Chapter (non-refereed)

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Resources for documenting changes in species and habitats

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INTRODUCTION

It is fashionable to regard environmental change as if change were an abnormal condition. In fact, the converse is true. Stability is the exception rather than the rule in the natural environment and change is a normal condition in ecological systems. Indeed, environmental change is the driving force for evolution. It is particularly interesting to speculate whether man, despite his present anxiety over the pace of environmental change, will succeed in becoming the first species to stem the tide of evolution through the degree of control he can exert over his environment.

The history of organised observation of the natural world has demonstrated a recent dramatic increase in the rate, the extent and the amplitude of change, and much of this increase has been directly or indirectly the result of man's activities.

It is hardly necessary in this paper to list the individual causes of environmental change. By now, we have become all too familiar with the consequences of man's success as a species and of the increasing demands his growing population places on the natural resources of this planet.

The effects of such changes on biological species may be direct – destruction of habitat or environmental pollution, for example, or indirect – the fragmentation of habitats, preventing the free movement of species, or the elimination of important components in foodchains. Recently we have become aware of the danger of more widespread changes in environmental conditions, notably the risk of global climate change resulting from increases in the concentration of 'greenhouse gases'.

In practice, our response to such threats usually takes the form of a compromise between our demand for material advancement and the need to preserve the natural environment which we all value and upon which we all ultimately depend. This compromise is necessary because, despite the undoubted attractions of the pre-industrial environment, few of us would be prepared to return to the social conditions of that period. Therefore, the only strategies for conservation and protection which carry with them a real prospect of success are those based on the principles of sustainable development (Pearce, Barbier & Markardya 1990).

To achieve a satisfactory compromise, we need information on conditions and trends in the various physical and biological components of the biosphere. We need information on baseline conditions, we need reliable indicators of change, and we need an understanding of how ecosystems respond to change, so that we may develop predictive models of these responses and take the required preventive action. The information needed often relates to long-term trends within a pattern of cyclic variation and random 'noise'. The long timescales involved, and the frequently poor signal-to-noise ratio of our monitoring systems, require considerable ingenuity in the manner in which we make use of available data.

Yet, ironically, the volume of information available to us and our skill in handling it provide instances where we can point to significant advances in our ability to respond to environmental threats. Never before has so much been known about current environmental conditions and about the way in which organisms and ecosystems respond to change.

In the remainder of this paper, I shall discuss, through examples, some of the ways in which information technology can contribute to environmental science and to environmental protection. The paper is intended as a bridge between the historical perspectives of the earlier papers and the following papers which examine how we are beginning to harness the growing power and sophistication of information processing systems to improve our understanding and capacity for effective environmental management.

BIOLOGICAL RECORDING

Before discussing the environmental databases available to us, some definition of 'biological recording' is needed. The Linnean Society, host for this Conference, was instrumental in the formation of a recent Working Party to consider how best to establish an effective network for biological surveillance.

This Working Party defined biological recording as:

> '. . . the collection, collation, storage, dissemination and interpretation of spatially and temporally referenced information on the occurrence of biological taxa, assemblages and biotopes. Basic information on occurrence is normally augmented and amplified with a variety of related

biological, environmental and administrative information. Biological recording normally excludes information on agricultural, horticultural or forestry crops, and agricultural, domestic or captive stock, except where it may concern wildlife, biotopes or the management of semi-natural areas.' (Co-ordinating Commission for Biological Recording 1989)

I shall use this definition in the subsequent discussion.

The preceding paper (Harding & Sheail 1992) described the Biological Records Centre (BRC) – the national focus of the network of biological recording in Great Britain. In this paper, I propose to review some of the other elements in this network, which help to ensure the continuity of the biological surveillance on which BRC largely depends to maintain the national archive.

Figure 1 provides an overview of recent (post-1980) developments in the evolution of this network, described in greater detail by Harding (1990).

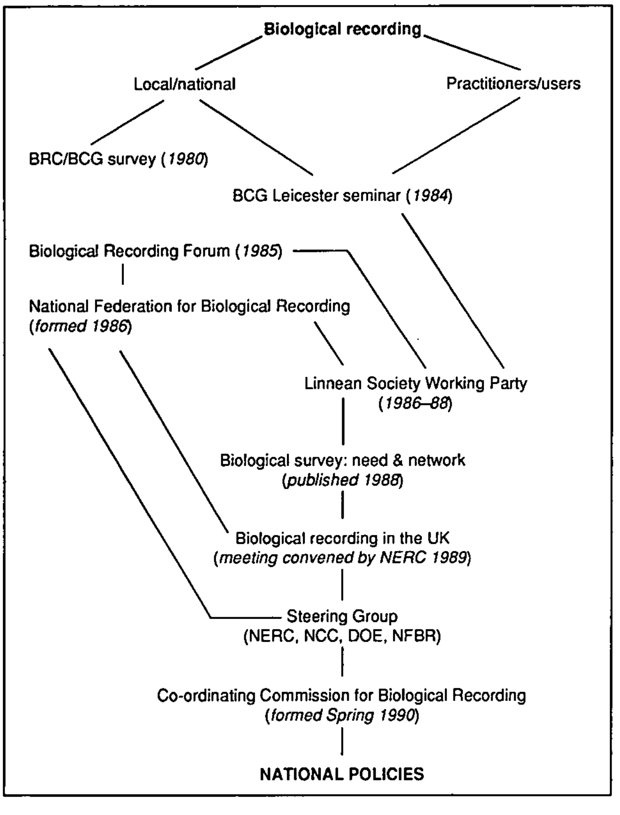

Figure 1. Progress towards national policies in biological recording (after Harding 1990)

LOCAL RECORDING

Although locally based collection of information on wildlife has been in evidence for at least 150 years, formalised environmental recording at the local level only came to the fore in the early 1970s. A conference in 1973 brought together many of those concerned with local biological records centres (Stansfield 1973) and, in 1977, the Museums Association convened a standing committee on Environmental Records Centres (Stewart 1980). Also in 1977, the Biological Recording in Scotland Committee (BRISC) was formed (Sommerville 1977). Following a meeting of records centre organisers at Monks Wood in December 1977, a *Handbook for local biological records centres* was published in 1978 (Flood & Perring 1978).

BIOLOGY CURATORS' GROUP

In the absence of any other co-ordinating group, many local centre managers looked to the Biology Curators' Group (BCG). BCG convened an important seminar in Leicester in 1984 to discuss biological recording. The seminar concluded:

1. that existing arrangements for recording, storing and retrieval of biological data were unsatisfactory and under-funded;
2. that agreed standards for biological recording should be set, bearing in mind the needs of both amateur naturalist and professional scientist;
3. that museums should, where possible, manage local biological databanks which should provide a range of information services to the general public.

The seminar resulted in two initiatives. At a practical level, in 1985, BCG and BRC jointly set up the Biological Recording Forum (Copp & Harding 1985), from which the National Federation for Biological Recording (NFBR) evolved in 1986. On the political front, the Linnean Society agreed to convene, under the chairmanship of Professor S Berry, the Working Party on Biological Surveillance, which brought to public awareness many of the issues needing to be addressed to establish biological recording on a sounder basis for the future.

Independently of these two initiatives, in 1986 the Nature Conservancy Council (NCC) and Wildlife Link formed the Joint NCC/NGO Data Handling Group.

Concurrent with all this activity (and perhaps a stimulus for some of it), there have been significant changes in both the purposes and the methods of biological recording. Computer-based methods of information management are increasingly in evidence and introduce strong pressures for rationalisation and harmonisation of data structures. The implementation of the RECORDER package for the management of computerised data by local records centres and wildlife trusts, through collaboration between NCC, the Royal Society for Nature Conservation, and the World Wide Fund for Nature, will inevitably accelerate this trend.

In the early years, mapping the distribution of species was almost the sole justification for recording. More recently public concern for the quality of the environment has led to increasing demands from Government and developers for biological information at all stages of the planning process, and especially in drawing up environmental impact statements. The emphasis has therefore shifted rapidly towards collecting data which relate species records to individual sites and thus to habitat.

These demands have opened up new markets for information at both local and national levels; however, the trend can result in a conflict of interest between the data provider and the custodian of the data; neither is it likely that commercial revenue alone will be sufficient to provide the necessary investment in capital and staff to ensure the efficient operation of a national network for biological recording.

THE LINNEAN SOCIETY REPORT

In 1986, the Linnean Society's Working Party on Biological Surveillance addressed these problems. Following publication of its report (Berry 1988), a meeting of more than 30 national organisations with an interest in biological surveillance was held at the Royal Society, under the chairmanship of Dr P B Tinker, Director of Terrestrial and Freshwater Sciences in the Natural Environment Research Council (NERC).

The meeting endorsed most of the recommendations of the Linnean Society report, and set up a steering group to suggest terms of reference and membership of a Co-ordinating Commission for Biological Recording. Once established, this Co-ordinating Commission would establish procedures for accreditation of participating groups and would oversee the operation of a national network.

The steering group reported at the end of 1989; Sir John Burnett has since accepted the invitation to convene and chair the Co-ordinating Commission itself, which has now prepared a statement of intent and a programme for the establishment of a national system (Co-ordinating Commission for Biological Recording 1990). The Commission is a unique development, in that it brings together those with an interest in using biological data and the recording community. It is likely to have a profound and beneficial impact on biological recording in the future.

ENVIRONMENTAL INFORMATION CENTRE

At the same time as these developments in the organisation of biological recording, NERC announced the formation of the Environmental Information Centre (EIC) at the Institute of Terrestrial Ecology (ITE), Monks Wood, to serve as its data centre in the terrestrial life sciences (Figure 2). The objectives of EIC are to develop improved methods for the storage, processing and analysis of ecological data, to enhance the ability to inter-relate datasets describing different aspects of the natural environment, and to improve the relevance of these information systems for applications in ecological research, in planning, and in environmental protection.

EIC brings together many of the groups in ITE with expertise in large and complex biological databases,

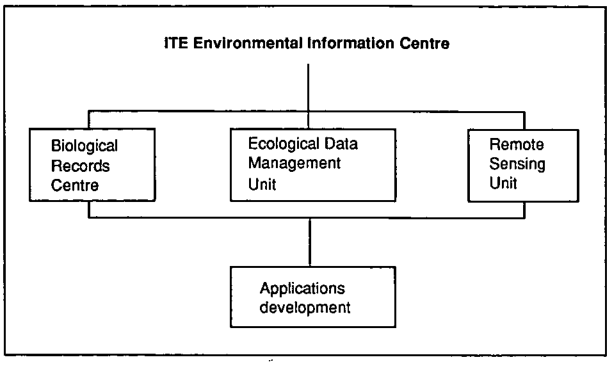

Figure 2. The Environmental Information Centre of ITE, a data centre for terrestrial ecology and rural land use – schematic structure

and particularly in the handling of geographically referenced data. The Biological Records Centre forms the single largest unit in EIC, with the most extensive data resource. Elsewhere in EIC, specialists are researching the use of data from earth observation satellites to map and to monitor changes in the land surface. Modern computer-based geographical information systems provide a powerful means of exploring relationships between environmental conditions and species distributions. EIC is beginning to apply these systems to the BRC database and to many other environmental datasets, to look at national trends in relation to soils, climate and environmental quality, and also to study ecosystems more locally at specific sites.

EIC currently offers access to digital information on species and habitat and to digital topographic and thematic maps covering environmental variables such as soil type, climate and land use. The Centre has been in existence for less than two years, but evidence of its practical benefits is already apparent: in improved access to information and expertise; in the integration of ecological data; in technology transfer within the Institute; and in the links to other disciplines. The growing interest in research into global environmental change will place a premium on many of these qualities – in particular, on the ability to access multidisciplinary data and expertise in pursuit of the understanding of complex, large-scale ecological processes.

A major development over the next two years will be the compilation, from remote sensing, of a national digital map of land cover. Information on the present and future disposition of natural and managed habitats is crucial to our understanding of how the environment will respond to future changes. Remote sensing will allow us to map the present situation, to generate a baseline against which to measure change, and subsequently to monitor these changes and their consequences. The land cover map is being compiled as part of the Countryside Survey 1990, a joint venture between NERC, the Department of the Environment and the British National Space Centre. The Countryside Survey includes intensive ground survey within sample areas, and this ground-based survey will generate reference data with

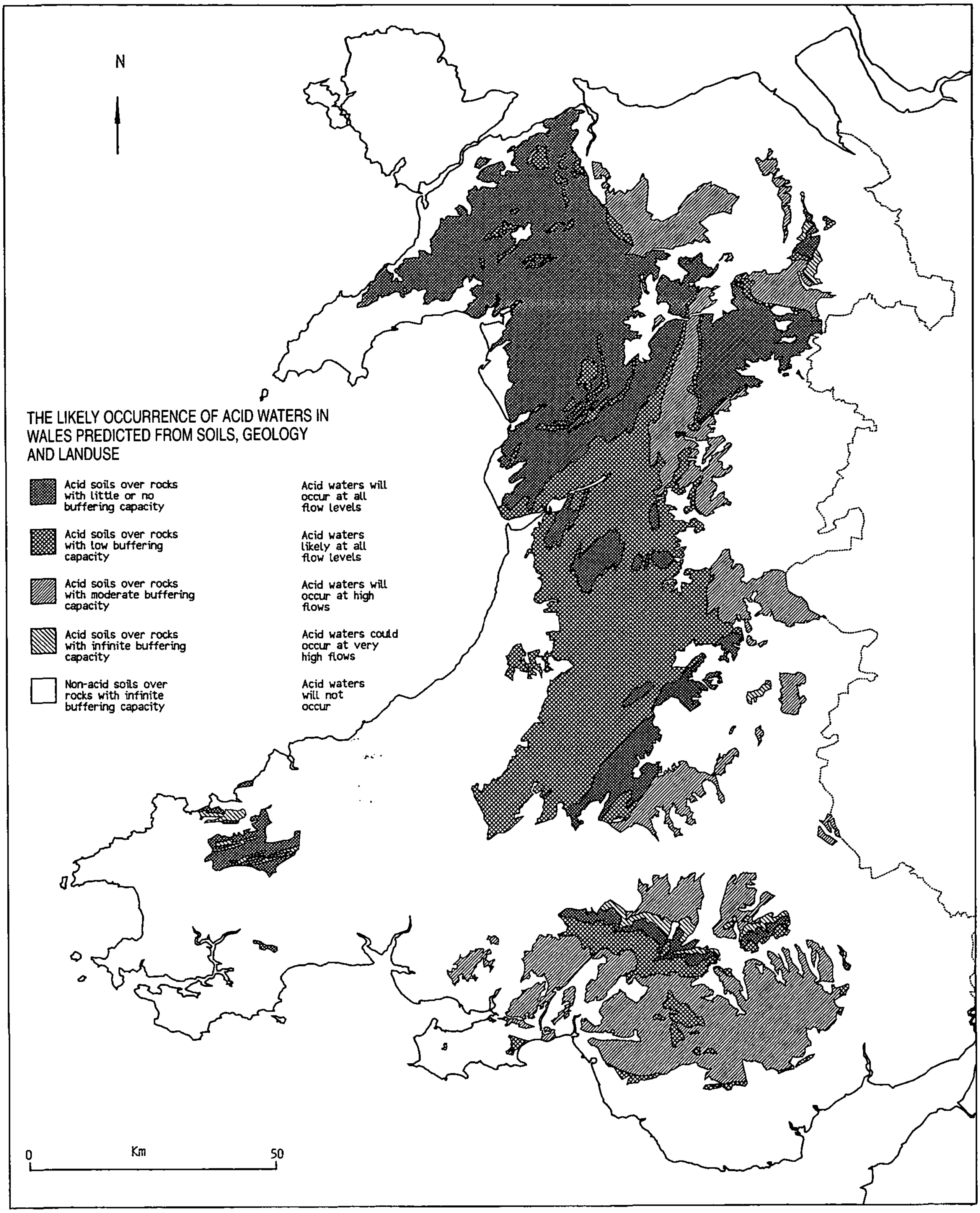

Figure 3. Vulnerability of surface waters in Wales to acidification from atmospheric pollution

which to calibrate the satellite maps, as well as more detailed records of field conditions than it is possible to observe from space.

Geographical information systems (GIS) allow us to explore spatial and temporal relationships between environmental variables, using spatial overlay and similar techniques. For example, information on soils in north Wales has been overlain with information on land use and with geological data to generate a map showing areas where surface waters are particularly vulnerable to acidification from atmospheric pollution (Figure 3). GIS allow us to extract information on surface water quality from an associated database in order to calibrate the map and to use the data predictively.

An extremely powerful technique is to use the GIS to process information from remote sensing in combination with digital map data. EIC is particularly well-equipped to develop and exploit these approaches, and a number of pilot-scale projects have been undertaken to demonstrate their potential for land resource planning, for environmental assessment, and for ecological research. In one example (Jones & Wyatt 1989), Landsat Thematic Mapper imagery was integrated with topographic map data, with a digital elevation model, and with thematic maps recording information on soil type, geology and hydrology for the whole of the Snowdonia National Park in north Wales. The resulting geographical database was used to evaluate the impacts on ecology and landscape of various proposed economic developments in the National Park, including the effects of forestry, tourism, and industry.

A second example uses remotely sensed imagery to delineate areas of mudflats used as feeding grounds by wading birds. Counts of bird numbers, measured in the field and held in a digital database, have been related to characteristics of the mudflats, which can be distinguished in the satellite imagery. Bird populations are correlated with sediment type because food supplies vary with, for example, sediment grain size or wetness. The calibration of bird numbers with mudflat type can then be applied over much more extensive areas in order to allow estimation of bird populations with less effort and at greater precision than has previously been possible.

These techniques have been applied at a variety of spatial scales and at different levels of generalisation. Some of the most ambitious applications have been in a European context, through the development of CORINE (Co-ordinated Environmental Information in the European Community) – an experimental programme of the Environment Directorate of the European Commission. The CORINE programme is generating a geographically referenced database covering the entire territories of the European Community and recording more than 50 different environmental variables from every sector of the environment. CORINE is intended to lead to improved policy decisions on the environment in the Community, and to help the Commission to assess the consequences of its development proposals for environmental resources.

EIC has provided technical experts who have assisted the European Commission in the design and development of the CORINE database, which has now been in operation for five years, providing an effective illustration of the potential of GIS for environmental planning and management. The principal contribution of EIC has been to design and implement a system for recording information on areas of importance for nature conservation on a Community-wide basis. This information has been used, for example, to identify important sites threatened by major development projects (Figure 4), or to help in drawing up the draft Community environmental protection legislation by examining the extent of threatened species or habitats in the Community as a whole (Figure 5).

We are beginning to use similar methods for analysing the national environmental databases which we are building, to predict and measure the ecological consequences of future changes in land use or environmental conditions.

SUMMARY

The use of computers for the collection, storage, management and analysis of environmental data has enormous benefits, in the improved efficiency with which existing information can be handled, in the increased volumes and complexity of the information that such systems can hold, in the relative ease with which data can be exchanged, and in the facility with which sophisticated analysis can be undertaken.

In this paper, I have illustrated examples of ways in which some of these benefits can be realised, particularly in relation to the computer-based analysis of spatially referenced data to model the consequences of environmental change.

However, these benefits are not totally without cost; if computer systems are to be exploited to their full potential, then it is necessary that the providers of data exercise discipline and adhere to basic minimum standards with regard to the form, the consistency and the accuracy of the data and that the users of such systems observe any restrictions which may be necessary, either because of characteristics of the data (eg precision) which constrain their use or because of other restrictions on their dissemination (eg considerations of confidentiality).

Such restrictions can be applied relatively easily in an environment where a single organisation is responsible for all aspects of the database. Biological recording rarely conforms to this pattern; by its nature, biological surveillance tends to involve many different subject specialisms, from many different organisational backgrounds. Comprehensive biological recording over large areas (eg nationally) can only be achieved through loose affiliations of distributed organisations and individuals. In this environment, enforcement is, at best, extremely diffi-

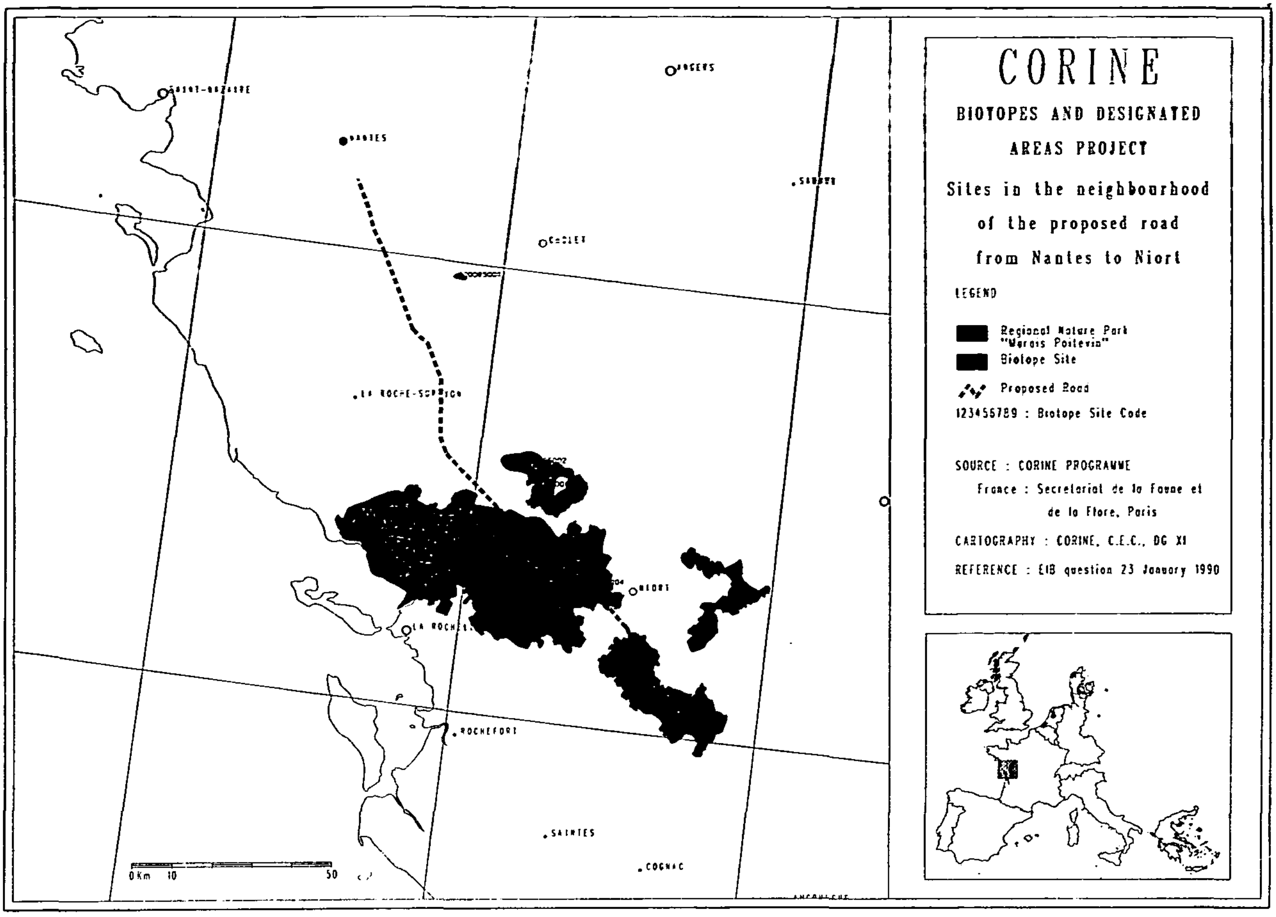

Figure 4. CORINE biotopes database. Biotopes and designated areas in the neighbourhood of the proposed road from Nantes to Niort

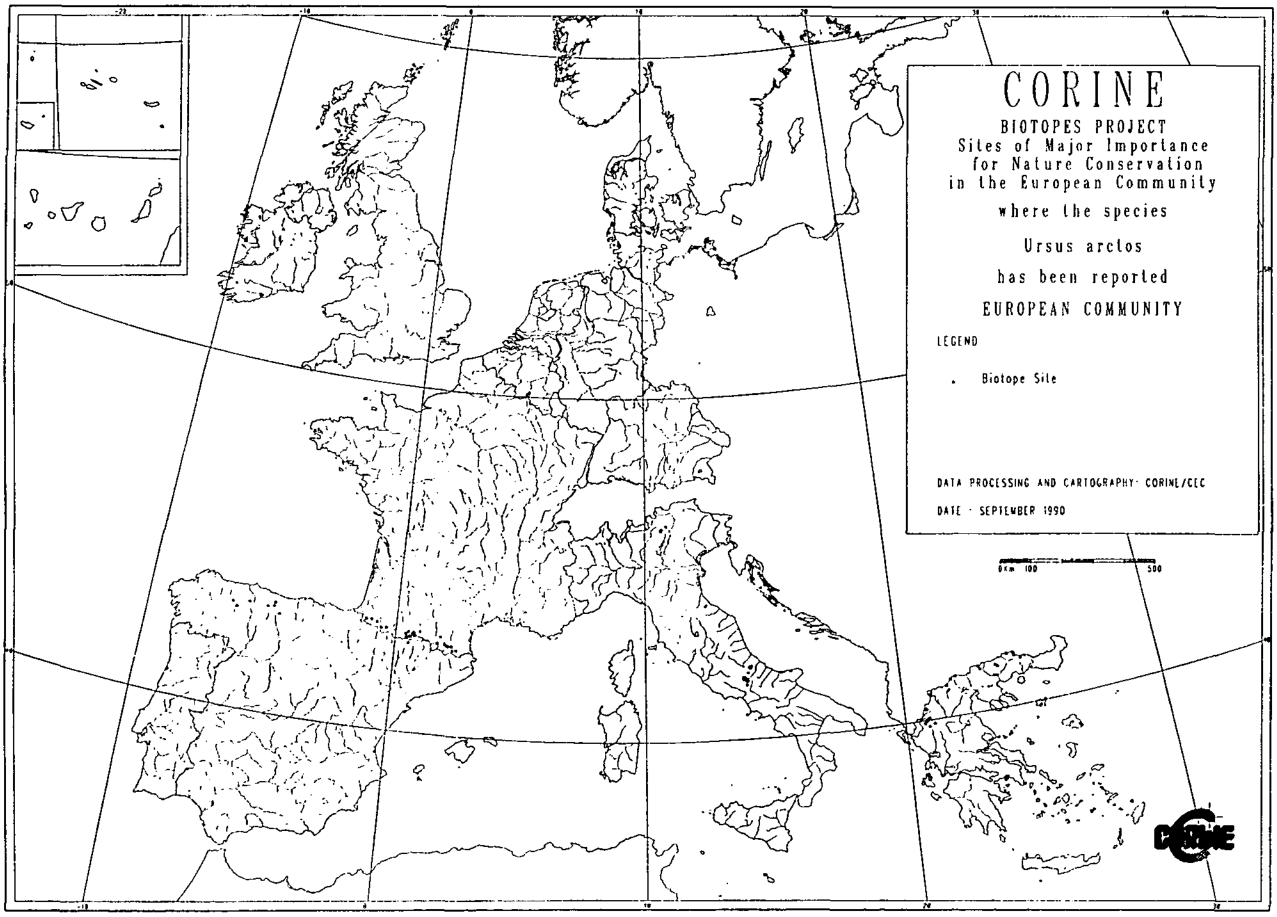

Figure 5. CORINE biotopes database. Recorded occurrence of the brown bear (*Ursus arctos*) in the European Community

cult. The solution most likely to succeed will depend on enlightened self-interest; each participant will recognise the advantages of adopting consistent standards. The work of the Co-ordinating Commission for Biological Recording, in drawing up the necessary standards, in ensuring their widespread adoption and in providing the necessary software support and documentation, will clearly be of crucial importance.

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