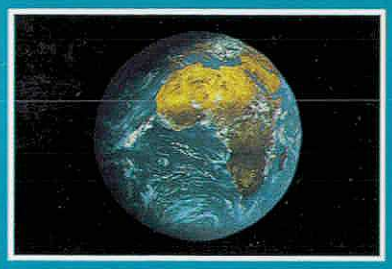
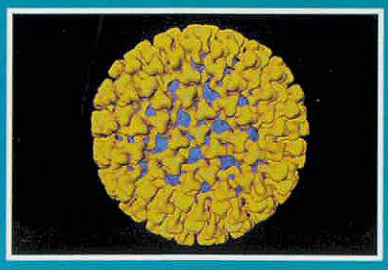




Centre for Ecology & Hydrology

Centre for Ecology & Hydrology

Annual Report 1994–95

Natural Environment Research Council

Professor John Krebs FRS, Chief Executive, NERC launching the new Centre for Ecology and Hydrology in December 1994 at the Queen Elizabeth II Conference Centre, London.

Foreword

The Government through the 1993 White Paper *Realising our potential – strategy for science, engineering and technology* provided the Natural Environment Research Council with a new mission. To deliver this mission effectively, it was necessary to restructure NERC.

An important element of this was the grouping of a number of the existing NERC Institutes into two new Centres: the Centre for Coastal and Marine Sciences (CCMS) and the Centre for Ecology and Hydrology (CEH). These Centres have during the past year moved rapidly to develop integrated science programmes and an integrated identity. In so doing, these two groupings are building new interdisciplinary capabilities and programmes to advance science, as well as to position themselves to meet emerging user needs. Although there is more to be done this, the first Annual Report of the Centre for Ecology and Hydrology, describes the excellent progress made in drawing together the activities of the component Institutes and in refocusing objectives over the past year. I commend this Annual Report to you.

John Krebs FRS
Chief Executive
Natural Environment Research Council

Report of the Centre for Ecology and Hydrology 1994–1995

Natural Environment Research Council

Contents

The CEH mission

- To advance the sciences of ecology, environmental microbiology (including virology) and hydrology through high-quality and internationally recognised research, leading to a better understanding and quantification of the physical, chemical and biological processes relating to land and freshwater and living organisms within these environments.

- To investigate, through monitoring and modelling, natural changes in the ecological, microbiological and hydrological environments, to assess both historical past and future changes, and to predict man's impact on these environments.

- To secure, expand and provide ecological and hydrological relevant data to further scientific research and provide the basis for advice on environmental conservation and sustainable development to governments and industry.

- To promote the use of the Centre's research facilities and data to provide research training of the highest quality and to enhance the United Kingdom's research base, industrial competitiveness and quality of life.

This is the first Annual Report of the Centre for Ecology and Hydrology (CEH). Professor Brian Wilkinson was appointed as Acting Director CEH in May 1994 and as Director in March 1995. It is his privilege to present this Report.

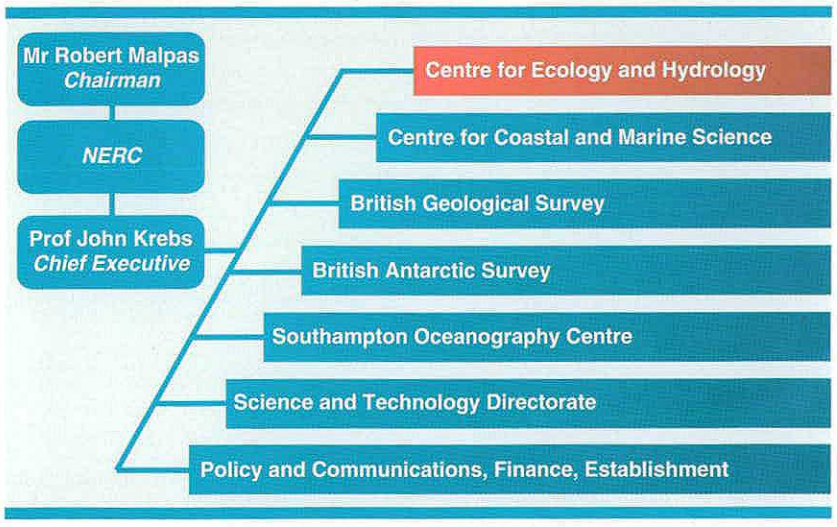
Director's review

Demands for answers to environmental problems increasingly require a multidisciplinary scientific approach, and CEH with its component institutes must have one of the strongest international capabilities in this respect.

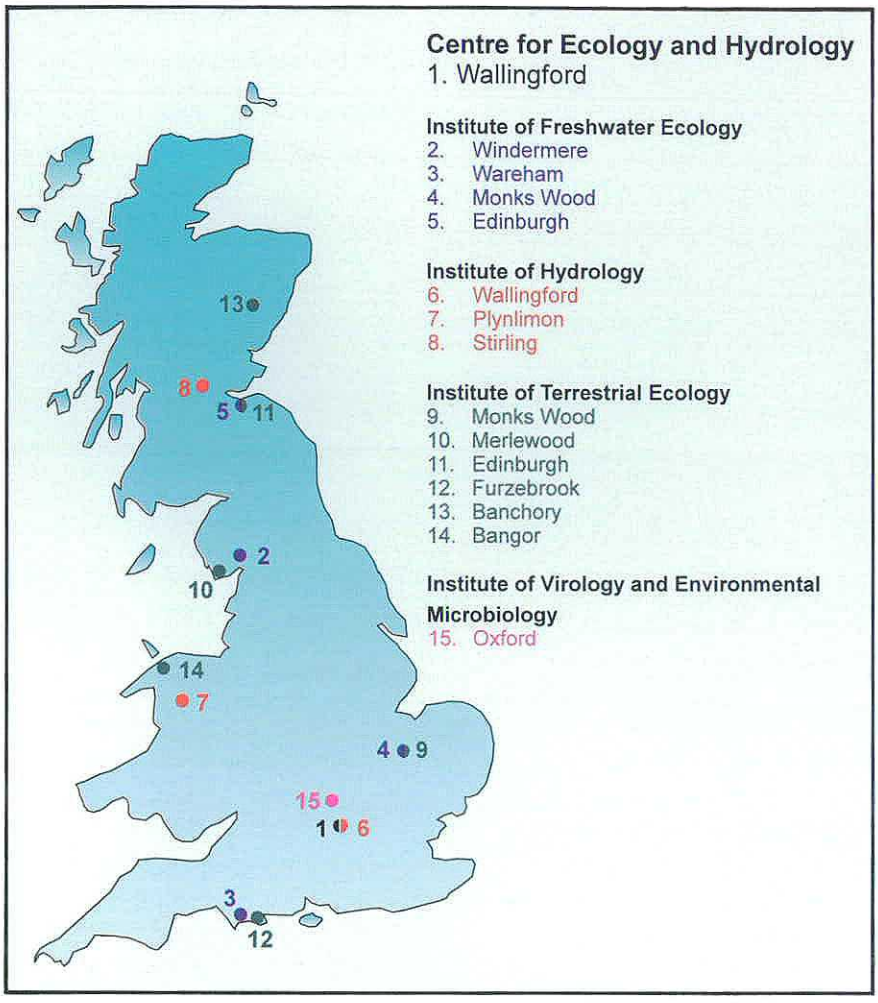
The formation of CEH

The 1993 White Paper *Realising our potential – a strategy for science, engineering and technology* reaffirmed the Natural Environment Research Council as the lead organisation for research, survey and training across the full breadth of environmental sciences. From 1 April 1994 it provided NERC with a new Mission – a requirement to carry out the highest-quality research, survey, environmental monitoring and post-graduate training. The White Paper placed special emphasis on the themes of wealth creation, quality of life, partnership in science and technology, and the establishment of closer links with the NERC 'user community'. To meet the aims of its new charter and the new programmes, Professor John Krebs, the Chief Executive, worked with Council to restructure NERC. The new overall structure is shown below. To fulfil its Mission the NERC Council now has:

- a new grouping of NERC Institutes into a Centre for Ecology and Hydrology;
- a Centre for Coastal and Marine Sciences and the Southampton Oceanography Centre;
- the existing British Geological Survey and the British Antarctic Survey;
- a number of Units for specialist research in the Higher Education Institution sector;
- a new Directorate of Science and Technology with responsibilities for Awards and Training, Technology Interaction and Scientific Services;
- six Science and Technology Boards in the following areas: Marine, Earth, Terrestrial and Freshwater, Atmospheric, Earth Observation, and Polar Sciences.



The NERC organisational chart.



CEH component Institutes.

The Centre for Ecology and Hydrology was formally 'launched' in December 1994

The Centre for Ecology and Hydrology and the Centre for Coastal and Marine Sciences were formally 'launched' in December 1994 at the Queen Elizabeth II Conference Centre in London, preceding the NERC Annual Lecture which was presented by the Rt Hon Michael Heseltine, now the Deputy Prime Minister.

CEH is concerned with research into the land on which we live, its freshwaters and the living organisms which share the environment with us. This diverse and complex area of science covers a wide range of scales in space and time and has strong interactions with the economic and social sciences and with industry and commerce.

CEH Management Board

Soon after the Centre's inception in 1994 an administrative and financial management structure was put in place and this was followed by the establishment of the CEH Management Board. Comprising the Centre and Institute Directors together with the Head of Administration, this is the most senior CEH forum at which science, financial and administrative policy and strategy are debated and developed. The arrangement has worked well, and during the course of the year I have been fortunate to have had the unstinting support of Professor Mike Roberts (Deputy Director CEH and Director ITE), Professor Alan Pickering (Director IFE), Mr Tony Debney (Acting Director IH), Dr Patricia Nuttall (Acting Director IVEM) and Mr Phil Williams (Head of Administration) as Board Members.

Integrating the science

To make full use of the science potential that lies within CEH the Directors recognised at the outset that, although there were some collaborative projects between the CEH Institutes, much more needed to be done. To further this a CEH integrating science fund was established. To qualify, proposed projects have to be of the highest-quality science, with collaboration between two or more Institutes and a project leader with responsibility for managing the project across Institute boundaries. The response has been most encouraging and the list of 'integrating fund' projects for the present year is given in Appendix 1 at the end of this Report. Seven per cent of the Institutes' Science Budget has been set aside for this purpose and, if the scheme works well, it will be progressively extended in future years.

As part of the integrating fund initiative, a number of projects were identified as priorities for the future. One such area concerns CEH

databases and geographical information systems (GIS). CEH holds a unique collection of databases which are invaluable to scientific research and have widespread industrial and commercial application. Two of the NERC Designated Data Centres – the National Water Archive at IH and the Environmental Information Centre at ITE – are part of CEH. As well as stewardship of data, these Data Centres are responsible for transforming data into user-friendly data retrieval systems, such as the Countryside Information System and the Water Information System. Full utilisation of CEH data and better interaction are essential, and an internal CEH workshop is planned for late 1995 to identify key research areas in database development and GIS. Similar workshops are to be held on remote sensing, wetlands and analytical chemistry.

CEH Management Board – Dr Patricia Nuttall (Acting Director IVEM), Professor Alan Pickering (Director IFE), Professor Mike Roberts (Deputy Director CEH and Director ITE), Professor Brian Wilkinson (Director CEH), Mr Phil Williams (Head of Administration), Dr Jane Metcalfe, and Mr Tony Debney (Acting Director IH)

Funding and research

In general, 1994–95 has been a satisfactory year but there has been a small decline in both the Science Budget and in Commissioned Research. Details are given in the financial section of this Report (p34). The holistic scientific approach which the Centre now has to offer should attract Commissioned Research from a wider range of organisations both within the UK, Europe and worldwide. During the coming years CEH will be promoting this capability within the compass of its new research programmes.

During the course of the past year a new Funding Model has been developed by NERC, comprising four main funding modes: *non-thematic, thematic, core strategic, and infrastructure*. The purpose of the model is to increase flexibility between thematic and non-thematic science, Unit/Centre/Survey funding, training, etc, and to ensure that the best value is obtained from the Science Budget. The new arrangements, which are likely to be introduced in April 1997, will provide funds for CEH to undertake a programme of core strategic science within its Institutes and an appropriate infrastructure. *Thematic Programmes* have been identified by NERC as areas that require research funding to help answer fundamental environmental questions. Several of the Thematic Programmes have CEH scientists as programme managers, who provide essential scientific support to NERC. A full list of CEH involvement in Thematic Programme management is given in Appendix 2.

Both the core strategic science research programmes and infrastructure support for CEH will be subject to annual review. The core strategic science programmes will be examined during the course of the coming year by four Programme Review Panels, responsible to the Terrestrial and Freshwater Science and Technology Board. Eleven core science programmes have been developed by CEH. In drawing up the programmes particular attention has been paid to the six major Environmental and Natural Resource Issues described by NERC in its 1995 Corporate Plan. Account was also

CEH obtains financial support from three principal sources:

- **NERC Science Budget in support of the Institutes' core strategic science and infrastructure (the well-found laboratory);**
- **successful bids into the NERC Thematic Programmes;**
- **Commissioned Research from UK Government departments, European Union, industry, commerce, etc.**

Eleven core science programmes have been developed by CEH.

taken of the priorities in the NERC Terrestrial and Freshwater Science Strategy and the findings which emerged from the National Technology Foresight Programme which were of particular relevance to NERC science. A brief description of the new CEH science programmes is given in the next section of this Report, and the way in which they map on to the Environmental and Natural Resource Issues and Technology Foresight topics is shown in Appendix 5

Performance

While the budget for CEH has shown some decline I am pleased to report that the Centre's performance as judged by publications, contract reports and contributions to books has increased from a total of some 840 in 1993-94 to 1030 in 1994–95. Details of these and other indicators of CEH performance are given later in this Report (p35).

Networks and outreach

All the CEH Institutes have extensive links with the wide-ranging community who use the results of their scientific research, monitoring and data. To understand or provide solutions to complex environmental issues almost always requires collaboration between many organisations, often at an international level. CEH has an extensive network in place with other research organisations, government departments, UN bodies, the universities, industry and commerce. Examples include:

- the UK Environmental Change Network (**ECN**), which consists of ten terrestrial and 37 freshwater sites. ECN is sponsored by a number of UK Government departments and several other agencies, and is managed by the Centre's Institute of Terrestrial Ecology;
- the Flow Regimes for International Experimental and Network Data programme (**FRIEND**), initiated by the Centre's Institute of Hydrology. FRIEND has been adopted as a component of the UNESCO International Hydrology Programme and is networked through 13 European countries. It is now being extended into eastern Europe, South Africa, West Africa and the Far East;
- the **EurAqua** network which provides for the co-ordinated research and advice on freshwaters to national governments and the European Union. EurAqua now has ten research organisations as members from ten Member States of the EU. IH was the co-founder member.

All the CEH Institutes have extensive links with the wide-ranging community who use the results of their scientific research, monitoring and data.

CEH influence has been further extended during the course of the year by both the Institute of Terrestrial Ecology and the Institute of Hydrology securing a role in consortia established by the newly formed (1994) European Environment Agency (EEA) to run the Nature, Water and Remote Sensing Topic Centres. It is also pleasing to see the publication by the EEA of *Europe's environment – the Dobris assessment*. Several CEH Institute scientists contributed sections to the report. The European Union's Fifth Action Programme for the Environment *Towards sustainability* identified the main environmental issues facing Europe. Research to address these issues is carried out through the EU Framework initiatives. The CEH Institutes worked through their European networks to select some 60 counterpart organisations with which to collaborate in submitting and successfully securing research within the Third Framework Programme. CEH has been even more active in responding to the call

for bids under the EU's Fourth Framework Programme and, while the outcome is presently unknown, it is anticipated that the Centre's research funding from the EU will increase during the coming year.

CEH has particularly strong links with the university sector and 13 Centre scientists have Visiting Professor status at British universities. Details are given in Appendix 4 of this Report.

Environmental policy needs to be based on timely objective information resulting from sound science. Through their scientific research programmes CEH Institutes deliver this to governments over a broad front. The CEH welcomes the Concordats recently established between NERC and a number of UK Government departments (Department of the Environment, Ministry of Agriculture, Fisheries and Food, Overseas Development Administration, Department of Trade and Industry) and other agencies (National Rivers Authority), and sees this as a means of further strengthening relationships, avoiding research overlap and increasing the efficient use of research resources.

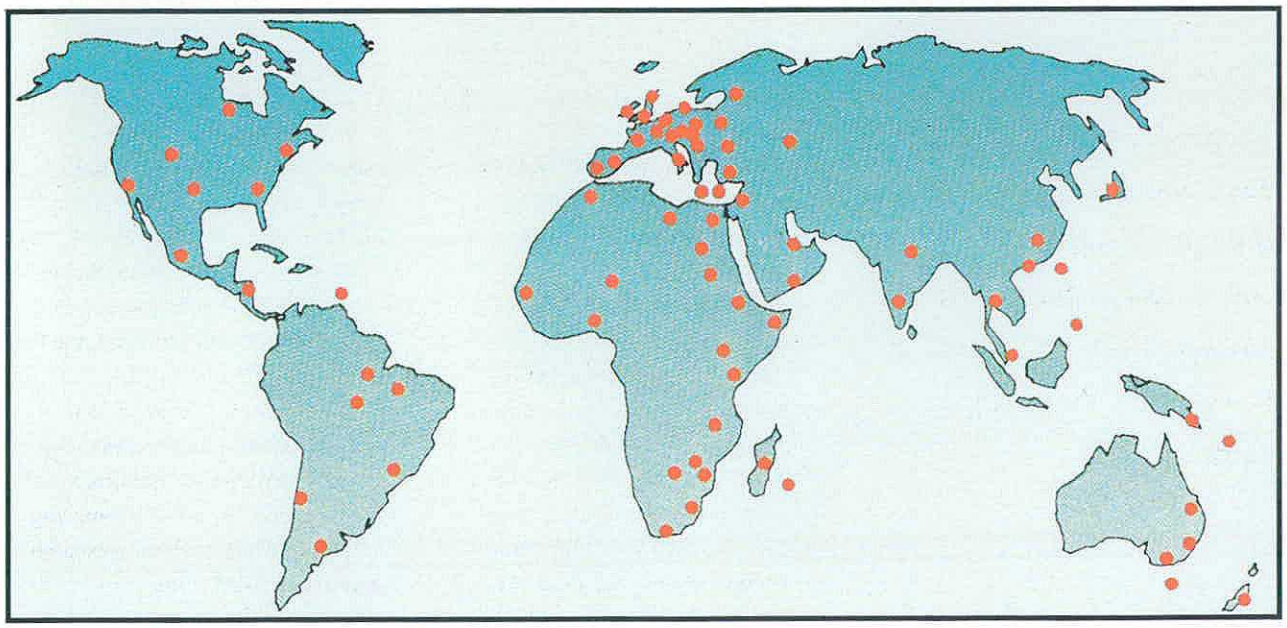
International science

Unsustainable land use and water resources and the loss of species and habitat diversity are global problems. An international scientific response leading to understanding of the processes controlling such changes is necessary if remediative/ ameliorative measures are to be put in place. All CEH Institutes have contributed to this area of international science during the past year through active participation in:

- the NERC Thematic Programmes, such as the Terrestrial Initiative in Global Environmental Research (TIGER) and the Land/ Ocean Interaction Study((see Appendix 2);
- international science programmes such as the International Geosphere–Biosphere Programme (IGBP), World Climate Research Programme (WCRP), International Decade on National Disaster Reduction (IDNDR), International Hydrological Programme (IHP), Man and the Biosphere (MAB), etc;
- UN commissions and other bodies with an international science remit.

CEH has particularly strong links with the university sector.

CEH Institutes have all contributed to international science programmes during the past year.



Locations of recent research contracts undertaken by CEH Institutes.

International programmes

The International Geosphere–Biosphere Programme (IGBP) aims to describe and understand the interactive physical, chemical and biological processes that regulate the total earth system, the unique environment that it provides for life, the changes that are occurring in the system and the influence of human activity. CEH is involved in three IGBP core activities: Global Change and Terrestrial Ecosystems (GCTE), Biological Aspects of the Hydrological Cycle (BAHC), and Land–Ocean Interactions in the Coastal Zone (LOICZ). CEH manages the GCTE Focus 3 Office.

The World Climate Research Programme (WCRP) is the research component of the World Climate Programme. CEH is involved through the Global Energy and Water Exchange programme (GEWEX).

The 1990s have been designated the **International Decade for Natural Disaster Reduction (IDNDR)**. The objective is to reduce, through technology transfer to developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters. CEH participates through the UK Drought Mitigation Working Party and the World Flood Study.

The UNESCO International Hydrology Programme (IHP) and the Programme on **Man and the Biosphere (MAB)** are scientific research, education and training programmes devoted towards:

- environmentally sound integrated water resource planning and management
- promoting the sustainable use of the biosphere, respectively.

The UK is not a member of UNESCO but has observer status and contributes to IHP and MAB's research. Senior CEH scientists chair the UK IHP and MAB Committees.

CEH contributes directly to UK wealth creation through its partnerships with industry and commerce.

Details of CEH Institute international activities are given in the individual Institute Annual Reports. From a personal point of view I was pleased to attend the World Meteorological Organisation (WMO) Congress as the Hydrological Adviser to the UK Permanent Representative. During the year I was also invited by the Canadian Government to serve on the Canadian National Committee which oversees their Global Energy and Water Cycle Experiment (GEWEX) programme. A number of CEH Institute staff are working closely with their Canadian counterparts and other international scientists on two major GEWEX projects which are located in Canada namely BOReal Ecosystems–Atmosphere Study (BOREAS) and MAckenzie GEWEX Study (MAGS). My place on the Committee strengthens the CEH links with the Canadian scientists in particular, and the GEWEX international science community in general.

Delivering the science to industry and commerce

CEH contributes directly to UK wealth creation through its partnerships with industry and commerce. The Centre has had an involvement with some 200 companies during the past year. There are several ways in which the CEH science interacts with industry:

- CEH enters into an arrangement and receives a royalty when a company manufactures and sells an Institute's inventions under licence;
- A CEH Institute enters into a joint venture with a company – both contribute to the research needed to develop a process or product which is then taken to the marketplace by the industrial/commercial partner;
- A company commissions a CEH Institute to undertake a research programme or provide data;
- A company and CEH bid jointly to undertake a project and, if secured, work together to its successful completion – CEH Institutes bring specialist facilities, expertise and research skills to such joint arrangements;
- Industry and commerce use the research outputs presented in CEH Institute publications or software packages to further their commercial interests. There is a major uptake through this route, though the 'wealth creation' benefits are difficult to quantify.

CEH recognises that more needs to be done in building the industrial/commercial links, and this aspect will be pursued with vigour in the coming year. It is also anticipated that the LINK and CONNECT schemes will present opportunities in the future.

Restructuring

New areas of environmental science are emerging from a number of sources, for example the NERC environmental issues, the Technology Foresight Programme and the European Union's Environmental Action Programme. Through its research base, CEH is able to respond rapidly and efficiently to these shifts in science priorities.

A planned restructuring, using NERC and CEH funds, which has included 21 staff leaving on voluntary or early retirement terms, has opened up an opportunity to change the CEH skills base. The ability of the existing facilities to meet these new challenges also needs to be examined, and the Management Board will be considering this during the coming year. Improving the present facilities will, of course, depend on the availability of restructuring funds.

In establishing CEH the opportunity was taken to draw together the Institute of Terrestrial Ecology (North) and the Institute of Terrestrial Ecology (South) into a single Institute with Professor Mike Roberts as Director. Although the two Institutes had been working closely and effectively together for many years, the reunification came about in October 1994 with the retirement of Professor Bill Heal, the Director ITE (North). Bill Heal had worked in NERC since 1964 and was Director for seven years. In steering the research of the Institute, and in his own right through his lectures, committee work and publications, he has made a significant contribution over many years to terrestrial ecology; his friends and colleagues within CEH offer him thanks and best wishes in his retirement.

At the start of this year Professor David Bishop was Director of the Institute of Virology and Environmental Microbiology (IVEM). He has since taken up a research post at the University of Oxford, and Dr Patricia Nuttall is now the IVEM Director (Acting). Professor Bishop was IVEM Director for ten years and made a substantial contribution to his area of science at both a national and international level during this period. I wish him well in his new post and look forward to the opportunity of working with him in the future.

Scrutiny

In 1994 the Office of Public Service and Sciences commenced an 'Efficiency survey of Public Sector research establishments'. The CEH Institutes were part of this survey. The outcome is not known at the time of writing but the scrutiny activity and the restructuring within NERC have led to uncertainties and disruption within the CEH Institutes. It is to the great credit of the Institute Directors and all the scientific and support staff that the science has remained buoyant and the scientific output during 1994–95 within CEH has not just been maintained but has shown a substantial increase.

The new grouping of the Institutes within the Centre for Ecology and Hydrology is timely in relation to the need for an holistic approach to environmental science. During the coming year the Centre will build on the sound foundation that has been established in this first year, and I look forward to reporting progress to you.

This report is an overview of the activities that have taken place within the Centre for Ecology and Hydrology during 1994–95. More details of the research undertaken in the CEH Institutes are given in their own Annual Reports:

- **Institute of Freshwater Ecology**
- **Institute of Hydrology**
- **Institute of Terrestrial Ecology**
- **Institute of Virology and Environmental Microbiology**

Brian Wilkinson
Director
Centre for Ecology and Hydrology

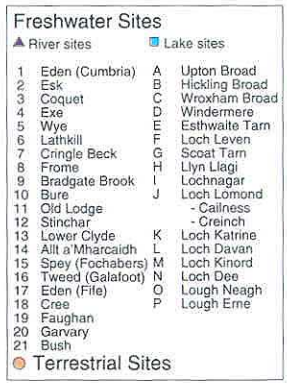
CEH research programmes

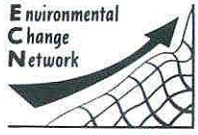
The science base required to underpin national and international requirements, as identified in the Environmental and Natural Resource Issues and in the National Technology Foresight topics, and to advise UK Government on decisions and policy formulation related to the environment, is substantial and varied. The relevance of the CEH science programme to these national priorities is described in the following pages.

Each of the four component Institutes of CEH has well-developed research projects, formulated in response to its specific mission. These projects are often interlinked or closely complementary, reflecting the fact that all facets of the environment are interdependent. In almost every case the projects are partially funded from the NERC Science Budget (core strategic research or thematic science), but the Institutes have also developed Commissioned Research that adds substantially to the value of the science base. There is thus a strong synergy between the CEH research funded by NERC and that from Commissions.

CEH has an extensive range of databases and information systems covering its research, of which the Environmental Change Network is an example.

Environmental Change Network





ECN is a long-term monitoring programme for identifying and quantifying environmental change associated with man's activities. It is conducting integrated measurements of climatic, physical and biological variables across a network of freshwater and terrestrial sites. Managed at CEH's Institute of Terrestrial Ecology, a Central Co-ordination Unit also runs two of the founding monitoring sites, one of which is at Moor House/Upper Teesdale (upper photograph). ECN has 17 sponsoring agencies: Biotechnology & Biological Sciences Research Council, Clyde River Purification Board, Dept of the Environment for Northern Ireland, Dept of the Environment, Dept of Agriculture for Northern Ireland, English Nature, Forestry Commission, Forth River Purification Board, Ministry of Defence, Ministry of Agriculture, Fisheries & Food, National Rivers Authority, NERC, North East River Purification Board, Scottish Office, Agriculture & Fisheries Dept, Solway River Purification Board, Tay River Purification Board and the Tweed River Purification Board.

CEH research programmes

- Land use and forest science
- Freshwater resources
- Urban environment
- Soils and soil/vegetation interactions
- Biodiversity
- Biological and biotechnological control of pests
- Global change
- Environmental risks
- Pollution assessment and control
- Cross-sectoral research
- Environmental impact assessment

CEH research is grouped into 11 programmes, described briefly on the following pages.

The spread of CEH research across the Environmental and Natural Resource Issues and the National Technology Foresight topics is shown in Appendix 5 (p36).

Environmental and Natural Resource Issues

- **Management of land, water and the coastal zone and their sustainability**
- **Biodiversity** – understanding and protection
- **Waste management**, bioremediation and land restoration
- **Pollution** of air, land, sea and freshwater in relation to environmental and human health
- **Environmental risks and hazards**, including release of genetically modified organisms
- **Global change**, including prediction on a range of time and space scales

National Technology Foresight Programme science & technology topics

- Industry/environment interaction
- Environmental valuation
- Land and soil
- Urban environment
- Prediction of extreme atmospheric events
- Mechanisms of climate change
- Fluid dynamics in natural resources management
- Coastal zone modelling/management
- Structure and properties of the earth's subsurface
- Use of natural processes and materials
- Sustainable use of marine resources
- Ocean circulation
- Remote data acquisition
- Society and human health impacts of environmental change
- Management of freshwater resources

Land use and forest science

Traditionally, the focus on land use research in Britain has been on agriculture. The UK is unusual in having only about 10% of its land forested. With less emphasis on the need to maximise food production in Europe, there is now the opportunity for a much greater degree of variety in the way land is used. There is the need to understand the consequences of such changes both in the UK and overseas. In the UK, increased afforestation will have long-term impacts for wildlife, recreation, timber production (with important implications), water resources and water quality. Increased urbanisation and changes in UK government policy in respect of agriculture (eg set-aside, the effect of subsidies on farming practices, managed retreat in the coastal zone) also have major consequences for wildlife and water resources. On a global scale, the impact of deforestation on the global water and carbon balance, and how this affects climate, are of major importance.

Research in this area is concerned with measuring, understanding and predicting the impacts of land use and changing land use practice on the water and carbon balance, on wildlife and habitats both within the UK and elsewhere in the world. In the tropics the development of sustainable agricultural systems, eg mixed agroforestry systems to halt or reverse the degradation of fragile environments, is a particularly important area of study. Changes in land use may also lead to major changes in hydrological regimes, eg increasing flood flows or exacerbating droughts.

The countryside, as shown here in north Somerset, is a complicated and changing mosaic of land cover types, such as agricultural crops, grassland, forest, moorland and buildings, including villages. This mixture is of paramount importance to a wide range of ecological and hydrological processes which forms the focus of CEH research.

IH is undertaking a major programme of research to assess the hydrological impact of tropical deforestation. Hydrometeorological measurements are being made in both forested and deforested areas. The upper photograph shows the IH tower in Rondônia (south-west Amazonia), and the lower at Pará (east Amazonia) in a deforested area now being used as ranchland.

The bush savannah of the Sahel is increasingly being replaced by agriculture. Soil tension measurements are being made in a crop of millet as part of a research programme to study the implications of land use change such as this on water resources and climate.

In the national context, the key challenge is to predict accurately the consequences of change and to provide the best advice for related policy and management issues, such as:

- **the implications for populations and communities of plants and animals of changes in land use and land use patterns;**
- **the impacts of land use on the hydrological cycle;**
- **achieving a balance between recreational advantages, enhanced biodiversity and the economic benefits of reforestation and other changes in land use.**

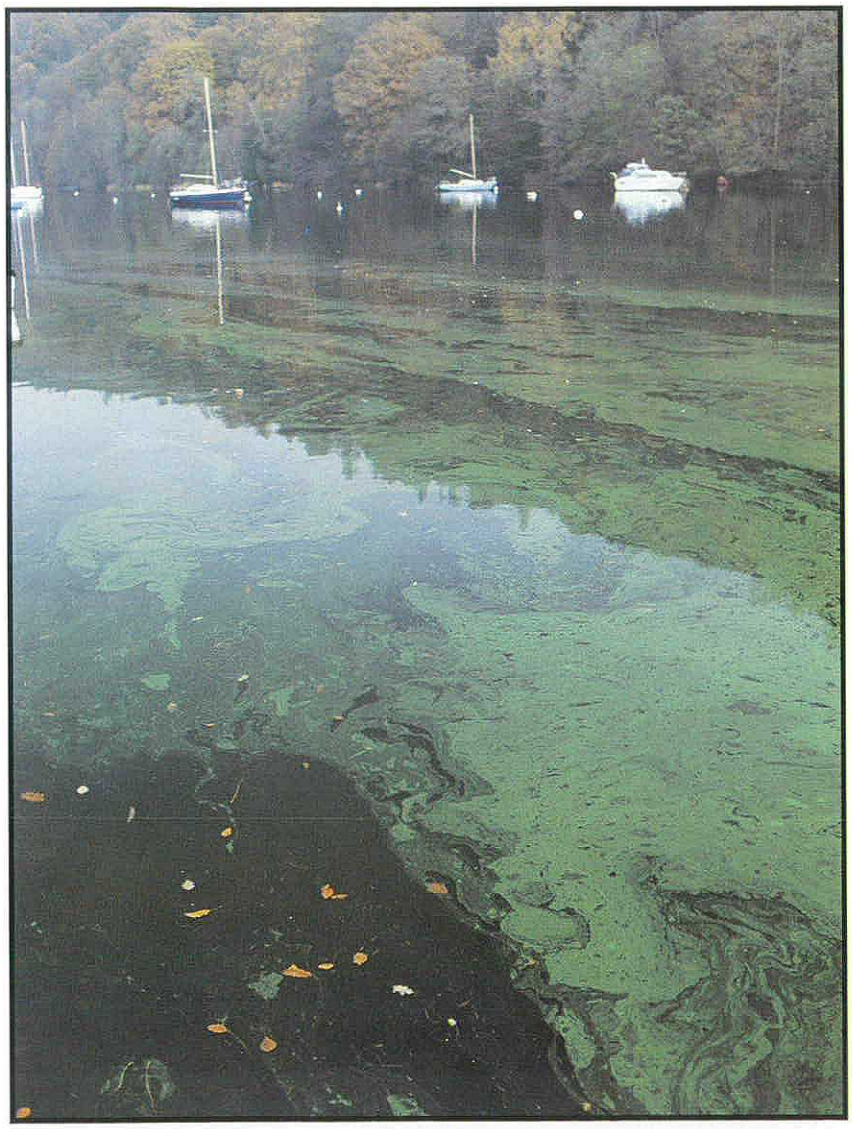
Globally, the challenges are to:

- **understand the biological, chemical and physical processes within forest, agricultural and other ecosystems and to determine the contribution of such systems worldwide to the global carbon, water and energy cycles;**
- **determine how best to conserve and restore forest ecosystems, from boreal lands to the tropics;**
- **develop sustainable systems of agriculture, forestry and natural resource exploitation that will help stabilise global climate.**

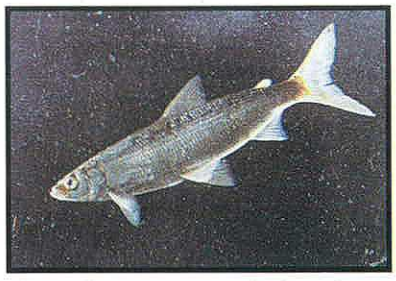
Freshwater resources

The focus of research is to provide scientific underpinning to the development of techniques for the effective assessment, planning, management and operation of freshwater resources, including groundwater, rivers, lakes and reservoirs.

CEH research includes modelling surface and groundwater systems to assess the impact of environmental changes, eg from climate changes or change in land use, on freshwater systems. Determining the consequences of water resource development and management and environmental change on fisheries, including aquaculture, and other aspects of freshwater biology, is also a significant area of study.

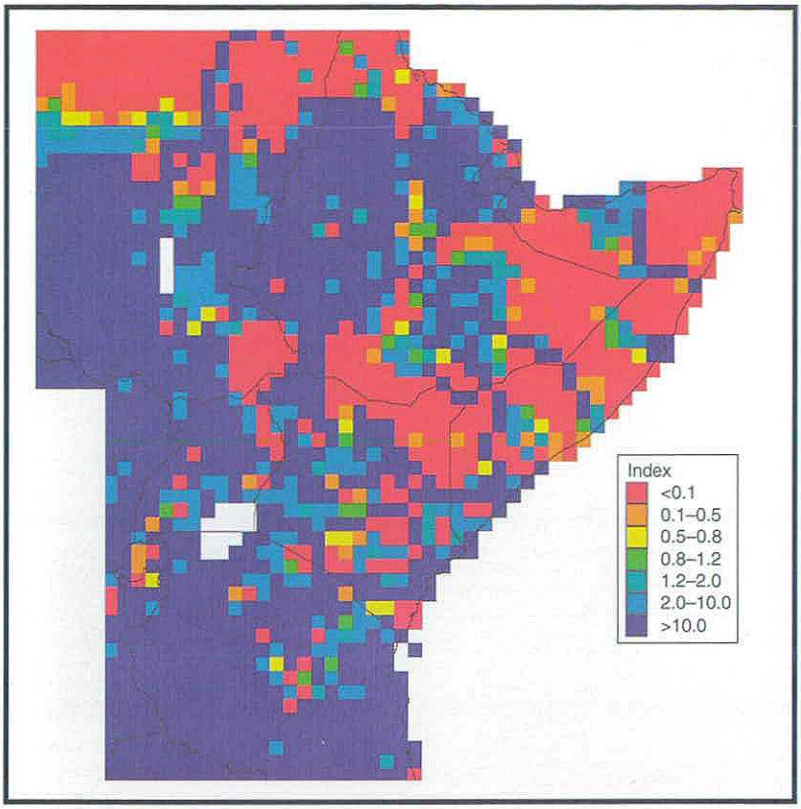


In freshwaters, the main nutrient controlling algal growth is phosphorus. Excess phosphorus inputs from point discharges and diffuse agricultural sources can stimulate algal growth to very high levels. When combined with calm meteorological conditions blue–green algal scums develop which are blown towards the shore creating a health hazard for animals and man. Windermere, a large lake in the English Lake District, has been subject to such blooms.

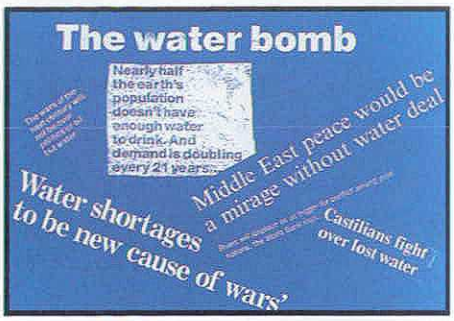


The vendace (Coregonus albula) *is the UK's rarest freshwater fish and now occurs only in Bassenthwaite Lake and Derwentwater in the English Lake District. It is threatened by low oxygen levels and siltation, both of which are consequences of excessive algal growth.*

Derwentwater, in the foreground, and Bassenthwaite Lake in the distance, the only two UK lakes still containing the vendace.



This approach uses rainfall/runoff/routing models and global datasets (0.5°x 0.5° grid). A 'water availability' index, being the ratio of water availability to demand, is calculated for each grid. An area of East Africa which supports an estimated population of 164 million was selected for the pilot study. This research is supported by the Overseas Development Administration.



Major water resource shortages will arise in some regions in the near future. The Figure illustrates the concern expressed by the 'media'. IH has developed a rigorous approach to assessing water demands and resource availability.

IH staff checking a river flow gauging station in Botswana.

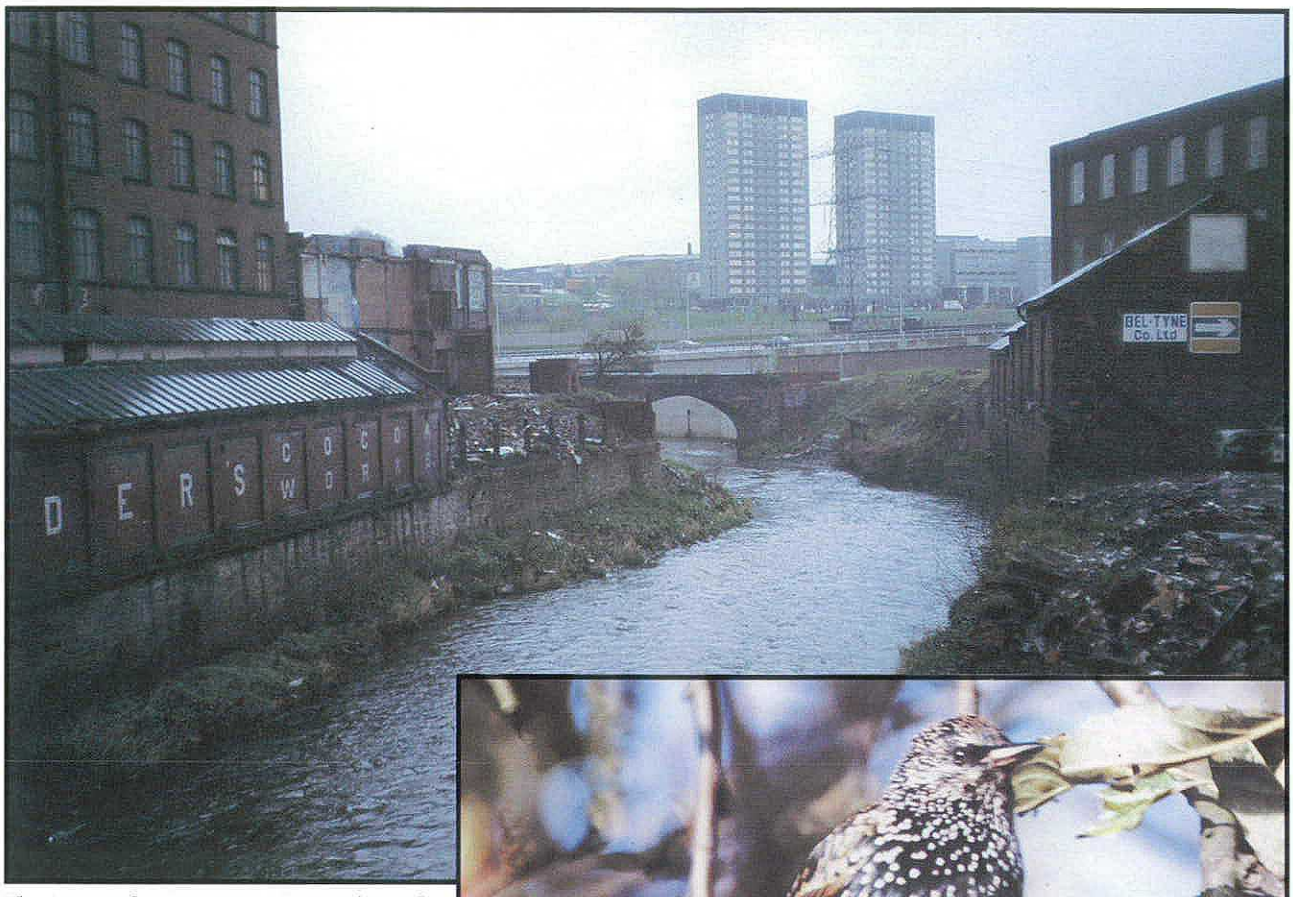
The key challenges are to:

- **provide the fundamental hydrological and biological understanding that will support the effective management of freshwater resources, freshwater fisheries and aquaculture;**
- **develop modelling systems which will assess the magnitude of national and global water resources, leading to strategies for use in developing optimum conservation and amenity measures for freshwater ecosystems and the commercial value of fisheries and aquaculture;**
- **integrate models of water resource and freshwater ecosystems in order to address the conflicting interests between water resource development/management and the maintenance of a healthy freshwater system, including fisheries and aquaculture.**

The urban environment

Although ten per cent of the UK is covered by urban developments, and inhabited by 90% of the population, the amount of research on urban environments is poorly integrated. The *CEC Green paper on the urban environment* published in 1990 considered the problems faced in urban environments and emphasised the need for an holistic approach so that solutions imposed for resolving one problem should *not* create or exacerbate others. The effective management of urban systems requires knowledge of processes within, and interactions between, many areas of science and engineering, eg water chemistry, hydrology, the role of atmospheric dynamics and chemistry, and terrestrial and freshwater rehabilitation methods.

CEH has a spread of research projects addressing urban environmental issues and these are now being integrated.

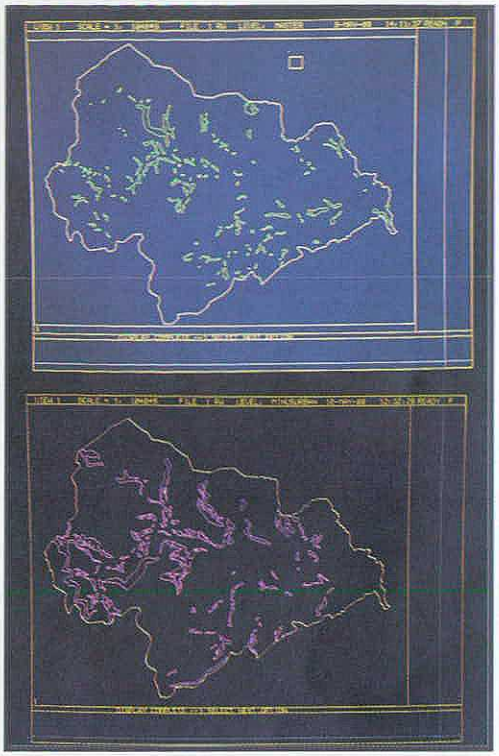


The rivers and watercourses in our industrial cities are often polluted and unsightly but they do not have to be. CEH hydrological and freshwater ecological research will lead to a better understanding of the processes operating within the urban environment, and thus to proposals for its improvement.

*Starling (*Sturnus vulgaris*) – a common sight in our cities. Fundamental research at ITE is investigating the effects of man-made alterations to the bird's environment on its distribution and abundance.*

Jagger Park Wood, in the Calder Valley, Yorkshire, is an ecologically important former mediaeval deer park in the middle of a highly industrial area.

A domestic refuse landfill site nearing completion. Successful restoration and re-vegetation require thorough remediation based on understanding of site geology, hydrology and soil processes, all of which influence the suitability of the site for plant growth.



Calder Valley, west Yorkshire, showing:
- *existing woodland (upper),*
- *slopes available for additional woodland planting taking account of constraints imposed by existing alternative (mainly built) land use and wildlife conservation and amenity considerations.*

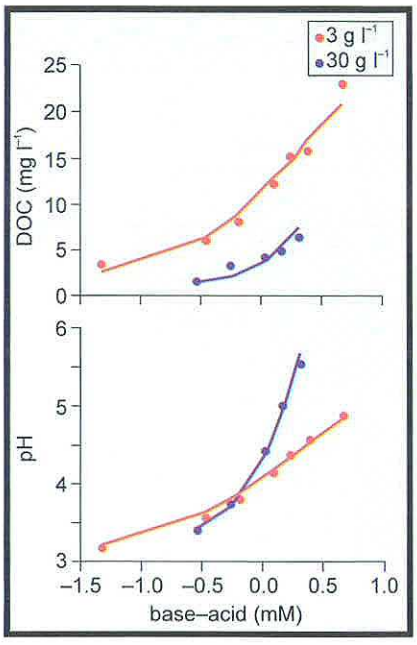
The key challenges include:

- **identifying patterns and processes in land use change in urban environments, including the use of remotely sensed data and the development of geographical information systems;**
- **assessing the ecological value of a range of urban habitats and understanding the patterns of distribution and abundance of species within them, and developing models to predict the response of species and/or communities to habitat/environmental change;**
- **developing models of water movement and pollutant transport for urban areas;**
- **understanding and modelling biochemical and microbiological processes in urban soils and water.**

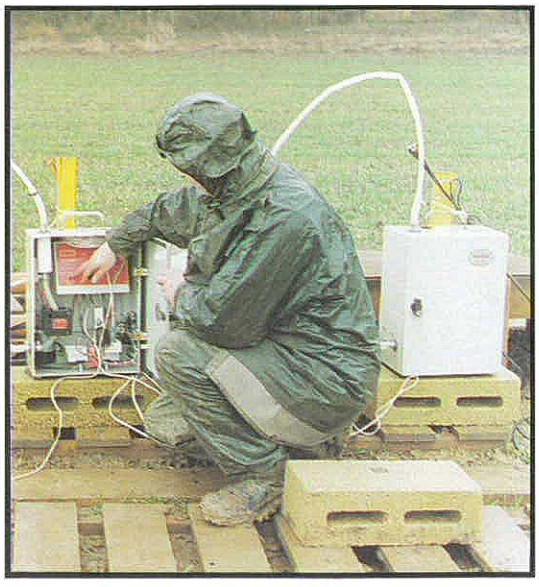
Soil and soil/vegetation interactions

Physical, chemical and biotic interactions in soils are intimately related to all aspects of land use and management, and hence to their impact on biodiversity. The combined interactions between soil, vegetation and atmosphere control the flux of water evaporating into the atmosphere and flow to rivers and aquifers. Quantification of such processes is thus of fundamental importance in the management and assessment of water resources. Understanding of soils and soil processes, from the macro to the microbial scale, is essential to the description and prediction of the persistence and environmental impact of pollutants in soils and their movement into lakes, rivers and aquifers. An understanding is also necessary of soil/vegetation heterogeneity and how the dominant processes change over a range of time and space scales.

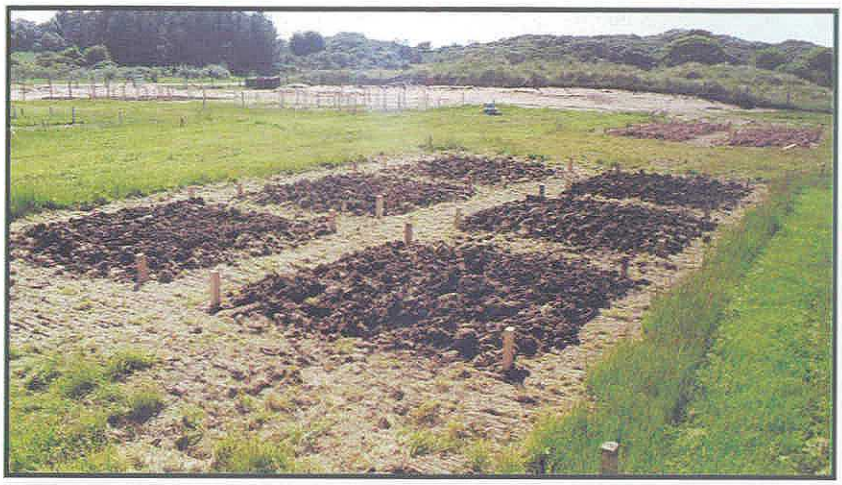
IH undertakes research on soil water measurements in many parts of the world. The photograph shows a scientist preparing a soil column for hydraulic conductivity measurements in central Amazonian pasture as part of the Anglo-BRazilian Amazonian Climate Observation Study (ABRACOS). The project was supported by the UK Overseas Development Administration.



The Windermere Humic Aqueous Model (WHAM) has been developed in order to interpret and predict the chemistry of aquatic and soil systems dominated by natural organic matter. The Figures show how the model is able to match observations of pH and dissolved organic carbon (DOC) in a sample of organic soil, titrated with acid and base. Such fitting is a prerequisite to understanding and predicting the responses of upland soils to changing loads of acidity, improvements in drainage, applications of lime, and climatic change.



The movement of pesticides is being measured through a heavy clay soil in Oxfordshire. Water flowing in the mole drains and field drains within the clays is automatically sampled for chemical analysis.



A study at ITE, funded by the Marine Pollution Control Unit, is testing the environmental acceptability of disposal, by burial and landfarming in sandy coastal areas, of oiled beach materials resulting from spills at sea. The research is centred on the processes of microbial degradation of hydrocarbons, the potential for hydrocarbon contamination of groundwaters, and the revegetation of disposal sites. The upper photograph shows the treatment plots at Eskmeals, Cumbria, where intensive studies are testing landfarming methods, and the lysimeters and meteorological station being used for manipulative experiments in the grounds of ITE's Merlewood Research Station are shown below.

Sap flow gauges are used to measure the transpiration rates of trees in an agroforestry project in Kenya, funded by ODA. The technique is one of a number used to separate the water used by different components of the soil/vegetaton system.

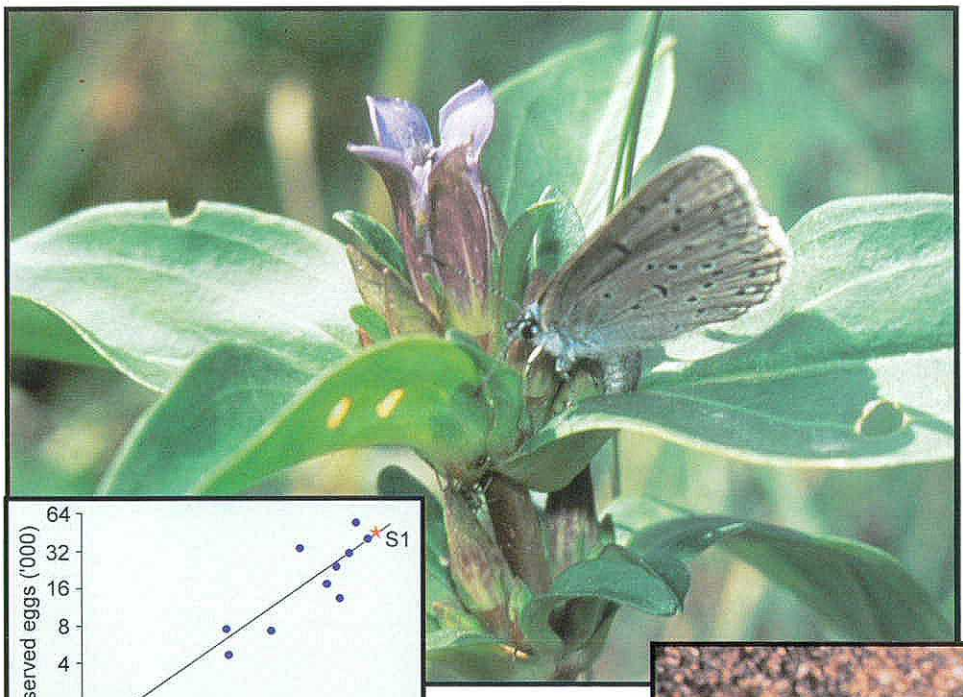
Key challenges being addressed are to:

- **define and understand the relationships between soil and vegetation processes, and use such understanding to detect, predict and reduce the adverse consequences of human activity in land, freshwater and coastal ecosystems;**
- **develop models of the flux of water through the soil/vegetation/atmosphere continuum, and use these to improve the efficiency of resource management;**
- **predict how major environmental change (including climate change) will affect soil and vegetation processes and the impact of such changes on water resources and land use.**

Biodiversity - monitoring, understanding and managing

The United Nations Convention on Biological Diversity places this topic high on the international agenda for research. Understanding biodiversity is necessary to guide conservation policies and to support the activities of the biologically based industries.

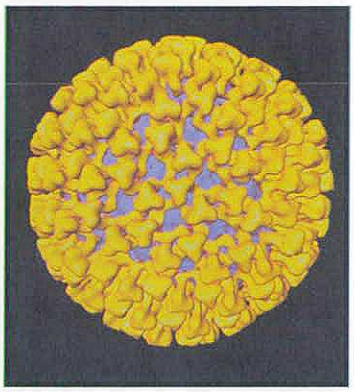
CEH research is directed towards improved understanding of the relationships between biodiversity and chemical, physical and biotic processes and interactions, including the impacts of management on terrestrial, freshwater and coastal environments. Understanding the factors and processes that are responsible for determining the abundance and distribution of organisms in freshwater and terrestrial environments, and which help to maintain community diversity, is essential for the conservation of important or endangered species. It is also important to quantify the extent of genetic variation in natural populations, to investigate mechanisms of population differentiation and speciation, and to develop genetic markers for application in studies of breeding biology, dispersal, gene flow and population structure.



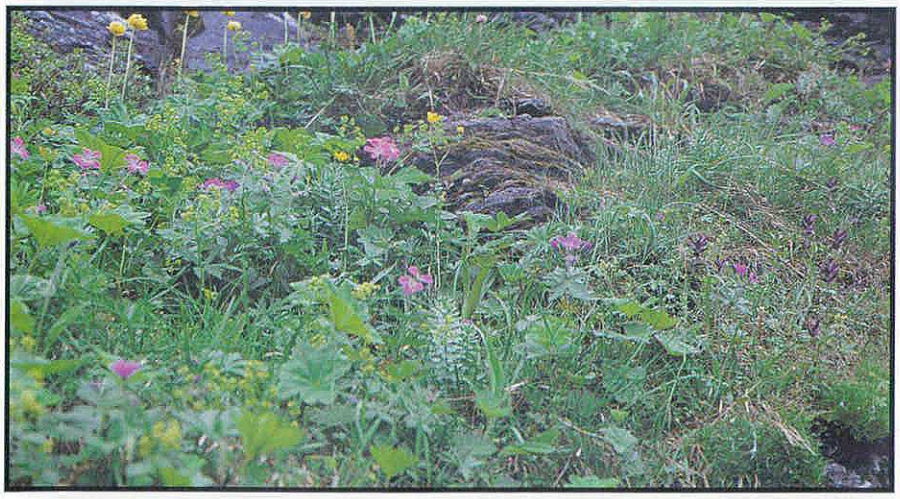
ITE has been studying the world's most endangered butterflies. As a result of its research, the only British species of large blue butterfly (Maculinea arion), *which became extinct in Britain in the 1970s, has been re-established. The photograph shows a female large blue butterfly* (Maculinea rebeli) *laying eggs on gentian* (Gentiana cruciata), *the foodplant of its caterpillars for the first three weeks of life. The lower photograph shows young caterpillars which are soon adopted into* Myrmica *ant colonies, where they live for 11 months, mimicking the ant grubs and being fed by worker ants.*

The ability of a stochastic spatial model of butterfly/ant interactions to predict the population size of Maculinea rebeli *butterflies, measured in the egg stage, on 13 other sites in the Pyrenees and Alps. The model was constructed from field and laboratory measurements of 18 parameters affecting the butterfly, ants and gentian (the butterfly's early larval foodplant), with field data originally parameterised from a single site (S1) in the Spanish Pyrenees. The final version of the model explains 92% of the between-site variation in* M. rebeli *population size across these mountain ranges, and can therefore be used with confidence to simulate different options for the conservation of this globally threatened species of large blue butterfly.*

The upper photograph gives an impression of the natural abundance and diversity of ciliated protozoa. In lake sediment placed in a glass chamber (1 cm wide) oxygen consumption exceeds supply, so the aerobic ciliates move upwards, following the retreating oxygen.



Reconstruction of a bluetongue virus core from a cryo-electron micrograph at 25 Å resolution, showing VP7 trimers (yellow) and the underneath scaffolding layer of VP3 molecules (purple).



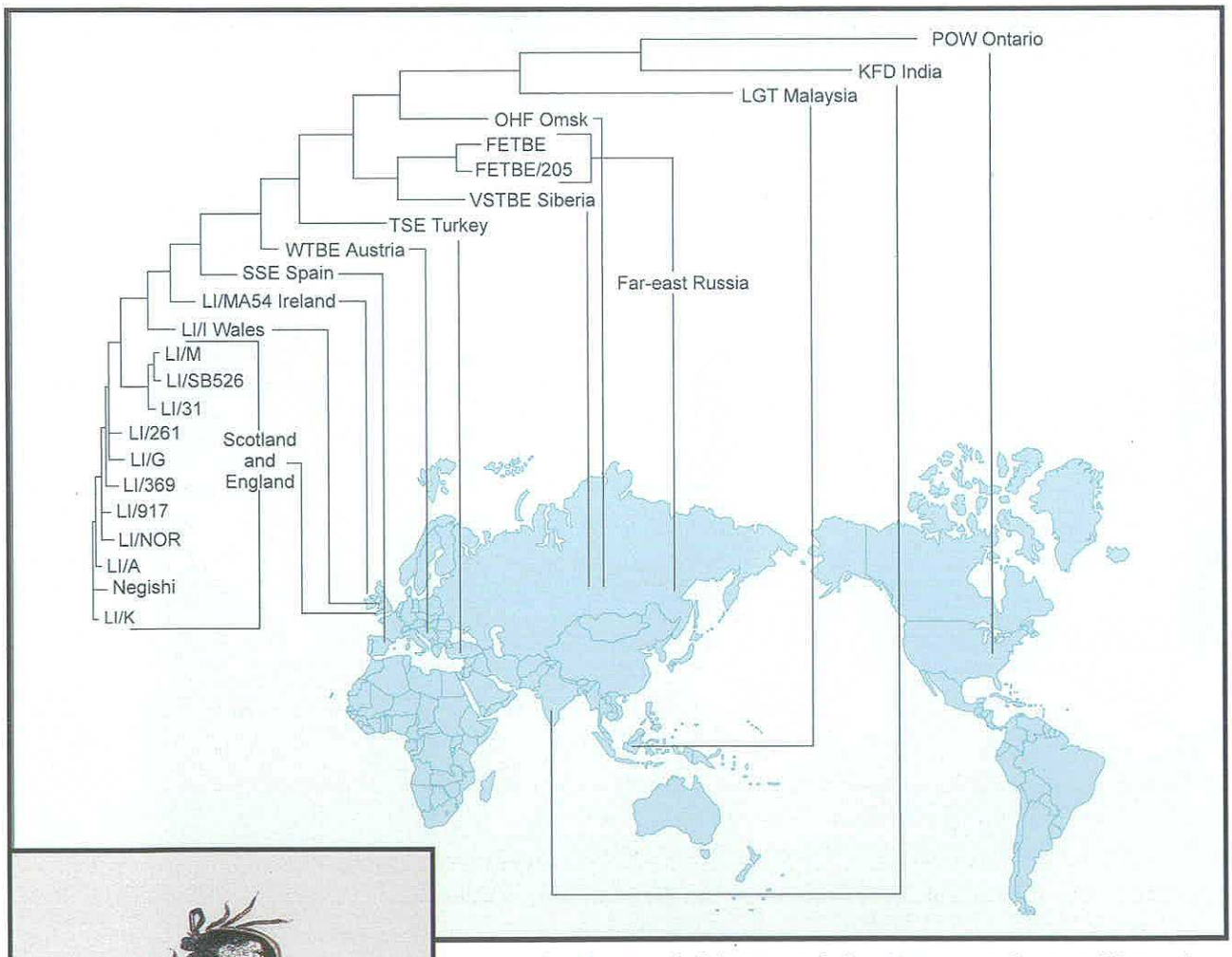
High plant species richness on Scottish alpine rock ledges is found almost exclusively on inaccessible (ungrazed) basic rock. The role of high pH in promoting species richness in this environment is still an enigma; in other continents many of the most species-rich communities are on acid soils. The effects of sheep and deer grazing in Scotland are better understood and are the subject of long-term research by the Institute of Terrestrial Ecology.

The key challenges are to:

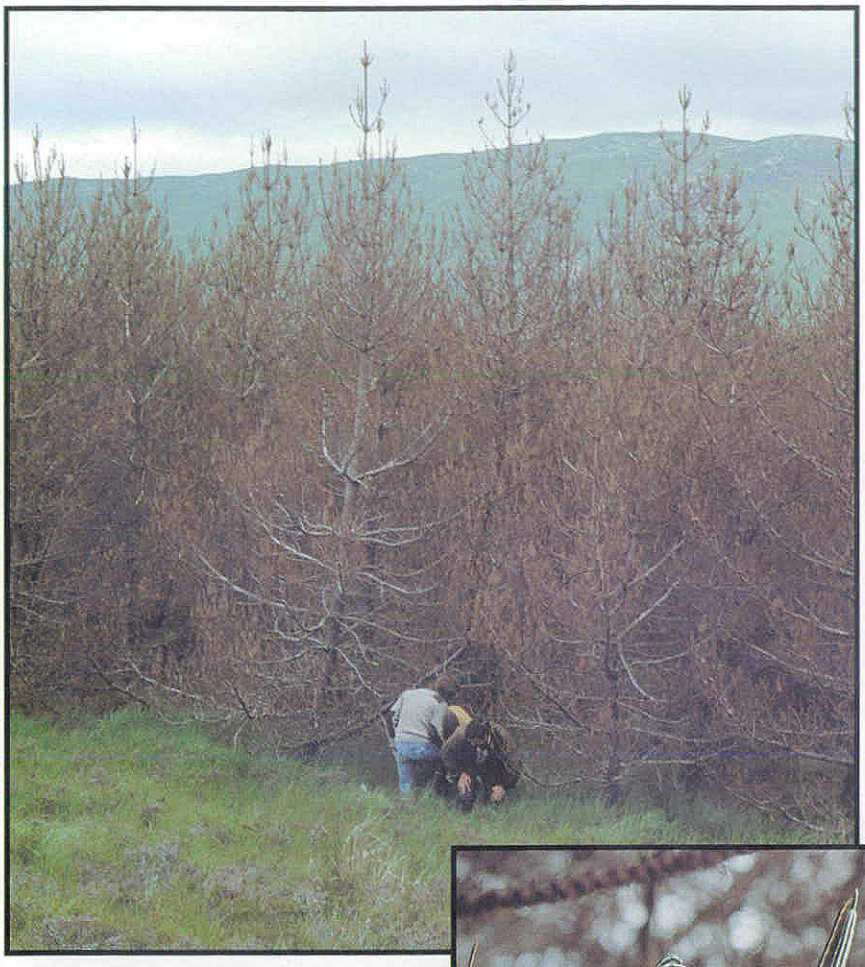
- **determine the factors controlling and maintaining biological diversity;**
- **develop the ability to model and predict the consequences for populations and communities of environmental change at a variety of spatial scales, in order to underpin strategies for wildlife conservation and the enhancement of biodiversity;**
- **quantify the extent of genetic variation in populations and predict the consequences for populations in relation to environmental change at both local and global scales;**
- **enhance our ability to identify and exploit natural biological and microbiological resources through better knowledge and understanding of biodiversity and the genetics and biology of species and populations.**

Biological and biotechnological control of pests and diseases

The programme is concerned with the development of new approaches and pathogens for the control of pests and diseases. This ranges from the use of pathogens (eg viruses, bacteria) for the control of pest species, to methods of controlling disease agents maintained by wildlife reservoirs and vectors. Thus the research includes the development and risk assessment of genetically modified viral and bacterial biopesticides (linked with the programme on environmental risks), the application of *Bacillus thurigensis* for controlling blackflies (simulids) in rivers, and the preparation and testing of vaccines. A key element of this programme is to develop control methods that are environmentally acceptable and technologically innovative, with the potential for wealth creation.



The mode and tempo of tick-borne encephalitis (TBE) virus evolution and dispersal can help to explain the dynamics of pandemics, epidemics and energy diseases. The cladogram demonstrates the mode of evolution of the tick-borne encephalitis virus complex. Assuming louping ill (LI) virus as the reference virus, a detailed phylogenetic analysis showed increasing sequence divergence in the west/east geographical orientation, indicating a cline. The key factor for this characteristic seems to be the tick, which imposes constraint on the dispersal of the virus. The inset shows the common sheep tick (Ixodes ricinus).



Deforestation by the pine beauty moth (Operophtera brumata): *a viral control agent has been developed for this pest at IVEM in conjunction with detailed studies at ITE on the role of other natural enemies in its regulation.*

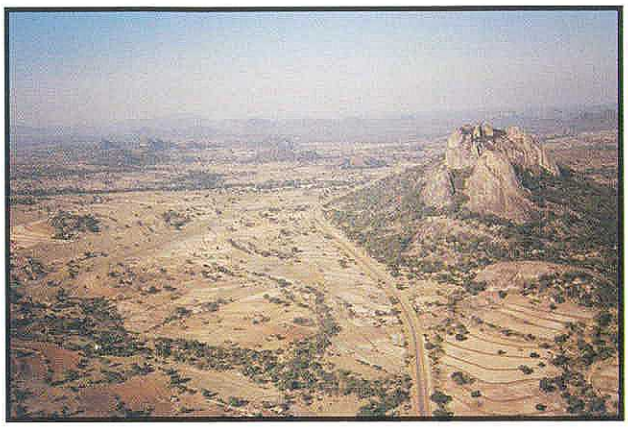
Larvae of the pine beauty moth attacking lodgepole pine (Pinus contorta).

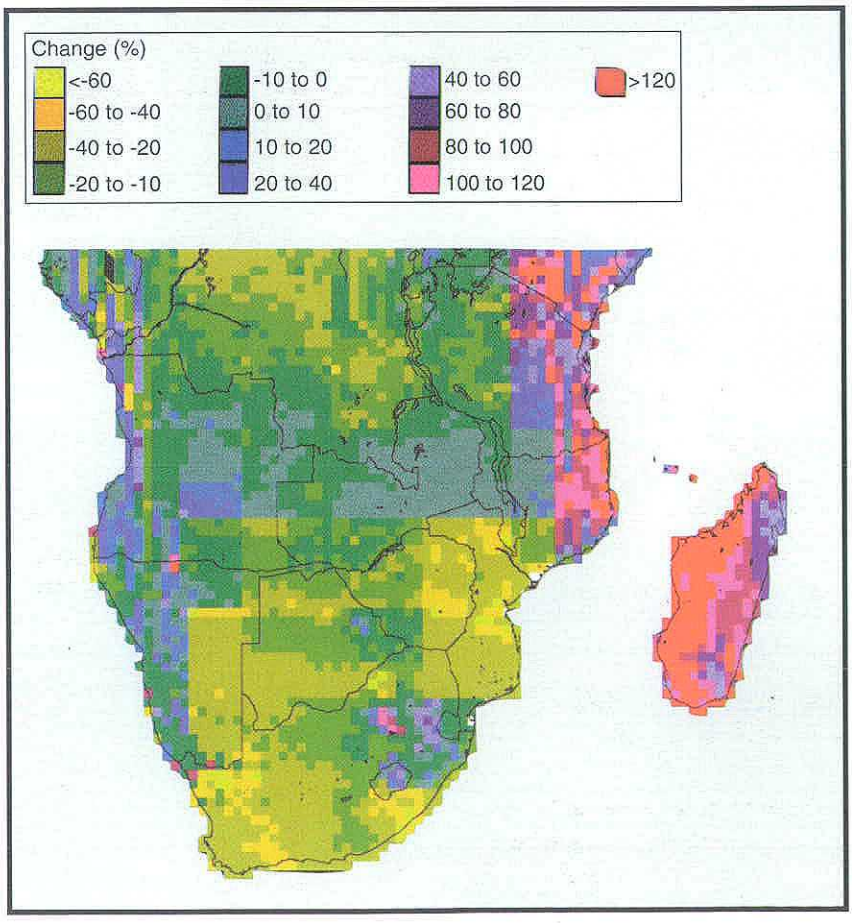
The key challenges are to:

- **explore and expand the range of naturally occurring pathogens which can be utilised for the control of disease vectors and the pests of agriculture and forestry;**
- **develop and assess the environmental safety of novel means of pest control using genetic modification;**
- **understand the processes of disease maintenance and transmission in order to assess and maximise the efficacy of new control methods;**
- **identify the components of host/pathogen interactions at a molecular, cellular, organismal and population level to identify and target control methods.**

Global change

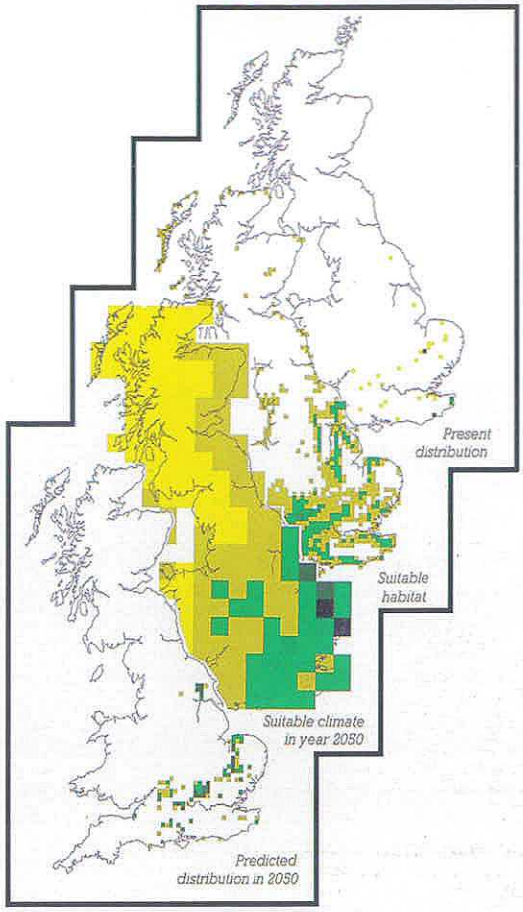
Scenarios derived from global atmospheric models are used to assess the impacts of global change on the hydrological and biogeochemical cycles. Changes in these cycles may alter the yield of existing or planned water resources and the size and frequency of floods and droughts. Raised temperature, atmospheric carbon dioxide and UV-B radiation resulting from such changes will affect terrestrial and freshwater ecosystems. A better representation of the hydrological and biological processes in the global atmospheric models should lead to an improvement in the predictions and scenarios, and hence in our ability to plan for change.





The changes in climate due to increasing levels of atmospheric carbon dioxide can be modelled by General Circulation Models (GCMs). Such models provide scenarios to assess the potential impact of global warming on hydrological and ecological systems.

Within CEH, IH has taken such scenarios and applied them to a series of hydrological models in a number of regions around the world. The photographs show a fragile southern Africa environment in Zimbabwe, potentially very sensitive to climatic and hydrological change. The modelled change in annual runoff for the region is shown in the map for the year 2050. Much of southern Africa, already prone to extreme drought events, experiences a further decrease in runoff, while some currently wet regions, such as Madagascar, show substantial increases.



Lizard orchid (Himantoglossum hircinum) – *distributions of certain plants are predicted to change with a warming climate. The maps show the suitable habitat and climate for the lizard orchid, and its predicted distribution in the year 2050.*

An open-top chamber at ITE Edinburgh where studies on the impact of elevated carbon dioxide on the status of forest pests are being carried out.

The key challenges are to:

- **improve the representation of hydrology and biology in global atmospheric models, enabling better predictions of global environmental change;**
- **predict the impact of global environmental change on natural ecosystems, water resources and land use/agriculture, at regional and global scales.**

Environmental risks, including rare events

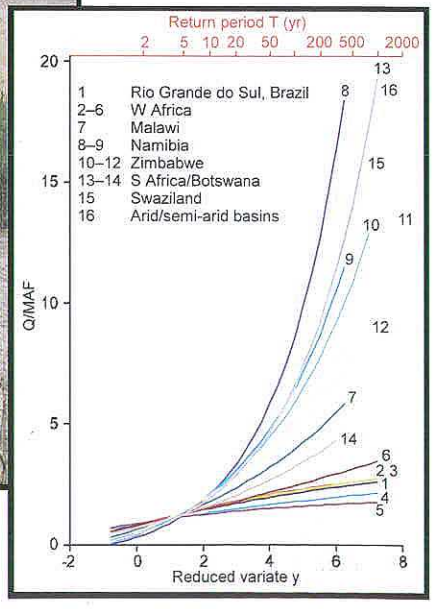
There are several distinct components to CEH research within this sector. Advanced techniques will be developed for assessing the frequencies of extreme rainfall excess or deficit leading to floods or drought of different durations and spatial extents. Methods for modelling the temporal and spatial dependence of hydrological extremes using integrated hydrological catchment models, including water quality, are particularly important. One element of this research is forecasting hydrological extremes using integrated hydrological catchment models coupled with real-time river flow data and precipitation fields estimated from radar.

A second aspect is concerned with the impact of rare events, such as forest or heathland fires, unusually cold winters, drought, exceptional winds, epidemics of disease, unusually high densities of pests, or loss of a key predator on ecosystems. Increasingly, ecologists are finding that the dynamics of many systems are dominated by such rare, extreme and often unpredictable events.

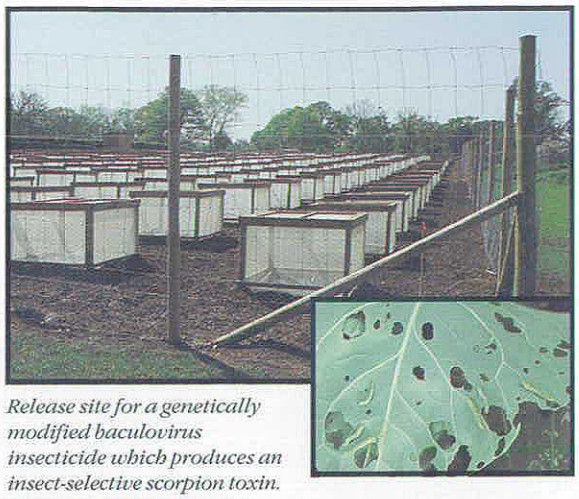
The third aspect to the research is concerned with the risks to the environment associated with releases of genetically modified organisms (GMOs). This is closely linked with the CEH programme on the biological and biotechnological control of pests.

Floods can pose a severe risk to human life and to infrastructure, and flash floods such as this are both difficult to forecast and expensive to design against. IH is working towards improved methods of flood forecasting and more reliable means of designing engineering works for flood protection.

Floods affect more people worldwide than any other natural hazard. Research by IH staff is aiming to improve methods of flood prediction by enabling hydrologists and engineers to estimate the flood magnitude with a given risk of exceedance (return period) for regions with little or no flow data. Q/MAF is a dimensionless ratio of flood peak over the mean annual flood, and curves for a number of African countries are shown below.



The past summer in Britain has been characterised by extremely low rainfalls and runoff. Concern has been raised as to the level of reliability of water supplies in such extreme droughts. CEH research provides objective techniques for estimating the severity of such droughts and also provides planners and engineers with methods for designing surface water sources capable of meeting demand during such extreme events.



Release site for a genetically modified baculovirus insecticide which produces an insect-selective scorpion toxin. The production of the toxin means that pest caterpillars (see inset) are killed more rapidly, resulting in less damage to the crop. IVEM are using this as a model system to assess whether there are any risks attached to the release of genetically modified biopesticides.

Wild cabbage in grassland on the cliff tops in Dorset which are the subject of genecology and virus impact studies in context with GMO releases.

The key challenges are to:

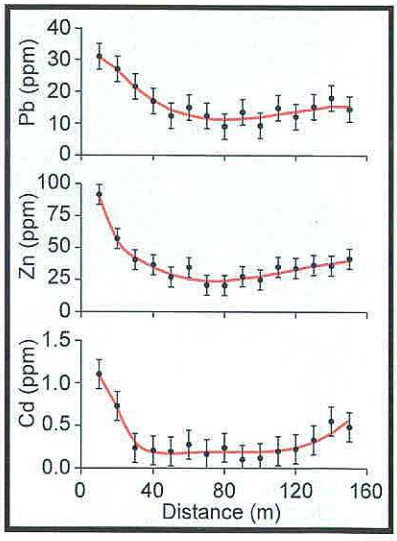
- **develop generic methods for the statistical estimation of risk of environmental extremes and the minimisation of environmental, economic and social impacts;**
- **develop and implement decision support systems for river flow and water quality forecasting, based on real-time data collection;**
- **understand and model the role of rare events in relation to ecosystem processes;**
- **predict, and thereby avoid, hazards that may be associated with releasing GMOs into the environment.**

Pollution assessment and control

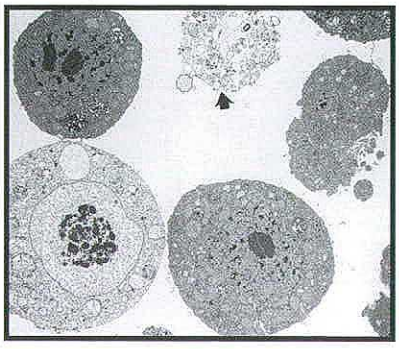
Within this programme the physical, chemical, hydrological, sedimentological and biological processes that determine the dynamics and impacts of all types of pollutants in air, land, freshwater and coastal regions will be measured and modelled. Research is also concerned with improving biological methods for detecting pollution through investigation of behavioural, physiological, cellular, and genetic responses of a range of organisms. It includes research on environmentally acceptable methods of waste disposal and on bioremediation and restoration of contaminated land and water. An important facet of the work is the application of the critical loads concept, to predict the consequences of atmospheric deposition of various types of air-borne pollutants on land and water with differing baseline geology and chemistry.

Major pollution incidents such as that which followed the explosion at Chernobyl, or the major industrial pollution of the Rhine, are distinguished by their rarity. The scale of resultant impact largely depends on the dynamics of the pollution dispersal, which is governed by the hydrological conditions prevailing at the time of, and immediately after, the event.

Pollutants can arise from a range of local or diffuse sources. Unless carefully located and managed, waste from landfills of the type shown above may lead to pollution of both surface and underground water. CEH is using existing and developing new mathematical models to predict the impact on the environment of the polluting materials flowing from such wastes.



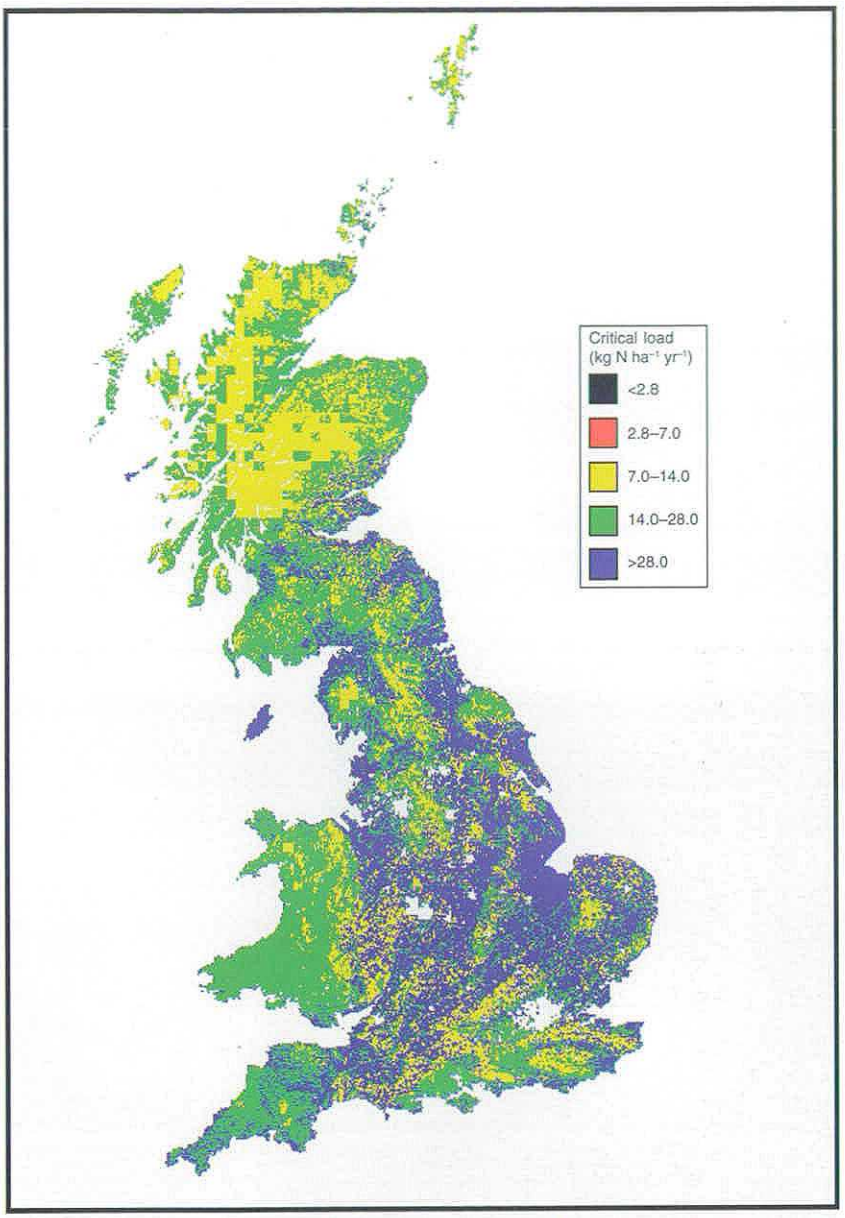
Heavy metal contamination along a transect leading away from a polyethylene warehouse destroyed by fire on a site occupied by a ruined Roman temple. Heavy metals provide very useful markers to assess the exent of terrestrial pollution resulting from plastics fires as many plastics contain high levels of heavy metals in their formulation (as colorants, plasticisers, flame retardants and stabilisers).



An electronic micrograph from IVEM of an insect cell culture, showing a lysed cell at different stages of damage.

Scientists at ITE Monks Wood are studying the effects of toxicants on earthworms. The photograph shows the experimental containers being positioned in the field.

On-site pollution resulting from a fire at a plastics recycling plant. This fire resulted in large quantities of heavy metals and organics being deposited in a neighbouring Scots pine (Pinus sylvestris) *plantation.*



A map produced by the Environmental Information Centre at ITE Monks Wood, showing critical loads of nitrogen for coniferous forest in Britain.

The key challenges are to:

- **describe and model the transport and fate of a wide range of pollutants, whether from point sources, such as waste disposal sites, or from diffuse sources, through the air, land and aquatic environments;**
- **determine the impacts of pollutants on water and land resources, organisms and communities, and develop strategies for their control and remediation;**
- **predict accurately the dispersal characteristics, fate and impacts of pollutants released into the atmosphere, water or on to the land following major industrial incidents.**

Cross-sectoral research

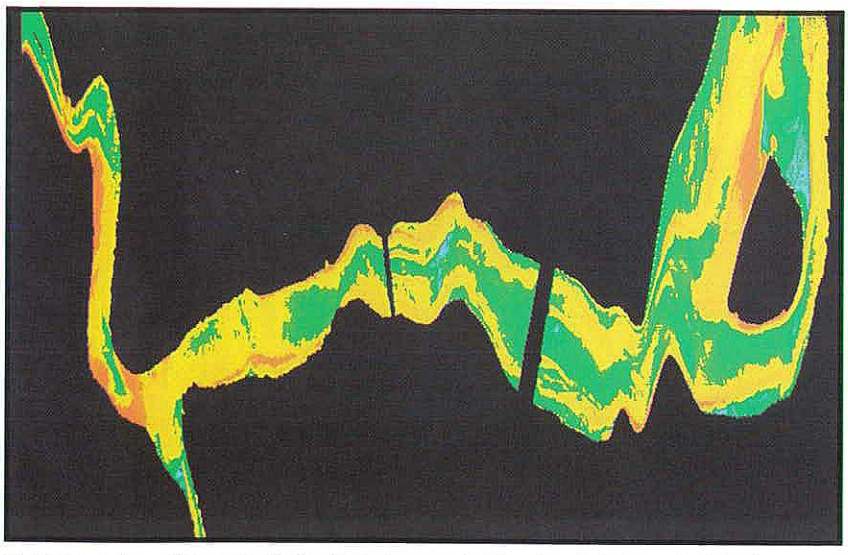
A number of CEH research activities are cross-cutting, often dealing with new and innovative technology, and are vital to the success of many of the more traditional research areas. Primarily these activities are concerned with:

- remote sensing
- national environmental databases, computing and collections
- instrumentation

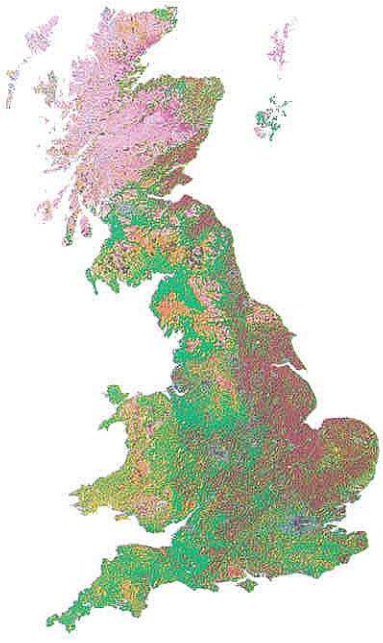
Remote sensing

Remotely sensed data from both aircraft and satellites have a very wide range of applications in environmental science at a wide range of spatial scales. CEH plays a prominent role in the interpretation and validation of remotely sensed data, and in the development of new applications as additional instrumentation and technologies become available. Applications include:

- land cover mapping and detection of environmental change in Britain;
- information gathering for the management of resources in arid lands;
- mapping changes in intertidal zones in relation to feeding areas for waders;
- determining the distribution of phytoplankton in rivers;
- detecting areas of deforestation and regrowth in tropical forests.



This image shows the suspended sediment concentrations in a tidal stretch of the river Ouse, north of Goole, on 2 August 1994. Low concentrations, shown in green, typify the centre of the river and the lee of the island, whilst high concentrations, shown in red, are found where the flow separates from the banks and the island and near bridge piers. The image is the result of processing data from the Compact Airborne Spectral Imager (CASI) mounted in the NERC aircraft. The high spectral resolution of this instrument provides the opportunity to develop novel methodologies for monitoring the spatial distribution of water quality parameters.



Land Cover Map of satellite-derived data for Great Britain, produced at the ITE Environmental Information Centre, gives 25 classes of land cover at a 25 metre resolution.

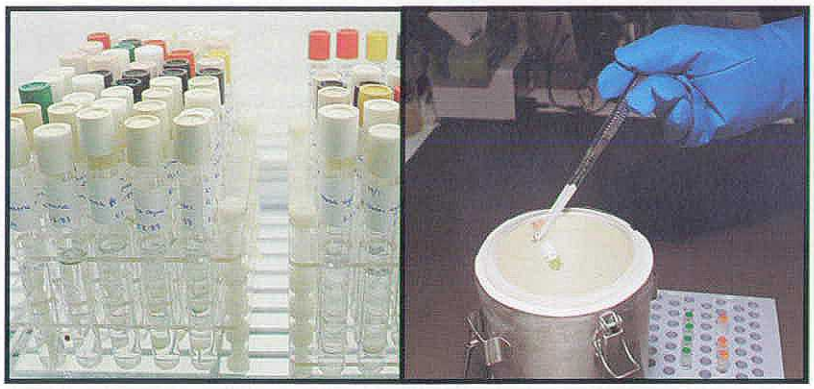
The key challenges are to:

- **develop algorithms to interpret remotely sensed data so as to improve understanding of ecological and hydrological processes;**
- **advance terrestrial and freshwater science by the use and interpretation of datasets from new sensors;**
- **extend existing data based on remotely sensed imagery and develop new datasets to meet the emerging requirements of the NERC user community.**

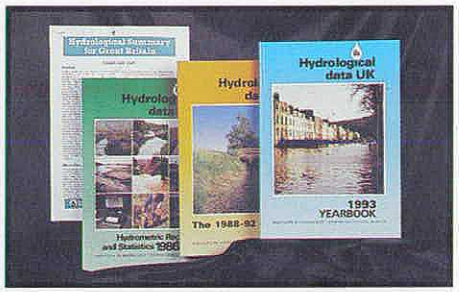
National environmental databases, computing and collections

CEH has an important national role in the collecting, collating and monitoring of environmental data. The ITE Environmental Information Centre (EIC) is an important repository of such data. For example, the distributions of over 16 000 species are held in the Biological Records Centre of the EIC. Data on the fauna of rivers throughout the UK are managed by IFE. These databases provide a resource for biogeographical research using advanced statistical and spatial modelling methods, whilst a knowledge of the geographical distribution of species underpins much ecological research and conservation work.

The rational exploitation, site design and management of water resources depend on quality-controlled time series and spatial datasets, as do flood peaks and their frequency of occurrence. The collation, organisation and analysis of large datasets from the UK and overseas are managed by CEH. These include the UK National River Flow Archive which contains 13.3 million items of information, and the Environmental Change Network (p8).



Through IFE, CEH also maintains the Culture Collection of Algae and Protozoa as a source of material for research, with around 1700 strains of algae and protozoa. The photographs show ex situ *conservation of protistan biodiversity: the maintenance of algal cultures under environmentally controlled conditions (left), and the cryopreservation of algal cultures (right).*



The National Water Archive (NWA) is maintained by IH. The NWA team prepares the Hydrological data yearbooks *and the monthly* Hydrological summary for Great Britain.

The key challenges are to:

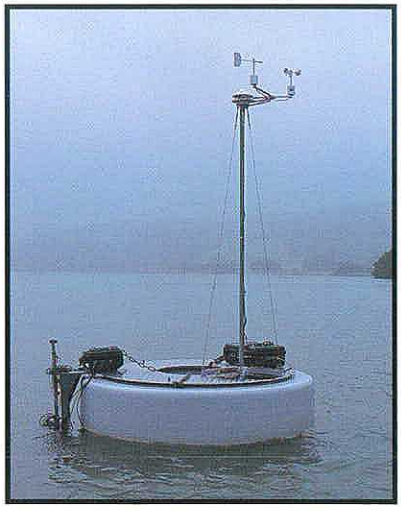
- **maintain the high quality of the existing national hydrological and biological data records and culture collections, and add new material;**
- **use predictive models to give an objective assessment of environmental quality;**
- **survey and monitor changing land use and predict the impacts on ecology and water resources;**
- **maintain the quality of the land classification, land use and other ecologically/ hydrologically related databases and secure their long-term integrity;**
- **make best use of GIS in the management, interpretation and presentation of the data resources;**
- **increase awareness, availability and usage of the data by the scientific, industrial and commercial communities and the public at large.**

Instrumentation

Experiments, environmental monitoring, manipulation and observation are vital components of CEH science, generating a need for instruments to perform and record the necessary measurements, often under harsh environmental conditions in remote areas. The degree of specialisation of the work of CEH Institutes often means that no suitable instruments can be obtained commercially. Where this is the case, CEH scientists have an impressive record of developing instruments to make measurements which were not possible previously. In some cases, a very expensive and rare facility needs to be set up.

Examples include the range of capacitance soil water sensors and atmospheric gaseous flux measurement systems developed by IH, radioactive pollutant detection equipment at ITE, atmospheric deposition collectors developed by ITE, and cryogenic electron microscopes at IFE and IVEM.

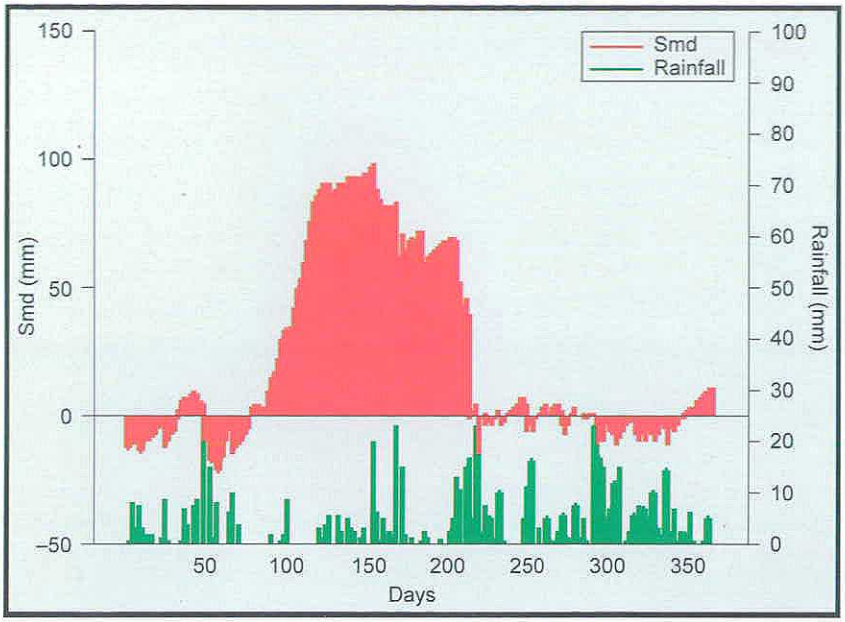
The emphasis in environmental instrumentation is moving away from the development of individual sensors and towards instrumentation *systems*, which record the measurements from an array of sensors in a co-ordinated fashion and allow several different environmental variables to be intercompared and/or combined. The IFE Automatic Water Quality Monitoring Station and the IH Automatic Soil Water Station are good examples.

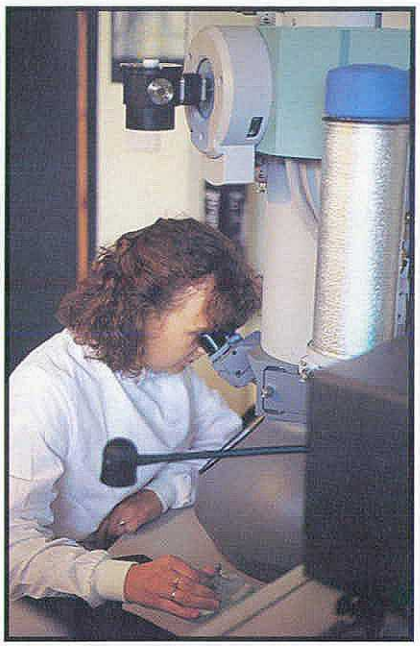


IFE has secured European Union funding to develop an automated network of water quality monitoring stations. The photograph shows the one on Esthwaite Water in Cumbria. These stations record a range of water quality and meteorological parameters. Data are transmitted by radiotelemetry to a shore station for retrieval by telephone modem. Initially seven stations will be deployed in Ireland, Spain and the UK. The project will demonstrate how this technology can improve our understanding of the response of freshwater systems to day-to-day changes in the weather.

A soil warming experiment by ITE on the crest of the Pennines in northern England has involved the design and production of a soil surface heating system to maintain soil cores in acrylic lysimeters, 3°C above that of similar controls. Lysimeter leachates and gas emissions are monitored for carbon flux with elevated temperature.

The Automatic Soil Water Station (ASWS), developed by IH, measures the key physical variables of the soil water content, water potential and temperature at three different depths on an hourly basis. The Figure shows measured soil water deficit at IH's Wallingford site over 1994, derived from the capacitance water content sensors of the ASWS. Other applications include flood hazard prediction, monitoring of soil water balances, aquifer recharge, and as an aid to measuring pollutant transport in the subsurface.





IVEM's cryo-electron microscope, a Philips CM120 cryo with the latest Oxford Instruments CT3500 cryotransfer system, was installed in 1994. This instrument was the first of its type in the UK and Oxford Instruments plc are world leaders in cryo-technology and are continuing to improve and develop cryo-EM in collaboration with IVEM. Cryo-electron microscopy enables scientists to investigate structural characteristics of viruses, bacteria, and/or any other type of microbe by observing them in frozen-hydrated state. The specimens are simply frozen rapidly in water without any preservatives or stains, and so their structure remains as it was in real life, albeit in 'suspended animation'. The cryo-images obtained are used to generate three-dimensional data using computer image processing techniques.

The key challenges are to:

- **to understand the basic environmental processes and issues sufficiently to specify, design, install and operate instrument systems for measuring the key variables in an appropriate manner;**
- **to develop instruments capable of monitoring an ever-increasing range of environmental variables;**
- **to make instruments capable of withstanding harsh environments (often with extremes of temperature, humidity and subject to flooding) for long periods;**
- **to design and operate instruments and logging systems over long periods unattended. This implies low power requirements and use of solar, wind, etc, energy.**

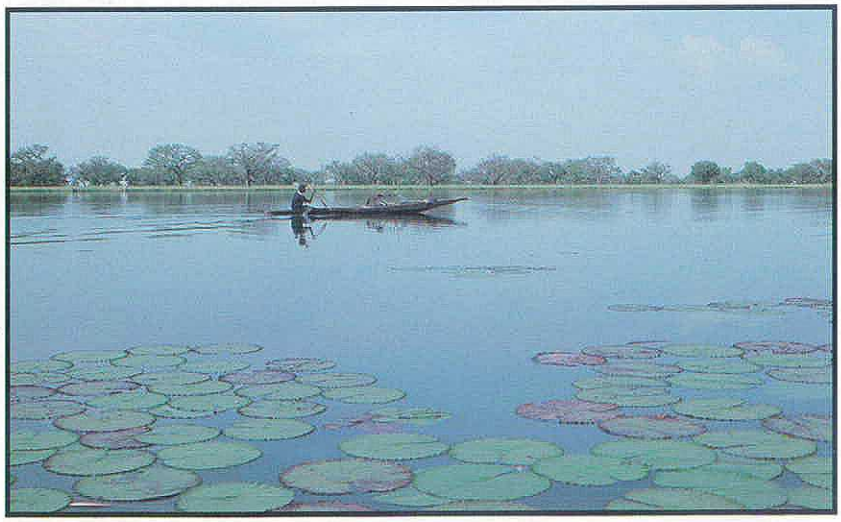
Environmental impact assessment and valuation

Evaluating the sociological and human health impacts of the environment and environmental change will provide the basis for cost benefit analysis of measures for environmental remediation and improvement. CEH has undertaken many research projects concerned with environmental impact assessment but only a very limited number of these have included any detailed consideration of economic or health-related issues. However, concern in relation to such issues is increasing, and this is a sector in which CEH plans to expand its core science. Close collaboration will be maintained with the Economic and Social Research Council and with the Medical Research Council.

Inadequate urban drainage can lead to flooding which may bring untreated sewage and street wastes into direct contact with people, and thus pose a serious health hazard. The picture shows the 1994 flooding in the centre of Lahore, in Pakistan. CEH's Institute of Hydrology is undertaking research within Lahore in collaboration with the Pakistan Centre of Excellence in Water Resource Engineering. The research will analyse and model urban floods and use the results to improve urban drainage design procedures in monsoon climates. The work is being extended to Kanpur in India and Dhaka in Bangladesh.

The restoration of natural and semi-natural habitats is increasingly becoming part of major civil engineering projects. Since 1991, when work started on the M3 motorway link at Twyford Down, ITE has been providing ecological advice to the consulting engineers, and has been responsible for the restoration of 7 ha of downland on areas of arable land and the relandscaped route of a defunct dual carriageway. Innovative methods have been developed and detailed botanical and invertebrate monitoring of the restoration is scheduled until 2004.

In developing the Wytch Farm oilfield beneath Poole Harbour and constructing the export pipeline to the Hamble Oil Terminal on Southampton Water, BP Exploration needed to take account of a range of conflicting interests. ITE has assessed the implications for semi-natural plant and animal communities of locating wellsites and associated structures in particular areas and so helped to choose optimal locations. It has also provided advice on route selection for pipelines and produced prescriptions for the sound restoration of disturbed habitats following pipeline installation.



Wetlands provide a wide range of important functions (including flood attenuation, nutrient removal, groundwater recharge, provision of wildlife habitat), products (such as fish, pasture land, fuelwood, medicines) and attributes (eg scenic beauty, historical/ cultural value). With funding from the Ramsar Convention for wetlands of international importance, in collaboration with the University of York, IH is producing guidelines for quantifying the economic value of these functions, products and attributes.

The key challenges are to:

- **model the pathways whereby pollutants impact on human health by ingestion in water or food or through inhalation;**
- **quantify the psychological and other health benefits of access to recreation in the countryside;**
- **predict the consequences on health of changing environmental conditions at a range of scales from local to global;**
- **estimate the real cost of environmental change to aid decision-making.**

Finance

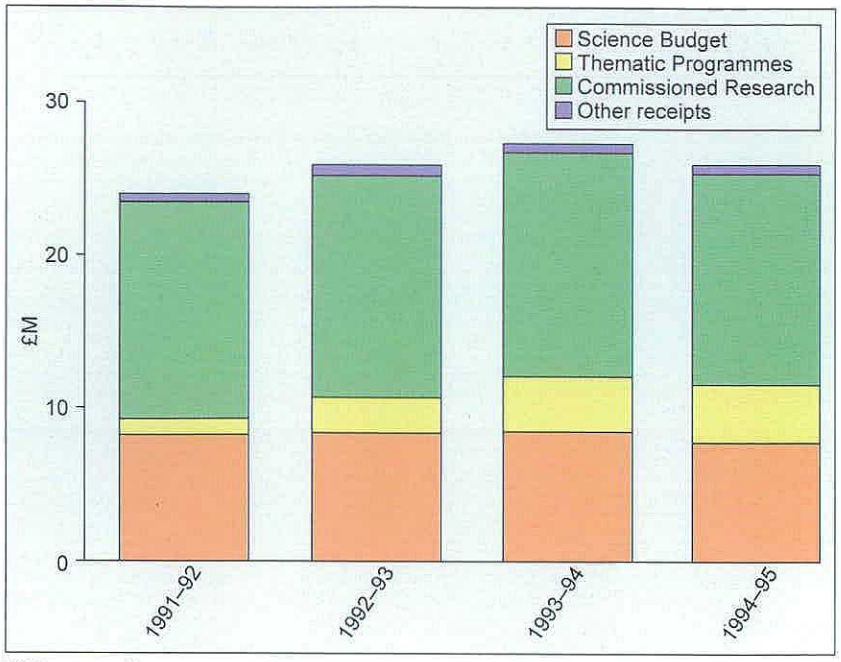
Science Budget

In the four years up to and including the formation of CEH, the level of Science Budget income available to maintain Institute infrastructure and core science first remained relatively stable in real terms but then fell in 1994–95. CEH Institutes have, however, successfully competed for NERC Thematic Programme funds and are currently receiving support under the following programmes:

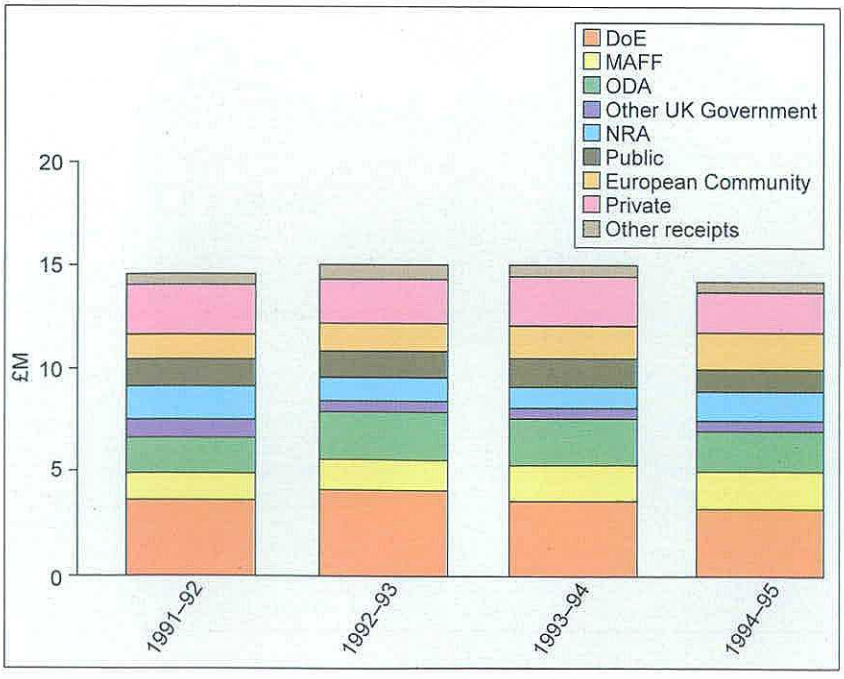
- Terrestrial Initiative in Global Environmental Research (TIGER)
- Land/Ocean Interaction Study (LOIS)
- Wildlife Diseases – NERC Special Topic
- Pollutant Transport in Soils and Rocks – NERC Special Topic
- Hydrological Radar Experiment (HYREX) – NERC Special Topic

Commissioned Research

A significant proportion of Institute income derives from customers for Commissioned Research. The synergy between CR activity and Institute research programmes brings added value to the core science. CEH wishes to continue to attract appropriate research, *complementing* core science work, although major departmental customers tend to offer to support *jointly* funded research, which creates pressures on limited internal funds available to Institutes for the core science. Similarly, whilst Institutes have been enjoying marked success in securing European Community funds, the terms of such support normally require matching funds to be identified by the Institute concerned.



CEH sources of income.



Receipts from major customers, 1991–92 to 1994–95.

The Figure above shows that, whilst income from all SB sources has grown slightly in real terms in three of the last four years, CR income has fallen. It is difficult for Institutes to forecast or respond quickly to a drop in funding over which they have no control. Their ability to market their skills to a broad range of customers in a variety of disciplines does, however, help limit the impact of reductions in particular areas. Thus, whilst income from the public and private sectors has been falling, support from UK Government customers has been stable overall, and EC income has increased, despite strong external competition.

For the future, it is anticipated that the holistic approach which CEH is able to adopt, and the establishment of new interdisciplinary teams, will be recognised more widely in the community. This should lead to an increase in Commissioned Research activity, particularly in the public and private sectors.

Indicators of performance

Qualitative and quantitative indicators used to assess performance and progress within CEH Institutes include:

- publications – papers, contract reports, books, popular articles
- peer review of projects and programmes
- the ability to secure research support
- the ability to secure commissioned funding
- qualifications/training
- commercial/industrial/HEI liaison
- support to the national and international scientific infrastructure, eg secondments to UK Government bodies, membership of scientific panels, committees and review groups, editing scientific journals and refereeing publications

Two key indicators which demonstrate the volume, depth and variety of CEH activity are publications and links, not only with UK Government departments, but also with Higher Education Institutions, commerce and industry.

Publications

Output of peer-reviewed publications, contract reports and authored books in CEH over recent years shows a rising trend. CEH Institutes, which account for approximately 20% of the staff within NERC, are responsible for approximately 35% of the annual NERC output of peer-reviewed publications. The level of contract reports has also risen, and in the three most recent years for which total NERC information is available (up to end 1993) approaching 50% of contract reports produced have come from CEH Institutes.

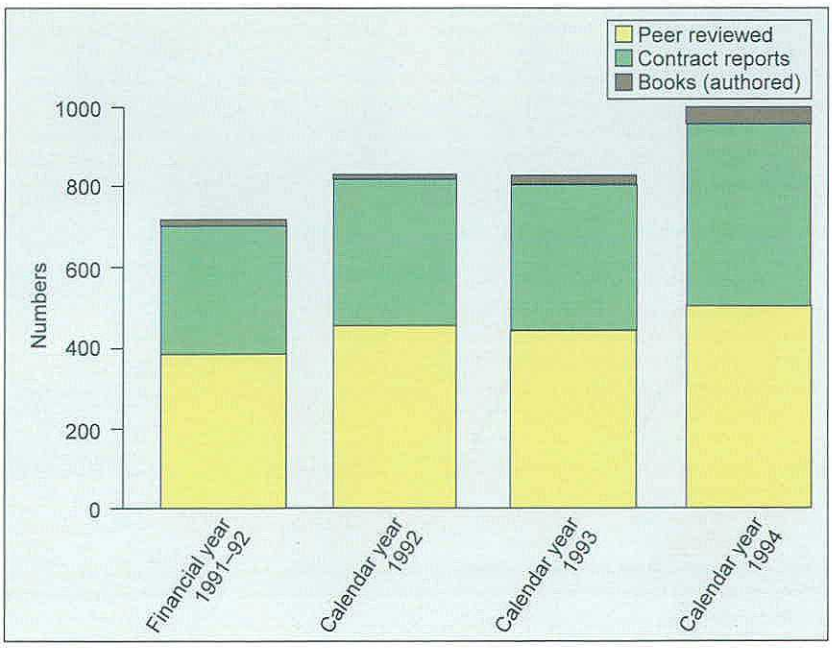
Links

CEH outreach involves a wide range of organisations. There are particularly strong links between CEH Institutes and the Higher Education sector. For example, there are memoranda of understanding with nine universities, 13 staff have Visiting Professor status, and some 258 students at 54 UK and ten overseas universities have Institute affiliations (see Appendix 3).

Insofar as industry and commerce are concerned, there are jointly funded projects, Commissioned Research contracts, and other links with approaching 200 organisations. Further details of the wide range of links, both formal and informal, in the UK and overseas, covering, *inter alia*, teaching, training, collaborative research and customer-funded work, are summarised in Appendix 4.

Plans for future collaboration include not only the maintenance and expansion of current links, but also the development of, and participation in, new Thematic Programmes and greater involvement in sectors which may be linked to bids to the National Technology Foresight Challenge Programme.

A wide range of indicators are used to assess performance and progress within CEH.



CEH staff publications.

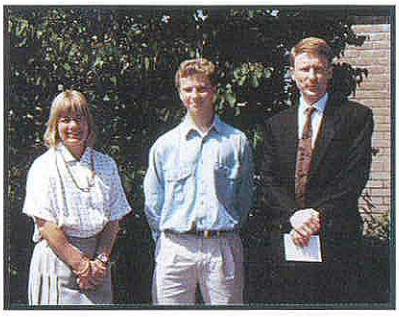
Staff

High-quality, well-qualified, well-trained and motivated staff are recognised as being the key resource of the Centre for Ecology and Hydrology. There are currently 629 staff in the organisation, of whom 182 are on fixed term appointments.

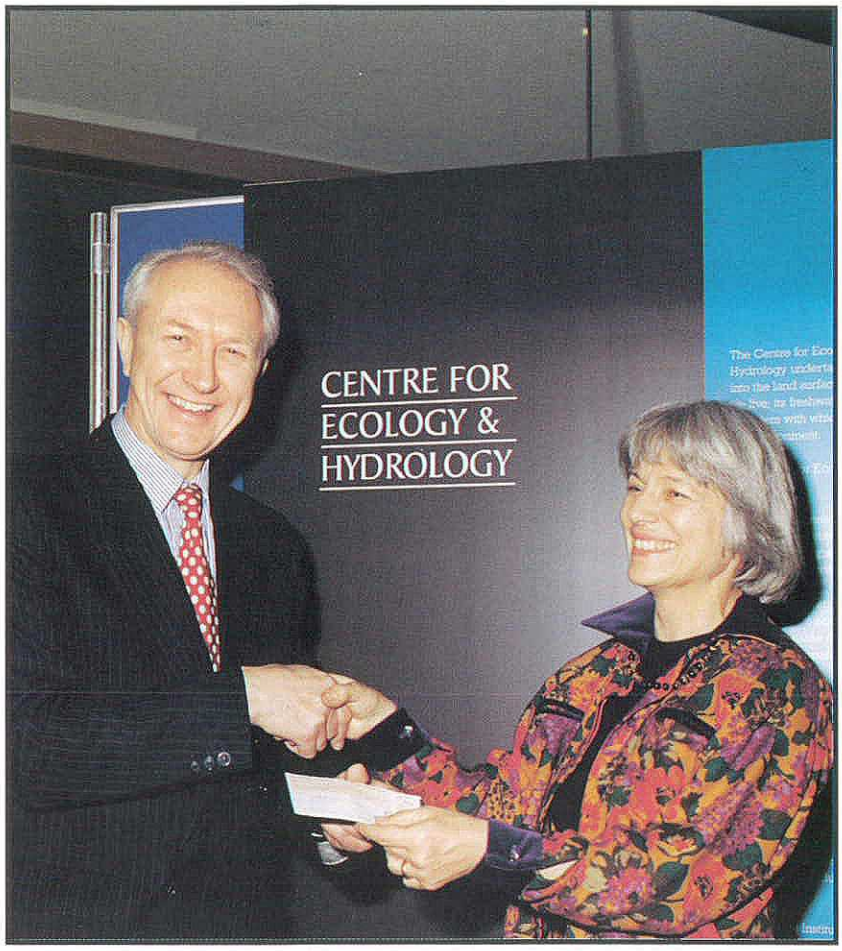
In addition to staff employed within CEH, some 45 visiting workers and 258 students (undergraduate, CASE and postgraduate) have been working in CEH Institutes during the year.

New areas of environmental science are emerging, and the mix of skills required to meet new challenges is changing. Through planned restructuring, NERC and CEH funds are being allocated to enable 21 staff to leave voluntarily on early retirement terms. This, coupled with careful management and a blend of new appointments, an active training programme, and imaginative and constructive introduction of students and other visiting workers, is helping CEH to meet these new challenges.

CEH site addresses and senior staff are listed in Appendix 6.



CEH scientists are encouraged to liaise with schools. Visits to Institute sites are welcomed, lectures are given and competitions held. The upper photograph shows Adam Wheldon (centre) who was the winner of the 1995 IH Environment Prize. He is seen with Jenny Preston, Head of 6th Form at King Alfred's School, Wantage, and Dr Andrew Etherall, IH Schools Liaison Officer. Adam's essay The Stenton-Hanney Reservoir *was a well-balanced, structured piece that demonstrated a wide understanding of the issues involved. The lower photograph shows schoolchildren from a local secondary school using the culture kit for microbiology and technology, developed and marketed by the Culture Collection of Algae and Protozoa.*



Professor Brian Wilkinson, Director CEH, presenting a cheque to Virginia Purchon, Secretary of the Action for Biology in School Initiative, in support of sponsorship for the 1995–96 Action for Biology in Schools Programme, at the official launch.

APPENDIX 2

Thematic Programmes

The NERC Thematic Programmes support basic and strategic research and training of the highest quality, targeted at specific themes arising from the NERC mission and identified through the National Technology Foresight Programme and the NERC strategic planning process. Several of the Thematic Programmes have CEH scientists as Programme Secretaries or Managers. The CEH Institutes bid into the programmes for research funding, often in collaboration with university partners. CEH is involved with two major Thematic Programmes – TIGER (Table 1) and LOIS (Table 2), and with a number of small ones (Table 3).

A total of 128 awards have been made to 42 organisations.

Terrestrial Initiative in Global Environmental Research (TIGER)

The £20M Directorate of Science and Technology programme is organised and run by CEH scientists. The programme is divided into four main parts:

TIGER 1 Carbon cycle on land
TIGER 2 Sources and sinks of trace greenhouse gases
TIGER 3 Influence of the water and energy budgets
TIGER 4 Impacts of global change on terrestrial ecosystems

The primary mode of funding is through consortia who address objectives set by the TIGER Steering Committee. In addition, there were three calls for Special Topic projects that were in responsive mode. Within TIGER there was also support for joint initiatives with the Biotechnology and Biological Sciences Research Council (BBSRC) Biological Adaptation to Global Environmental Change (BAGEC) Thematic Programme, concerning facilities for manipulating carbon dioxide and UV-B radiation. Support is provided for the TIGGER, or Geology in TIGER programme, and for designated Environmental Change Network sites. A total of 128 awards have been made to 42 organisations.

The programme manager is Mr Max Beran (IH). His office acts as Secretariat for the Steering Committee and maintains records, both scientific and financial. He is supported by three scientific co-ordinators: TIGER 1 and 2, Mr Graham Bell (ITE); TIGER 3, Dr Howard Oliver (IH); TIGER 4, Dr Clive Cummins (ITE). Co-ordination of the TIGGER programme has also recently been taken over by Dr Oliver. This team reports to committees for each area who are responsible to the Steering Committee for the overall policy and control of their part of the programme.

All proposals for funding within this directed programme were internationally peer reviewed, and CEH Institutes were successful in a significant number of cases. TIGER projects are grouped into consortia, and these are listed in Table 1, indicating involvement by CEH and other institutions, including universities.

Table 1. TIGER projects, showing CEH involvement.

TIGER consortia	*CEH Institute*	*University*	*Other*
TIGER 1 – Carbon cycle on land			
Modelling the terrestrial carbon cycle	ITE	Edinburgh	
Carbon flux in tropical forests	ITE	Edinburgh, Swansea, Southampton	
Role of biodiversity in carbon flux		Leeds	CPB, NRI, Natural History Museum
Carbon storage and turnover in upland communities	ITE	Lancaster, York	
Carbon turnover in upland soils	ITE, IFE	Reading, Bristol	
Microbiological processes in the terrestrial carbon cycle	IFE, ITE	Liverpool, Warwick Liverpool – John Moore	
TIGER 2 – Trace greenhouse gases			
Processes and production of methane	ITE	Queen Mary, Westfield College, Essex, Edinburgh	
Processes and production of nitrous oxide	ITE	Dundee	Scottish Agric Coll
Field and regional scale emissions of trace gases	ITE	UMIST, Edinburgh, Open University	
Oxidation processes in the troposphere	ITE	East Anglia, Birmingham, Lancaster	
Global modelling of the atmosphere methane budget		Cambridge, Nottingham	
TIGER 3 – Energy and water budget			
Water energy and carbon budget in a tropical forest	IH	Edinburgh, Lancaster	
Water and energy in Soil/Vegetation/Atmosphere Transfer (SVAT) schemes	IH	Lancaster, Reading, Edinburgh, Stirling, Swansea, UCL	NUTIS
Continental-scale hydrological modelling	IH	Newcastle, UCL, Imperial College	
TIGER 4 – Impacts on ecosystems			
Physiological change as a consequence of climate and CO_2 change	ITE, IFE	Essex, Lancaster, Sheffield, Bangor, UCL	
Impact of change on population dynamics of species	ITE, IFE	East Anglia, Durham, Lancaster	
Impact of change on the interaction between species	ITE	Sheffield, Aberdeen, Birmingham, Exeter, Oxford	
Impact of change on ecosystem structure and function	IFE	Reading, Imperial College	UCPE, CABI
Effects of climate change at regional and landscape scales	ITE, IH	Cranfield, Oxford, East Anglia, Durham	UCPE
Influences of climate change on the global distribution of biomes	ITE, IH	Cranfield, Sheffield	Hadley Centre

NERC/BBSRC joint programme			
Feasibility studies of facilities for large-scale CO_2 manipulations		Essex Sussex	Silsoe Research Institute
Impact of UV-B radiation on natural large-scale CO_2 manipulations	ITE	Essex Cambridge Lancaster	 UCPE
Insect/vegetation interactions	ITE	Lancaster	

Appendices

APPENDIX 1

Integrating fund projects

The following projects have been identified by Directors as being suitable for full scientific collaboration between two or more CEH Institutes. The projects are funded from Science Budget (see Director's introduction).

Project title	*Collaborating Institutes*			
	IFE	*IH*	*IVEM*	*ITE*
Hydrological and ecological significance of shallow subsurface processes on upland water quality	●	●		●
Upland forest canopy closure – its significance for chemistry, ecology and hydrology	●	●		●
Combined growth and water use modelling of mixed vegetation		●		●
Combined hydro-ecological and socio-economic models of land use, land management and environmental degradation – CHASM project		●		●
Modelling the chemical availability of radionuclides in upland organic soils	●			●
The role of microbial diversity in regulating ecosystem function	●		●	●
The development of a whole-catchment lake eutrophication model by the integration of a nutrient leaching/runoff model and a lake eutrophication model	●	●		
The microbial basis of methane oxidation in soils	●		●	●
Interactions of viruses, aphids and wild *Brassica* – a GMO impact study			●	●
Molecular genetics and process level events in the biodegradation of xenobiotics in rhizosphere soils			●	●
Role of seabirds in the epizootiology of lyme disease			●	●

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NERC/BBSRC joint programme			
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Impact of UV-B radiation on natural large-scale CO_2 manipulations	ITE	Essex Cambridge Lancaster	 UCPE
Insect/vegetation interactions	ITE	Lancaster	

The programme combines marine, geological, freshwater and terrestrial science.

Land–Ocean Interaction Study (LOIS)

LOIS is a £20M NERC Thematic Programme, managed by the Centre for Coastal and Marine Sciences (CCMS). The programme combines marine, geological, freshwater and terrestrial science, and CEH Institutes are involved in many aspects of the research. The LOIS river basin science is concerned with the quantification of river fluxes (physical, biological and chemical) to the marine environment and the modelling of future fluxes under a range of scenarios. The study area covers the catchments and coastal zone extending from The Wash to the Tweed estuary. The river basin component has about 25% of the LOIS budget and is managed by Mr Graham Leeks (IH).

The river basins core science includes:

- operation of large-scale river monitoring networks;
- measurement of atmospheric deposition;
- physical, chemical and biological analysis of water and sediment samples;
- remote sensing;
- database development and predictive modelling.

The LOIS programme has support from and collaboration with the National Rivers Authority (NRA) and the Tweed River Purification Board. There are a number of associated projects funded by the Department of the Environment, the Ministry of Agriculture, Fisheries and Food and the NRA.

CEH Institutes also participate in LOIS Special Topic projects and this involves collaboration with many university research teams. All proposals for funding under the LOIS Special Topics were subject to national and international peer review. Those Special Topic projects involving CEH Institutes are listed in Table 2.

Table 2. LOIS Special Topic projects, showing CEH involvement.

Special Topic projects within LOIS	*CEH Institute*	*University*	*Other*
LOIS – Rivers The propagation of changing riverine chemical signals in estuaries and coastal regions of freshwater influence	IFE IH	Southampton	Plymouth Marine Laboratory
Migratory fish as vectors of energy, organic carbon and nutrients between freshwater and marine environments	IFE		
Contribution of river sediments to translocation of pesticides	IFE	Reading	
Dynamics of bank sediment supply and suspended sediment transport in lower river reaches and estuaries	IH	Birmingham	
Effect of environmental conditions on the plankton production dynamics in feeder rivers of the Humber Estuary and flux of autochthonous carbon	IFE		
Riverine particles and their chemical reactivity at estuarine interfaces	IFE	Plymouth	
Suspended sediment sources sediment delivery and longer-term sediment response within river basins	IH	Exeter Coventry	
Development and application of improved procedures for estimating river loads	IH	Exeter	
Microbial N and P cycling in two river systems	IFE	Durham	
LOIS – Estuarine and coastal Mapping of intertidal habitats from remote sensing for ecological modelling	ITE		
Spartina anglica and sediment dynamics in the RACS study area	ITE		
Documentary evidence of changes in the fluxes of the riverine and coastal ecosystems between the Tweed and the Yare	ITE		

Table 3. Other Thematic Programmes with CEH involvement.

Programme description	*CEH contribution to management*	*CEH collaboration with universities*
Wildlife diseases Theoretical and structured observational studies in the field to establish the ecological significance of natural disease in vertebrate and invertebrate populations *Cost £762K over three years*	Dr D Osborn (ITE) Steering Committee Secretary and Programme Manager	Cambridge, Leeds, Imperial College
Large-scale processes Promotion of innovative and productive studies that improve the understanding of relationships between processes that occur at large spatial and temporal scale and those that take place at lower levels of spatial resolution *Cost £1.5M over three years*	Dr R Caldow (ITE) Steering Committee Secretary	Aberdeen, Dundee, Sheffield, Birmingham, East Anglia
Pollutant transport in soils and rocks A BBSRC/NERC initiative concerned with research into the transfer of anthropogenic pollutants through soils and the subsurface into groundwaters *Cost £1.39M over three years*	Mrs A M Roberts (IH) Programme Manager	Reading, Cranfield
Hydrological radar experiment (HYREX) Use of weather radar as a remote sensing device to investigate precipitation processes which will lead to improved forecasts for rainfall and runoff. The NRA, Meteorological Office and MAFF also provided support to this programme *Cost £720K over three years*	Mrs A M Roberts (IH) Programme Manager	Reading
Testable models of aquatic ecosystems Study of aquatic ecosystems from a number of perspectives, including the establishment of populations in communities, food web structure and community stability, dynamics in heterogenous environments and the consequences of individual-based models on population dynamics *Cost £890K over three years*	Dr S C Maberly (IFE) Steering Committee Secretary	Liverpool, Glasgow, Swansea, Strathclyde, Sheffield, York, East Anglia, Southampton, Wales, Queen Mary, Westfield College, Aberdeen, Warwick
Environmental diagnostics Gaining understanding of the effects of industrial waste materials on the environment and suggesting options for improved management of such materials. The detailed programmes are currently under development *Cost £7.238M over five years*	Dr D Osborn (ITE) Programme Manager	

APPENDIX 3

University links

In addition to numerous collaborative research projects with sister Institutes in the Natural Environment Research Council, CEH Institutes have a wide range of formal links, collaborative projects and affiliations with Higher Education Institutions.

Formal links with nine universities, including those through co-location:

Aberdeen	Oxford	Wageningen
Edinburgh	Reading	Wales
Lancaster	Southampton	

Thirteen members of CEH staff acting as **Visiting Professors**

I R Calder	Birkbeck College
D Fowler	Nottingham
J Hilton	Reading
M Hornung	Lancaster
J G Jones	Liverpool
A D Pickering	Brunel
T M Roberts	York
J Sheail	Leicester
B W Staines	Aberdeen
J B Stewart	Southampton (Readership)
E W Tipping	Lancaster (Readership)
P G Whitehead	Imperial College *(from January 1995 moved to Reading as Professor of Physical Geography)*
W B Wilkinson	Reading

258 **students** (including sandwich course and CASE students) at CEH institutes from 54 UK and 10 overseas universities

Some 400 university **lectures** given by staff during the past year

CEH staff acting as **external examiners** on undergraduate and postgraduate courses at UK and overseas universities

Collaborative research with 26 universities through Thematic Programmes such as TIGER, LOIS, TIGGER (see Appendix 2) and extensive involvement with university counterparts in the development of new Research Council Thematic Programme proposals

Close collaboration with universities on **Commissioned Research** programmes. For example,

- IFE manages nine subcontracts with six universities
- IH collaborates with ten universities on various projects
- ITE manages approximately £1M in university subcontracts for UK Government departments involving 25 university departments
- IVEM collaborates closely with the University of Oxford and has plans for future specific research programmes with Lancaster, Leicester, Reading, and Imperial College.

APPENDIX 4

Industrial and commercial links

CEH has a wide range of links and contacts with organisations in the industrial and commercial sectors.

Jointly funded projects with:

- Albright & Wilson
- Agrevo
- Biotrack Ltd
- British Biotechnology Ltd
- British Trust for Ornithology
- European Small Hydro Asociation
- Forest Authority
- Game Conservancy Trust
- Glaxo Research and Dev Ltd
- Grundon
- HR Wallingford Ltd
- ICL
- Logica
- National Power
- North West Water plc
- Nuclear Electric
- Oxford Instruments (UK) Ltd
- Powergen
- Pfizers Ltd
- Pitman-Moore Ltd
- Royal Society for the Protection of Birds
- Shell International
- Soil Survey and Land Research Centre
- Smith-Kline Beecham Ltd
- Zeneca Ltd

Work subcontracted by CEH Institutes to/from industry/commerce includes:

IFE contracts with:

- British Petroleum
- British Petroleum Operating Co Ltd
- British Nuclear Fuels plc
- BOC Ltd
- BOC Foundation
- Cronch, Hogg, Waterman (Consulting Engineers)
- Forth River Purification Board
- Mott McDonald Civil Ltd
- North West Water Ltd
- Transmanche Link
- Travers Morgan Environment
- W H Knights & Sons
- Wallace Evans

IH has:

- 46 projects with 21 consulting firms
- 21 projects with 15 utilities
- 18 projects with 14 commercial companies

ITE contracts with:

- British Gas plc
- BP Exploration Operating Co Ltd
- British Coal Corporation
- Esso
- Forest Industry Committee of GB
- Sir William Halcrow & Partners Ltd
- Hoescht UK
- MRM Partnership
- Mott Macdonald Civil Ltd
- Rutland Group
- Scottish Forestry Trust
- Shell International

IVEM contracts with:

- Biosys Inc
- Centocor (UK) Ltd and Centocor Inc
- Glaxo Ltd
- Horticulture Research International
- Laboratoires VIRBAC
- Oravax Inc
- The Wellcome Foundation Ltd

Licence agreements for manufacture or for use of patents – approaching 300 overall.

APPENDIX 5

Spread of CEH research

This Appendix shows the way in which the CEH research programmes map on to the Environmental and Natural Resource Issues, and National Technology Foresight Programme science and technology topics, as given on page 9.

		Land use and forest science	Freshwater resources	Urban environment	Soils and soil/vegetation interactions	Biodiversity	Biological and biotechnological control of pests	Global change	Environmental risks	Pollution assessment and control	Cross-sectoral research	Environmental impact assessment
CEH science programmes												
Environmental and Natural Resource Issues	Sustainable management	■	■	■	■						■	■
	Biodiversity					■					■	
	Waste management		■	■								
	Pollution						■			■	■	■
	Risks and hazards								■		■	
	Global change							■			■	
National Technology Foresight topics	Industry/environment interaction		■	■		■				■		■
	Environmental valuation						■			■		
	Land and soil	■		■	■					■	■	
	Urban environment	■	■	■		■			■	■	■	■
	Prediction of extreme atmospheric events						■				■	
	Mechanisms of climate change	■						■			■	
	Fluid dynamics in natural resources management		■	■	■					■		
	Coastal zone modelling and management	■	■			■					■	
	Structure and properties of earth's subsurface											
	Use of natural processes and materials											
	Substainable use of marine resources											■
	Ocean circulation											
	Remote data acquisition										■	
	Society and human health impact of environmental change	■		■			■			■		■
	Management of freshwater resources	■	■	■	■	■		■	■	■		

APPENDIX 6

CEH organisation as at 31 March 1995

Director	**Professor W B Wilkinson**
Management Board	Professor W B Wilkinson, Director CEH Professor T M Roberts, Director, Institute of Terrestrial Ecology and Deputy Director CEH Professor A D Pickering, Director, Institute of Freshwater Ecology Mr A G P Debney, Director (Acting), Institute of Hydrology Dr P A Nuttall, Director (Acting), Institute of Virology & Environmental Microbiology Mr P Williams, Head of Administration, CEH
Total staff	629

DIRECTORATE
Wallingford Laboratory
Crowmarsh Gifford
Wallingford, Oxon OX10 8BB
Tel: 01491 838800 Fax: 01491 692424

Director	**Professor W B Wilkinson**
Director's secretary	Mrs V Lynch

Administration	
Head of Administration	**Mr P Williams** (based at NERC Swindon Office and Wallingford)
Finance Officer	Mrs H M Wood
Establishment Officer	Mr I C Smith
Finance/accounts	Miss A S Dickerson
Contract Officer	Vacant
Science and Marketing	
Science policy and co-ordination	Dr J C Metcalfe (from 1 November 1995)
GCTE Project Office	Mr J I Ingram
Marketing	Dr D Coates
Information	
Information services	Mrs P A Ward (based at ITE Merlewood)
Technical	
Safety technician	Mr C Hankinson (based at ITE Merlewood)
Staff	11

INSTITUTE OF FRESHWATER ECOLOGY
Windermere Laboratory
Far Sawrey, Ambleside
Cumbria LA22 OLP
Tel: 015394 42468 Fax: 015394 46914

Director	**Prof A D Pickering**

Head of Division	**Dr J M Elliott**	Conservation of rare fish Fish stock assessment and management Modelling recruitment and growth The stress response of fish
Head of Division	**Dr B J Finlay**	Microbial diversity in fresh water Management of lakes and reservoirs Culture Collection of Algae and Protozoa Genetics of freshwater bacteria Algal productivity Palaeolimnology
Head of Division	**Dr E W Tipping**	Radionuclide fluxes Modelling upland acid soils Pollutant transport Nutrient fluxes in the aquatic environment Automated water quality monitoring
Director	**Prof J G Jones**	Freshwater Biological Association

The River Laboratory East Stoke Wareham Dorset BH20 6BB Tel: 01929 462314 Fax: 01929 462180	**Dr J Hilton**	Land/river interactions RIVPACS ecological impact of low flows Ecological assessment Aquatic weed control River Habitat Survey
Eastern Rivers Laboratory Monks Wood Abbots Ripton Huntingdon Cambridgeshire PE17 2LS Tel: 01487 773381 Fax: 01487 773467	**Dr L C V Pinder**	Restoration of fisheries Environmental impacts on lowland rivers Flow regimes and fish recruitment
Edinburgh Laboratory Bush Estate Penicuik Midlothian EH26 0Q Tel: 0131 445 4343 Fax: 0131 445 3943	**Dr A E Bailey-Watts**	Land use change and water quality Eutrophication in Scottish water bodies Conservation of fish Tropical limnology
NERC LOIS Laboratory c/o Dept of Biology University of York Heslington York YO1 5DD Tel: 01904 434040 Fax: 01904 434041	**Mr D V Leach**	Land–Ocean Interaction Study
Teesdale Laboratory c/o Northumbrian Water Lartington Treatment Works Lartington, Barnard Castle Co Durham DL12 9DW	**Dr D T Crisp**	Salmonids in upland streams Impacts of impoundments Afforestation and the aquatic environment
Staff	103.5	

INSTITUTE OF HYDROLOGY
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Director (Acting) **Mr A G P Debney**

Head of Division	**Dr J S Wallace**	Global processes Vegetation and soil processes Sustainable agrohydrology Impacts of global change
Head of Division (Acting)	**Dr A Jenkins**	Water quality systems Pollution hydrology Hydrochemistry Catchment modelling
Head of Division (Acting)	**Dr A Gustard**	Flow regimes and environmental management Flood and storm hazard Systems modelling Water resource systems
Head of Division	**Mr F M Law**	National Water Archive Hydrology software Hydrologic GIS
Head of Division	**Prof I R Calder**	Land use and water efficiency Experimental catchments Sediment and waterborne fluxes
Head of Section	**Mr M A Beran**	Community science and management
Plynlimon Office Staylittle Llanbrynmair Powys SY19 7DB Tel: 01686 430652 Fax: 01686 430441	**Mr J A Hudson**	
Stirling Office Unit 2, Alpha Centre. Innovation Park Stirling FK8 4NF Tel: 01786 447612 Fax: 01786 447614	**Mr R C Johnson**	
Staff	197	

INSTITUTE OF TERRESTRIAL ECOLOGY
Monks Wood
Abbots Ripton
Huntingdon , Cambs PE17 2LS
Tel: 01487 773381 Fax: 01487 773467

Director **Prof T M Roberts**

Monks Wood Abbots Ripton Huntingdon Cambs PE17 2LS Tel: 01487 773381 Fax: 01487 773467	**Dr S Dobson**	Environmental management Ecological processes Avian biology Ecotoxicology
Merlewood Research Station Windermere Road Grange over Sands Cumbria LA11 6JU Tel: 015395 32264 Fax: 015395 34705	**Prof M Hornung**	Land use Soil ecology Radioecology Analytical chemistry R&D Environmental Change Network
Edinburgh Research Station Bush Estate Penicuik Midlothian EH26 0Q Tel: 0131 445 4343 Fax: 0131 445 3943	**Dr M G R Cannell**	Forest modelling Tropical forest ecology Pollutant and trace gas fluxes
Furzebrook Research Station Wareham Dorset BH20 5AS Tel: 01929 551518 Fax: 01929 551087	**Dr A J Gray**	Plant ecology and genetics Lowland vertebrate ecology Plant ecology and genetics Invertebrate ecology
Banchory Research Station Hill of Brathens, Glassel Banchory Kincardineshire AB3 4BY Tel: 01330 823434 Fax: 01330 823303	**Prof B W Staines**	Upland community ecology Applied ecology Upland vertebrate ecology
Bangor Research Unit University of Wales, Bangor Bangor Gwynedd LL57 2UW Tel: 01487 773381 Fax: 01487 773467	**Dr J E G Good**	Biogeochemical cycling Air pollution effects Upland/montane ecology
Environmental Information Centre Monks Wood	**Dr B K Wyatt**	Biological recording Remote sensing Geographical information systems
Staff	269	

INSTITUTE OF VIROLOGY AND ENVIRONMENTAL MICROBIOLOGY
Mansfield Road
Oxford OX1 3SR
Tel: 01865 512361 Fax: 01865 59962

Director (Acting) **Dr P A Nuttall**
Deputy Director **Dr E A Gould**

Science sections		Molecular microbial ecology Microbial diversity Virus ultrastructures Plant virology Ecology and biocontrol Flaviviruses water-borne viruses biotechnology Virus protein functions Tick-borne pathogens Molecular biology Orbivirus research
Staff	50.5	

ISBN: 1 85531 1526

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ISBN 1 85531 152 6

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