the figure sums to more than 82 because some species are subject to more than one threat). As can be seen, in a large number of cases the main threat is unknown. Of the threats that are known, however, tourism, agriculture and

Plate 9.1 **The mountain flora of the Pyrenees. Some of the most beautiful, fascinating and vulnerable plant species in the European Community are associated with mountain areas such as the Pyrenees and Alps. Here, natural stresses combine with pressures from human activities such as tourism, afforestation and agricultural intensification. The photographs below illustrate the typical Arctic-Alpine flora from the high Pyrenees.**

Photos: D. Moss, Nature Conservancy Council urbanisation are predominant. The distribution of these threats is shown at a national level in Figure 9.3. The pattern highlights the preponderance of 'unknown' threats in Greece: here, more than anywhere, the need for improved data is paramount.

9.2.2 Invertebrates

Invertebrates are by far the largest biological group in the world: the European Community alone probably supports some 100,000 species. Compared to all other groups, however, relatively little is known about these species. Some orders such as butterflies (Lepidoptera) have attracted attention, but the vast majority have not been surveyed in any detail.

The lack of data on invertebrates is hardly surprising. Compared to other groups of animals they are difficult to study and, with the exception perhaps of butterflies, do not generally attract public concern. Few of the member states of the European Community, therefore, have attempted to produce a detailed 'red list' of invertebrates. The Netherlands, however, has listed 589 threatened species, of which 202 are Mollusca (snails, slugs etc.), 134 are Trichoptera (caddis flies) and 105 are Lepidoptera (butterflies). In addition, the United Kingdom contains an estimated 1108 threatened insects and 23 threatened non-marine molluscs.

Total numbers of threatened invertebrates for the whole Community are consequently a matter of conjecture. Nevertheless it has been estimated, that about 20% of Europe's invertebrate species are threatened - a total of perhaps 20,000 species. Only the status of butterflies is known in any detail, and these are shown in Figure 9.4. At this scale of analysis, patterns are difficult to identify, although there is a tendency for threatened species to be more abundant in Mediterranean areas. This probably reflects the same factors discussed in relation to plants, in section 9.2.1.

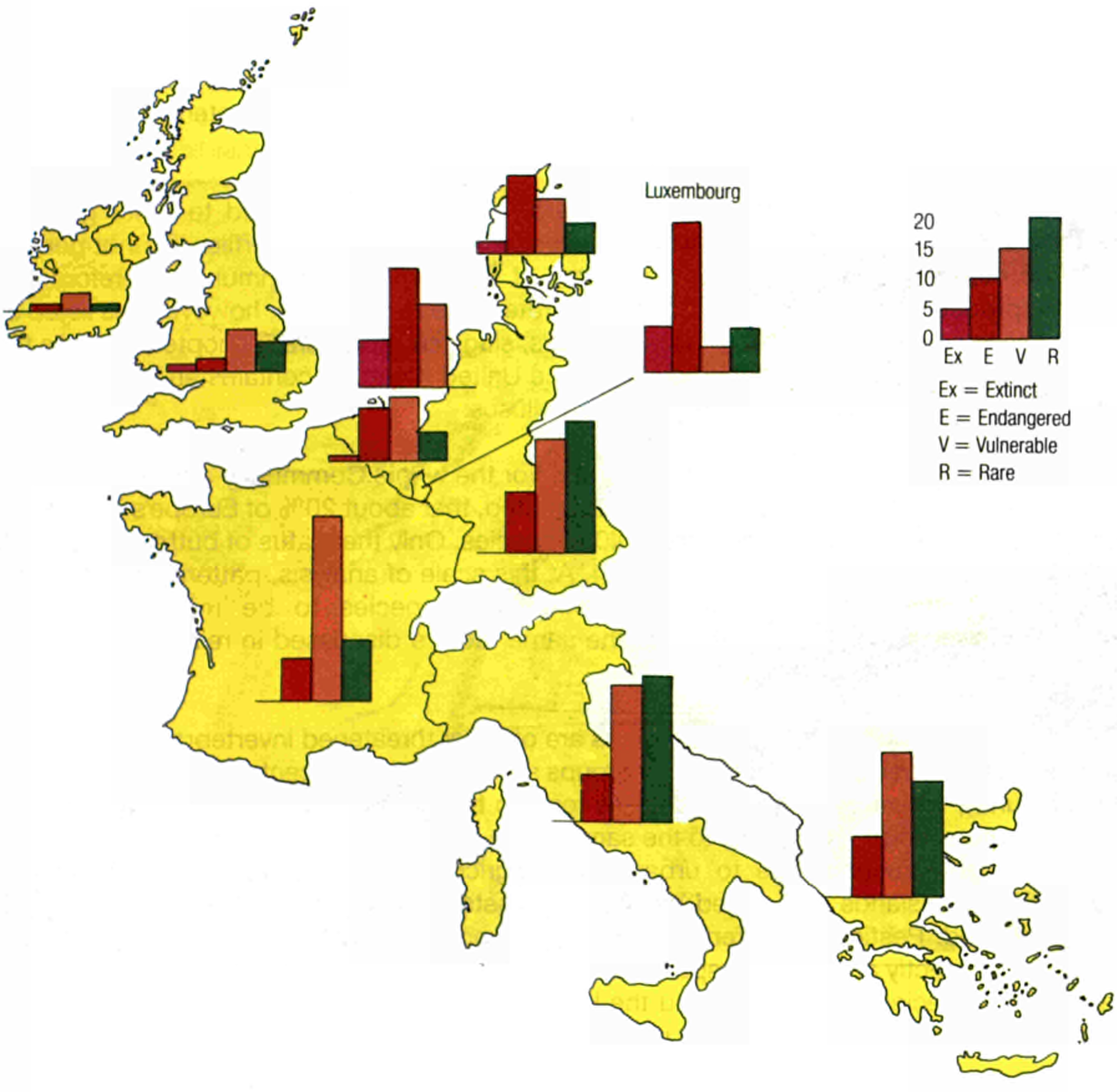
How representative these distributions are of other threatened invertebrate groups is not clear. In general, however, it seems that other groups show a similar concentration in southern parts of the Community, where ecological conditions tend to be more favourable. It also appears that many invertebrate species are subject to the same range of threats. Chief amongst these is habitat disturbance and destruction, due to urbanisation, agricultural development and afforestation. Wetland, natural grasslands and mixed deciduous forests - all major invertebrate habitats - are particularly affected. Pestiçide and fertiliser usage also pose significant threats. Insecticides and nematicides may directly attack some species while applications of fertilisers and pesticides lead to changes in plant species composition and the loss of vital food plants. In addition, soil pollution, tourism and collecting threaten some species.

9.2.3 Freshwater Fish

Data on the distribution and abundance of most species of freshwater fish in the Community are generally sparse and inadequate. Due to economic and sporting incentives, most research programmes deal only with angle fish species. The status of smaller species, usually of negligible importance to anglers is still poorly known.

The Nature Conservancy Council lists 65 indigenous freshwater fish species in the European Community, 47 of which are considered to be endangered. The main threats comprise drainage of wetlands, water pollution, regulation of water levels for water storage, dredging for

Figure 9.4 **Threatened and extinct butterfly species in Community member states.**



Source: data from Heath 1981

drainage purposes, introduction of exotic species, control of fish populations by unsuitable methods, canalisation of rivers and destruction of spawning grounds. The danger is that many of these threats will go unheeded, for fish rarely raise any sympathy, either politically or amongst the public, and therefore tend to be ignored in most conservation programmes.

Plate 9.2 **Despite their effective camouflage, few reptile species escape completely the effects of human activities. Tourism, agricultural intensification, deforestation and urban development all lead to loss of habitats and disturbance of populations.**

Photo: D. J. Briggs

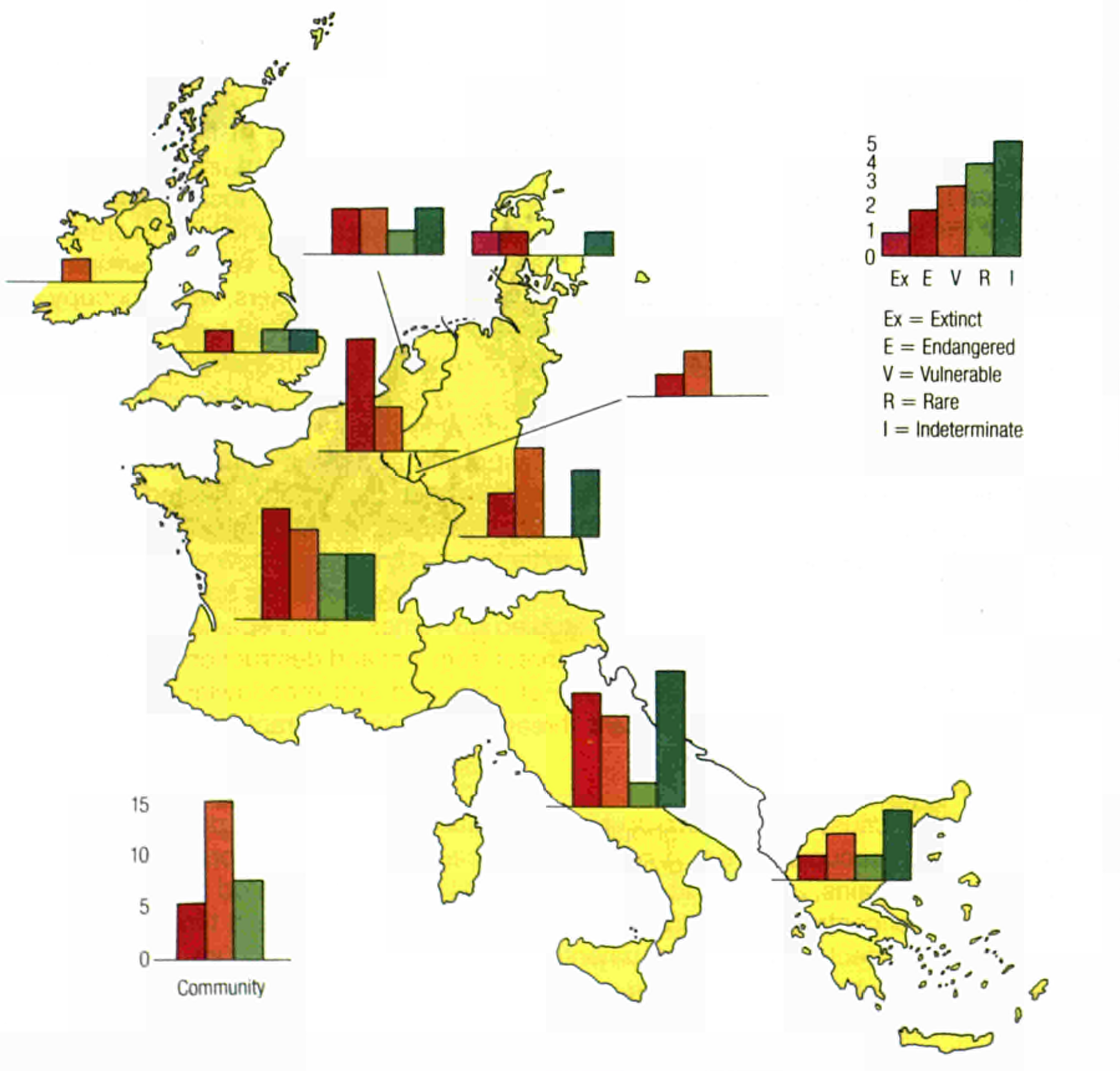
9.2.4 Amphibians and Reptiles

A total of 111 reptiles and amphibians are believed to occur in the wild in the European Community. Though few of these appear to be in immediate danger of extinction, almost all are under some degree of threat throughout at least part of their range due to a wide variety of pressures. Chief amongst these are problems of habitat disturbance and destruction. Reptiles and amphibians are particularly vulnerable to these effects because they are relatively immobile and closely tied to their habitats. Moreover, these habitats typically comprise small, sensitive features such as shallow ponds, pools, brooks, marshes and cisterns, all of which are easily disturbed or removed by agricultural and other activities. Thus, in a questionnaire survey of 143 scientists in the United Kingdom, nine of the 12 species found in the wild were considered to be declining in numbers in at least some regions. Between 69% and 93% of the responses for these nine species cited loss of habitats as the major reason for decline.

A similar situation is found in the Community as a whole. Using data from experts in member states, the Nature Conservancy Council identified 26 species of reptiles and amphibians believed to be threatened. The distribution of these, and their status according to the IUCN classification, is shown in Figure 9.5. In general the threatened species appear to have a slightly southern range although it is notable that in a large number of cases the status is indeterminate; this reflects the lack of detailed knowledge about many species.

The main threats to these species are habitat disturbance and removal. Causes of disturbance are numerous, but include wetland drainage, expansion of cultivation, woodland clearance, dredging of streams and urbanisation. In addition, some species are threatened by other activities such as tourism, aquatic pollution (especially by agricultural chemicals and boats) and collection. As was shown in Chapters 3 and 4, almost all these activities are increasing and the pressures on amphibians and reptiles are likely to grow. In this case many of the vulnerable species are likely to move into the endangered category, and some species, such as Orsini's viper (*Vipera ursinii*) and the Spanish terrapin (*Mauremys leprosa*) will be threatened with complete extinction.

Figure 9.5 **Threatened and extinct reptile and amphibian species in Community member states.**



Source: data from Nature Conservancy Council 1982

9.2.5 Birds

Bird species have attracted particular attention in the Community, from amateur ornithologists, scientists and politicians. This led to the adoption, in 1979, of the Bird Directive, aimed at conserving wild bird populations and actively protecting threatened species. This lists 144 species which are considered as being vulnerable to habitat destruction (so-called Annex 1 species - see Inset p. 296).

As a result of this widespread interest, much effort has been devoted to the collection of information on bird species and their habitats in the Community. A large body of data therefore exists, including scientific reports, bird atlases and data bases, and results of national and international surveys. Inevitably, the quality of these sources is variable, and some disagreement occurs about the status, active distribution and population size of some species. In addition, data on Italy and Greece are acknowledged to be poor. Nevertheless, the data available do give a reasonable overall picture of the status of threatened bird species, and this information will undoubtedly be improved as more data become available.

IRSNB, for example, have collected information on the species listed in Annex I of the Bird Directive. Figures 9.6 and 9.7 thus present the numbers of these species - both nesting and total - in each of a series of regions of roughly equal size derived from the NUTS system of territorial classification in the Community.

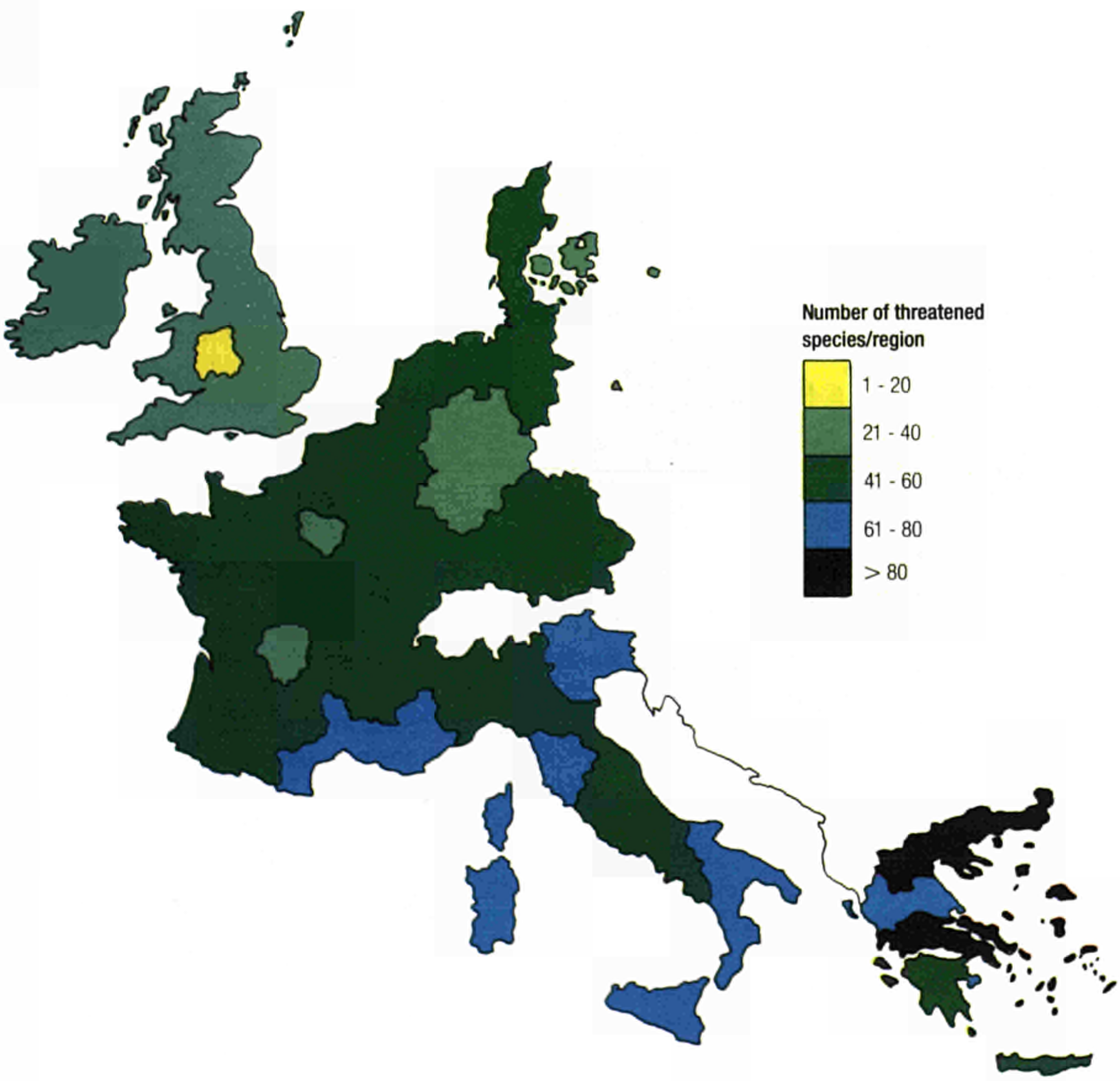
As can be seen, a clear pattern exists, with a marked concentration of listed species in southern parts of the Community, and especially in southern France and Greece. In broad terms this reflects both the greater ecological diversity of these southern areas of the Community and the acuteness of conservation problems which occur there. Nevertheless, at a more detailed level it is apparent that the distribution of these listed bird species is even more localised than these maps indicate. For the most part, they are concentrated in coastal, estuarine and upland areas (see Figure 9.15). This relates to the circumstance that many of the threatened species are wetland birds, including pelicans, ducks, geese, swans, waders, terns, rails and warblers, which occupy sites such as marshes, streams, estuaries and beaches. Most of the remainder are birds of prey - especially Falconidae (falcons), Accipittridae (eagles, hawks etc.) and Pandionidae (ospreys).

All these species are subject to a considerable variety of pressures. Undoubtedly, the most widespread threat comes from habitat loss, especially as a result of intensification or extension of agriculture and deforestation. Wetland species have been particularly affected, for land drainage for agriculture and as a means of flood control has resulted in the destruction of many habitats. Locally, these losses are being offset to some extent by the creation of new wetlands (e.g. by gravel extraction), but in many parts of the Community the populations of these species are declining. The Nature Conservancy Council, for example, studied 53 Annex 1 bird species in 1979-81, and the results suggest that over 20 of them are under threat from wetland destruction. Deforestation, scrub clearance, loss of heathlands and conversion of moorland and meadowland to arable crops or coniferous plantations also pose significant threats, particularly to raptors which depend upon a mixture of habitats within their territory.

A further cause of pressure on bird populations is the use of pesticides. This threat is exacerbated by the circumstance that many bird species (especially raptors) are at the top of long and complex food chains, and thus absorb large quantities of accumulated pesticide residues. As a result, pesticide concentrations in birds of prey may be several thousand times those in the wider environment. The effects are well-documented: eggshell thinning occurs resulting in reduced breeding success; higher mortality occurs amongst adult birds; behavioural patterns are altered and parent birds become more inclined to attack and eat their own eggs; diminished population densities result in fewer encounters between birds and lower rates of breeding. In addition, the use of pesticides has more indirect effects, by disrupting food supplies.

The use of organochlorine insecticides such as DDT and dieldrin was paramount in causing pesticide poisoning of bird species. Since the late 1960s these insecticides have been widely banned and replaced by less persistent organophosphate compounds (see Chapter 4). Nevertheless, the mobility of birds means that they can come into contact with many different sources of pesticides, often outside the European Community. Controls on the more harmful pesticides are, however, proving successful, as the data for the sparrow-hawk populations in Figure 9.8 indicate.

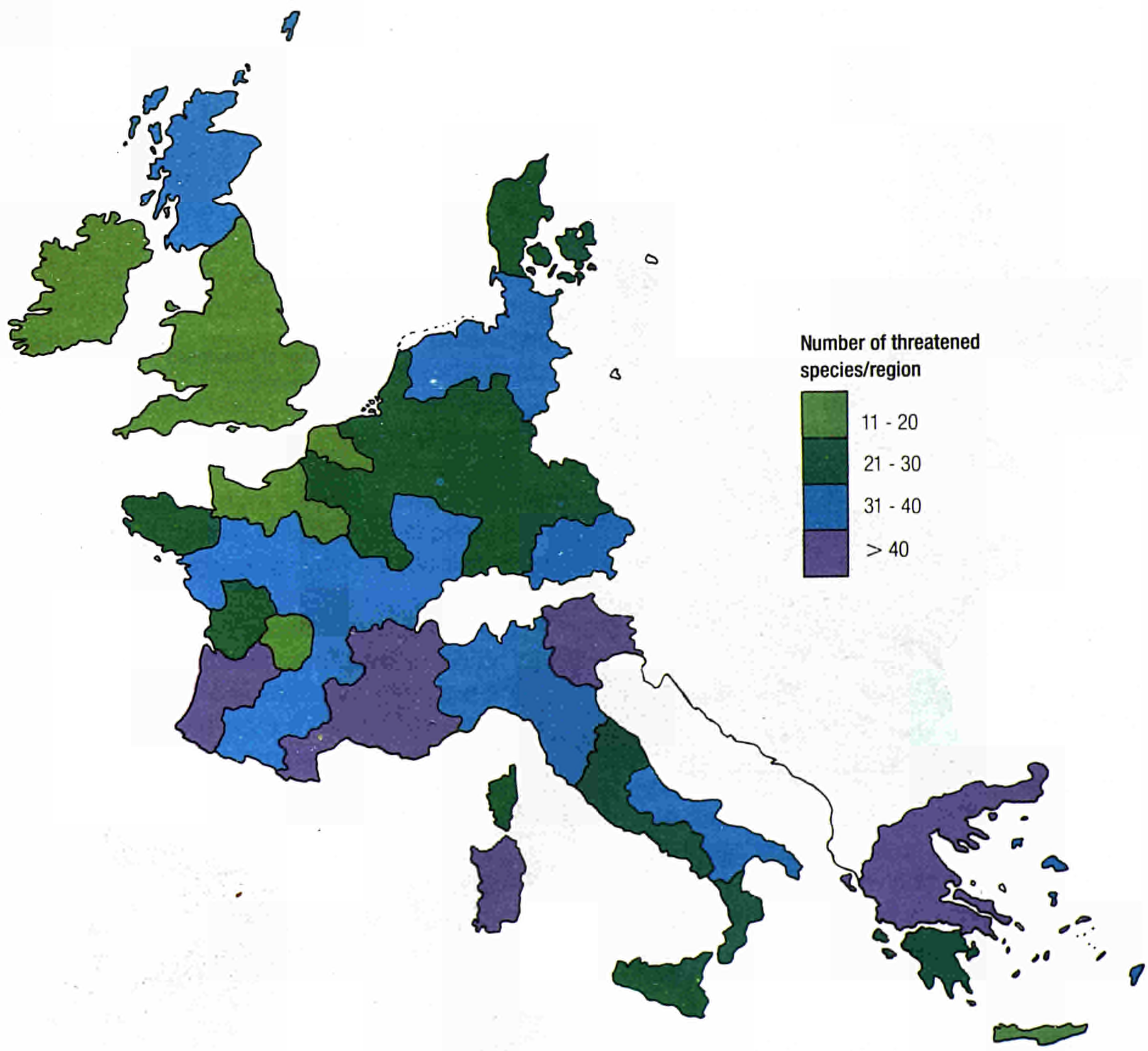
Figure 9.6 **Threatened bird species in the European Community.**



Source: data from Institut Royal des Sciences Naturelles de Belgique 1985

Pollution effects are not restricted to pesticides. A significant threat to seabirds is from oil pollution, as we saw in Chapter 8. Over the last twenty years, the incidence of marine oil spillages, especially from oil rigs and tankers, has increased considerably, often affecting large numbers of birds. Control measures, such as the use of detergents, have a further impact both directly on contaminated birds and indirectly by reducing fish stocks.

Figure 9.7 **Threatened nesting bird species in the European Community.**



Source: data from Institut Royal des Sciences Naturelles de Belgique 1985

Plate 9.3 **The razorbill (*Alca torda*): a seabird which breeds mainly along coastal cliffs in north-western Europe. In recent years it has been subject to pressures from marine oil pollution, though populations are not considered significantly threatened.**

Plate 9.4 **The polecat (*Mustela putorius*): a widely distributed carnivore species, whose numbers have fallen during the present century as a result of loss of habitats, deliberate killing and trapping, and competition from ferrel ferrets.**

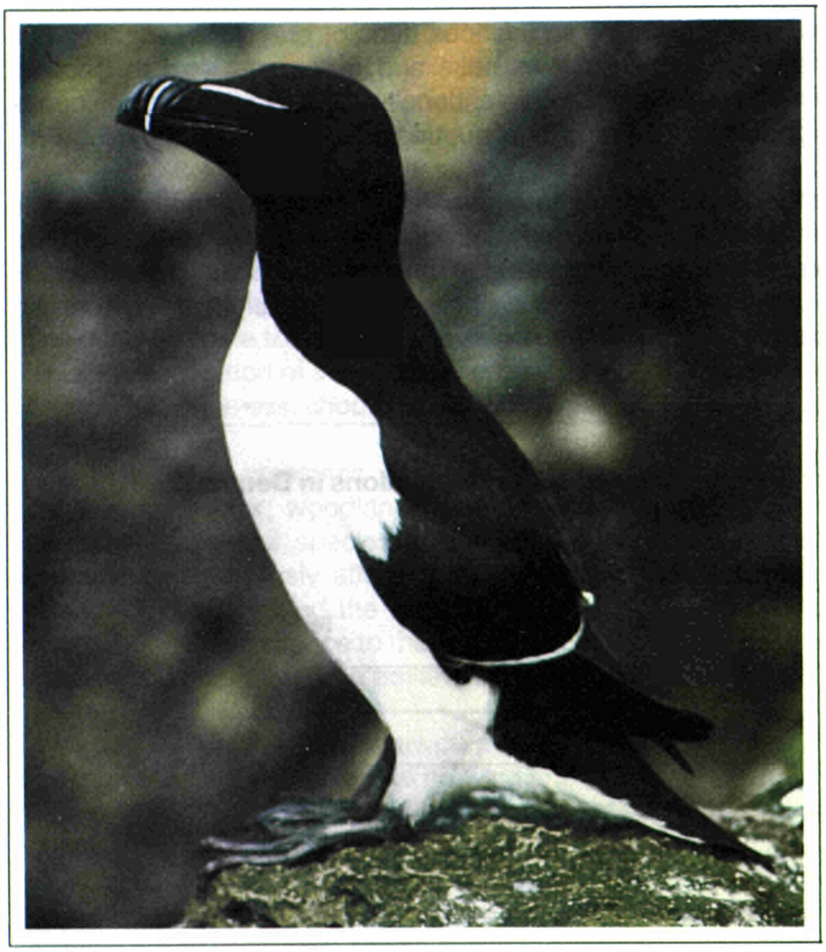


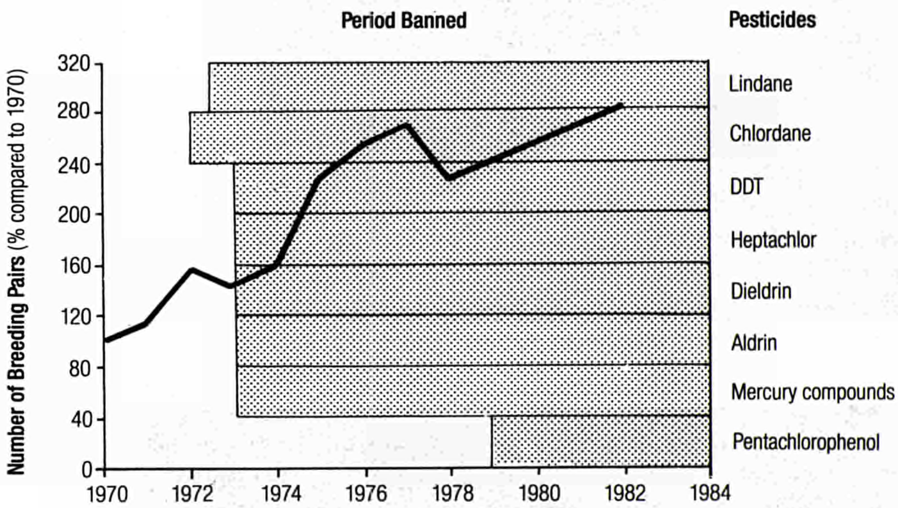
Photo: D. Moss, Nature Conservancy Council

Photo: R. Harris, Nature Conservancy Council

In addition, some species are still affected by direct interference and killing. The Bird Directive banned deliberate killing, capture or the collection of eggs of naturally occurring wild birds, but all these practices still persist illegally, especially in remote areas of the Community. Accidental killing also remains a problem. White stork, pelicans and various birds of prey, for example, seem susceptible to damage by power lines; Alcidae such as auks and guillemots tend to become entangled in fishing nets. Raptors, in particular, may be unintentionally killed by taking of poisonous bait. Almost all species may be accidentally shot during legal hunting or killed by traffic.

Inevitably, many of these threats are difficult to control, and one of the greatest needs is thus for public education so that they may take more care in activities which might endanger wildlife. Certainly action is required, for at present, as a result of the wide range of threats which exist, a total of 39 species in the Community are under serious threat of extinction. Of these, eight are raptors and twelve are seabirds or aquatic species.

Figure 9.8 **Pesticide usage and sparrow-hawk populations in Denmark.**



Source: data from Ministry of Housing, Physical Planning and Education 1985

9.2.6 Mammals

Of the 120 or so species of mammal found in the wild in the European Community, 86 are land-based species, 31 are flying species (bats) and the remainder are aquatic species (whales, seals etc). Many of these species are known to be threatened by a wide range of human activities. Opinions on exactly which species are in danger vary, but in the case of mammals seventeen species are generally considered to be threatened with extinction in the Community. Information on fourteen of these has been collected by the Nature Conservancy Council (1982) and their known ranges are shown in Figure 9.9.

It must be admitted that several of these distributions are open to debate. The active range of the otter (*Lutra lutra*) for example is defined very differently by different authorities (as can be seen by comparing its distribution in France in Figure 9.9 with that for 1980-84 on page 315). Similarly, some uncertaintly exists about the viability of several reintroduced populations of species, such as the beaver (*Castor fiber*). It is clear, however, that with the exception of the otter most of these species have a very restricted distribution and are now confined to a few isolated habitats in more remote areas of the Community.

To a great extent, these patterns reflect the long history of persecution and pressure experienced by these species. Many mammal species are hunted for sport and game, or because they are regarded as agricultural pests. In addition, species such as the lynx (*Felis lynx*) and wolf (*Canis lupus*) are feared as a threat to humans. In reality, many of these perceptions are inaccurate. The damage done to crops and livestock by most wildlife species seems to be grossly exagerated, while the reputation of some species for attacking humans is based more on myth and folklore than on fact. Nevertheless, shooting and trapping remain a major cause of population decline.

Other pressures are also important. Habitat loss has undoubtedly been a major contributory factor; woodland clearance, for example, has greatly reduced the range of habitats available to several species, including the wolf, brown bear (*Ursos arctos*) and lynx. Wetland drainage has seriously affected the otter and root vole (*Microtus oeconomus*); bank clearing in streams has eliminated the beaver from many areas. In addition, tourism and urbanisation have increased the disturbance to many habitats, causing the resident species to retreat into more remote areas, while pesticides and pollution may also have had a minor effect.

All these pressures are currently increasing, as we saw in Chapters 3 and 4. In consequence, the threats to many species are growing and populations are continuing to decline. The situation with regard to bats is no better. All European bats are insectivores, and between them they cover a wide range of habitats. Many species, however, are known to occupy mainly woodland or aquatic habitats, roosting in summer or hibernating in winter in caves, mines and old buildings. As a consequence, bat populations have in many instances increased as a result of human activity which has provided suitable mixed vegetation and sheltered tunnels and roofspaces. On the other hand, these populations have also been increasingly threatened by human action. Collection and disturbance of roosts and vandalistic killing pose particular threats, whilst many colonies have been affected by chemical treatment of timber in buildings. In Britain, for example, the number of dwellings treated with chemicals such as lindane and dieldrin rose from 35,000 in 1972 to 100,000 in 1979. These chemicals remain on the surface of the timber for many years and are actively absorbed through the skin and lungs of the bats. The effects upon the populations have been particularly severe in the Netherlands.

Similar effects have been produced by habitat destruction. Woodland clearance, removal of old trees and wetland drainage all result in loss of breeding and feeding grounds, whilst the use of insecticides has often disrupted the food chain of bat species. The colonial nature of many species, which may gather in colonies of several hundred individuals from an area of several thousand kilometres, makes them particularly vulnerable. Destruction of a single breeding colony can eliminate the species from a wide area.

As a consequence of all these effects, populations of most bat species in the European Community are declining, and twenty-nine species have been identified as being under threat. The collective distributions of these are shown in Figure 9.10.

Data on the threatened species shown in this figure are derived from a study by the Nature Conservancy Council of Great Britain. This collected information on bat populations, distributions and threats from a survey of about 430 scientific reports, supplemented by consultations with scientists at the first European Symposium on Bat Research at Bonn in March 1981. Information on the ecology and population status of most species is lacking, so subjective decisions were

THE OTTER IN FRANCE: A CASE STUDY OF A SPECIES IN DECLINE

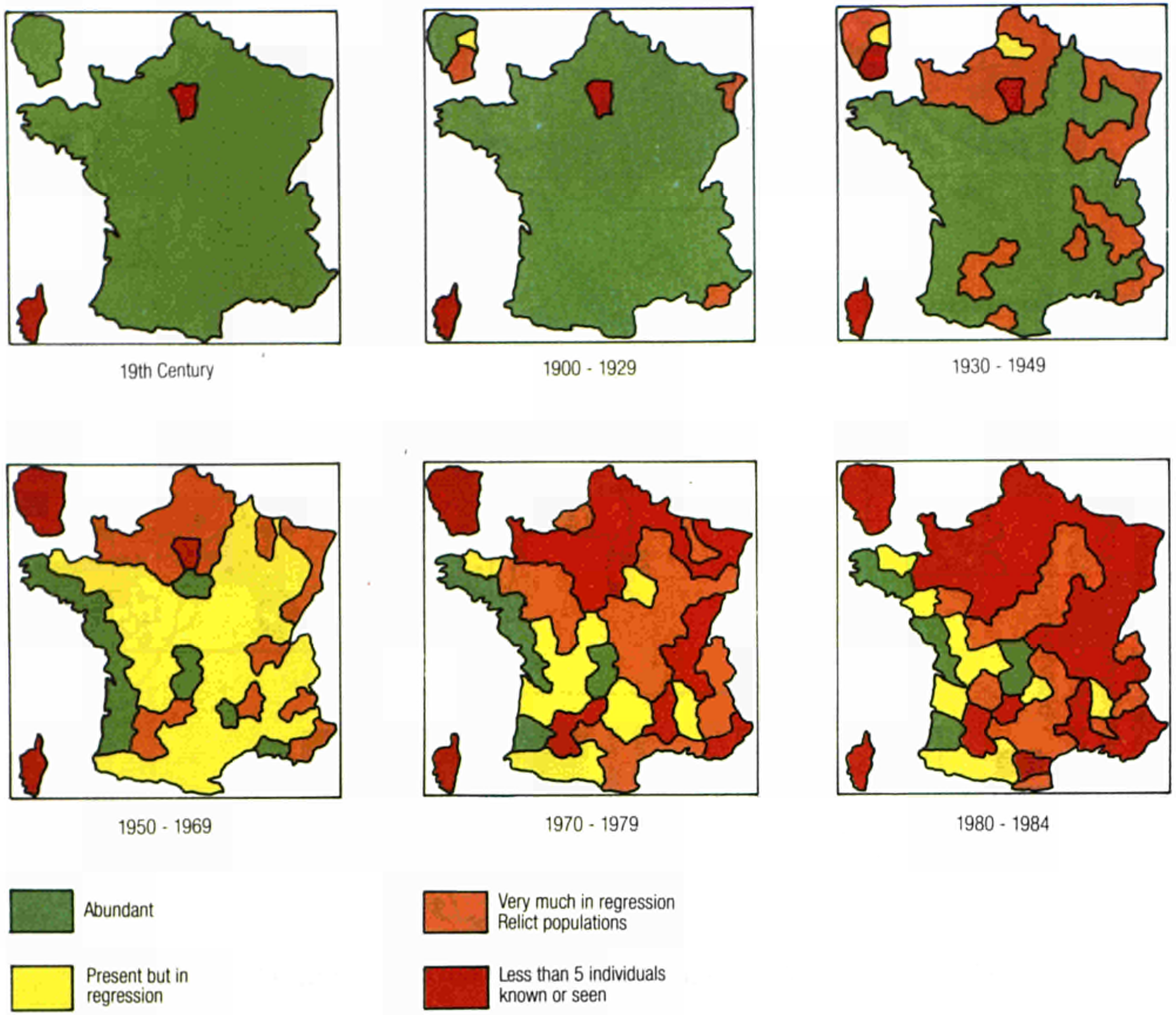
The European Otter is almost everywhere a species in retreat. Throughout much of its range it has been considered as a pest, or as a target for sport. Hunting, trapping and poisoning of the species have therefore been common. Its natural habitats have also been under continuous and growing pressure. In the wild it occupies a range of territories: moorland and marsh, river banks, lakes, and the seashore. All these environments have, during the course of this century, been increasingly affected by agriculture, urban development and tourism. Marshes have been drained, river banks cleared and treated with herbicides, rivers polluted by pesticides or disturbed by boats, the sea coast built up or trampled by tourists.

In the face of these pressures, the otter has for long been in decline. In France, for example, it was abundant throughout the whole rural area of the country, with the single exception of Corsica, until the late nineteenth century. Early in the present century, however, the impacts of urban development began to be felt. First in the Paris region and then around Nice, it began to diminish in numbers (Figure, opposite). By the 1930s the decline had spread to much of northern and eastern France as not only urbanisation but also agricultural intensification and afforestation began to have an effect. Between 1950 and 1980 it disappeared almost entirely from the basins of the Rhine, Rhone and Seine, and from the Mediterranean coasts. Today, in these regions, it is restricted to only scattered localities, often up to 200 km apart, and even then, in only small numbers. Elsewhere - especially in the Garonne, Loire and parts of the Pyrenees - it remains abundant, but still under threat. In order to avoid its total elimination, urgent efforts are needed to protect the otter's remaining habitats in these areas by reducing pollution, limiting disturbance of stream and river banks and controlling agricultural development. It is a situation - and a need - true of many other parts of the Community.

The European Otter

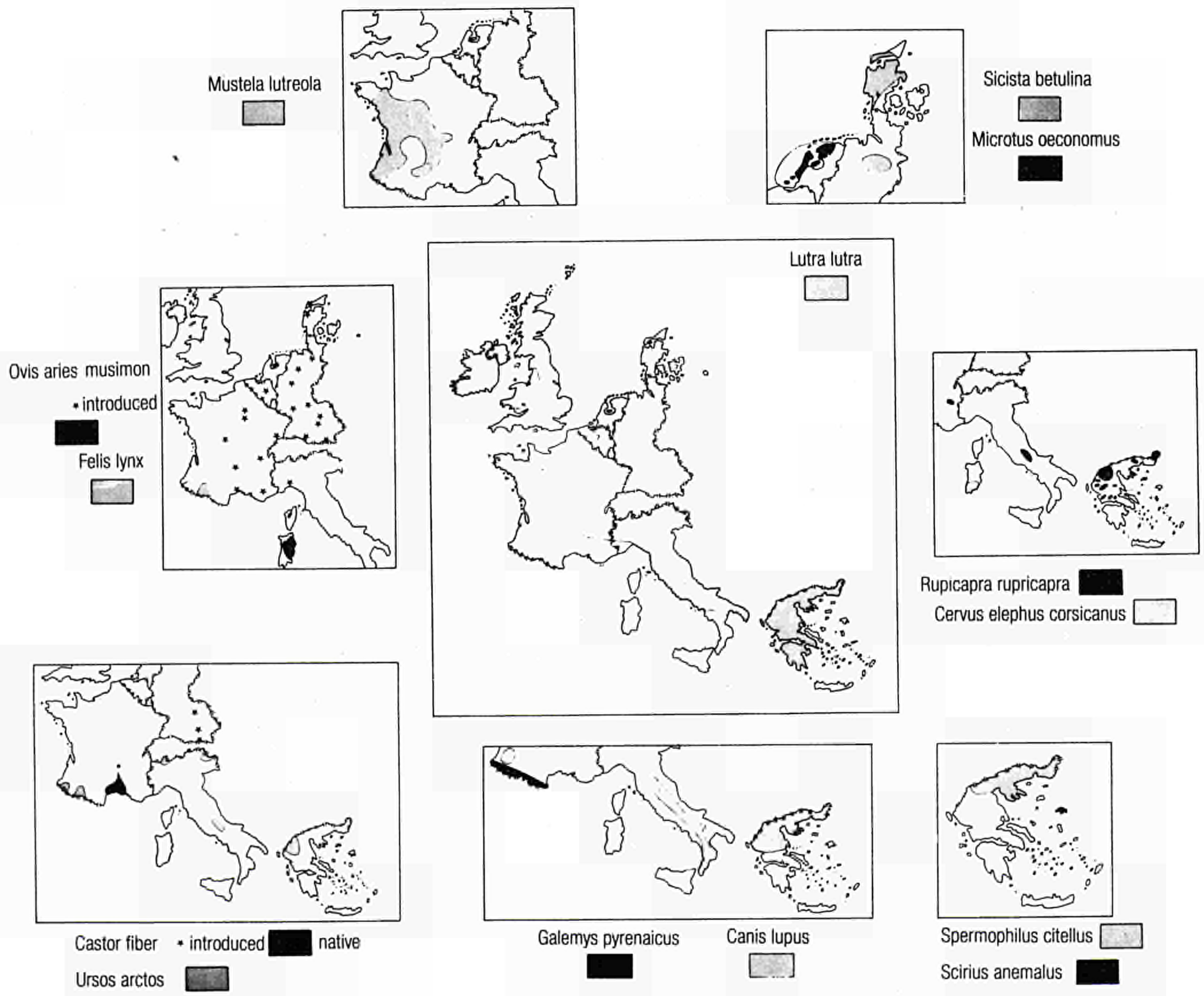
Photo: copyright of Philip Wayre, Norfolk Wildlife Park

*Changes in otter (*Lutra lutra*) populations in France, pre-1900 to 1980-84.*



Source: Commission Interministerielle des Comptes du Patrimoine Naturel 1985 *Comptes de la faune et de la flore*. Paris: Ministère de l'Environnement

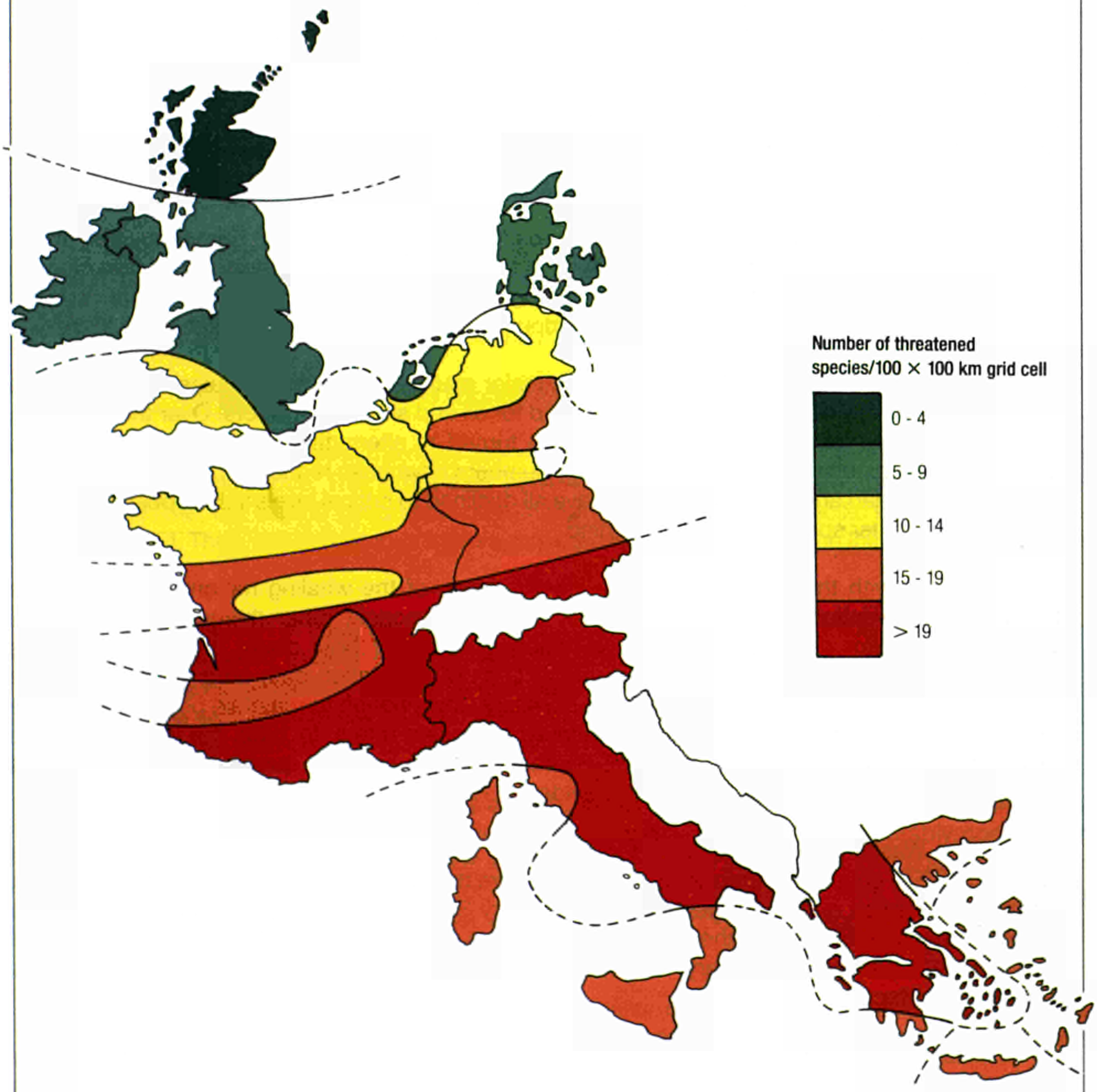
Figure 9.9 Threatened mammal species in the European Community.



Source: data from Nature Conservancy Council 1982; Van den Brink 1976

Figure 9.10 **Threatened bat species in the European Community.**

Interpretation of the distribution of bat species needs care, for bats are migratory, often moving considerable distances between their summer and winter roosts. Several European species even spend the winter in Community countries but move to form nursery colonies in Poland and Russia during the summer. Moreover, the distribution of many species is markedly discontinuous, with large concentrations found in widely separated localities. These factors not only make it difficult to map bat distributions in any meaningful way, but also cause severe problems for conservation.



Source: data from Nature Conservancy Council 1982

necessary in the selection of threatened bat species and in mapping their distributions. The distributions mapped by the Nature Conservancy Council can only be considered as provisional, therefore, and as knowledge expands will undoubtedly be modified. Moreover, within the distributional area of any species, considerable variations in population densities may occur, while small populations may exist outside the specified range. In addition, different species may differ greatly in their abundance across the Community as a whole.

Given these limitations, it would clearly be invalid to subject the available data to any complex manipulation or analysis. In order to provide a general picture of conditions across the Community, therefore, the mapped distributions were overlain on a 100 km x 100 km grid map and the numbers of threatened species in each cell summed. The results were then generalised to provide regional contours.

As Figure 9.10 shows, the greatest concentrations of threatened species occur in the south, especially in Greece, Italy and southern Germany and France. This pattern reflects the broad distribution of bat species in the Community as much as the inherent distribution of threats. Most European bat species have an essentially southerly or easterly range, possibly due to climatic controls. Nevertheless, the concentration of threatened species within the Mediterranean areas indicates that developments in this region - such as urbanisation, agricultural intensification and improved pest control - are likely to have major impacts on bat populations.

Terrestrial mammals are not the only ones to cause concern in the European Community. Similar problems affect many marine species. Of almost thirty cetacean species which are found in European waters, for example, thirteen are suffering significant declines in their populations, while the monk seal (*Monachus monachus*) is under serious threat of extinction (see Inset, page 288).

In all these cases, hunting has been a major source of pressure. Whales and seals have both been extensively exploited for their skins, and for oil and skeletal products. Over the centuries, as one species has been depleted, attention has turned to alternative species which have then themselves been extensively exploited until their numbers have been reduced. Thus the blue whale, right whale, bowhead and humpback whale have all declined to critical levels in European and North Atlantic waters; other species are not far behind.

Faced with these declining whale stocks, many of the whaling nations concluded the International Convention for the Regulation of Whaling. Amongst other things, this provided a procedure to monitor catches and agree on national quotas. Without doubt these controls have helped to reduce the pressures on some species. Lack of population data on a number of whale species, however, means that quotas are not necessarily low enough to maintain populations, while continued hunting by non-IWC countries continues to pose a threat. In 1982, the IWC decided to phase out commercial whaling by the 1985-6 season, and to set zero quotas thereafter unless a decision to the contrary - based on scientific evidence - is taken.

The Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) covers all cetacean species which are thereby subject to trading controls. In 1979, the Bonn Convention on the Conservation of Migratory Species of Wild Animals listed five species requiring protection. Imports of the main whale products into the Community were prohibited as of 1 January 1983, and from 1 January 1984 that measure is extended to all parts and derivatives as well as to live cetaceans.

Nor is hunting the only cause for concern. Several marine mammals are also threatened by pollution. The ringed, common and grey seals, for example, have been found to be susceptible to high levels of PCBs, resulting in reproductive failure. Similarly, the harbour porpoise may owe its declining population at least in part to pesticide pollution. The monk seal, too, has been affected by pollution, though in this case the habitat loss and disturbance has also played a major part (see Inset page 288).

9.3 HABITATS AND SITES

A habitat is defined as an area within which organisms live, including all influential external factors. Habitats thus comprise distinct - although not necessarily contiguous - units of the earth's surface, together with the plants and animals which occupy them, and the rocks, soils, water, air and climate on which they depend. A site, on the other hand, refers to a specific, self-contained area of the land which is occupied by plants and/or animals. It forms the basic unit for conservation and management.

The need to conserve habitats and sites is evident. They provide the physical frameworks within which the plants and animals exist, and in which they can be monitored, managed and protected. Many also have an additional significance, for they are integral parts of the landscape: components which contribute to the visual and aesthetic quality of the environment. For these reasons, as Table 9.4 shows, all member states of the Community have identified sites worthy of protection. The character of these sites, and the basis on which they have been defined, vary, however; in this section we consider the nature of selected natural habitats in the European Community and show some of the pressures acting upon them.

9.3.1 Biotopes of Significance for Nature Conservation

At whatever level attempts are made to define habitats or sites of importance for nature conservation, similar fundamental problems must be tackled. In particular, a decision must be made about:

i. the geographic area within which their 'importance' is to be considered;

ii. the criteria on which this importance is to be assessed.

At a Community level, the main concern is with areas which are of international, national or gross regional significance. This is not easy to define, however, for unless a complete inventory of sites is available, the extent, geographic distribution and character of specific types of site cannot be determined. Thus, the definition of importance can only be made after the initial data on sites has been collected.

The selection of assessment criteria poses similar difficulties. Traditionally, many different factors have been used to define the conservation potential of sites, including rarity, size, diversity, representativeness, freedom from interference, stability, availability of scientific records, and degree of isolation. The evaluation of any one of these criteria involves a degree of subjectivity; classification of habitats on more than one raises also the question of the relative importance of different criteria.

Because of these problems, any attempt to compile a consistent and comprehensive list of important conservation sites in the European Community as a whole is inevitably complex. In 1982, however, the Commission undertook a pilot study to devise a methodology for assessing what were termed 'biotopes of significance for nature conservation'. On the basis of this procedure, experts in each of the then ten member states identified important biotopes and a provisional register was drawn up containing some 1900 sites.

Despite the guidelines established, a number of omissions and discrepancies were apparent in the results obtained from this provisional study. Consequently, the register has since been extended and refined as part of the
CORINE programme (see Inset, page 28). The original sites were reappraised by a panel of experts using revised selection criteria, and where necessary new sites were added. In addition, data on sites important for the 144 bird species listed in Annex 1 of the Bird Directive (see Inset, page 296) were incorporated, and the register is currently being extended to cover Spain and Portugal.

Table 9.2 **Sites registered as important for nature conservation in the Biotopes Register, 1986: by site type.**

Site type	Number	%
Rocky	906	8.6
Coastal	941	8.9
Wetland	1982	18.8
Marsh and bog	1115	10.6
Woodland	2391	22.7
Grassland and scrub	2090	19.8
Agricultural	1095	10.4

Source: CORINE data base.

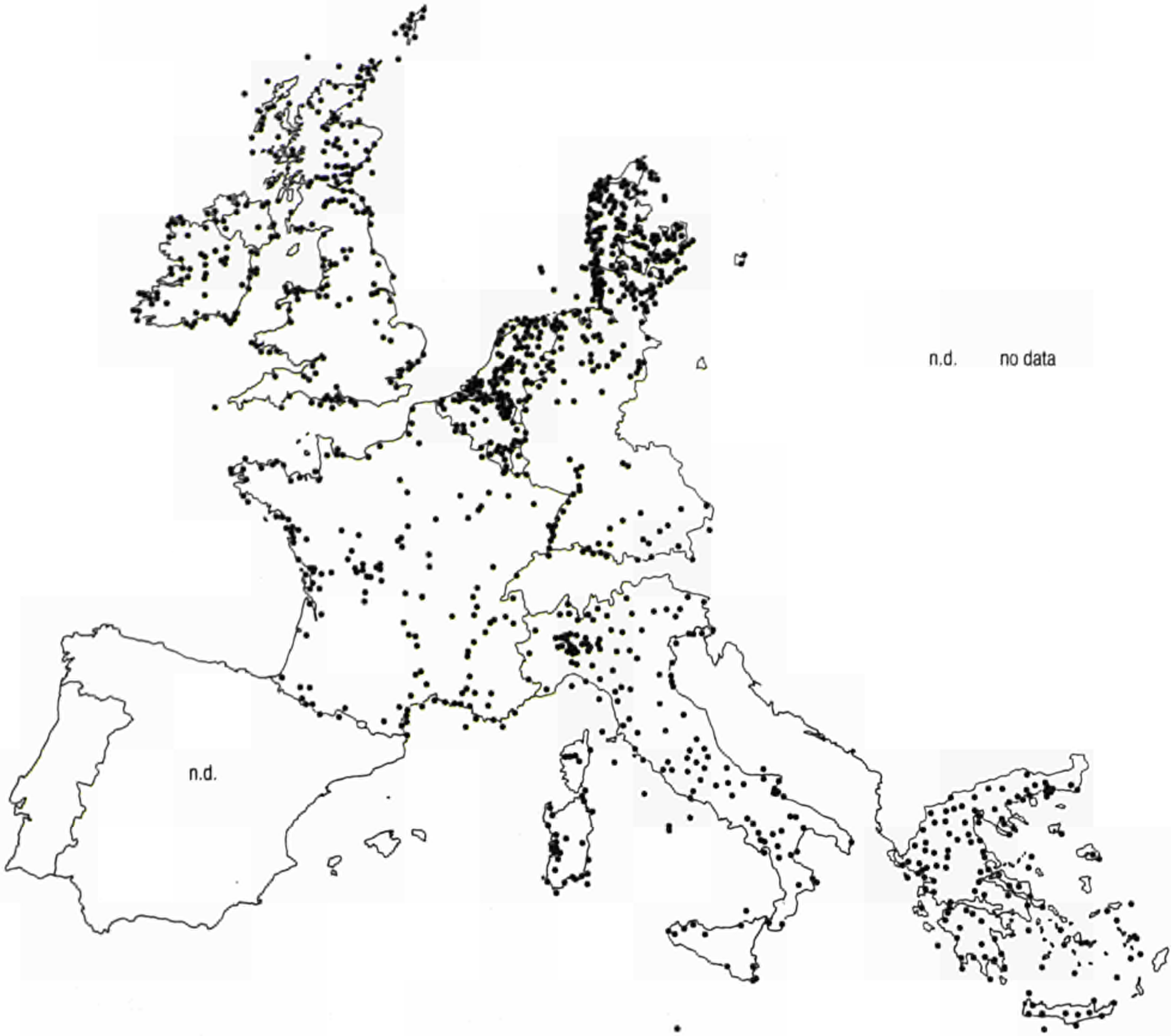
The results of this revision of the original biotopes register is not yet complete, but summaries are given in Tables 9.2 and 9.3. As can be seen from the data in Table 9.2, wetlands, coastal and marsh/bog biotopes make up about 40% of sites presently included in the register. This reflects the importance attached to these sites both as breeding grounds for threatened bird species (i.e. those included in Annex 1 of the Bird Directive), and as habitats for other wildlife species. It is an aspect similarly reflected in the distribution of listed sites, shown in Table 9.3, and is emphasised by the pattern for wetlands shown in Figure 9.11. As can be seen, there is a relative preponderance of listed sites in the Low Countries (including Belgium, the Netherlands and Denmark), where there is a concentration of lakes, streams, lagoons and other wetland habitats. Conversely, Germany, France, Greece, Spain and Portugal contain relatively few sites. In the case of the Iberian countries this is due, at least in part, to the incompleteness of the selection procedure. Elsewhere, however, it relates to the general scarcity of coastal or freshwater biotopes - a function both of the physical geography of these areas and of the impact of past human activities.

Table 9.3 **Sites registered as important for nature conservation in the Biotopes Register, 1986: by member state.**

Member state	Number	Total Area (km^2)	% of National Area
Belgium	253	5699.8	18.7
Denmark	153	11002.5	25.5
France	472	35467.9	6.5
Germany	304	19477.8	7.8
Greece	252	17322.5	13.1
Ireland	257	3446.5	4.9
Italy	1559	80995.9	26.9
Luxembourg	6	895.0	34.4
Netherlands	596	5438.8	13.2
Portugal	130	8392.1	9.1
Spain	145	18112.4	3.5
United Kingdom	351	10808.0	4.4

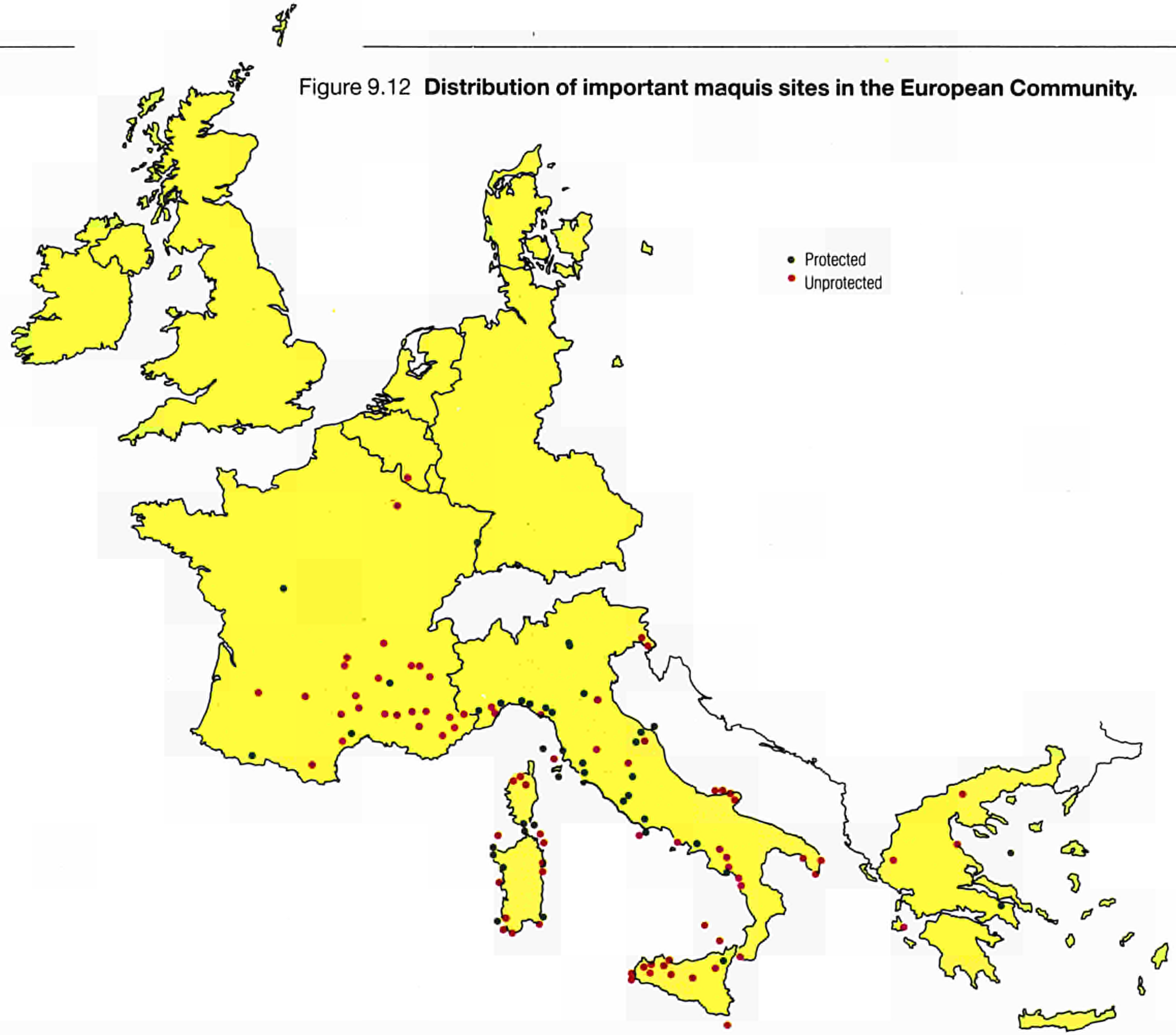
Source: CORINE data base

Figure 9.11 **Distribution of important wetlands in the European Communities**



Source: CORINE data base

Figure 9.12 **Distribution of important maquis sites in the European Community.**



Source: CORINE database

Although these sites are all regarded as important for nature conservation, they are not necessarily under any form of statutory protection. This is illustrated by the data for listed maquis sites in Figure 9.12. Whilst these sites have, as might be expected, a generally Mediterranean distribution, it is apparent that marked differences occur in the degree of protection which they are afforded. A far higher proportion of sites are protected in Italy, for example, than in France or Greece. In part this may be an artefact of the selection procedure; but to some extent also it seems to reflect real differences in national policies on these sites - differences which may need to be addressed if adequate, Community-wide protection is to be given to important biological sites in the face of the growing pressure from economic development.

9.3.2 Protected Areas

Definitive information on protected areas in the European Community is difficult to obtain due to the widely varying scope of protection which may be afforded, and the lack of any consistent terminology for protected areas. Protection status, for example, may vary between, at one extreme, stringent controls on public access and all human activities within an area and, at the other extreme, mere designation of an area as one of scenic beauty or biological interest with little or no statutory control on development. In the same way, protected areas may variously be described as national parks, nature reserves, natural parks, protected natural areas, sites of scientific interest, and so on. Moreover, not all member states recognise all these categories. Denmark, for example, does not have legislation to protect specific areas as national parks; rather, it defines broad areas of the country which are covered by different levels of planning protection. Similarly, national parks vary in character from what are essentially deliberately maintained wilderness areas, within which no economic activities are permitted (e.g. in Italy), to much more loosely protected areas within which a wide range of environmentally compatible activities take place (e.g. in the United Kingdom).

For these reasons, comparisons between member states are difficult and attempts to define the distribution of protected habitats, such as that in Table 9.4 and Figure 9.13, inevitably require somewhat arbitrary judgements to be made about which areas to include and which to exclude. Thus they disguise the fact that many of the areas identified differ in terms of their function and level of protection, while numerous sites not shown also enjoy a degree of protection.

Nevertheless, these data do indicate the broad pattern of habitat protection across the European Community and they demonstrate the considerable discrepancies between the extent of protection in different member states. On whatever basis the calculation is done, Ireland and Greece contain only small areas of protected habitats compared to countries such as Germany and the United Kingdom. A bias also occurs in the types of area designated for protection. Most protected areas tend to be in coastal or upland and mountain areas, perhaps because these are the main zones still relatively unaffected by development.

Over recent years, awareness has been growing of the value of nature reserves and national parks, both as a means of nature protection and a basis for recreation. In response, most member states have been designating new areas of protection and the total area of protected land has increased. Figure 9.15 shows data for a number of countries. Direct comparisons are difficult because of the different definitions used, but the general trend is clear: between 1977 and 1982 the total area of protected land has risen by about 5%. As pressures on wildlife grow, however, further extension of these protected habitats will undoubtedly be necessary.

9.3.3 Important Bird Habitats

The adoption by the European Council in 1975 of a Recommendation to the member states to adhere to the Ramsar Convention on the Conservation of Wetlands, and the Paris Convention on the Protection of Birds, highlighted the need for action to protect bird breeding and

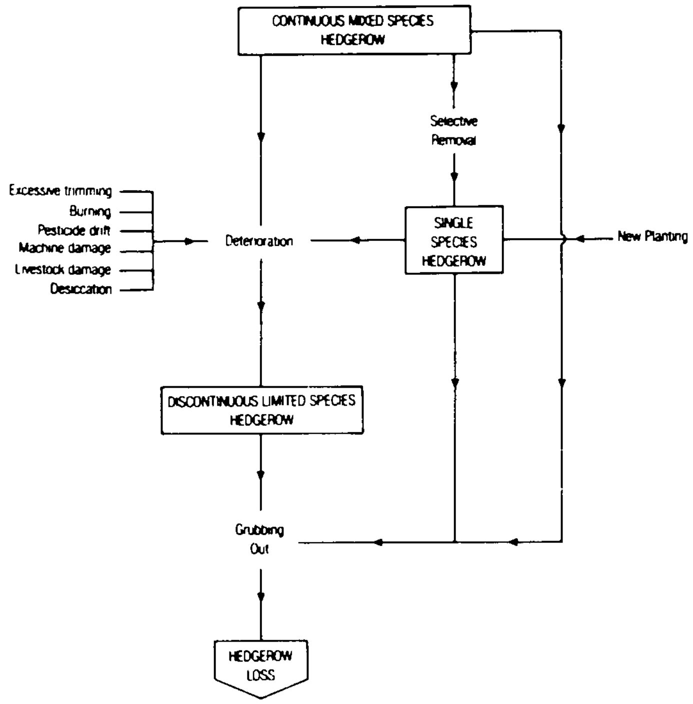
HEDGEROWS

To those of us who live in areas of enclosed agricultural land, such as the grasslands of the Ardennes, and the fields of Jutland, Thrierache or south-west England, hedgerows are a natural and integral part of the landscape. They are part of the cultural and physical character of the environment, established over many centuries by a combination of woodland clearance, field enclosure and deliberate planting. They are also zones of considerable and increasing concern, for in many parts of the Community they are coming under pressure from agricultural intensification, and progressively hedgerows are being lost through neglect, poor management and deliberate removal.

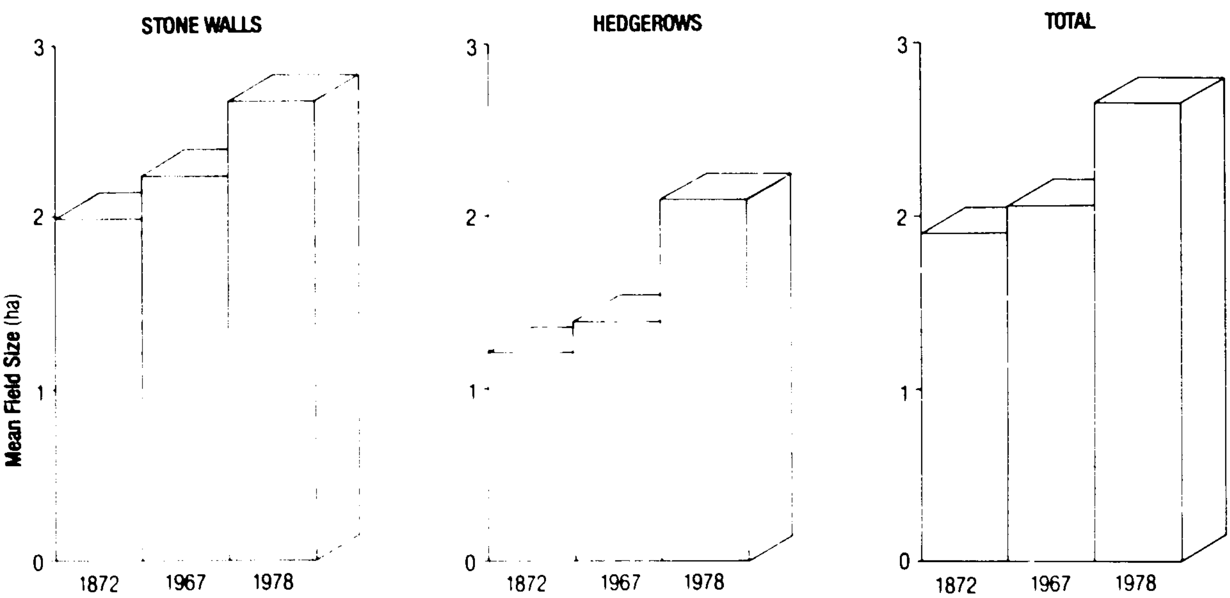
The conflict arises because, on the one hand, hedgerows serve an important agricultural function. They provide shelter to livestock, and they protect the soil from wind erosion and crops from exposure. On the other hand, they also inhibit many aspects of modern farming: they restrict the use of machinery, they harbour pests and weeds, they compete with crops for water and nutrients, they require costly management, they occupy small areas of land which could be used for crops. Economically, therefore, there is a strong argument for their removal. In addition, hedgerows are often damaged accidentally as a side-effect of agricultural practices. Stubble burning, application of pesticides and the use of farm machinery all lead to deterioration of hedgerows; and once damaged they no longer serve their purpose as field boundaries and are often removed (Figure, opposite, top).

As a result, in recent decades there has been widespread loss of hedgerows in the Community. The figure opposite (bottom) shows examples for upland areas of England. Between 1945 and 1970 in England as a whole, hedgerows were probably removed at a rate of 8000 km/yr. The effects have been considerable. While undoubtedly increasing the efficiency of some farming practices, hedgerow loss has also exacerbated the problem of wind erosion in many areas. More than that, their removal has had major ecological impacts, for hedgerows are important and unique habitats. They provide breeding and feeding grounds for a wide range of organisms, and, although few species depend entirely on hedgerows for their main habitat, they are nevertheless important where other habitats are scarce. In addition, they act as corridors for migration and dispersal, by which species move to re-occupy or invade new habitats. Loss of hedgerows, therefore, may have far-reaching implications for wildlife as well as the scenic quality of the landscape. Careful monitoring and management of hedgerows in the Community is therefore required.

Processes of hedgerow loss



Changes in field size in a sample of twelve upland parishes in England and Wales



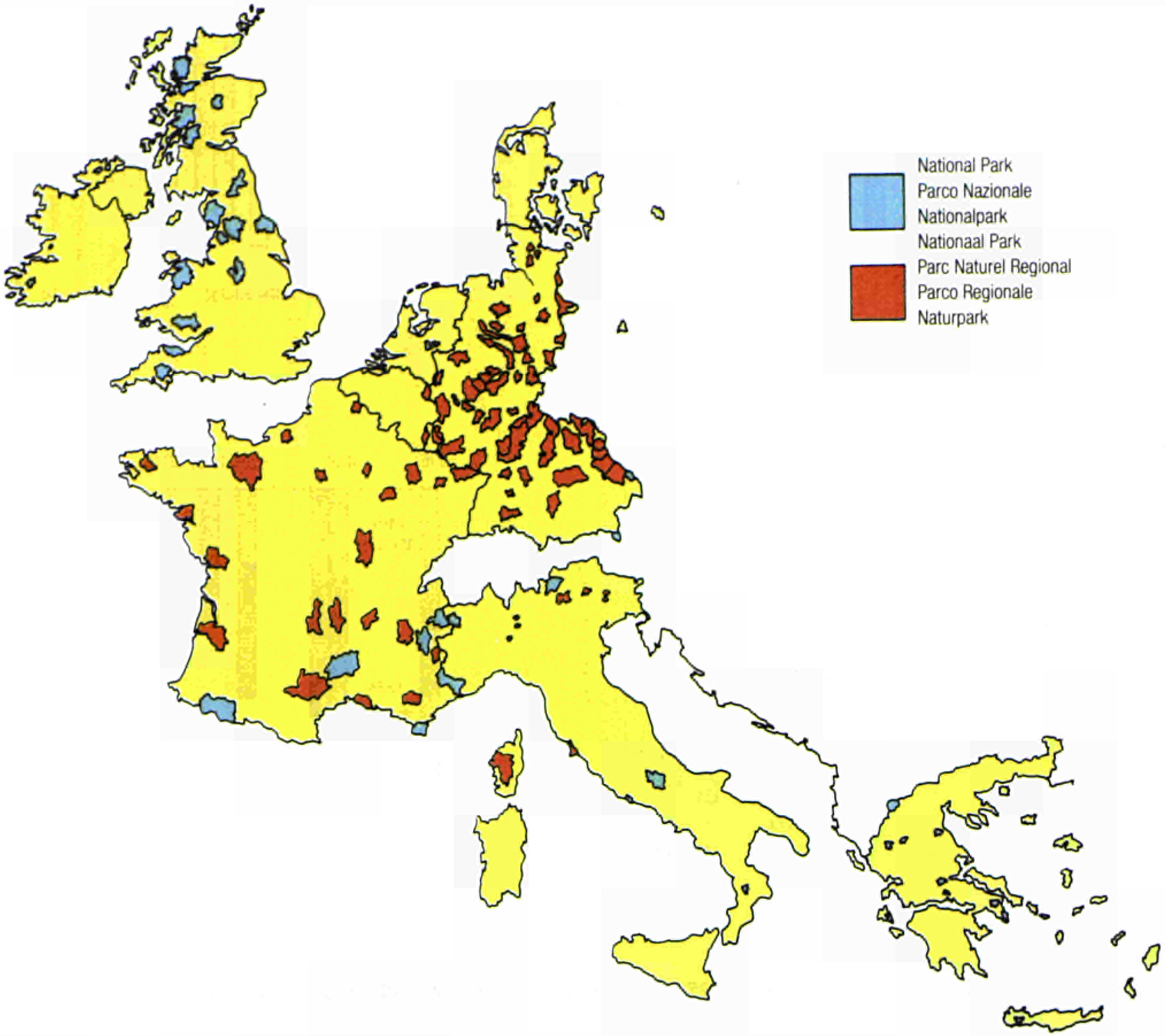
Sources: data from Briggs, D.J. and Courtney, F.M. 1985 *Agriculture and Environment*. London: Longmans; Department of the Environment 1985 *Digest of environmental protection and water statistics. No. 7, 1984*. London: HMSO

Table 9.4 **National parks and nature reserves in Community member states.**

MEMBER STATE	NATIONAL PARKS Number	NATIONAL PARKS Area (km^2)	NATURE RESERVES (number)	COMMENTS
Belgium	0	0	201	National Parks not recognised; Nature Reserves include 24 State Reserves and 177 Private Reserves; 3 Forest Reserves and 1 Nature Park are also defined.
Denmark	0	0	93	National Parks not recognised, but 550 Landscape Protection areas are defined; Nature Reserves include 14 Animal Reserves and 75 Game Reserves; 19 Nature Parks also exist.
France	6	3440	63	Figure for National Parks includes only central zones; with peripheral zones totals 12,281 km^2. France also defines 24 Regional Natural Parks.
Germany	2	340	1850	Germany also defines 65 Nature Parks; covering 51,693 km^2, and 5000 Landscape Protection Areas.
Greece	10	366	0	Nature Reserves not recognised, but 19 Aesthetic Forests and 490 Game Reserves are defined.
Ireland	4	208	28	One National Park (4 km^2) not yet open to the public; Ireland also defines 11 Woodland Reserves.
Italy	5	2734	158	3 new National Parks are proposed; Italy also defines 10 Regional Natural Parks, 10 Wildlife Refuges and 3 Forest Reserves.
Luxembourg	0	0	98	Luxembourg also defines 2 Nature Parks.
Netherlands	4	n.d.	n.d.	The Netherlands also defines 17 National Landscape Parks and 100 State Forests.
Portugal	1	600	11	Portugal also defines 4 Nature Parks.
Spain	9	1349	38	National Parks include 4 parks in the Balearic Islands; Nature Reserves are defined as National Reserves; Spain also defines 31 National Fauna Sanctuaries and 12 Natural Parks.
United Kingdom	10	13636	356	UK also defines 40 National Scenic Areas in Scotland; Nature Reserves include 235 National Reserves and 121 Private Reserves; UK also defines 5 National Park Direction Areas in Scotland; 38 Heritage Coastlines and 43 Areas of Outstanding Natural Beauty.

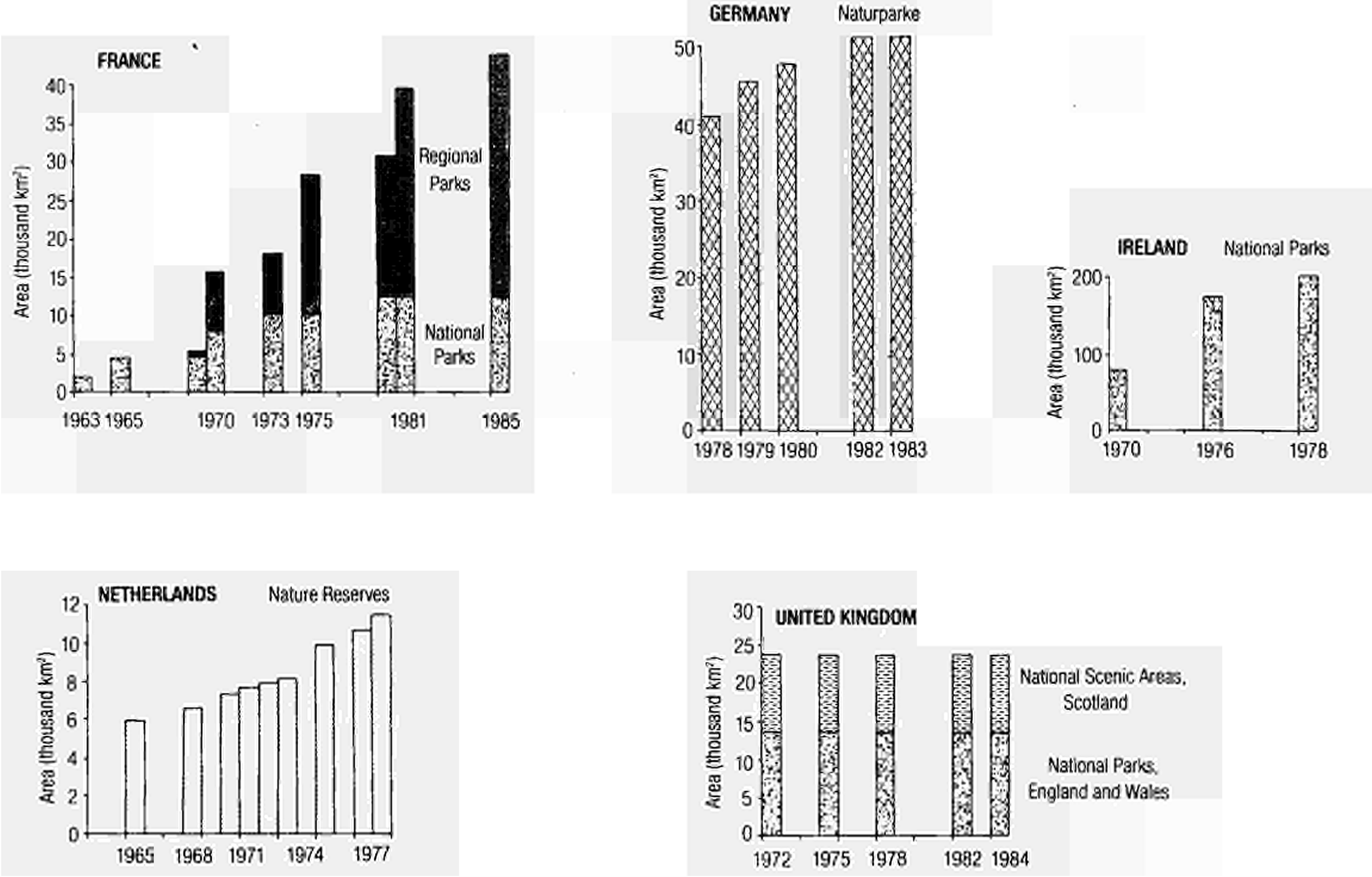
Sources: Notes and Sources, page 337.

Figure 9.13 **'Nature reserves' and 'national parks' in the European Community**



Sources: see Notes and Sources, p. 338

Figure 9.14 Extent of protected areas in selected member states.



Sources: data from Ministère de l'Environnement 1984; Umweltbundesamt 1984; Cabot 1985; Natuurmonumenten 1980; Department of the Environment 1985 wintering grounds. Since then, the Council has adopted two further measures: a Directive on the Conservation of Wild Birds (1979) and a Decision on the Convention of Wildlife and Natural Habitats (1982). Together, these have led to efforts to collect a large body of data on bird breeding grounds, so that there now exists reasonably comprehensive inventories of important bird areas.

One of the earlier comprehensive studies which was undertaken in the light of these actions was that by the International Council for Bird Preservation (ICBP). This applied the following criteria to identify important bird sites.

For breeding species:

i. sites supporting >1% of the breeding pairs of the population; or, if this is not applicable, sites considered important in view of the specific characteristics of dispersion and habitat preference of the species.

ii. sites supporting marginal or isolated populations containing at least 25, 100 or 250 pairs for colonial species, or 5 pairs for other species.

iii. all regular breeding sites of rare and endangered species or sub-species; or small and endangered distinct biogeographical populations (species with <2500 breeding pairs).

iv. strongholds of widely dispersed breeding species.

For non-breeding species:

v. sites supporting >10,000 ducks, geese and swans; or >10,000 coots; or >20,000 waders; or >5,000 birds of prey on passage during a migration season.

vi. sites acting as flyways or resting places for at least 1% (where this represents a minimum of 100 birds) of the population of the species.

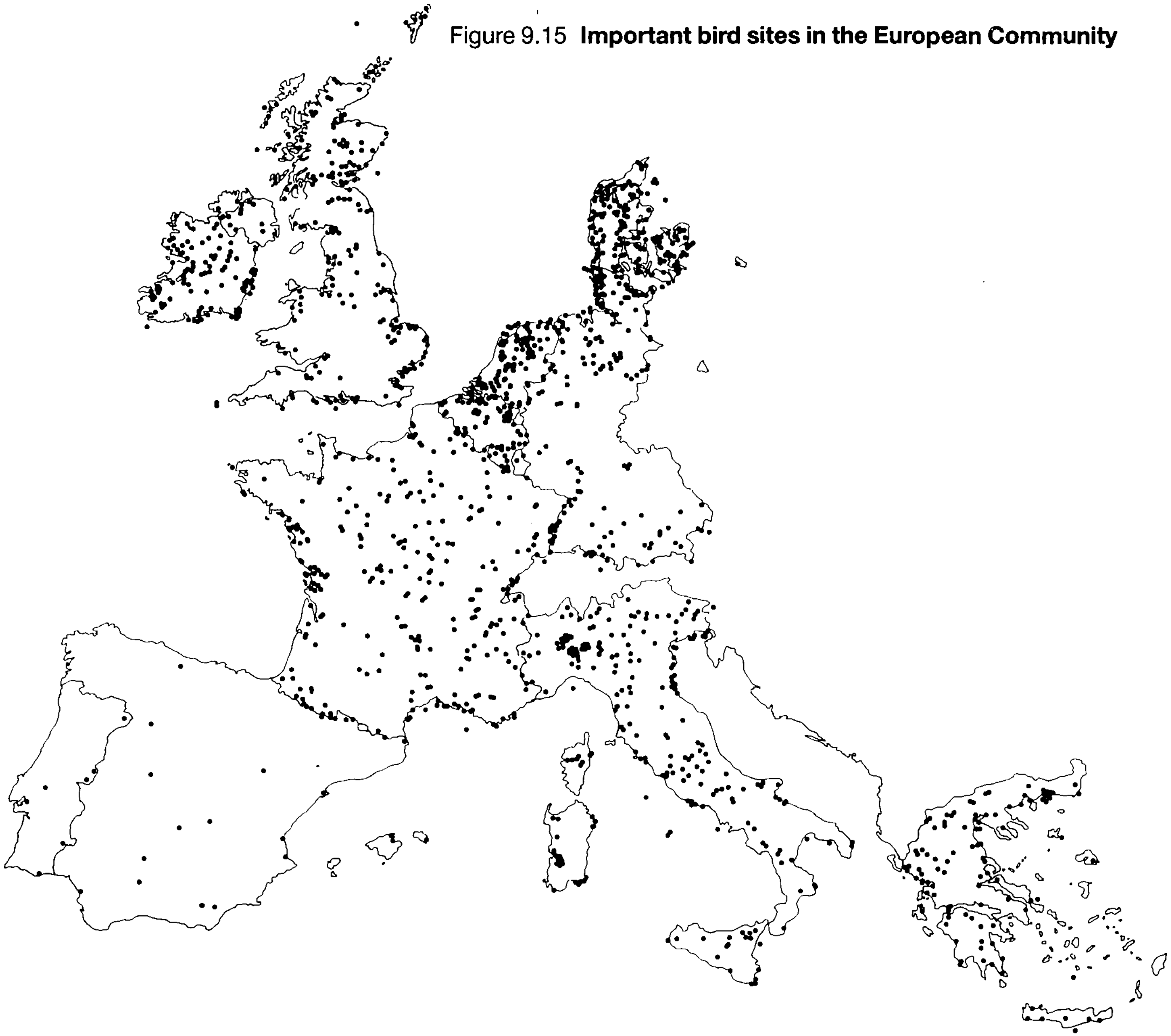
vii. sites supporting marginal or isolated populations containing at least 25 birds.

viii. sites supporting at least 5 (or 25 for gregarious species) individuals of rare and endangered species or subspecies and endangered distinct biogeographical populations (>10,000 individuals in number).

Qualitative criteria were also used where numerical data were inappropriate: for example, where quantitative information on breeding was not available, in mountainous areas, and to identify important wetlands not specified by the numerical criteria.

Since then, a more comprehensive analysis of the distribution of bird sites in the Community has been made by the Secretariat de la Faune et de la Flore, in France. Using the criteria established by ICBP, they evaluated sites important for all 144 bird species listed in Annex 1 of the Bird Directive (see Inset, page 296). A summary of results from this study are shown in Table 9.5 and Figure 9.15. (Both these exclude Spain and Portugal for which data are not yet complete). At a national level, it is apparent that Greece contains a disproportionately large number of sites for its size, a reflection both of the richness of the bird fauna of the country and of the extent of threats to birds in the Mediterranean area. In addition, however, it is clear that marked concentrations of bird sites occur in the Netherlands, Denmark and Scotland. This relates to the circumstance that many of the species included in Annex 1 of the Bird Directive favour aquatic habitats and, together, wetlands and coastal sites make up almost half of those listed (compare the distribution of bird sites in Figure 9.15 with that of wetlands in Figure 9.10).

Figure 9.15 **Important bird sites in the European Community**



Source: CORINE data base

Plate 9.5 **Wetlands provide some of the most important - and some of the most seriously threatened bird breeding grounds in the European Community.**

Photo: D. J. Briggs

9.4 CONCLUSIONS

9.4.1 The Need for Action

The pressures on wildlife are undoubtedly increasing. Agriculture is becoming more intensive, towns, tourism and transport systems are expanding. As a result, many changes are being wrought in natural and semi-natural ecosystems. A major effect is the loss of habitats - especially wetlands, lowland meadows and ancient woodland. In many areas pollution is becoming more severe: nitrate and phosphate levels in streamwaters are increasing; the problem of acid deposition seems to be worsening. Disturbance of habitats by tourism is also becoming more acute, while illegal hunting, collecting and shooting remain significant threats.

If allowed to proceed unchecked, these processes will lead to a progressive reduction in the populations of many species, and the eventual elimination of some. That this indeed is happening is shown by the data for France, in Figure 9.16: in almost all parts of the country, species diversity declined between 1900-30 and 1970-80. The effects of such losses are far-reaching and often irreparable. The extinction of species involves not only the loss of those plants or animals, but the disturbance of entire ecosystems. Competition between associated species is affected, food webs are disrupted, and natural balances of predators and prey upset. Like a pebble dropped into a pool of still water, the loss of a species sends ripples far out into the surrounding ecosystem.

Nor do the effects stop there. In many cases they spread even further and cause social and economic impacts. Reductions in the populations of predatory species, for example, may allow their prey to increase in numbers: these may then become a greater agricultural pest or a larger

THREATENED WILDLIFE SPECIES IN ITALY

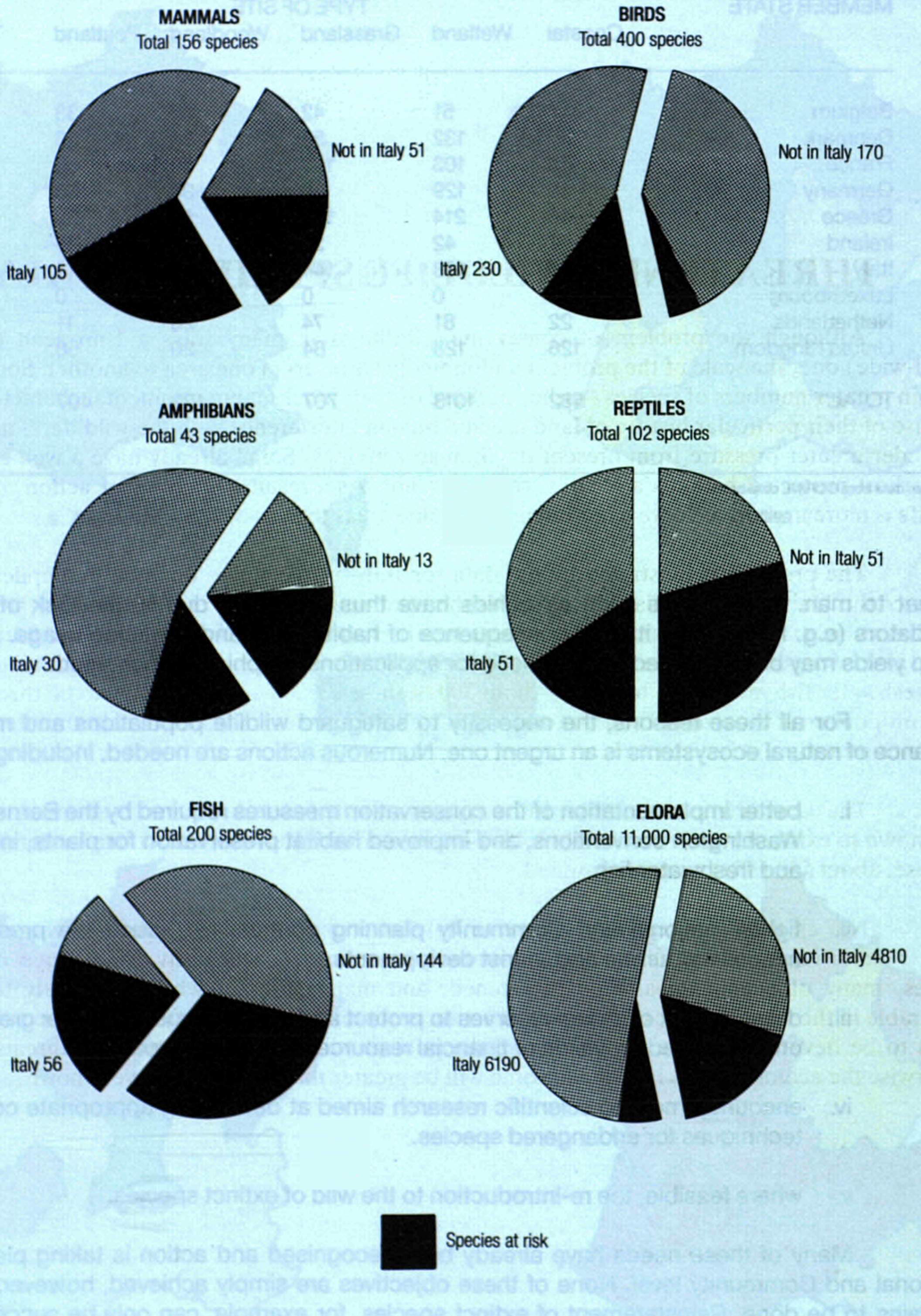
Although the problem of conserving wildlife is in many ways a European (and even world-wide) one, the scale of the problem undoubtedly varies from one area to another. Some regions contain greater numbers of species - either because of their inherant environmental characteristics, or because of their particular history of land use and human interference with the wildlife. Some regions are under greater pressure from present day human activities. Some already have a well-established network of protected habitats and sites; others do not. As a result, the need for action to conserve wildlife is more urgent, or more wide-ranging, in some areas than in others.

The problem is illustrated by the data for Italy, in the figure opposite (compiled by Prof. Pavan of the University of Milan). This shows the total number of species classified as threatened in the 21 member states of the Council of Europe, together with the proportion which are found in Italy. In the case of vertebrates, for example, 901 species of mammals, breeding birds, amphibians, reptiles and freshwater fish are known to occur. About 300 of these (33%) are considered to be threatened. A large proportion also occur in Italy: in total 472 vertebrate species, of which 155 are threatened in one form or another.

The same is true of the flora. In Europe as a whole (excluding Russia) about 11,000 species are known to exist, of which about 374 (3.4%) are threatened. Italy provides a habitat for some 6,190 of these, about 537 (9%) being threatened.

Not all these species are confined to Italy, of course: they also occur elsewhere. But, like other Mediterranean countries, Italy undoubtedly contains a particularly wide range of wildlife species, many of which are already threatened, and many more of which are likely to become vulnerable in the future if necessary remedial action is not taken. The lesson is clear. Especial attention needs to be devoted to these regions where the pool of wildlife is richest and the threats greatest. Otherwise the ecological loss in years to come will be greater than any we have yet known.

Threatened species in Italy, compared to the whole of Europe.



Source: data from Prof. Pavan, University of Milan

Table 9.5 **Important bird sites in Community member states.**

MEMBER STATE	TYPE OF SITE Coastal	Wetland	Grassland	Woodland	Peatland	TOTAL
Belgium	7	51	42	35	33	168
Denmark	95	132	52	34	58	371
France	45	103	105	80	58	391
Germany	48	129	60	38	56	331
Greece	146	214	127	91	70	648
Ireland	47	42	21	3	15	128
Italy	46	133	144	101	48	472
Luxembourg	0	0	0	1	0	1
Netherlands	22	81	74	20	11	208
United Kingdom	126	128	84	20	58	416
TOTAL	582	1013	707	423	407	3132

Source: data from CORINE data base.

threat to man. Insect pests such as aphids have thus expanded due to the lack of control by predators (e.g. ladybirds) - itself a consequence of habitat loss and pesticide usage. As a result, crop yields may be threatened and the need for applications of aphicides increased.

For all these reasons, the necessity to safeguard wildlife populations and maintain the balance of natural ecosystems is an urgent one. Numerous actions are needed, including:

i. better implementation of the conservation measures required by the Berne, Bonn and Washington conventions, and improved habitat preservation for plants, invertebrates and freshwater fish.

ii. tighter national and Community planning controls to reduce the pressures from agricultural, urban and tourist devlopments.

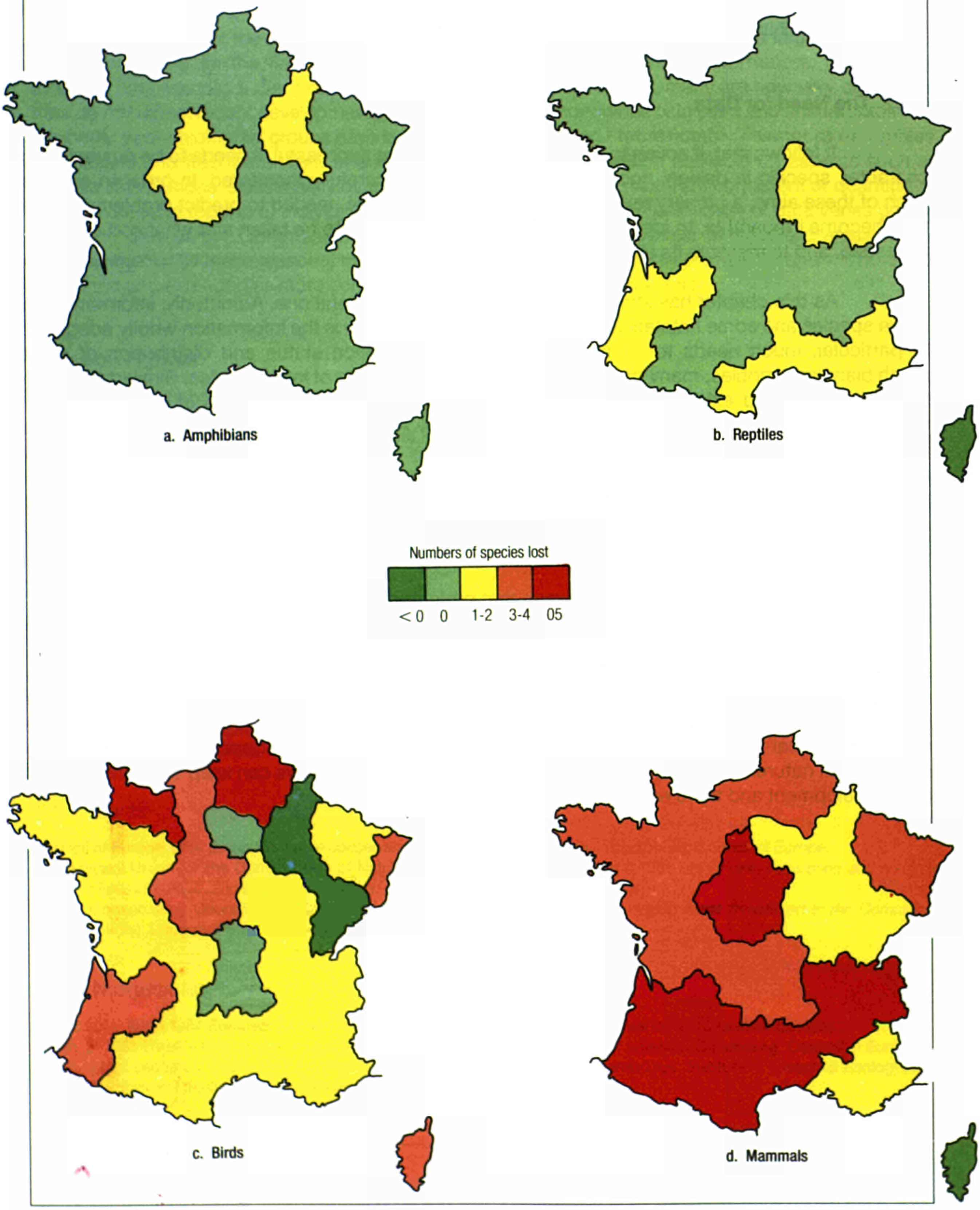
iii. development of nature reserves to protect and maintain species under greatest threat and increased provision of financial resources for habitat protection.

iv. encoûragement to scientific research aimed at developing appropriate conservation techniques for endangered species.

v. where feasible, the re-introduction to the wild of extinct species.

Many of these needs have already been recognised and action is taking place at both national and Community level. None of these objectives are simply achieved, however, and much remains to be done. Reinstatement of extinct species, for example, can only be successful if the appropriate niche for the species exists or is created - complete with necessary food webs and freedom from external pressure. To date, success has been limited. Controls on development and destruction of natural habitats are only likely to be effective if the status and location of important sites is recognised soon enough to allow the necessary preventive action to be taken before development proceeds too far. As several recent examples have shown, this requires not only

Figure 9.16 **Absolute changes in the number of wildlife species in France since the nineteenth century.**



Source: data from Commission Interministerielle des Comptes du Patrimoine Naturel 1985 information on important habitats but also an efficient communication system between the authorities concerned. Above all, attempts at conservation and protection will only have the desired effect if they are properly implemented on the ground. This involves more than the adoption of the relevant legislation; it demands the will to apply the actions specified, and to police their use. All too often, controls on, for example, hunting, collection or development are simply flouted because of the lack of any machinery to enforce them.

9.4.2 The Need for Data

It follows that, if action to safeguard wildlife is to be successful, it needs to be preventive in character, specific in design, rigorously implemented and carefully monitored. In order to achieve each of these aims, a primary requirement is for data. These are needed to predict problems before they become irreparable, to identify exactly where action needs to be taken and what sort of action is needed, and to measure its effects.

As this chapter has shown the need for data is a general one. Admittedly, information on some species and some habitats is better than others, but rarely is the information wholly adequate. In particular, much needs to be learned about the population status and distribution of most amphibians and reptiles, many bird species and the vast majority of invertebrates. Similarly, data on the importance and extent of many habitats are lacking, especially in some of the ecologically richest areas of the Community such as Greece and Italy. A major step has been taken to resolve this deficiency with the establishment, as part of a wider information system on the Community environment (CORINE), of a register of biotopes important for nature consevation. Although this will provide a vital framework for information, however, it will not solve all the problems. More detailed data on species distributions, population changes and threats will still be needed for all these sites. This requires regular and comprehensive field monitoring.

In addition, it has to be recognised that protected areas are essentially havens for wildlife; they are not the only localities in which wildlife species exist or are important. Over the whole of the rest of the Community, on small patches of suitable land - on streambanks, in ditches, hedgerows and copses, for example - wildlife attempts to survive. In these areas as much as anywhere, wildlife species play a fundamental part in the wider ecosystem. Equal concern needs to be expressed for these species and their habitats; they may not be type examples and wholly unmodified, but they are of vital ecological significance and they provide, for many of us, our main opportunities to come into contact with nature. Here, too, therefore, we need information so that we can keep a watchful eye on their development and try to ensure their survival.

NOTES AND SOURCES

Data Availability

Because of the long history of scientific and public interest in wildlife, a large body of data has accumulated on the flora and fauna of the European Community. Nevertheless, many of the available data sources suffer from severe limitations. In the first place, many are now very dated, and thus do not reflect recent developments either in ecological conditions or in plant and animal taxonomy. Secondly, some biological groups have been relatively neglected - most notably, invertebrates, reptiles, amphibians and freshwater fish. In addition, much of the information available on aspects such as species distributions is essentially qualitative in nature, and derives not from consistent or quantitative surveys but from reports of individual sightings and finds. Finally, the availability of data varies greatly from one part of the Community to another, and is generally weakest in southern areas of the Community. For all these reasons, the data presented here are often only provisional and will no doubt be refined and extended as more consistent information becomes available.

Notes on Figures

Figure 9.9 Distributions of species shown in this figure are derived mainly from Van den Brink (1976) and are therefore now soemwhat dated.

Figure 9.11 At the time of publication, complete data for Spain and Portugal were not available in the CORINE data base and were thus excluded from this figure.

Figure 9.13 Because definitions of national parks and nature reserves differ substantially between member states, this figure does not imply that the areas shown have similar protection status.

Figure 9.14 As above. Scottish National Scenic Areas were referred to as National Park Directive Areas before 1978.

Figure 9.15 At the time of publication, input of data for Spain and Portugal to the CORINE data base had not been finished. The distribution of important sites in these countries is therefore incomplete.

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PART FOUR

ECONOMIC IMPLICATIONS AND IMPACTS

CHAPTER 10.

ECONOMIC IMPACTS OF ENVIRONMENTAL POLICY

10.1 INTRODUCTION

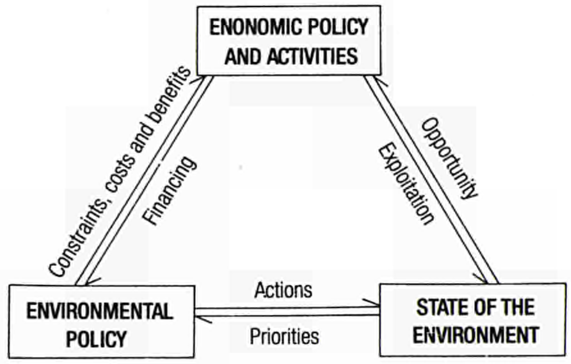
Two issues which have emerged with increasing strength and insistence in the European Community over the last ten years are concern about the economy and concern about the environment. They are issues which arise from a number of different causes - many of them outside the Community itself - and they are issues which, in the past, have often been considered as separate, even mutually exclusive. They are, however, concerns which are now seen to be intimately and inextricably related. Indeed, questions of economics and environment are in reality often one and the same thing. For they are both directed towards the same basic problems: the management and use of the environment and its natural resources. And they both have the same ultimate goal: to safeguard and improve the welfare of the people in the Community.

The links between economics, the environment and environmental policy are therefore close (Figure 10.1 presents an illustration of these links; and see also Figure 2.1). In the first place, economic policies and activities affect the state of the environment. They exploit, and may deplete or exhaust, natural resources. They modify the landscape and may impinge on natural habitats, wildlife, and other human activities. But at the same time, the availability and quality of natural resources are major factors in determining the potential for economic developments. The geographic distribution of these resources governs in part the location of the developments, and thus contributes to the regional diversity of the Community. The character of the resources (e.g. the depth of coal reserves or type of soil) helps to control the way the activities are carried out.

Similiarly, economic policies and conditions affect environmental policies. Levels of rentability, for example, determine the financial resources available for investment in environmental programmes or environmental technology. Economic developments may highlight new areas of concern, around which new environmental policies are formulated (e.g. responses to new hazardous chemicals), or result in the diminution or disappearance of others (e.g. the reduced impacts of iron and steel processing as activity in the industry has declined). And technological innovations often open up new possibilities for environmental management or protection (e.g. new pollution control or monitoring devices).

Finally, environmental policies affect economic activities and policies. They do so in two ways. In the first place they act as direct constraints on some economic activities. They may impose regulatory limits on emissions; they may require the use of certain technologies or design criteria; they may demand that EIAs are carried out. In the second place they act indirectly. For the requirements set by environmental policies affect production costs and prices, competitiveness and profitability, levels of demand and employment. All these have secondary effects on other industries and other activities. They alter costs or prices in complementary industries; they stimulate or discourage competitive products and substitutes; they encourage the development of environmentally more sensitive technologies and processes; they create new public preferences and alter the pattern of consumption.

Figure 10.1 **Economics, environmental policy and the state of the environment.**



Thus, environmental policies have economic impacts. It is the nature and magnitude of these impacts, arising from environmental policies in the Community, which will be considered in this chapter.

10.2 COSTS AND BENEFITS OF ENVIRONMENTAL POLICIES

The economic impact of environmental policies is essentially a question of costs and benefits. On the one hand, these policies undoubtedly impose costs on the industries concerned (e.g. in investment in new technology, higher raw material costs, pollution charges). On the other hand, they also create benefits: both tangible benefits such as reduced damage costs, increased productivity or increased demand and employment due to pollution control investment, and intangible ones such as improvements in environmental quality and social conditions. While the financial effects on industry - which depend on the extent to which costs bear directly on the enterprises concerned - may well be negative, the overall net cost depends on the balance between total costs and benefits: that is it comprises the net economic benefit. In recent years, therefore, as economic considerations have become more pressing, increased attention has been given to assessments of the net economic effect - the balance between costs and benefits - of environmental policies.

It is, nevertheless, a question which is not easy to resolve. Although the essential criterion that benefits should exceed costs (appropriately discounted to a base year) is clear, there are in practice a number of problems in calculating the effects. These relate not only to the lack of data - which is often severe enough - but also to the very definition of what constitutes a cost or a benefit. This arises because the economic impacts of environmental initiatives may manifest themselves in many different ways, at very different scales, and over very different periods of time. For this reason, it is useful here to outline some of the terms and concepts involved in the analysis of costs and benefits, and to point out some of the problems faced in such analyses.

The economic effects of environmental (or any other) policies can conveniently be considered according to the nature of the effect - direct or indirect, tangible or intangible and short-term or long-term - and the scale of analysis.

10.2.1 Direct and Indirect Effects

Direct effects of environmental expenditure include, for example, the stimulus given to companies which supply environmental equipment or services, and the changes in production costs and output in the industries subject to the legislation (i.e. the target industries). Such effects are generally immediate and apparent.

Indirect effects tend to emerge more slowly. Amongst other things, they comprise consequent changes in costs, production and employment in other industries as a result of changes in their input prices, and the multiplier effects of changes in income and demand.

In practice, this distinction is not entirely satisfactory, and in several instances confusion has arisen in cost-benefit analyses through double-counting as a result of including effects such as transfers, on-flows, capitalisations and annualisations. Although these may sometimes be employed as surrogates for other effects which cannot directly be determined, great care is needed in cost-benefit analyses to avoid double-counting. At the same time, it must be stressed that it is essential to take account of the full range of significant effects of a proposed measure, if the economic implications of environmental policies are to be fairly and comprehensively evaluated.

10.2.2 Tangible and Intangible Effects

The distinction between tangible and intangible effects relates in broad terms to the ease with which the economic value of any cost or benefit can be quantified. This, however, depends on two main factors: whether the effect can be discerned and measured, and whether a value can be assigned to it. The effects of pollution-induced climatic change on agricultural production, for example, can readily be assessed in economic terms if it can be physically determined; the problem is to isolate and quantify the effect of pollution on the climate. The effects of development on natural habitats, conversely, can readily be measured (e.g. in terms of the area of habitat destroyed) but it is very difficult to attribute any economic value to the effect. In both these cases the effects tend to be intangible. Most intractable, however, are those effects which can neither be easily measured nor evaluated economically: for example, changes in landscape attractiveness.

The evaluation of intangible effects presents one of the main difficulties in cost-benefit analyses, and one of the main areas in which their results have been challenged. In some cases the problem can be overcome by the evaluation of downstream effects (e.g. on-flows) which are more amenable to assessment: for instance the amenity effects of environmental amelioration may be imputed from the numbers of new tourists visiting the area, or the effects of pollution control investment may be determined from changes in the value of capital assets. In other cases surrogates may be used to impute effects (e.g. estimates of the 'willingness to pay'). Often, however, such evaluations provide at best only order-of-magnitude estimates, and the greater the proportion of intangible effects in the analysis the weaker the results tend to be. Nevertheless, it is certainly not valid simply to ignore these intangible effects, and even if they cannot be evaluated they should be recorded in the balance sheet.

10.2.3 Short-term and Long-term Effects

The economic effects of environmental policies also differ in terms of their timescale. Many of the direct effects, such as impacts on demand, costs, prices and production in the environmental supply and service industries and in the target industries of any policy, emerge relatively rapidly. Indirect effects, however, take much longer to work their way through the economy. Indeed, just how long-term comprehensive cost-benefit analyses should be is shown by the case of hazardous chemicals or radioactivity. The full cost of these - in terms of environmental damage or effect on public health - may not be apparent for twenty or more years.

This has a number of implications. In the first place, it raises problems of analysis, for unless the long-term effects are included it is clear that any assessment of the consequences of the policy will be only partial, and biased towards the (often more direct) short-term effects. Secondly long-term assessments involve much longer-period predictions, which are almost inevitably less reliable. Thirdly, long-term analysis generates also the problems of discounting - the relative value placed upon current as opposed to future costs and benefits. Depending on the discount rate, this can significantly reduce the weighting of costs and benefits in the distant future compared to those which arise immediately. Unless all these aspects are satisfactorily addressed in the analysis, the results are likely to be erroneous.

10.2.4 The Scale of Analysis

Another factor of fundamental importance in the analysis of costs and benefits is the scale of investigation.

In terms of the *geographical* scale, it is clear that the effects of environmental policy vary markedly according to the size of the undertaking, the sector it belongs to, its location and the area under consideration. In the short run, companies in the environmental equipment and service sector tend to gain from the policy, but those in the emission-intensive basic industrial and consumer goods sectors tend to lose. Because of the regional distribution of these different sectors the overall effects of the policy may be seen to be very different according to the geographic area considered. Moreover, 'global' analyses frequently mask these regional disparities, although in political, as well as economic, terms they may be very important. This is particularly so when the environmental dimension is an integral part of regional policy, or land use planning, or where marked regional differences in the ability to pay for environmental initiatives exist.

The same is true of the *analytical* scale. There are two, well-established scales of analysis. *Micro-level* analysis focuses on the direct (or first-order costs and benefits - both tangible and intangible - which accrue to the government, the productive sector and the household sector as a result of a policy decision. In its formal version, such a micro-level assessment can be performed using orthodox methods of social cost-benefit analysis. *Macro-level* analysis, in contrast, considers the net effects (positive and negative) on aggregate variables such as gross domestic product (GDP), prices and employment. Changes in these variables can only be estimated from full working models of the regional, national or Community economy, usually by the application of econometric or input-output models. The extent to which these variables are seen as costs or benefits in this context is dependent upon the policy objectives of the society.

In this context it must also be borne in mind that any attempt to evaluate the overall effects of environmental policy must make a clear distinction between gross and net effects. The net effect of a policy can only be determined when a complete balance sheet of the positive and negative, direct and indirect, tangible and intangible, short- and long-term effects have been drawn up. Inevitably this is difficult, for it requires not only data on a wide range of often almost unquantifiable variables, but also the comparison of situations with and without the environmental policy, while all else is kept constant. In reality this can rarely be achieved, and comparisons are usually made of the existing situation with some assumed or modelled alternative. The quality of the assessment is therefore dependent on the accuracy of the modelled situation.

Moreover, the calculation of the net effects must take account of many inter-related and varying conditions, including:

i. whether environmental expenditure is in addition to, or at the expense of, other expenditure which has an effect on the economy.

ii. the competitive position of organisations whose costs and prices are affected in comparison to competitive establishments as a result of the environmental policy.

iii. whether current conditions are ones of full or under-employment, and the sectoral and geographic patterns of employment.

iv. what action is being taken in other areas (e.g. in other regions or countries) where competitors exist or operate.

v. how the environmental expenditure is funded.

Because of all these difficulties - and because also of the lack of data in many areas - it is as yet impossible to carry out a comprehensive assessment of the costs and benefits of environmental policy in the European Community. Nevertheless, a number of more limited analyses of the economic impacts of environmental actions have been attempted in recent years, most notably in France, Germany and the Netherlands. In the following sections, therefore, some of the main costs and benefits and the macro-economic effects of these policies will be examined.

10.3 THE COSTS OF ENVIRONMENTAL POLICIES

10.3.1 Types of Policy and Associate Costs

All environmental policies have costs. At the very least they involve the costs of formulating the policy, debating and adopting it in the appropriate political bodies, passing the necessary legislation and policing its eventual implementation.

The vast majority of policies also involve abatement and transaction costs both to the public and industrial sectors. These comprise several different costs, including:

- the costs of research, design and testing of new equipment or technologies;
- the capital costs of producing, purchasing and installing the equipment, purchasing land or otherwise establishing the necessary infrastructure;
- the running and maintenance costs involved in using the equipment or in carrying out the provisions of the policy `(e.g. conducting EIAs, collecting data, monitoring the application of the policy);
- ancillary costs for rent, leasing, insurance etc;
- pollution or other environmental charges imposed by the policy.

Many of these costs have secondary effects as they filter through the economy. Higher raw material costs and taxes, for example, affect the profitability of other firms; they may lead to loss of export revenue and taxation for the country; and they may increase social or other government expenditure (e.g. on unemployment benefits, social welfare). In addition, some of these effects may manifest themselves as intangible costs - for example, in the social impacts of any resulting unemployment, a restriction of public freedom or loss of amenity, and an increase in environmental damage elsewhere (e.g. because of the transfer of economic activities or wastes to other areas).

For a number of reasons many of the costs of environmental policies are difficult to determine, and they become moreso the further the effects pass through the economy. In the first place this is because it is not always easy to attribute costs to specific environmental policies: many costs (e.g. of administration, research) are shared with other measures, and many are hidden. In addition, environmental action may be taken at many different levels, while the costs may fall variously on many different public agencies, companies and private individuals, and are often passed from one to another. Indeed, as has been noted, what is a cost to one sector of society may be a benefit to another. Great care is therefore required in determining where within the whole economy the costs are actually computed. Moreover, as has also been seen, the intangible costs are often not readily amenable to quantitative analysis, and somewhat arbitrary costs often have to be imputed.

10.3.2 Costs of Environmental Policies in the European Community

Any generalisations about the costs of environmental policies in the European Community are fraught with difficulties. This is due not only to the scarcity of data, but also to the marked variations in the magnitude and type of expenditure from one policy, or one member state, to another. These discrepancies are themselves a reflection of the inherent diversity of environmental, social, political and economic conditions in the Community, which together lead to marked differences in:

- the nature of the problems which actually occur (e.g. due to differences in quantities of emissions or the geographic distribution of sources);
- the perception of these problems and the priorities attached to solving them;
- the scope for expenditure on environmental protection.

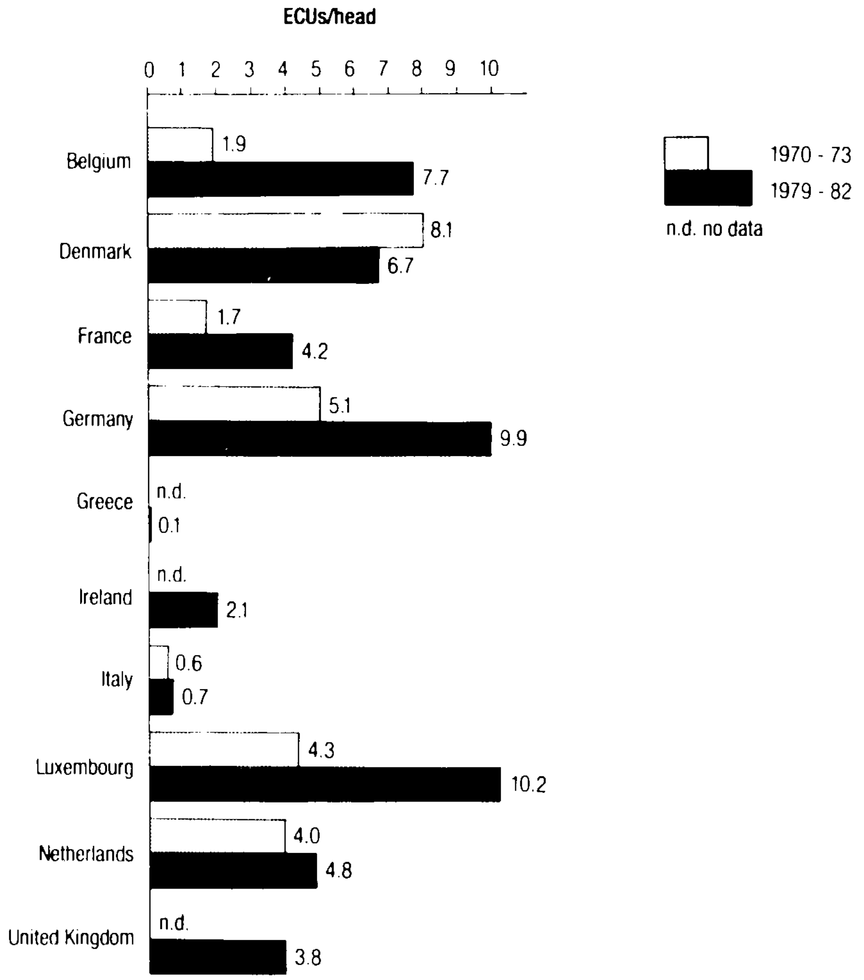
As a result, considerable variations exist at national or regional level in the type of problems being tackled, the measures used, and the degree of policy enforcement.

Some of these factors are illustrated by the data in Figure 10.2. This shows per capita capital investment in sewage treatment plants in member states, during the early 1970s and early 1980s. Expenditure in the later of these periods is highest in Germany, Luxembourg, Belgium and Denmark. It is somewhat less in the Netherlands, France and the United Kingdom, and relatively low in Ireland, Italy and Greece. There is no single or simple explanation for these differences: most of the countries for which data are available had well-developed sewerage networks by 1980; the percentages of the population connected to the sewerage system in these countries is shown in Table 10.1

More general estimates of expenditure on environmental protection in some member states are shown in Table 10.2 - though it shold be emphasised that these are in some cases very approximate. Overall, this expenditure represents an average of between 1.0 and 1.5% of gross domestic product.

As has been noted, comparisons between countries are difficult because of differences in definitions and in the quantity and type of data available. Figure 10.3, however, summarises data on environmental expenditure in three member states: France, Germany and the Netherlands. Total expenditure on pollution control, environmental conservation and environmental amelioration amounted to 7,000 million ECUs in France, 13,000 million ECUs in Germany and 1,700 million ECUs in the Netherlands. This accounted for 1.2% of GDP in France and the Netherlands, and 1.7% in Germany. Costs per inhabitant range from 118 ECUs in the Netherlands to 206 ECUs in Germany. In all cases, water treatment was the main cost, comprising 40-50% of the total, while waste collection represented 20-30%. Air pollution is also a major category of expenditure, ranging from 9% of total costs in France to almost 29% in Germany, where particularly active policies are being conducted against atmospheric emissions.

Figure 10.2 **Capital expenditure on sewage treatment plants in Community member states, 1970-73 and 1979-82.**



Source: data from SOBEMAP 1984

Table 10.1 **Percentages of population connected to sewerage systems in Community member states.**

Member state (date)	%
Belgium (1981)	55
Denmark (1977)	92
Germany (1980)	84
Ireland (1983)	67
Italy (1971)	56
Luxembourg (1983)	96
Netherlands (1980)	90
United Kingdom (1980)	96

Source: data from SOBEMAP 1984

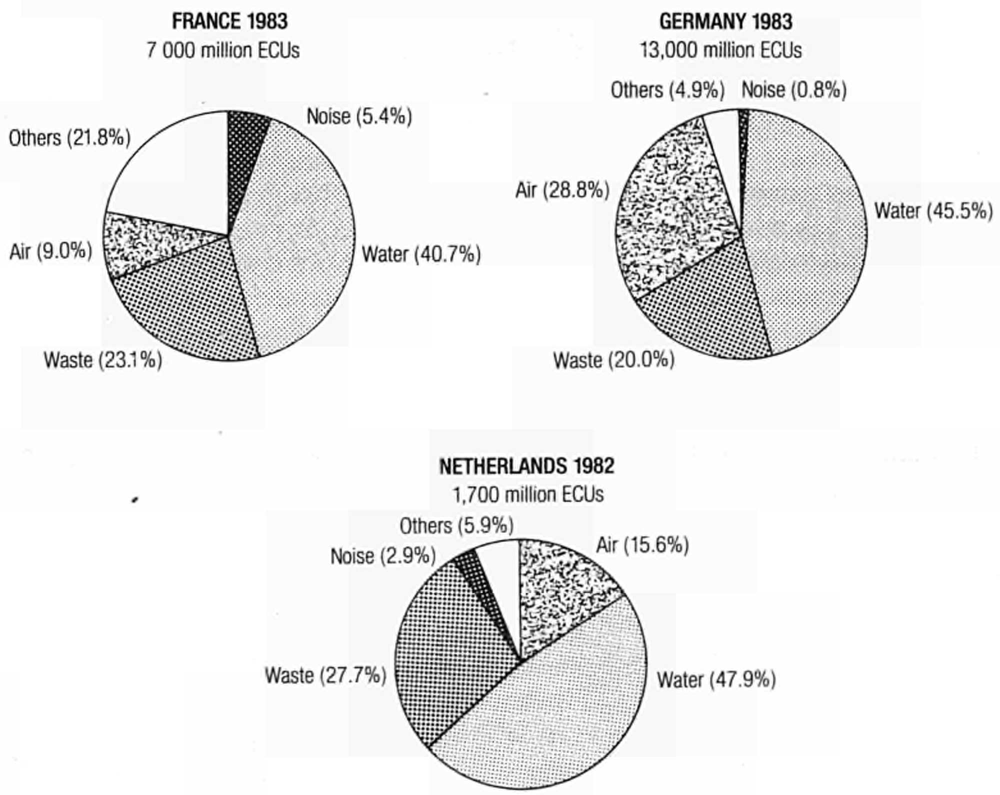
Table 10.2 **Estimated expenditure on environmental protection in Community member states, 1978.**

Member state	Total expenditure (million ECUs)	% GDP
Belgium	(290)	(0.4)[2]
Denmark	435	1.0[2]
France	2970	0.8
Germany	7854[1]	1.5
Greece	107	0.3
Ireland	(90)	(0.9)
Italy	n.d.	n.d.
Luxembourg	n.d.	n.d.
Netherlands	1412[2]	1.1
Portugal	20	0.2
Spain[3]	(175)	(0.2)
United Kingdom	(3608)	(1.4)
Total	(16,884)	(1.2)

Notes:( ) - estimated. 1 - revised data 2 - revised 1980 data 3 - partial data

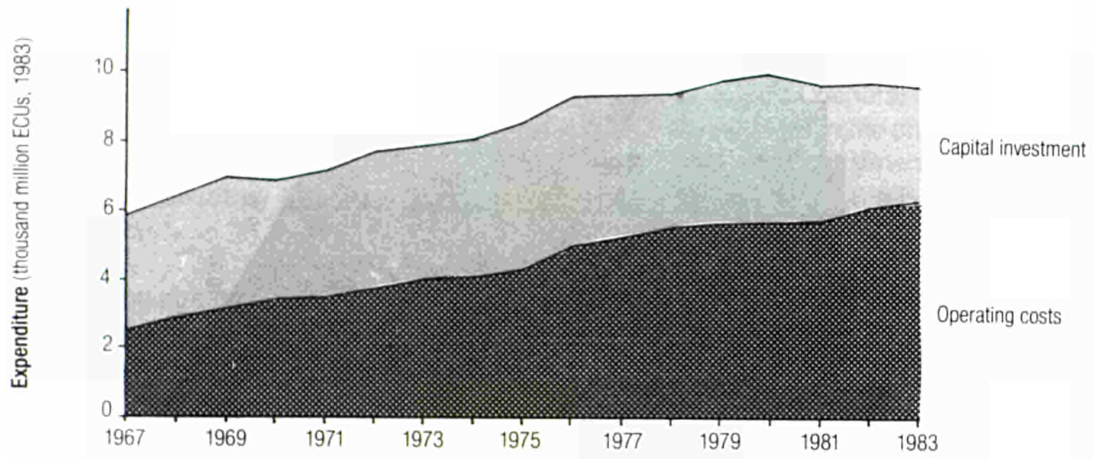
Source: data from SEMA-METRA 1986

Figure 10.3 **Environmental expenditure in selected member states.**



Source: data from SEMA-METRA 1986

Figure 10.4 **Environmental expenditure in France 1967-1983.**



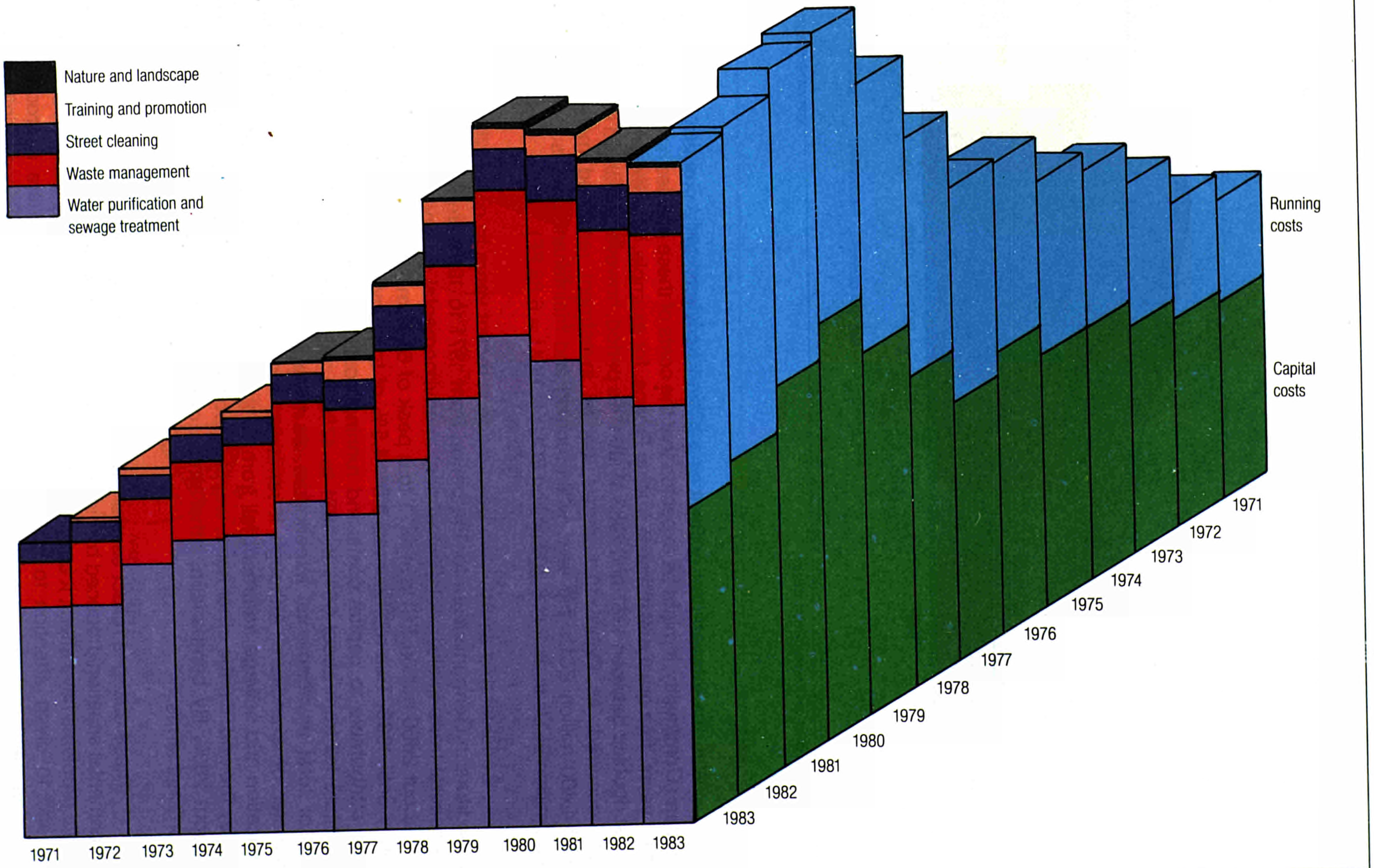
Source: data from Ministère de l'Environnement 1984b

With the increased attention being given to environmental problems and policies in the European Community, it might be expected that the costs of these policies have risen in real terms in recent years. To a great extent this is true. In France, for example, total expenditure (at 1983 prices) almost doubled between 1967 and 1983. Within this period, however, a marked shift in the balance of costs occurred. As Figure 10.4 shows, capital investment remained more-or-less steady at 3,650-4,400 million ECUs per year, while running and maintenance costs increased from about 2,650 million ECUs to almost 6,600 million ECUs (1 ECU = 6.85 FF).

Considerable efforts have been made in recent years to collect data on environmental expenditure in Germany. Data for the period from 1971 to 1983 are summarised in Figure 10.5. The general trend is clear. Total investment in environmental expenditure rose in absolute terms from about 2666 million ECUs in 1971 to a peak of 6338 million ECUs in 1980, before declining slightly until 1983. This represented 3.5 - 4.5% of total investment. As in France, however, the share attributable to capital costs and running costs changed. In proportional terms, capital exenditure fell from about 66% in 1971 to 47% in 1983; running costs increased from 34% to 53% of total environmental expenditure. At the same time there was a slight shift in the character of exenditure. Although it remained the single largest area of expendture, water purification and sewage treatment fell from 78% of the total at the start of the period to about 63% by the end. On the other hand, waste disposal increased its share of expenditure from 15% to about 26%. By comparison, other areas of expenditure were small and changed little in proportional terms.

These changes reflect several different factors. In part they are a result of the changing environmental situation produced by the environmental policies themselves: as measures to control specific problems have effect, it becomes possible to reduce or simply maintain expenditure in that area and to divert attention to other problems. In addition, they are a product of changing perception, new problems emerging into the public and political conscience as information on them becomes available. The problem of acid deposition, and its related implications for air pollution control, are a particular example.

Figure 10.5 Investment on environmental protection in Germany, 1971-1983.



Source: data from IFO-Institut

10.3.3 The Broader Effects of Environmental Measures

Broader effects of environmental measures have been studied by the use of macro-economic models, though to date only limited conclusions can be drawn from the results. In general they show that environmental measures have a fairly small effect on prices, consumption, the balance of trade and GDP. The overall effect on employment also appears to be relatively slight and not consistent. This suggests that environmental improvement is not in general obtained at a high cost in job losses (although there may be severe localised adverse effects in the short run associated with particular measures). It would therefore appear that negative employment effects are to a considerable extent offset by the positive impacts whereby environmental measures stimulate the demand for labour.

It must be stressed that the models do not consider any benefits of environmental policies which are not included in national accounts: the effects on factors such as GDP, trade and prices are only one element of the impact of environmental policies.

10.4 ECONOMIC BENEFITS OF ENVIRONMENTAL POLICIES

10.4.1 Nature of Benefits

Environmental policies give rise to many economic benefits. Chief amongst them is the avoidance of damage to the environment, some of the effects of which are (indirectly) measurable in money terms.

Without preventive environmental policies, various (albeit long-term) damage and displacement costs are generated. Some of these are borne by the target industries - those at which the policies are aimed. Excessive waste production, for example, represents a cost in terms of loss of important resources, increased raw material inputs and higher waste disposal charges. Corrosive or other environmentally damaging emissions may attack the industrial plant, reducing its effectiveness and lifespan; health damage to workers impairs their efficiency and reduces their productivity.

The bulk of these impacts, however, falls more widely on the economy. Pollutants damage buildings and other infrastructure, creating additional costs of maintenance and repair. They inhibit plant growth, reducing agricultural yields and increasing the need for fertilisers or other inputs. They contaminate water supplies, creating extra costs of purification for water authorities. Wastes use up land which might be put to other uses. Environmental despoilation diminishes the aesthetic quality of the landscape and discourages tourism. Toxic chemicals released into the environment may cause widespread health damage, with consequent increases in medicinal and welfare costs. Ultimately, all these forms of environmental damage need to be controlled; in the long run the costs of remedial action are often greater than the preventive costs which would have been incurred by a preventive policy.

The economic benefits of environmental policies are also seen in terms of their employment effects. These are probably most readily discernible in the industries directly associated with the environment: those, for example, which supply the environmental equipment or services necessary to carry out the policies. These depend directly upon levels of environmental expenditure; as expenditure rises so the activity of these industries increases. This not only leads to increased employment in and production by existing industries but, in many cases, results in the establishment of new industries.

Nevertheless, these effects are not confined to the environmental service industries. They also have an impact on many other industries, including in many cases the target industries. Adoption of environmental policies may help to shape consumer preferences, with resulting changes in demand in favour of environmentally friendly products and firms. They may also aid exports, by making the goods more acceptable to environmentally conscious overseas markets. They may reduce imports, by rendering foreign goods less acceptable to internal markets. In many cases they help to increase productivity by encouraging the replacement of old, and often inefficient plant or technologies by new and more effective ones. At the same time, they may improve staff relations, so that labour efficiency also rises.

Table 10.3 **Estimated levels of activity in environmental industries and services in Community member states (including Spain and Portugal).**

Activity	Level of activity (thousand million ECUs)				
	Total	Air	Water	Wastes	Noise
1. PROVISION OF SERVICES					
Operation of installations	26.0	0.8	11.0	14.2	-
Engineering	2.9	0.6	1.7	0.4	0.2
2. PROVISION OF EQUIPMENT					
Basic equipment	6.2	1.1	4.2	0.7	0.2
Transport/collection equipment	1.1	0.1	0.1	0.9	-
Monitoring equipment	0.8	0.3	0.5	-	-
Civil engineering	10.9	0.6	8.1	0.2	2.0
3. PROVISION OF GOODS/PRODUCTS					
Utilities (e.g. energy)	5.2	0.4	2.8	2.0	-
Consumables	10.1	0.1	7.0	0.5	2.5
TOTAL	63.2	4.0	35.4	18.9	4.9

Source: data from SEMA-METRA 1986

10.4.2 Economic Benefits of Environmental Policies in the European Community

As has been noted, the economic benefits of environmental policies express themselves in many different ways: i. through the effects on existing industries and the generation of new industries; ii. through the damage costs saved; and iii. through the consequent effects all these have on levels of economic productivity, costs, employment, inflation and the balance of trade.

I. Industrial cost savings.

The effects on new and existing industries are not easy to compute, but data by SEMA-METRA for 1982 give some indication of the direct input into the economy from environmental policies. They suggest a total market for environmental goods and services of between 60 and 65 million ECUs (for all twelve member states). This relates mainly to the running of treatment and management services for water and wastes and, to a lesser extent, the production and installation of capital equipment (Table 10.3). In addition, target industries may experience significant benefits. No overall figure is available, either for individual countries or industries within the Community, but examples are shown in Table 10.4. The main benefits in these cases arise from savings in energy, raw materials and pollution control costs or charges.

Table 10.4 **Potential economic benefits of integrating clean technologies into industrial processes.**

INDUSTRY	COUNTRY	PROCESS	TOTAL SAVINGS (or cost -) ECUs	% OF TURN-OVER	MAIN AREAS OF SAVING/COSTS
Sugar processing	Netherlands	Process change and in-plant cycling	4,132,000	2.0	Product losses
Sugar processing	Netherlands	End-of-pipe effluent treatment	- 31,000	-	Energy saving; increased other costs
Sugar processing	Netherlands	Yeast production etc	-	-	Energy savings
Leather tanning	France	In-plant recycling	10,344	0.3	Raw materials savings; increased other costs
Leather tanning	France	In-plant recycling	8,467	0.2	Raw materials savings; increased labour, energy and other costs
Leather tanning	France	In-plant recycling	3,532	0.1	Reduced raw water, raw materials costs; increased energy costs
Metal finishing	France	Process change with new product	160,580	-	Energy savings
Metal plating	Germany	Process change with new product	3,488 - 22,325	-	Raw materials, water and other savings
Micro-processor production	Germany	Recycling and by-product	24,046,500	0.001	Raw materials savings
Chlorine production	United Kingdom	New production process	714,285	0.03	Labour and energy savings
Adhesive tape coating	United Kingdom	Process change and energy recovery	239,682	-	General savings
Adhesive tape production	United Kingdom	Process change and material substitution	592,000	-	Raw materials savings
Pesticide spraying	United Kingdom	New product	-	-	Raw materials and water savings

Source: data from SEMA-MATRA 1986

II. Savings in damage and remedial costs.

More far-reaching, and more important, in many instances are the benefits due to savings in damage costs. Inevitably these, too, are difficult to determine in any rigorous manner, for it is never easy to predict with confidence what would have happened without the policy - or how much of the change is a direct result of the policy. Substantial savings nevertheless occur in many sectors of the economy.

Some of the most important are in the area of public health. One study in Germany, for example, estimated that the health effects of air pollution - including lost working hours, medicinal costs and the costs of loss of human life - amounted to 1.1-2.7 million ECUs per year. In France, damage to health from sulphur dioxide and particulates in 1978 was estimated at 1200 million ECUs (0.35-0.43% of the GDP). Introduction of measures to control atmospheric emissions would obviously save some portion of these costs, as well as reducing the human suffering involved.

Considerable savings are also possible in relation to remedial actions, such as water treatment, noise insulation or building repair which arise as a result of environmental damage. Water purification, for example, is a major cost in almost all member states. In Germany alone the cost of removing heavy metals and other toxic substances is estimated at 0.7 million ECUs per year. In France, the estimated total cost of water purification, excluding investment, was 1400 million ECUs in 1982. Similarly, the damage to buildings by acid deposition in the European Community is estimated to be in the range of 540-2700 million ECUs per year (Table 5.4). In all these cases, policies to control discharges of pollutants into the environment would help reduce these costs, as the data in Table 10.5 indicate. This presents estimated benefits from reduction of salinity levels of the Rhine in the Netherlands. Overall, a total benefit of 81-230 million ECUs is possible, a large proportion of it from the increase in recreational activities which would result.

Table 10.5 **Potential savings from reduction of salinity levels of the Rhine in the Netherlands.**

	Saving (million Gld)	Saving (million ECUs)
Municipal water treatment	33-59	14-24
Industrial water treatment	11	4.5
Reduction in damage to household equipment	10-30	4-12
Agriculture	20-60	8-25
Recreation	110-330	45-136
Other	12-61	5-25
TOTAL	196-551	81-230

Source: data from Delft Hydraulics Laboratory 1983

The control of waste emissions also offers considerable savings. Once more, data on the potential benefits are difficult to determine, but the costs of waste disposal are high and, in many countries, rising. In France, between 1973 and 1982, the costs of waste management (excluding capital investment) doubled from 400 million ECUs to 785 million ECUs - in part, it must be said, because of more stringent environmental controls. None the less, it is clear that considerable possibilities exist for reducing these costs. Lower rates of waste production would result in savings in both waste collection and disposal. Recovery and recycling of waste materials would also enable savings to be made in rates of raw material use.

Perhaps the most significant savings, however, arise from reducing the secondary impacts on other economic activities. The prime example of this is provided by the effects of acid

Table 10.6 **Impacts of the *Amoco-Cadiz* accident on the coast of France, 1976.**

SOURCE OF LOSS	COST (million FF)	COST (million ECUs)
Impacts on fishing industry:		
Loss of fish stocks	183	27
Damage repair	1069 - 1171	156 - 171
Compensation costs:		
For cancelled visits	81	12
To visitors	10.8 - 468	1.6 - 68
To residents	45.4	6.6
Loss of oil cargo	109.6 - 174	16 - 25
Non-monetary ecological costs:		
Loss of benthic fauna	? 250	? 36
Loss of birdlife	? 0.41	? 0.05
TOTAL (excluding non-monetary ecological costs)	1500 - 1700	220 - 250

Source: data from SEMA-METRA 1986

deposition. As was noted in Chapter 6, this has resulted in extensive damage to forests and agricultural crops. Tentative estimates suggest that costs are in the region of 300 million ECUs per year for damage to forests in the European Community (mostly in Germany) and almost 1,000 million ECUs for the loss in agricultural production. In addition, losses of revenue from tourism and sport may amount to a further 28 million ECUs.

Similar damage costs occur due to other impacts such as soil pollution, soil erosion and water pollution. Nor are all these costs associated only with long-term effects. Often they are the result of instantaneous and unforeseen events. Accidents, for example, generate large, and often avoidable costs. Industrial explosions, accidental releases of chemicals (e.g. the Seveso incident) or major oil spillages (e.g. the *Amoco Cadiz* accident) are examples. In the case of marine oil pollution, the average cost per head is estimated to be 0.2 ECU/year in France and the United Kingdom. Major accidents, however, may greatly inflate this cost in any year, as data for the *Amoco Cadiz* incident, on the French coast, show (Table 10.6). In total, this cost between 220 and 250 million ECUs, equivalent to a per capita cost of 4.1-4.7 ECUs at 1983 prices. Yet again, costs such as these can be reduced or eliminated by the implementation of suitable preventive environmental policies.

10.4.3 The Employment Benefits of Environmental Policies

An important economic aspect of environmental policy is its effect on employment. In recent years, increasing attention has been given to the employment implications of both national and Community policies. Environmental policies have been no exception: while their objectives are clearly distinct from those of employment policies, it is evident that they can (and do) have a considerable influence on employment opportunities in the Community.

They do so in two main ways. On the one hand they create jobs - either directly in the industries and services specifically associated with the environmental policies, or indirectly through the secondary effects which this new employment has on the wider economy. On the other hand, they also result in job losses - both in the target industries which have to comply with the environmental legislation, and, more indirectly, in sectors of the economy which are adversely affected by consequent increases in raw material costs or reduction in demand.

These effects would appear to have considerable relevance when seen in the context of changes which have occurred in the pattern of employment. Over the last fifteen years, unemployment in the European Community of ten has risen from a little over 2 million (2% of the workforce) in 1970 to about 12 million (10.3% of the workforce) in 1983, and the trend has continued up to the present. This increase is due to a number of factors. In part it reflects the economic recession which has hit the Community, as it has many other parts of the world. But this has been superimposed upon another important trend: the persistent growth in the size of the workforce as more young people come to employable age, and as the number of women seeking employment continues to increase.

I. Positive effects on employment.

The positive effects of environmental policies on employment arise in a number of ways. Amongst the most obvious and direct are those deriving from specific job-creation programmes, many of which are concerned with environmental protection and amelioration. Over recent years, several member states have introduced such programmes, including Germany, France, the Netherlands, Denmark and the United Kingdom. The numbers of jobs created depends, of course, on the amount of investment provided, the area in which action was taken, and the general state of the national economy at the time, but the experience of these programmes has been broadly similar. In Germany, for example, 51,000 jobs were created between 1974 and 1978 as a direct result of such programmes, while in France, between 1981 and 1983, some 1200 jobs were generated at a cost of 23.3 million ECUs (160 million FF). Similarly, three programmes in Denmark, from 1975 to 1983, provided a total of 10,600 to 11,800 new jobs.

Employment is also created by other environmental programmes (i.e. actions introduced specifically for their environmental as opposed to employment effects). In particular, these lead to direct employment benefits in industries which provide the necessary environmental equipment and in their associated services: for example in the construction and operation of pollution abatement systems, in waste collection, recycling and disposal, in sewage treatment, in water treatment and in the broad field of environmental research. In addition, however, other jobs (often the larger proportion) are produced indirectly. These arise from the increased demand for raw materials, training, administration and other services by the environmental sector. Thus, for each job directly created in water purification activities in France, 3-4 indirect jobs were created; in noise abatement activities one additional job was produced for every four directly generated jobs.

The importance of these sources of job creation in the European Community in recent years can be illustrated by a number of examples. In the Netherlands, for example, almost 70,000 jobs were produced in 1982 as a result of environmental initiatives. These included 20,000 jobs in the field of waste disposal and sewage tratement, 27,000 in the installation, maintenance and operation of capital equipment, and 22,000 in commercial waste treatment.

In Germany, in 1980, an estimated 380,000 new jobs were generated through public and private expenditure on environmental protection, representing a gain in employment of about 1.4% of the total work force at the cost of about 1.2% of the GDP. These included:

- some 180,000 people employed directly or indirectly in the construction of pollution abatement systems;
- about 76,000 people in operating domestic pollution control equipment (e.g. municipal wastewater treatment plants, waste collection and disposal);
- about 40,000 people in the provision of goods and services for the operation and maintenance of municipal pollution facilities;
- approximately 25,000 people in administration;
- some 27,000 jobs involved with the export of pollution abatement equipment;
- about 23,000 people employed in the reclamation and recycling of solid wastes;
- almost 9,000 people employed in environmental research and development in non-industrial institutions.

These figures exclude the indirect employment created through the multiplier effects of the initial environmental expenditure.

Table 10.7 **Estimated net additional jobs created in the European Community (excluding Spain and Portugal) by Community waste Directives, 1975-83 and 1984-5.**

	Net number of jobs created (thousands)		
Category	1975-83	1984-95	1975-95
Direct	16.5-44.0	27.0-89.0	43.5-133.0
Indirect	16.5-22.0	23.5-34.0	40.0-56.0
Total	33.0-66.0	50.5-123.0	83.5-189.0

Source: data from Environmental Resources Limited 1984

As these examples indicate, waste disposal and treatment present particularly fruitful areas for job creation in the environmental field. They are also areas in which Community initiatives have undoubtedly played a major role. Estimates of the employment which has arisen in the Community as a result of its various Directives on wastes, adopted since 1975, are shown in Table 10.7. Calculations are based on case histories describing the implementation of different Directives, from which the net number of new jobs created was estimated. These were then extrapolated to give overall figures for the whole Community. In total, between 16,500 and 44,000 new jobs were generated as a direct result of these Directives in the period from 1975 to 1983, representing an increase in employment in the waste management sector of 3-8%. In addition, some 16,500 - 22,000 jobs were created indirectly. Based on these data, predictions for the period to 1995 suggest a further increase of 50,500 to 123,000 jobs, an additional rise of 10-25% in employment in the waste sector.

II. The negative effects.

The employment effects of environmental policies are not wholly positive. Negative effects also occur, for the introduction of legislation requiring the adoption of environmental measures interferes with the normal running of target industries and may have small but significant impacts on costs for others. At the least these effects may inhibit or deter expansion in the industries affected, or encourage them to divert their investment to foreign countries with less stringent environmental controls. The necessary investment in environmental protection measures may also force up prices and reduce demand in these industries. Under extreme circumstances it may even reduce their economic viability to such an extent that they are forced to close. In all these cases, jobs are likely to be lost.

In fact, the evidence for such effects is limited. Although changes in production costs can be attributed to environmental legislation in some cases, the effects on employment generally seem to be small. Similarly, there have been few instances where investment has been lost to foreign countries directly as a result of environmental legislation. In addition, although industrial development and expansion has, in some cases, apparently been deterred or delayed by the existence of environmental legislation, the problem seems in most instances to have arisen not from the objectives of the environmental measures *per se*, but from the way in which they have been implemented (e.g.because of inflexibility in the procedures adopted or delays in certification).

The effects of environmental policies on plant closure also appear to be small. Some closures have undoubtedly occurred within industries which were the subject of environmental legislation, but they rarely seem to be entirely (or even primarily) a result of the environmental legislation. Instead, in most cases closures have occurred in older, heavily-polluting industries in which many firms were already economically marginal. In these cases, closures seem to have occurred due to the cumulative effect of many different factors, including generally unfavourable market conditions and inherent problems of obsolete equipment and production processes. Indeed, in many cases it is likely that environmental legislation merely acts in such circumstances to hasten the closure of plants which are already doomed.

III. The net effects on employment.

What the net effect of environmental policies is on employment clearly depends upon the relative magnitude of the gains and losses that they invoke. These, however, are not easy to predict, for they depend in turn upon many different factors, including:

- the general state of the economy in which the environmental policy is being implemented;
- the specific character of the environmental measures being taken;
- the ways in which the environmental expenditure are financed;
- the extent to which any increases in costs are passed on to other industries or consumers;
- the degree to which the demand for environmental equipment and services is met internally, as opposed to provision from external suppliers;
- the extent to which other countries and competitive industries are adopting the same (or similar) policies.

Initially, short-term positive effects may predominate, with increases in employment in environmental industries and services. Over time, however, more complex and contradictory responses are likely to emerge, affecting production costs and competitiveness.

10.5 CONCLUSIONS

10.5.1 The Major Effects

In recent years both the economy and the environment have been the object of increasing concern within the European Community. The past fifteen years have seen severe recession and general staganation (accompanied by high rates of inflation), during which the economies of member states have undergone considerable restructuring. As a result, there has been massive unemployment. This constitutes a severe challenge to policy makers for structural change gives rise to new industries, whose patterns of employment and environmental effects differ from those of the traditional industries which have been in decline. New environmental problems and hazards have therefore emerged, sometimes with frightening immediacy: the widespread effects of acid deposition, the Seveso accident, the Bhopal incident, and most recently of all the accident at Chernobyl are all examples.

Probably more important in the long run, however, is that these two concerns should now be drawing together, highlighting the relationship between economics and the environment. It is, as this chapter has shown, a vital relationship. For, whilst economic conditions and activities undoubtedly influence the effects we have on the environment and - to some extent - the nature of environmental policies, equally, environmental policies have a wide range of economic implications.

Environmental policies can have negative economic effects in as much as they may raise production costs in target industries and, under certain conditions, inhibit output, reduce demand and increase unemployment in the industries affected. In extreme cases, they may even contribute - along with other factors - to plant closure. On the other hand, there are also considerable positive effects which can more than offset the negative impacts: environmental policies tend to stimulate production, demand and employment in the environmental industries, services and administrations. Often, their effects spread more widely, and they lead to important developments in many other parts of the economy. The demand for environmental technology, for instance, stimulates the various supply industries. The need for environmental workers encourages training and education. The introduction of new technology may increase productivity, while more pleasant working conditions in the firms affected can improve staff relations and public attitudes. And the benefits of a better environment - such as improved water quality, cleaner air, a diverse and protected wildlife and landscape - can have direct economic significance. They help to encourage tourism and the associated leisure industries; they increase output from agricultural and forest land; they reduce damage costs in almost all walks of life.

10.5.2 The Need for Data

Given their importance, it is understandable that increasing attention has been devoted to the evaluation of all the economic effects of environmental policies in the Community. Results from a number of studies have been reviewed in this chapter, and they indicate the magnitude of some of the implications of environmental initiatives taken in the Community and its member states over the last 10-15 years. They show, for example, the way in which environmental policies have helped to create a new industrial sector, providing employment for a growing number of people, helping to conserve resources for other activities, and improving environmental conditions for everyone.

But it is clear, too, that there is an urgent need for improved data on the economic effects of environmental policies, both at national and Community level. At present, we cannot compare the complete range of costs and benefits and assess the net effects of environmental policies, and thus we cannot evaluate in any detail the economic implications of these policies. Neveretheless, it is apparent that, under present conditions, the net economic effect of Community policies on the environment is, at worst, only marginally negative and - in many cases - quite strongly positive. The conclusion to be drawn is that, given also their considerable social and environmental benefits, the majority of policies are well worth the financial and other resources spent on them.

NOTES AND SOURCES

Data Availability

Considerable difficulties are liable to beset any attempt to produce comprehensive estimates of the costs or benefits of environmental policies in the European Community, not least because of a general scarcity of data. The studies which have been carried out of costs, for example, relate almost exclusively to running and capital costs and tend to vary substantially in terms of the policies considered and the way in which costs are categorised. Similarly, few quantitative studies have been made of the benefits of environmental policies, and those data which do exist relate mainly to direct (as opposed to indirect) benefits. The same is true of most assessments of the employment impacts of environmental policies; these are generally based on partial sectoral models and, as with all such analyses, encounter problems in designing realistic and comprehensive models and in finding the necessary input data. Moreover, many of the models used and the time periods studied vary from one case to another so care is needed in comparing results from different studies. As a consequence, all the data in this chapter should be interpreted with caution.

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The present report fulfils an undertaking given by the Commission to the European Parliament to develop an information base which can improve understanding both of changes in the Community environment, and the effects of Community policies, in the environmental field and also in other areas with an impact on the environment.

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