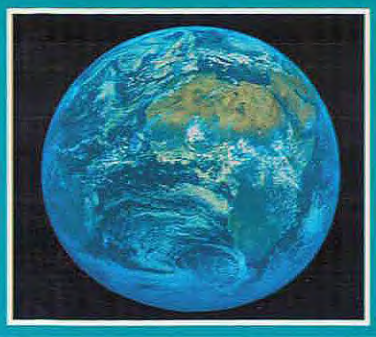

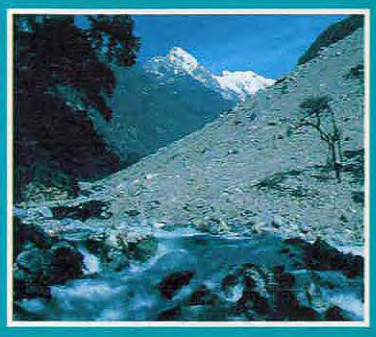

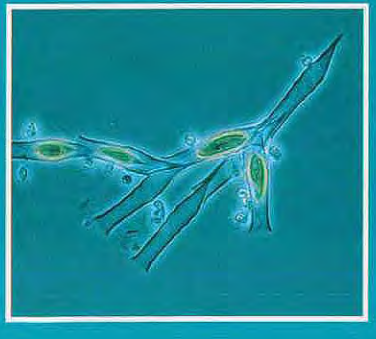

Centre for Ecology & Hydrology

Centre for Ecology & Hydrology

Annual Report 1995–96

Natural Environment Research Council

John Krebs FRS
Chief Executive
Natural Environment Research Council

Foreword

The 1993 Government White Paper on *Realising our potential – a strategy for science, engineering and technology* provided the NERC with a new mission. One element of the re-organisation necessary for Council to meet this mission was to group a number of its Institutes into a Centre for Ecology and Hydrology (CEH). The Centre was formally launched in December 1994. Over the last two years, CEH has moved rapidly to build integrated science programmes and management structures. This has been achieved against a background of uncertainty created by Prior Options Reviews.

During the first half of 1996, NERC carried out a Prior Options Review of three of its research establishments: the British Geological Survey (BGS), the Centre for Coastal and Marine Sciences (CCMS), and the Centre for Ecology and Hydrology (CEH). This review was part of a wider Government review of more than 50 public sector research establishments. The NERC steering committee, chaired by a Council member and Vice Chancellor of Dundee University, Dr Ian Graham-Bryce, carried out a searching analysis and reported to Government in July 1996.

In January 1997, the Minister for Science and Technology, Ian Taylor MBE MP, announced the Government's decisions relating to the Prior Options Reviews of three NERC research establishments (BGS, CCMS and CEH).

The key decisions are:

- the functions of BGS, CCMS and CEH are needed;
- BGS, CCMS and CEH should remain in the public sector and retain their separate identities;
- NERC should pursue the opportunities for rationalisation and restructuring identified by the reviews;
- NERC should build on its arms length relationship with the establishments and improve their financial and management systems.

I am delighted that this uncertainty has now ended and that the outcome provides recognition by Government of the past record of achievement of NERC and its Centres and Surveys. It endorses the future delivery of excellent, relevant and independent science in the public sector and the integrated environmental research capability of NERC Centres and Surveys. This outcome is the best one for the delivery of the NERC mission.

The CEH staff have shown great resilience in maintaining vibrant, on-going science programmes and in planning future science during the long period of uncertainty associated with these reviews.

This 1995–96 Annual Report from CEH focuses on the new science Core Strategic Programmes that have been developed. The breadth of the science covered by these programmes and their relevance to regional, national and global environmental issues are impressive. It is also noteworthy that the annual output of publications and contract reports from CEH has been further improved.

I am confident that through an evolutionary process we can build on the considerable progress which has already been made to enhance the scientific excellence and relevance for which CEH is renowned.

I commend this Annual Report to you.

Cover photographs

The scale of CEH research in the terrestrial and freshwater environments ranges from global to microscopic.

CEH undertakes research in fragile ecosystems, such as the arid-cold Himalayan region of Nepal.

Maintaining an automatic weather station at Moor House.
Moor House/Upper Teesdale is a founder site of the Environmental Change Network. This is a long-term monitoring programme for identifying and quantifying environmental change due to human activities, and is managed by CEH.

Dinobryon – *a species of algae common in the plankton of oligotrophic waters.*

Report of the Centre for Ecology and Hydrology 1995–1996

Natural Environment Research Council

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Centre for Ecology & Hydrology

Mission statement

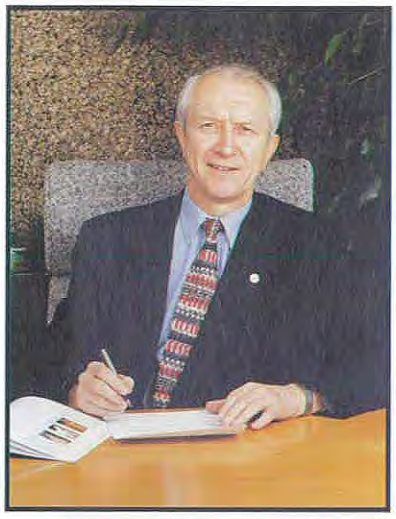
- To advance the sciences of ecology, environmental microbiology (including virology) and hydrology through high-quality and internationally recognised research, leading to a better understanding and quantification of the physical, chemical and biological processes relating to land and freshwater and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

Robust and timely responses to major environmental problems, such as the sustainability of natural resources, climate change and pollution, are only possible if based on sound interdisciplinary science.



Director's review

CEH is concerned with the land on which we live, its freshwaters and the living organisms which share the environment with us.

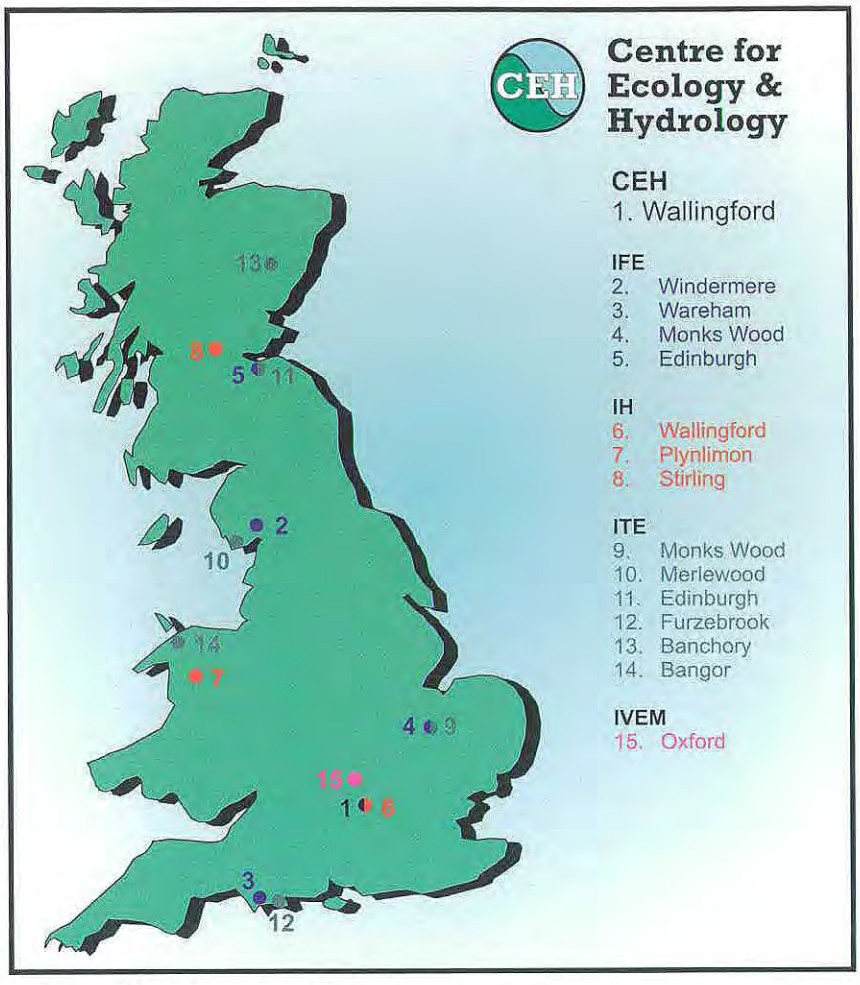
Recognising the importance of an holistic approach and in responding to the aims of the UK Government's 1993 White Paper *Realising our potential – a strategy for science, engineering and technology*, the Natural Environment Research Council restructured its activities during 1994. In the Director's Review in the first Annual Report of the Centre for Ecology and Hydrology 1994–95, I described in some detail the restructuring arrangements that Council had put in place. A major element of this was the formation of the Centre for Ecology and Hydrology (CEH) (Appendix 1).

CEH is concerned with the land on which we live, its freshwaters and the living organisms which share the environment with us. This covers a diverse and complex area of science with a wide range of scales in space and time and has strong interactions with the needs of industry and commerce, economics, sociology and politics. The land and its freshwaters are threatened by natural hazards, eg floods, drought and windstorms, as well as man-made pollutants resulting from waste discharges or careless acts of man leading to land degradation, uncontrolled deforestation, loss of biodiversity or climate change. Our mission is to advance knowledge and understanding of the processes relevant to these and other environmental issues and to predict change. This objective is achieved through programmes of research, monitoring and data collection. The CEH mission is given in full on the facing page.

The component Institutes which have been drawn together in CEH are:

- the Institute of Freshwater Ecology (IFE)
- the Institute of Hydrology (IH)
- the Institute of Terrestrial Ecology (ITE)
- the Institute of Virology and Environmental Microbiology (IVEM).

CEH has 625 staff (475 scientists) and about 300 visiting scientists and students, well-equipped laboratories located throughout the UK, and a reputation for excellence in national and international scientific research, monitoring, and data collection. As such, CEH, through its Institutes, has one of the strongest capabilities in



Locations of the CEH component Institutes.

CEH has a reputation for excellence in international scientific research, monitoring, and data collection. It has one of the strongest capabilities in the world for holistic research in terrestrial and freshwater sciences.

the world for undertaking holistic research in the terrestrial and freshwater sciences.

To gain full benefit from the scientific skills, experience and facilities which exist within the individual Institutes it is, of course, necessary to cross Institute boundaries and draw together the science and the scientists. Excellent progress has been made in this respect during the course of the year. This has been helped particularly by the need to realign the CEH activities to the New Funding Model which is being introduced progressively by NERC for the allocation of its Science Budget. The Model has four components, namely:

- Non-Thematic research
- Thematic research
- Core Strategic research
- Infrastructure.

The latter component is essentially for the provision of major science facilities, including the 'well-found laboratory'. CEH bids for research funding from the Core Strategic and Thematic elements of the Model.

CORE STRATEGIC PROGRAMME

Under the new arrangements, CEH is required to submit its Core Strategic research programmes for assessment by Programme Review Groups (PRGs). The PRGs report to the NERC Terrestrial and Freshwater Science and Technology Board (TFSTB) (see Appendix 1). The Groups' membership is drawn from a wide science community which includes the universities, industry, environment agencies, etc (see Appendix 2).

The new research programmes will begin on 1 April 1997. In my Director's Review last year I referred to these new programmes but at that time they were still at the formative stage. During the course of the year they have been developed and strengthened. An outline of the structural and the scientific challenges for each of the ten programmes is given in the following section of this Report.

The ten new programmes, once approved by the NERC TFSTB, will chart the course for CEH over the next five years and beyond. This does not mean that the research will become ossified. It will be subject to annual review against a set of PRG-approved targets, and the programmes will be modified as necessary to encompass newly emerging areas of important environmental science.

Although the PRG are independent of CEH, they nevertheless have provided the CEH research scientists with valuable comments on the scientific content and balance within and between programmes at their

formative stage. I am grateful to the PRG chairmen, Professor Howard Wheater (Imperial College), Professor Chris Payne (Chief Executive, Horticultural Research International), Professor Rick Battarbee (University College London), and Dr John Rodda (President, International Association of Hydrological Sciences), and to all Group members for their guidance in this respect.

Each of the ten programme areas will require a research input from at least three of the CEH Institutes. All four Institutes are involved in some programmes. The act of developing and drafting the detailed proposals within each programme has brought the terrestrial and freshwater environmental scientists from different disciplines and Institutes together to share experiences and exchange ideas in a way and to an extent that have not happened before.

THEMATIC PROGRAMMES

The NERC Thematic Programmes provide Science Budget support for basic and strategic research and training in specific themes which have been identified through the NERC science planning process. CEH has continued to provide the secretariat or management of some of these Programmes. CEH Institutes also have been successful with a number of research bids into the Programmes, often in collaboration with the university sector. The Centre scientists are active in developing ideas for new Thematic Programmes for consideration by the Science and Technology Boards and Council. More details on the role of CEH within the NERC Thematic Programmes is presented in a subsequent section in this Report.

INTEGRATING FUND PROJECTS

Last year some 7% of the CEH Science Budget was used to fund inter-Institute collaborative projects. These have become known as 'Integrating Fund projects'. To qualify for support, projects have to lie within the compass of one of the new CEH programme areas, to be of the highest science quality, involve collaboration between two or more Institutes, and have a project leader with the responsibility for managing resources across Institute boundaries. Funding may be for a period up to three years in the first instance. Seven such projects were started last year. The Integrating Fund project leaders recently reported to the CEH Management Board on the scientific progress that had been made during the course of the past year. The Board was pleased with the science that is emerging at this early stage and in particular noted the high level of inter-Institute collaboration. As a consequence, a further 7% of the Science Budget was committed to the Integrating Fund for 1996–97, bringing the total to 14%. Six new projects were selected. A brief description of all the approved Integrating Fund projects is given in a following section.

The excellent progress that has been achieved in the formation of

Mr Max Beran, CEH's Programme Manager of TIGER, with the Rt Hon John Gummer MP, Secretary of State for the Environment, at the 'Tiger's Tale' meeting, 24 October 1996. The Terrestrial Initiative in Global Environmental Research (TIGER) is one of NERC's major Thematic Programmes (photo Terry Moore).

CEH scientists are active in developing ideas for new Thematic Programmes for consideration by the Science and Technology Boards and Council.

During the year CEH has expanded its collaboration and involvement with a wide range of organisations within the UK, Europe and worldwide.

Member organisations of EurAqua and CONNECT are able to act through the networks in a collective way and in doing so can influence research policy within the European Union.

multidisciplinary science teams in so many areas has resulted firstly from a recognition by the scientists of the added value that is brought to their research through such collaboration and, secondly, from the positive encouragement that Institute Directors have given their staff to cross their Institute or site boundaries, where appropriate.

CEH OUTREACH AND INFLUENCE

During the year CEH has expanded its involvement and collaboration with a wide range of organisations within the UK, Europe and worldwide.

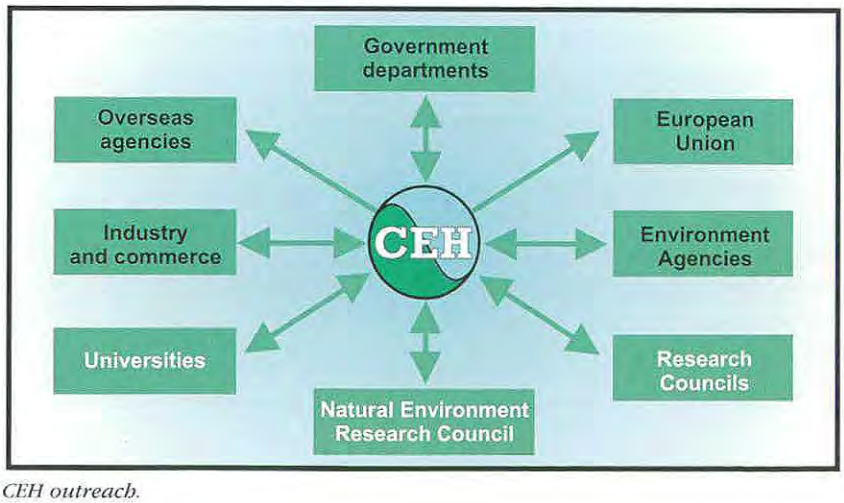
Outreach

Europe

The EurAqua and CONNECT networks give a good indication of the extent of our links within Europe. EurAqua is the European Network of Freshwater Research Organisations; its aims are to:

- encourage collaboration between research scientists,
- promote the transfer of knowledge relating to freshwaters from the science base into policy at national and union level, and
- make expert advice readily available to enhance European competitiveness.

All the European Union Member States have representation in EurAqua. CEH's IH was a founder member in 1992, but, as the activities of EurAqua extend beyond hydrology and water resources into aquatic ecology, it was appropriate for membership in the coming year to pass from IH to CEH centrally. This new arrangement will enable IH to continue to make an important input to EurAqua, but will also give IFE's aquatic ecologists greater involvement. CONNECT, the European Conservation Institutes Research Network, although not so extensive a grouping as EurAqua, operates in a somewhat similar way. CEH's ITE is the UK participating Institute. The member organisations are able to act through the networks in a collective way and in doing so can influence research policy within the European Union.



CEH outreach.

During 1995, the European Environment Agency (EEA) established the European Environmental Information and Observation Network (EIONET), which includes the European Topic Centres (ETCs), National Focal Points and National Units. CEH participates in three of the seven ETCs: Inland Waters, Biodiversity and Nature Conservation, and Land Cover. CEH's IH is a member of the ETC on Inland Waters. One of the major activities in 1995 has been an overview of monitoring requirements laid down in international legislation and an examination of how each Member State has organised its networks for monitoring water quantity and quality. CEH's ITE is a partner in the Biodversity and Nature Conservation ETC, where the focus during the year has been to review existing data monitoring procedures for species and habitats. ITE is also a partner in the Land Cover ETC.

International science

All CEH Institutes have continued to contribute to the international

science programmes during the past year. For example, several scientific studies have been undertaken as part of the International Hydrology Programme (IHP) of UNESCO and the Operational Hydrology Programme (OHP) of the World Meteorological Organisation (WMO). The Institutes have been particularly active within the WMO's Global Energy and Water Experiment (GEWEX) and ran a WMO/IAHS workshop on *Continental-scale hydrological models: charting the future*, at CEH's Wallingford Laboratory; 46 invited scientists from 14 countries attended the Workshop. CEH also hosts the Focus 3 office of the International Geosphere–Biosphere Programme's core project on Global Change and Terrestrial Ecosystems (GCTE). The activities of the GCTE Office, and examples of CEH's participation in international science are described in a subsequent section of this Report.

Universities

Our university links have continued to grow and within CEH there are now 21 scientists who carry professorial status. Details of the university links are given in Appendix 3.

Influence

CEH is frequently called upon to express views on areas of developing policy or concern to UK Government or to the Environment Agencies. The Centre was, for example, given the opportunity to submit both written and oral evidence to the House of Commons Environment Committee during its review of water conservation and supply. The Environment Committee reported in November 1996. Several of the items raised in the CEH evidence have been referred to in its Report and some are identified as areas where action is needed.

Centre scientists also provide advice on a wide range of science policy relating to UK, European and international issues through the many committees on which they serve. A listing of the CEH committee representation is given in Appendix 4.

FINANCE

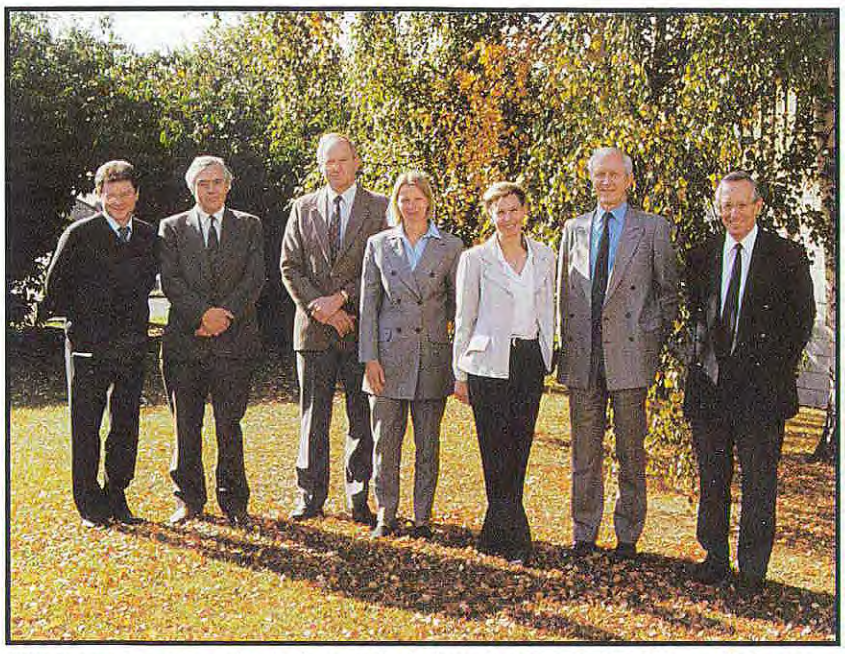
The year 1995–96 saw a small decline in CEH's overall level of funding. CEH income derives from the NERC Science Budget (as described above) and from a wide range of customers who fund Commissioned Research (CR). An analysis in a later section of the Report shows that 52% of CEH income is obtained from this latter source. All of the Commissioned Research is complementary to CEH's Science Budget programmes (Core Strategic and Thematic) and there are a number of research projects which have been initiated on a jointly funded basis. Although some of the CR projects are long term, the income from some customers may fluctuate from year to year. While every attempt is made by CEH and its Institutes to forecast such changes, this is not always possible. A drop in income, which is outside CEH control, may occur so unexpectedly that it is difficult for the Institutes to respond quickly. Such a decline, though small, occurred in 1995–96.

OUTPUT

In my overview in last year's Annual Report, I referred to the marked increase in the number of CEH Institute publications and contract reports produced in 1994–95 compared with those in 1993–94. I am pleased to note that this high level of performance has been further increased. This has been achieved during a year in which there has been an exceptionally heavy workload on the many scientists who have been associated with the detailed

The first Chairman of EurAqua, Dr Yves Le Bars (Director General of Cemagref), visited CEH at Wallingford during the year. He was accompanied by Professor Henri Gibert (French Embassy) and Mr Patrick Lavarde (Director, Cemagref). The party was hosted by Mr Tony Debney (Acting Director IH) and Professor Brian Wilkinson (Director CEH).

The number of CEH Institute publications and contract reports prepared during the year has increased compared with last year's output.



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

development of CEH's ten research programmes. In highlighting the efforts and achievements of the CEH scientists, I do not overlook the substantial contribution that the administrative and other support services staff at all the CEH sites have made. They have had to accommodate additional work due to the delegation of a number of functions previously undertaken at NERC Swindon.

Professor Pat Nuttall has been appointed as Director IVEM and Dr Jim Wallace as Director IH.

CEH MANAGEMENT BOARD

The CEH Management Board is the forum where the Centre's scientific, financial and administrative strategies and policies are debated and developed. During the course of the year, the Board has addressed issues such as the content and management of new CEH science programmes, budget allocations, re-structuring, computing requirements, the 'Prior Options Review' and many others. The Management Board is composed of the Director CEH (Chairman), the CEH Institute Directors (Professor Mike Roberts, Deputy Director CEH and Director ITE, Professor Alan Pickering, Director IFE, Professor Pat Nuttall, Acting Director IVEM, and Mr Tony Debney, Acting Director IH) and the Head of Administration (Mr Phil Williams). Dr Jane Metcalfe, Head of Science Policy, is the Board Secretary. I am grateful to the Board members for their unstinting support during the course of the past year. Mr Tony Debney retired in November 1996. I wish to thank Tony for his help in establishing CEH during its formative years and for the significant contribution he has made to the management and the science of IH over the last 28 years. Both the posts of Director IH and IVEM were subject to open competition recently. I was delighted that Professor Pat Nuttall was confirmed as Director of IVEM and that Dr Jim Wallace (formerly Head of Processes Division, IH) has been appointed as Director of IH.

PRIOR OPTIONS REVIEW

Above, I refer to CEH's improved performance during the past year in terms of publication and report output. This has not only been accomplished with an increased workload but also under the uncertainty associated with the Government's *Review of the public sector research establishment* – the so-called 'Prior Options Review'.

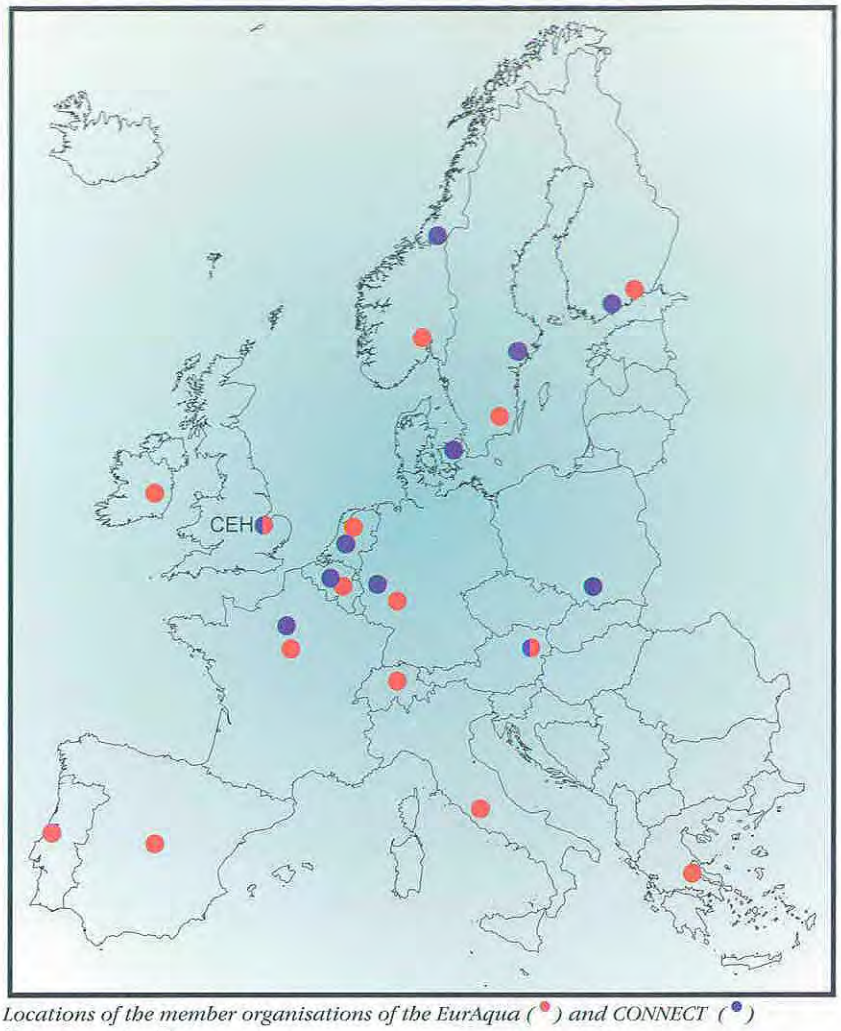
During 1994 the CEH Institutes were required to prepare papers and give evidence to the Office of Public Science and Services as part of the *Efficiency survey of the public sector research establishment*. The published report of the survey left unresolved the role of many Research Council Institutes within public sector science. In September 1995 the Government announced that 42 public sector research establishments would be subject to further review to assess whether the 'functions' of the establishments were needed and whether the public sector should provide them. Scope for further

rationalisation was also to be examined.

CEH was subject to this 'Prior Options Review'. The Centre provided extensive documentary evidence and made a verbal presentation to the Steering Committee undertaking the NERC Prior Options Review. CEH took the opportunity to highlight the major benefits that have been derived and will continue to flow to the ecological and hydrological sciences as a result of the strong interdisciplinary focus that is now possible through CEH. The NERC Steering Committee presented its report to Government in late July 1996. In January 1997, the Minister for Science and Technology, Ian Taylor MBE MP, announced the Government's decisions relating to the Prior Options Reviews of three NERC research establishments: British Geological Survey, the Centre for Coastal and Marine Studies, and the Centre for Ecology and Hydrology. The key decisions are given in Professor Krebs' (Chief Executive, NERC) Foreword to this Report, but in essence the Government has decided that the function of CEH is needed, that it shall remain as an entity in the public sector, and that opportunities for rationalisation and restructuring will be pursued within NEC. This outcome is good news for CEH.

It is to the credit of all CEH staff that the research has remained so buoyant, such excellent progress has been made in developing new integrated science programmes, and that the outputs have been improved during the year against this background of uncertainty and potential change.

Professor Krebs and Council showed great vision in establishing CEH. The Council's actions preceded the re-organisation of the environmental regulatory agencies which involved the formation of the multidisciplinary



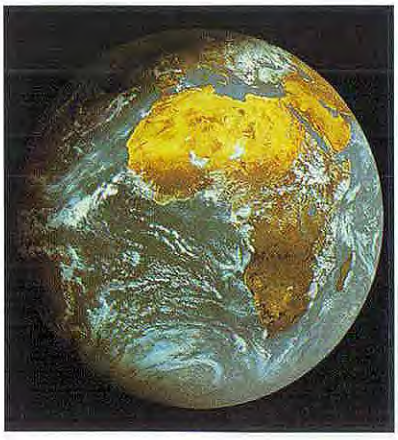
Locations of the member organisations of the EurAqua (●) and CONNECT (●) European networks.

Environment Agency for England and Wales and the Scottish Environment Protection Agency. NERC, through CEH, is well positioned to respond to the terrestrial and freshwater research needs of these new organisations. CEH is now experiencing at first hand the positive benefits to national and international science arising from greater integration. I am delighted, following the Prior Options Review, that such major benefits will be retained. The future for CEH is bright.

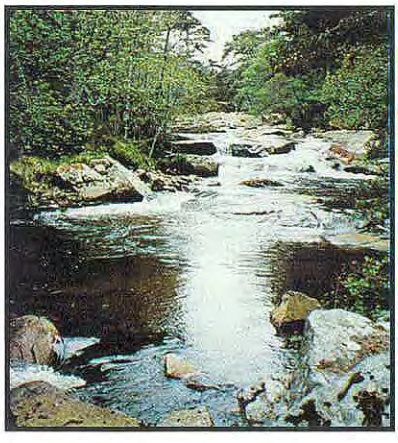
This Report can be no more than a brief overview of the wide range of scientific activity within CEH. A more detailed description of the science is presented in the individual Annual Reports of the CEH Institutes which I commend to you.

The strong interdisciplinary focus that is possible within CEH continues to advance ecological and hydrological science.

Brian Wilkinson
Director
Centre for Ecology & Hydrology

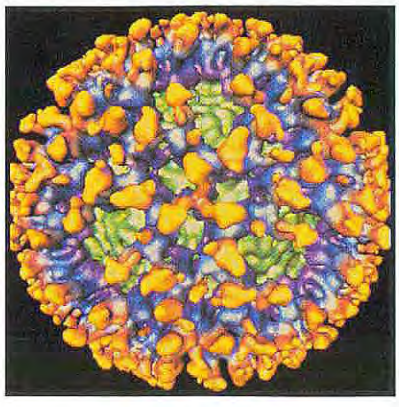


A major task for CEH has been to develop an integrated science programme across its Institutes. The emerging programme was described in the first Annual Report for CEH in 1994–95. Over the preceding year CEH has made major progress in refining and developing this research into its new Core Strategic Programme. The complete Programme has been developed to reflect the holistic nature of the terrestrial and freshwater sciences, whereby physical, chemical and biological processes interact in time and over spatial scales from the molecular to the global.



The Core Strategic Programme

A fundamental requirement of CEH is to develop an interdisciplinary science programme that poses important research challenges while addressing the key environmental questions of the time. The Core Strategic Programme of CEH has been developed to provide a science base that underpins national and international requirements in the terrestrial and freshwater sciences and enables the Natural Environment Research Council to fulfil its mission with respect to terrestrial and freshwater ecology, hydrology and environmental microbiology. In shaping the new Programme, the environmental and natural resource issues as identified by NERC, the EU Fifth Action Plan, the major international programmes and Technology Foresight have all been taken into account. The complete Core Strategic Programme has been developed to reflect the continuous nature of the science, though for management purposes it has been subdivided into discrete programme areas. Strong links exist naturally between the individual programmes.



The CEH Core Strategic Programme both contributes to, and depends on, terrestrial and freshwater research in the UK and overseas, in particular through extensive collaboration with academic organisations and through programmes such as the World Climate Research Programme (WCRP), the International Geosphere–Biosphere Programme (IGBP), the International Hydrology Programme (IHP), and others. The Programme is also supported and

augmented through Commissioned Research, which is generated by the extensive user base for the science conducted by CEH. The CEH Programme has been devised to be dynamic and subject to change, as it responds to new environmental challenges, including those related to wealth creation and quality of life. It encourages an active flow of information between the UK science base and the users of the science.

The science programmes are due to start in April 1997, in line with the implementation of NERC's New Funding Model. As part of NERC's commitment to maintain scientific quality, all the programmes have been reviewed during 1996 by independent panels of experts called Programme Review Groups (PRGs). The composition of these Groups is given in Appendix 2. The Programme Review Groups have focused on the strategic direction of the science and the quality of the research programme presented. Their comments have been used to modify and strengthen the research programme of CEH. The PRGs will assess progress on an annual basis, reporting to the February meeting of the NERC Terrestrial and Freshwater Science and Technology Board (Appendix 1), with a major review of the science every five years.

It is a significant achievement and a credit to all the scientists involved that an integrated research programme, to which all the Institutes of CEH contribute, has been developed over the last year and is ready to begin by the planned date of April 1997.

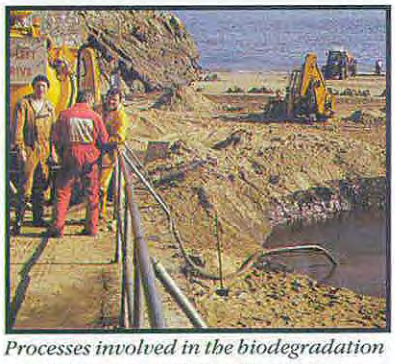
The following pages present a brief description of the themes and challenges within each of the ten CEH programmes.

CEH's ITE has produced the first complete Land Cover Map of Great Britain since 1960, using satellite imagery and ground survey. The information is available in digital form or as paper maps.

Institute staff are quantifying major sources and sinks of important greenhouse gases within the CEH programme on Global Change.

The ten science programmes and the participation of the CEH Institutes

CEH programmes	*IFE*	*IH*	*ITE*	*IVEM*
Soil and soil/vegetation interactions	•	•	•	•
Land use science	•	•	•	•
The urban environment	•	•	•	
Freshwater resources	•	•	•	
Biodiversity	•	•	•	•
Pest and disease control	•		•	•
Pollution	•	•	•	•
Environmental risks	•	•	•	•
Global change	•	•	•	•
Integrating generic science	•	•	•	•



Processes involved in the biodegradation of oiled beach sand from the Sea Empress *oilspill in February 1996 are being studied in a CEH contract for the UK Marine Pollution Control Unit within CEH's programme on Pollution.*

The common pill millipede is one example of the diversity of soil fauna being investigated within this research programme.

Inocybe longicystis – *decomposer fungi growing on woody litter. Staff in CEH's ITE are currently using molecular techniques to investigate the species composition of mixed fungal communities involved in decomposition.*

Intact soil columns used in the study of soil processes. Collaborative studies by ITE and IFE using these systems have revealed the impacts of global warming on soil drainage water quality.

Soil and soil/vegetation interactions

Soils have key roles in the control of global change, pollution impacts, maintenance of biodiversity and sustainable development. An understanding of soil processes and functions is essential to the optimal and sustainable management of soils, land and water resources, and the prediction and management of the impacts of pollution, environmental change and land use. An understanding of soil components, properties and processes underpins all six environmental issues identified by NERC. The recent Technology Foresight scoping exercise identified 'Land and soil at risk' as a priority area for research. The Royal Commission on the Environment programme has identified the need to expand research on soil processes in the UK.

PROGRAMME THEMES

The programme aims to improve our understanding and ability to model key soil processes which control the transformations of materials in soils and the transfers of water, solutes and gases between soil pools and between soils and the atmosphere, and soils and drainage waters. There are three interlinking projects, which cover:

- physico-chemical processes affecting soil/water balances
- biologically mediated soil processes
- physical and physiological processes controlling soil/water balances.

THE CHALLENGES

The key, overall challenges for the programme are to:

- improve the detailed description of soil chemical and biological processes and their incorporation in models applicable at a range of scales
- gain an understanding of the functional role of soil biological populations and communities
- improve our ability to describe and quantify the bioavailable fraction of soil nutrient elements and pollutants/contaminants and the fraction available for plant uptake and for transport
- understand and model for predictive purposes the flux of water through the soil/vegetation/atmosphere continuum
- predict how soil processes and soil/vegetation interactions will respond to environmental stress and land use change.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Prof M Hornung
ITE Merlewood

Land use science

Land use is subject to continual change driven by economic, social, political and environmental pressures. A number of recent policy statements relate directly to land use issues, eg at the global scale Agenda 21, and at the national scale the Rural England and Rural Scotland White Papers. Integral to all environmental and societal processes is the availability of fresh water. The manner in which land use may affect this resource, both in terms of quantity and quality, is a matter of growing concern to society at large, which now has a much greater expectation that new forms of land use shall be sustainable and environmentally benign.

NERC plays a leading role in land use research, and CEH is providing the Secretariat for the NERC Land Use Research Co-ordination Committee.

PROGRAMME THEMES

The research programme aims to promote an integrated approach to land use science that is applicable to the wide range of user community needs. The research focuses on:

- monitoring and understanding the impacts of land use change on water and carbon balances and on habitats and wildlife
- modelling the processes and effects of land use change
- developing strategies for the optimisation of land use.

These themes will be developed to provide the basis for large-scale, long-term analytical studies of land use change.

THE CHALLENGES

The key challenges for the programme are to:

- apply hierarchical and biogeographical theories to landscape-scale dynamics in order to develop management techniques that maintain landscape quality
- analyse biological and land use systems to provide a basis for the integration of environmental and production criteria in land use planning and management
- achieve a full understanding of the interlinking processes involved in the hydrology and ecology of river basins and their impacts with human activities.

CEH's Institute of Hydrology has been commissioned by Somerset County Council and the Royal Society for the Protection of Birds to supply hydrological expertise and advice on a reedbed creation scheme at Ham Wall, Somerset.

The interactions between the mosaic of upland land use and hydrology and ecology is a major focus of the work of CEH's IH and ITE. Typical of these upland land uses is the area shown around the Clywedog reservoir in mid-Wales.

Eucalyptus plantation in India have raised concerns about impacts on water resources. CEH staff are providing advice to the Karnataka Forest Department in Southern India, through a contract funded by the Overseas Development Agency.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Prof I R Calder
IH Wallingford

A 10 km x 15 km area of central London, mapped from Landsat satellite image data by CEH's ITE. The map shows the River Thames (blue) cutting through the continuously built-up core of central London (black), with residential areas (grey) and open spaces (green) including woodlands (red); the detail, though recorded from 800 km up in space, is fine enough to show the herring-bone pattern of streets in suburban areas and the bridges across the River Thames.

*Teasel (*Dipsacus fullonum*), a plant often found in gardens, riverbanks and roadside verges. It is a good food source for butterflies and seed-eating birds in urban and waste areas.*

Urban amenity areas often become degraded wasteland. The implications for the development of healthy, sustainable urban environments will be studied in this programme.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE

Programme Leader
Dr J E G Good
ITE Bangor

The urban environment

By the year 2000 half of the world's population will live in cities. In the UK, 90% of people live in urban areas which occupy only 10% of the land. Urban areas provide employment, housing and social contact but they consume resources, generate waste and pollution, destroy habitats and are prone to environmental hazard and decay. The Earth Summit in 1992 highlighted the need to develop more socially and ecologically sustainable cities. A new Global Action Plan for cities was launched by the UN in 1996. In the UK, urban issues permeate the priority areas of science and technology identified in the Technology Foresight Programme. CEH has responded to the need for research dedicated to understanding urban environmental problems through the development of this new science programme.

PROGRAMME THEMES

The programme has two main themes:

- the development and extension, through survey, monitoring and modelling, of the interdisciplinary knowledge base required to plan and achieve more sustainable urban environments
- understanding the key environmental patterns and ecological and hydrological processes in urban situations and their responses to change, especially those resulting from man's activities.

THE CHALLENGES

The key challenges associated with these aims are to:

- identify and characterise patterns of land and water use, habitats, biodiversity and species distribution in differing urban environments in relation to historical and current human activities
- understand the impact of key aspects of urbanisation on the functioning of soil and aquatic sediments and to develop and integrate models covering water and pollutant movement, chemical and biological processes, and the ability to support healthy and diverse communities of flora and fauna
- improve understanding of patterns and processes in air pollution and deposition to soils, vegetation and fresh water and to improve atmospheric pollution models and the prediction of poor air quality that may damage human health
- determine urban impacts on water flow rate and pollutant flux/concentration in the aquatic environment and identify effects on the physical and ecological balances in aquatic ecosystems.

Freshwater resources

The need for adequate and sustainable water resources forms the basis of much environmental policy worldwide, but the conflicts between demands for fresh water and resource conservation are increasing, even in climatically wet countries like the UK. The driving objective behind this programme is the need to improve the scientific basis for the effective strategic and sustainable management of freshwater resources required to overcome these conflicts.

Progress towards developing a balance between allocating water resources to meet economic demands and simultaneously meeting an increased demand for long-term protection of the freshwater environment is dependent on the participation of a wide range of users.

PROGRAMME THEMES

The programme brings together CEH's research in water quantity, water quality and the ecological components of freshwater systems into an integrated research programme, with major themes including:

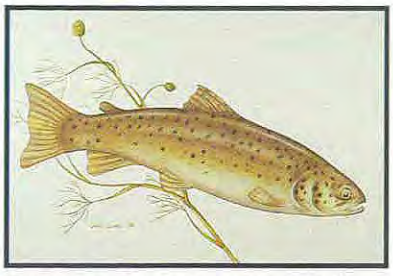
- water quantity – improving understanding in surface/groundwater interactions and water resource modelling
- water quality – measuring and modelling responses of aquatic biota to physical and chemical properties and improving water quality management
- fisheries and aquaculture.

THE CHALLENGES

The key challenges in the programme are to:

- establish and quantify hydrological flowpaths and storage in freshwater systems and to improve understanding of the interactions between surface and subsurface processes
- develop mathematical models to simulate water resource systems accurately and realistically and to estimate extremes
- develop integrated catchment resource management systems which include water quantity, water quality and hydroecological models to enable sustainable water resource development in a holistic manner
- improve our understanding of the ecology of fresh waters and to develop mathematical models to simulate, accurately and realistically, the relevant processes and biotic responses.

View of Thirlmere, Cumbria. The programme seeks better understanding of the factors affecting water yield from catchments and reservoirs.



*Factors regulating the production of freshwater fish species of economic importance (eg brown trout (*Salmo trutta*)) also constitute an important aspect of the programme.*

There has been increased concern in recent years over the appearance of toxic cyanobacterial blooms. This is one of the issues being studied in the water quality element of this programme.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE

Programme Leader
Dr C S Reynolds
IFE Windermere

Biodiversity and population processes

Through the Convention on Biological Diversity and a wide range of European and global protocols and legislation, the UK Government is committed to the conservation and sustainable use of biodiversity. Biodiversity is essential – though to an unknown extent – for the functioning of ecosystems, including wild places, rivers, lakes, forests, farmed land and urban environments. Understanding biodiversity is required to build sound national and international policies on the conservation of ecosystems and the sustainable use of natural resources from local to global scales.

Priest Pot – a small pond at the north end of Esthwaite Water in the Lake District. The pond is the site of an intensive study of the reciprocal interactions between microbial diversity and ecosystem function.

*CEH's ITE has been looking at the distribution of the small mountain ringlet butterfly (*Erebia epiphron*), and the likely consequences of land use and climatic change on this species for the Scottish Natural Heritage.*

Understanding the hydrological functioning of wetlands is a prerequisite to conserving their biodiversity. CEH's IH is advising on the management of Karavasta Lagoon, Albania's first wetland to be designated as a Ramsar site of international importance.

PROGRAMME THEMES

The programme aims to improve our understanding of microbiological and biological resources at a range of scales. The research addresses biodiversity as the earth's biological capital, considers the underlying processes and resulting functions, and directs knowledge to the sustainable management of biodiversity through four major themes:

- biodiversity characterisation, pattern and monitoring
- ecosystem function and biodiversity
- population processes underlying biodiversity
- conservation and sustainable use of biodiversity.

THE CHALLENGES

The research focuses on a number of key challenges:

- developing techniques for defining and measuring biodiversity, especially at the genetic level, monitoring changes and identifying patterns against environmental gradients, over both time and space
- determining the reciprocal interactions between biodiversity and the functioning of ecosystems by investigating processes involved in the evolution and maintenance of diversity
- identifying the population processes at the level of single species and groups of interacting species that underlie and maintain biodiversity, including the genetic aspects of population ecology
- based on the principles established through the above research, developing policies for conservation, restoration and sustainable exploitation of biodiversity and improving knowledge in order to manage ecosystems with ecological continuity.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Dr J I Cooper
IVEM

Pests and disease control and risk assessment for GMOs

There is a serious need worldwide for more effective control agents for pests and diseases that are both sustainable and environmentally friendly. Despite the wide range of pest control products currently available, pests (eg insects, weeds, fungi, viruses) cause severe damage to food crops in the field and in storage. Wildlife, livestock and human diseases are also an expanding problem, particularly arthropod-borne diseases.

The quest for alternative environmentally friendly pest and disease control strategies has itself given rise to new problems, eg risk assessment involved with the release of genetically modified organisms (GMOs), which carries its own legislation. The primary aim of the programme is to help in the provision of novel control strategies for pest and disease control.

PROGRAMME THEMES

The primary aims of the programme are to assist in the provision of novel pest and disease control strategies whilst assessing any possible risk to the environment. The programme falls into two main themes:

- pest control
- animal disease control.

Molecular biology is essential to much of the work which helps give the programme a novel and progressive approach.

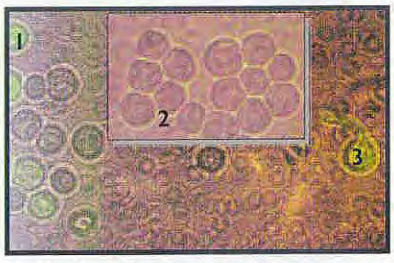
THE CHALLENGES

The programme describes the problems of pest and disease control using environmentally sustainable methods. The key challenges are to:

- determine the interrelationships between insect pests and their natural enemies at ecological and molecular levels as a basis for developing sustainable pest management strategies
- evaluate transgenic genes in natural plant communities and exploit pathogen-derived genes for virus/vector management in crops
- develop realistic, quantitative assessments of the environmental impact of releasing genetically modified viruses, bacteria and plants
- improve water quality monitoring through biotechnology and knowledge of the ecology of pathogens in fresh water.

*A pine beauty moth (*Panolis flammea*) larva, feeding on lodgepole pine (*Pinus contorta*) in Scotland. Research within CEH is studying the dynamics between pest, host plant and natural enemies (such as insect viruses) in order to develop generic models to assess the threat to forests and the impact of different control strategies.*

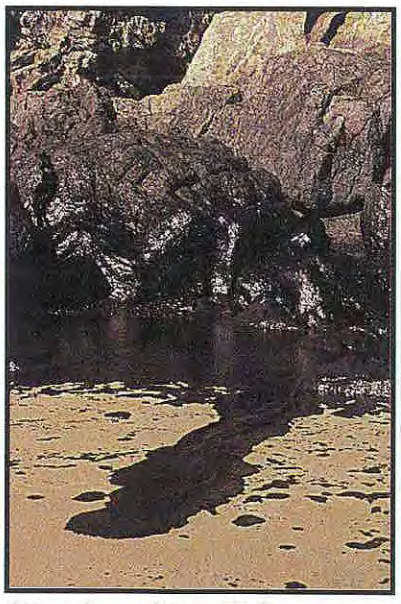
'Blanket dragging' – the method of collecting ticks that transmit the Lyme disease agent.



Inhibition of Pythium ultimum *oospore germination in the presence of stationary phase cells of* Pseudomonas fluorescens *– an example of biological control activity*
[1] metabolically active oospore
[2] (inset) treated oospores – no evidence of metabolic activity
[3] germinating oospore.

PARTICIPATING CEH INSTITUTES: IFE, ITE, IVEM

Programme Leader
Dr J S Cory
IVEM



CEH staff are advising UK Government agencies on remedial action following accidental oil spills at sea.

Pollution

Recent years have seen the rapid development of legislation, at both national and international level, to regulate chemicals in the environment – particularly those pollutants known to produce adverse effects on the environment or on human health.

Effective control of chemicals through legislation requires methodology to estimate the fate, hazard and risk associated with each chemical. The formation of the Environment Agencies in the UK and Europe will increase the priority for this kind of research and the need for monitoring to demonstrate the benefits of policy implementation.

CEH's ITE is monitoring the effects on vegetation following a tanker spill of vinyl chloride.

PROGRAMME THEMES

The programme aims to develop a better understanding of generic processes such as transport processes, fluxes of pollutants and the fate of pollutants in order to predict more accurately the likely impacts on environments and organisms. The main themes of the programme are:

- long-range transport of persistent organics and metals
- further development of the critical loads approach, particularly for acidifying pollutants
- environmental pollution and human health.

THE CHALLENGES

The key challenges are to:

- develop the tools necessary to predict the transport and fate of a prioritised set of pollutants, from both diffuse and point sources, through air, land and aquatic environments, maintaining a whole-ecosystem approach
- predict the dispersal characteristics, fate and impacts of pollutants released to atmosphere, land or water following major accidental discharges or major industrial accidents
- determine the impacts of pollutants on water and land resources, organisms, populations and communities
- communicate research on environmental quality to benefit regulators and users in all sectors.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Dr S Dobson
ITE Monks Wood

Environmental risks and extreme events

The 1990s have been designated as the International Decade for Natural Disaster Reduction (IDNDR). CEH is contributing significantly to IDNDR through its programme of research into the prediction of extreme natural events such as floods and droughts, which are disasters affecting tens of thousands of people and causing billions of pounds' worth of damage annually around the world. In addition, other unusual unpredictable events such as fire, strong winds and temperature extremes can often have dramatic effects on ecological communities, paradoxically often being both a threat and an opportunity to different species at the same time.

This research programme aims to understand how environmental extremes affect mankind and the natural environment, and to develop quantitative predictive tools to describe these effects.

An empty Haweswater illustrates how the British climate has become increasingly variable in the past decade leading to several periods of extreme drought. CEH's IH is assisting the Environment Agency and water utilities plan more effectively for such extremes.

CEH's IH has assisted in assessments of flooding in Truro city centre.

CEH's ITE is measuring the responses of a variety of vegetation types and plant species to wildfires across several different heaths in the Dorset landscape.

PROGRAMME THEMES

Preventative or ameliorating measures for extreme events can only be planned for once suitable models have been developed. Such models require long-term datasets, many of which are held and managed by CEH. The programme aims to take a holistic view of the environment, to recognise particular risks and to identify those areas most prone to environmental risks and rare events. The main themes of the programme are to:

- develop models and methods for estimating the magnitude, frequency, and occurrence of environmental extremes
- produce forecasting and decision support tools for flood, droughts and water quality
- understand and model the role of rare environmental events on natural ecological systems.

THE CHALLENGES

The key challenges are:

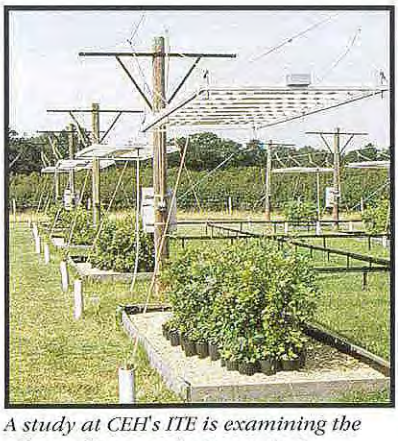
- risk assessment and estimation of floods and other extreme events through development of new and improved design tools
- development of new generic solutions to the problem of determining the combined probability of occurrence of two independent events
- development of improved real-time flow and water quality forecasting and decision support systems
- extending existing forecasting techniques into ungauged regions and into new climatic zones, such as arid regions
- combining physical and biological datasets in order to model the role of rare events on ecological systems.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
F A K Farquharson
IH Wallingford

The CEH's IH Hydra, an instrument for the direct measurement of evaporation fluxes, at a site near Ny-Ålesund, Svalbard, in Sweden. The measurements are part of a programme of research into the effects of global climate change on the Arctic.

An experiment in the Pennines, in northern England, to determine the impacts of climate change on plants and soils.



*A study at CEH's ITE is examining the effects of increased ultraviolet-B radiation on the growth and leaf litter decomposition of pedunculate oak (*Quercus robur*) using a computer-controlled outdoor irradiation system.*

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Prof M G R Cannell
ITE Edinburgh

Global change

Many changes are occurring globally as a result of man's activities. Some, such as losses of biodiversity, freshwater eutrophication and the emission of short-lived air pollutants, are occurring simultaneously in many places and their local or regional impacts are seen repeated around the world. Others, such as industrial activity, deforestation and desertification, occur locally but cause significant long-term changes directly or indirectly to the atmosphere or oceans so that their effects persist and are seen globally. These global changes are the main focus of this programme.

PROGRAMME THEMES

The programme aims to help reduce the uncertainty in the magnitude of global change and its impacts. The research is focused on improving the accuracy of global change predictions by:

- improving our knowledge of greenhouse gas budgets and land/atmosphere interactions
- forecasting global change impacts on species, ecosystems and water resources.

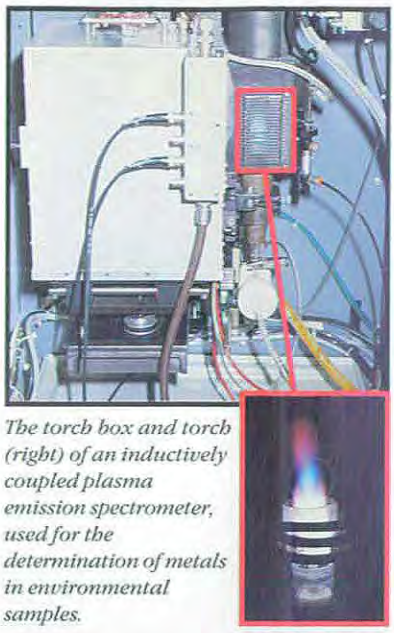
THE CHALLENGES

The key challenges include:

- reducing uncertainty in energy, water and greenhouse gas budgets through intensive measurement programmes
- development of scaling-up methods from the point scale to the landscape, regional and global scales
- development of coupled physical–biosphere models within atmospheric models to study interactive changes concerning greenhouse gases and climate
- identification of whole-ecosystem responses to global change through the use of large-scale manipulation facilities.

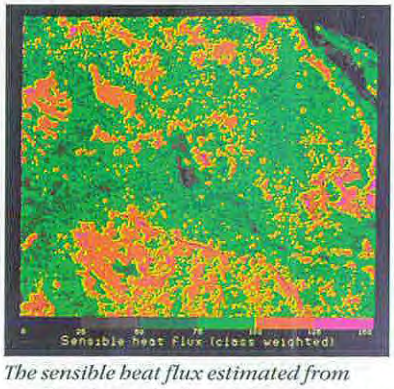
Integrating generic science

This programme has been designed to provide a research framework for those areas of CEH science that underpin the nine other programmes. These activities are cross-cutting, often dealing with new and innovative technology. As well as providing essential data and technological support to the CEH science programmes, this programme aims to develop the research capability of the component areas in their own right.



The torch box and torch (right) of an inductively coupled plasma emission spectrometer, used for the determination of metals in environmental samples.

A joint research project between ITE and the Department of Molecular and Cell Biology at the University of Aberdeen is investigating how new genetic techniques can increase understanding of detailed ecological processes.



The sensible heat flux estimated from satellite thermal infrared data for an area of 255 km² of sparse vegetation in Niger. The river Niger is in the top right corner.

PROGRAMME THEMES

The programme consists of a number of projects covering:

- environmental assessment, economics and history
- remote sensing
- instrumentation and technology development
- analytical chemistry
- management of databases and reference collections.

THE CHALLENGES

The key challenges associated with this wide-ranging programme are to:

- develop methodology for monitoring, assessing and predicting environmental consequences of defined human activities at a range of scales
- develop new methods of environmental remediation for ecosystems such as wetlands, coastal areas and contaminated land, in collaboration with environmental valuation techniques
- develop new algorithms to interpret remotely sensed data so as to improve understanding of ecological and hydrological processes
- develop image analysis techniques for the automation of many of the routine biological tasks
- maintain and expand CEH's high-quality environmental databases and enhance accessibility of databases and collections.

PARTICIPATING CEH INSTITUTES: IFE, IH, ITE, IVEM

Programme Leader
Prof J Hilton
IFE Wareham

CEH is committed to encouraging integration between its Institutes and across traditional scientific disciplines. Several initiatives are in place to further this aim, which include:

- ***the CEH Integrating Fund projects***
- ***interdisciplinary collaborative research funded by the European Union, including two or more CEH Institutes and other partners***
- ***commissioned research on environmental problems that draws on expertise across CEH.***

CEH established the Integrating Fund projects in 1995.

CEH integrating science

CEH INTEGRATING FUND PROJECTS

CEH established the Integrating Fund projects in 1995. The aim of the projects is to advance science in those areas where collaboration between subject areas is required and to capitalise on the range of complementary expertise within the component Institutes of CEH. Seven projects were initiated in 1995–96 and six in 1996–97.

For each of the seven projects in Round 1, a first-year report has been prepared along with a presentation on progress to the CEH Management Board. Summaries of Round 1 projects follow.

CEH Integrating Fund projects

Title	*IFE*	*III*	*ITE*	*IVEM*
Projects commencing in 1995–96				
The microbial basis of methane (CH_4) oxidation in soils	•		•	•
Microbial diversity and ecosystem function – Phase I	•		•	•
Interactions of viruses, aphids and wild *Brassica*			•	•
Combined growth and water use modelling of mixed vegetation			•	
Molecular genetics and process-level events in the biodegradaton of xenobiotics in rhizosphere soils			•	
Modelling the chemical availability of radionuclides in upland organic soils	•		•	
Upland forest canopy closure – its significance for chemistry, ecology and hydrology	•		•	
Projects commencing in 1996–97				
The role of seabirds in the epizootiology of Lyme disease				
Combined hydro-ecological and socio-economic models of land use, land management and environmental degradation (CHASM)		•	•	
The environmental characteristics of urban environments	•	•	•	
Microbial diversity and ecosystem function – Phase II	•		•	
50 m solar grids for the UK		•	•	
Modelling the fate of viruses in the aquatic environment		•		•

The microbial basis of methane (CH_4) oxidation in soils

CEH Institutes: IFE, ITE, IVEM
Project Leader: Dr P Ineson, ITE

One of the most important of the greenhouse gases is methane (CH_4), which is estimated to contribute 15% of anticipated global warming. However, it has only recently been realised that natural and semi-natural systems are responsible for the oxidation of considerable quantities of this trace gas. In addition, the principal organisms responsible for methane oxidation at atmospheric concentrations and across different soil types and land uses are largely unknown.

Of particular interest is the close link between the nitrogen status of a soil and the rates of CH_4 oxidation. Recent evidence suggests directly opposite responses to N additions in natural and agricultural soils. Understanding these differences requires an increased characterisation of the microbial populations involved, together with a deeper knowledge of the environmental factors controlling the activities of these organisms. The research at CEH's IFE, ITE and IVEM combines field flux observations with laboratory investigations and identifies the bacteria involved, using modern molecular techniques (PCR, FAMES and isotopes).

The research has initially concentrated on a forest site in north Wales which has received regular simulated pollutant N additions since October 1990. Field measurements using the ITE mobile laboratory have found high rates of CH_4 oxidation at the site, and demonstrated that N additions have resulted in a significant reduction in CH_4 oxidation rates. Laboratory studies are locating the horizons in the soil where oxidation is greatest and characterising the organisms responsible. Conventional isolation techniques are being combined with the application of molecular techniques recently developed within the NERC Terrestrial Initiative in Global Environmental Research (TIGER) programme.

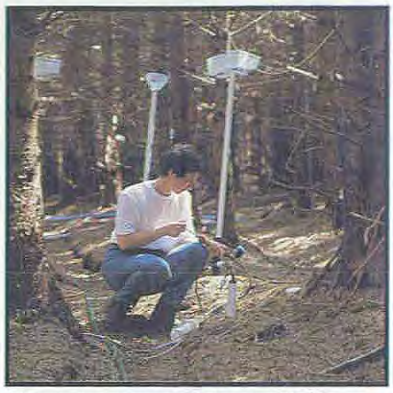
Microbial diversity and ecosystem function – Phase I

CEH Institutes: IFE, ITE, IVEM
Project Leader: Dr B J Finlay, IFE

Microbial diversity is the least well understood component of 'biodiversity'. As part of this Integrating Fund project, microbial diversity and its role in a small, productive, freshwater pond (Priest Pot) in the English Lake District have been characterised. The work is starting to show that microbial diversity is inextricably linked with ecosystem function.

Like many small ponds, the dominant biology is microbiological, with many hundreds of species of micro-organisms and viruses active at any one time. A considerable diversity of active forms does persist in Priest Pot and this appears to be facilitated by two factors. First, the microbial diversity is separated into vertical compartments, arranged with respect to the principal chemical gradients. Compartments of anaerobes, microaerophiles and fully aerobic forms exist. Second, there is further vertical separation of individual species within these compartments.

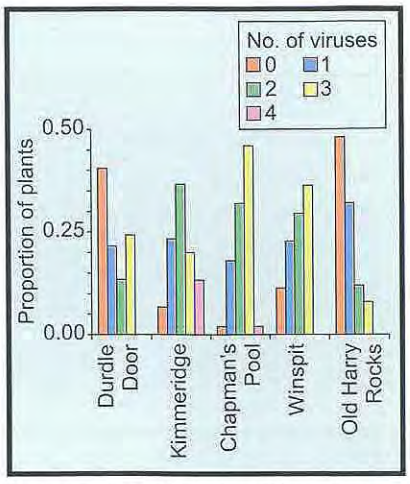
The pond consists, at least during the summer period, of superimposed, functionally different microbiological communities, between which direct interactions (eg predation) are rare, but which are loosely connected by fluxes of chemicals. This division of total microbial diversity into compartments may be responsible for the considerable microbial diversity observed in the pond as a whole.



Nitrogen treatments being applied by CEH's ITE staff beneath the canopy at the Aber site in north Wales have resulted in reductions in methane oxidation rates.

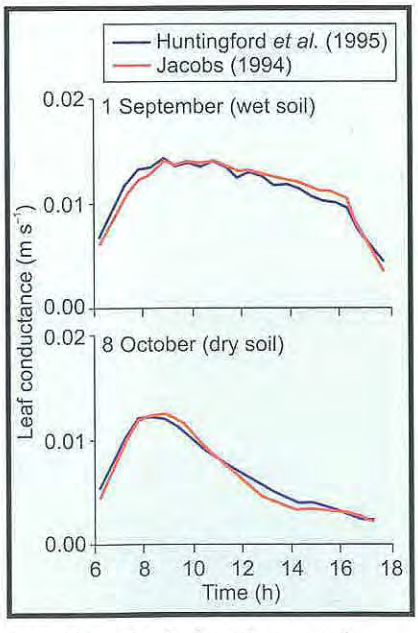
Microbial diversity is the least well understood component of 'biodiversity'.

Water samples collected at 10 cm depth intervals from Priest Pot, being incubated with ^{14}C bicarbonate in a controlled environment mimicking deep water in the pond, to determine the rate of carbon assimilation by micro-organisms.



The proportion of plants with no, single and multiple virus infection in five populations of wild cabbage in Dorset is being studied by CEH's ITE and IVEM.

Initial results show that many plants have multiple virus infections and that the pattern of infection varies among populations.



Diurnal trend in leaf conductance of Guiera senegalensis *calculated using two conductance models over two days with contrasting soil moisture conditions. The models are being developed by CEH's IH and ITE.*

Interactions of viruses, aphids and wild *Brassica*

CEH Institutes: ITE, IVEM
Project Leader: Prof A J Gray, ITE

Increased virus resistance through the expression of viral genes in plants is one of the most promising applications of crop genetic modification. There are concerns, however, that if these genes spread to wild crop relatives, new pathogenic viruses may arise. Also, the introduction of genetically modified virus resistance may alter the dynamics of natural populations if virus infections have significant effects on plant growth and reproduction.

As part of the risk assessment of genetically modified virus resistance, the pattern and effects of virus infection are being studied in five natural populations of wild cabbage (*Brassica oleracea*). Over 200 plants have been marked and tested for the presence of beet western yellows virus (BWYV), turnip mosaic virus (TuMV), cauliflower mosaic virus (CaMV) and turnip yellow mosaic virus (TYMV).

Multiple infections are not the result of random association among viruses. Plants infected with BWYV, TuMV or CaMV have significantly higher amounts of infection with other viruses, compared with plants without each respective virus. The association of BWYV, TuMV and CaMV may be because they are transmitted by a common herbivore vector (possibly aphids).

Work is in progress to investigate whether levels of viral infection correlate with the distribution of various herbivores and whether genetic differences in cabbage populations play a role in determining virus distributions. Virus effects on plant fitness are also being assessed by field trials and observation of the growth and reproduction of the marked plants in the wild.

Combined growth and water use modelling of mixed vegetation

CEH Institutes: IH, ITE
Project Leader: Dr S J Allen, IH

By far the greatest amount of the world's vegetation grows as mixed species. To predict correctly their possible responses to global change and/or different management options, it is imperative to be able to model the growth and water use of the individual components as well as the community as a whole. This project brings together the multi-species energy and water balance models and detailed growth models, currently being developed at IH and ITE respectively, to address problems in combined growth and water use modelling in mixed canopies.

The main aim is to produce a fully interactive and dynamic soil/vegetation/atmosphere transfer (SVAT) model. The model will allow the complex interplay between atmospheric CO_2, vegetation dynamics and surface energy balance to be properly simulated. Four key modelling tasks have been identified:

- plant response to CO_2
- soil respiration
- within-canopy flux interactions
- seasonal growth of mixed vegetation.

Significant progress has already been made. Initial comparisons of two models of plant canopy conductance using entirely different approaches have shown encouraging agreement. Soil respiration models have been reviewed and a best candidate is ready for application and testing in savannah. Some of the current inadequacies of in-canopy flux transfer models have been identified and improvements in this important area are planned.

Molecular genetics and process-level events in the biodegradation of xenobiotics in rhizosphere soils

CEH Institutes: ITE, IVEM
Project Leader: Dr M J Bailey, IVEM

In order to develop appropriate methodologies for the decontamination of sites, it is essential that the biological processes influencing bioremediation are understood.

Organic xenobiotics are typical environmental pollutants that persist in bulk soils because of their slow rates of degradation and low bioavailability. In this project changes in the diversity and activity of the resident microflora in the presence of dichlorobenzene (DCB) have been examined. The aim is to determine whether enhanced DCB degradation is due to nutrient effects, the selection and growth of specialised bacterial populations, or individuals acquiring the ability to utilise the DCB as a result of gene transfer (forced evolution).

When single DCB treatments were compared over a 112-day period, the numbers and biomass estimates for bacteria and fungi were greater in rhizosphere-treated soils, irrespective of the presence of DCB. In these studies the rate of DCB transformation can be up to 30 times greater in soils containing plant root material.

In contrast, the effect of a single large dose of DCB compared to the impact of the same dosage administered by ten regular applications showed no significant differences in total numbers of bacteria. However, the density of pseudomonad bacteria in the multiple-treated soils decreased by almost a thousand-fold. Molecular analysis of a representative sample of bacterial isolates confirmed this change in diversity.

IVEM is currently extending these studies to the genetic characterisation of isolates to determine whether the ability to catabolise DCB is a result of genetic transfer and recombination, the selection of resident strains, or the result of the activity of a consortia of micro-organisms.

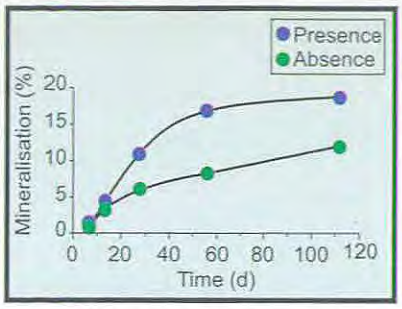
Modelling the chemical availability of radionuclides in upland organic soils

CEH Institutes: IFE, ITE
Project Leader: Prof J Hilton, IFE

In the event of fallout from a nuclear incident it is important to have identified areas from which contaminated drinking water and foodstuffs may arise. Experience from the Chernobyl accident showed that soil type is a major factor in determining the long-term contamination of both vegetation and surface waters by radionuclides (in particular radiocaesium). IFE and ITE are developing relationships between fallout of radiocaesium from Chernobyl and soil type and land cover type at a catchment scale for Cumbria. These have been integrated using environmental datasets within a geographical information system. The aim is to develop generic relationships between the spatial characteristics of a catchment and the radiocaesium contamination of lakes and vegetation.

The occurrence of three land cover types from the ITE Land Cover Map of Great Britain (upland and lowland bogs; marsh/rough grass; dwarf shrub/grass moor) has been shown to be strongly correlated with long-term radiocaesium contamination of lakes in Cumbria. After further testing, this correlation should allow the production of a map of areas vulnerable to high rates of radiocaesium mobility.

Field studies on the changes in radiocaesium activity in vegetation over ten years since the Chernobyl accident show that rates of decline in radiocaesium contamination in vegetation are similar to those in lake waters. This suggests a common mechanism for the decline, namely the changing chemical availability of radiocaesium in the soil.



*^{14}C 1,2-DCB was added to an agricultural soil in the presence and absence of Yorkshire fog (*Holcus lanatus*) plant roots (6% by wt) contained within a closed microcosm, n=3. Mineralisation (degradation) was determined over time by liquid scintillation counting of sampled NaOH traps.*

A plot of data from the ITE Land Cover Map of Great Britain, for the Derwentwater area, showing all 25 land classes. The data were used to study radiocaesium transport from peat bogs into lake waters.

*Sitka spruce (*Picea sitchensis*) plantations making progress towards canopy closure in the upper part of the Cwm catchment, at Llanbrynmair. Also shown is riparian wetland left unplanted for conservation purposes, and to help maintain water quality. The excessive heather (*Calluna vulgaris*) growth seen under the young trees is causing competition for nutrients.*

Upland forest canopy closure – its significance for chemistry, ecology and hydrology

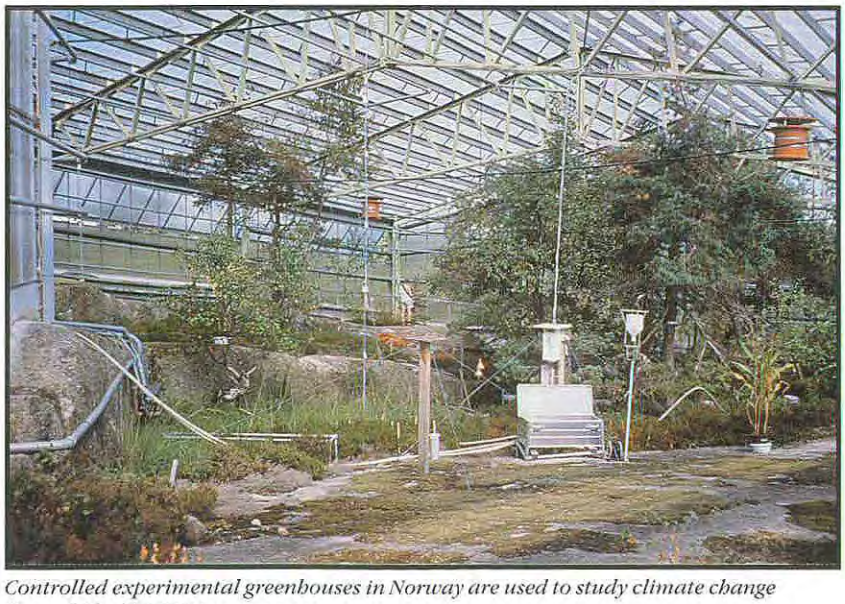
CEH Institutes: IFE, IH, ITE
Project Leader: Prof I R Calder, IH

Canopy closure is an important phase in the life cycle of upland plantation coniferous forests, occurring between 15 and 25 years after planting. Using two catchments, the Cwm (forested) and Delyn (moorland control) on Llanbrynmair Moor in Wales, the hypothesis under test is based on the question: 'Is there evidence that forest canopy closure has resulted in changes in evaporation, streamflow, stream chemistry and biology (particularly fish) in the Cwm, either as a step change from initial conditions or as differences between the Cwm and the adjacent Delyn moorland control catchment?'

Analysis of long-term data clearly indicates that initial disturbance due to afforestation affects chemical composition. NO_3 concentrations increased, then fell to levels characteristic of moorland. The Cwm now exhibits greater seasonality than the Delyn, with chemical concentrations lower in the summer and higher in the winter due to increased microbial action and continued aeration and mineralisation. Forest growth has also resulted in increased evaporation from the catchment.

Spatial surveys of physical and chemical characteristics of streamflow, particularly temperature, pH, low flows and alkalinity, largely explain the variation in breeding success, productivity and diversity of invertebrate populations and migratory fish (principally sea trout). There is a large annual variation in recruitment within fish populations and it appears that some areas of the catchment may be particularly well buffered from increased acidic inputs. In consequence, canopy closure effects may eventually be seen as changes in spatial variability rather than overall changes in the fish populations.

Good progress has been made in modelling the hydrochemical system. The WHAM model is being used to predict the correct aluminium speciation in the catchments. The first runs of the CHUM model, linking inputs, soil and streamwater chemistry, have successfully characterised the hydrological response of the Cwm catchment. Information on the spatial distribution of stormflow chemical response is the next step required in improving the model calibration.



Controlled experimental greenhouses in Norway are used to study climate change through the CLIMEX programme.

CEH EU-FUNDED RESEARCH

CEH Institutes are both leading and collaborating in a number of European Union Framework IV projects, which is further strengthening the integrating nature of science in CEH.

CLIMEX: Climate manipulation experiment

Led by IH, with collaboration from ITE

Objectives

- To establish the effects of raised temperature and CO_2 in enclosures

on northern temperate ecosystems in Norway.
- To study the consequent effects on energy balance, water flux, gas exchange and nutrient cycling.

DYNAMO: Dynamic models of nitrogen flux

Led by IH, with collaboration from ITE

Objectives
- To develop nitrogen dynamic models applicable at the catchment scale.
- To validate the model against existing long-term and regional datasets and carry out sensitivity tests.

ECOMONT: Ecosystem structure and function for European montane ecosystems

Led by ITE, with collaboration from IH

Objectives
- To assess the effects of changing grazing pressures and land abandonment on vegetation structure and composition.
- To study the implications of changing vegetation structure on gas exchange, water flux and nutrient cycling.

LAPP: Carbon fluxes and energy balance in tundra regions

Led by IH, with collaboration from ITE and other EU partners

Objectives
- To better understand the basic processes underlying the balance of water, energy and carbon for the arctic land surfaces.
- To incorporate this knowledge into improved descriptions of arctic land surfaces within climate models.
- To assess the effects of climate change on energy, water and carbon balances of arctic surfaces.

CEH COMMISSIONED RESEARCH

As CEH becomes more established it is also improving its success in winning commissioned research projects that draw on the range of expertise within the Centre. Examples of these projects are given below.

Lake Victoria environmental management programme

Contract to the Food and Agriculture Organisation of the United Nations

CEH scientists have supported the Regional Task Force in the preparation of a five-year implementation programme for the environmental management of Lake Victoria. The work has included:
- preparing proposals for strengthening water quality monitoring and for research priorities;
- preparing proposals for strengthening non-point pollution assessment capabilities and for research;
- reviewing changes of wetland use and analysing the impact on Lake Victoria.

Economic impacts of the hot dry summer and anomalously warm year of 1995

Contract to the UK Department of the Environment

CEH is leading the study which aims to assess the economic impacts, in terms of costs and benefits, of the hot summer and warm year of 1995. As well as physical and biological effects, climate change will also have economic impacts. Certain sectors are likely to be more economically vulnerable than others to climate change and will thus require more strategic planning and possibly investment. The UK Government needs such information in order to plan for change. Sectors under study include agriculture, forestry, the natural environment, the water industry, health, tourism, the energy industry, transport, construction and the retail industry.

Colonisation of high ground by pines at the Allt a'Mharcaidh catchment in Scotland. ITE and IH are examining the effects of extension of tree cover on the ecological and hydrological characteristics of the catchment, as part of the ECOMONT programme.

CEH Institutes are both leading and collaborating in a number of European Union Framework IV projects, which is further strengthening the integrating nature of CEH science.

CEH has a vital national role in the monitoring, collecting and collating of environmental data.

The Centre plays a major part in the monitoring, management and dissemination of environmental data. CEH holds very significant amounts of such data and some of the datasets comprise long-term records, collected over many years. These CEH data are a major asset for UK and international science, and the need for effective custodianship of data is essential.

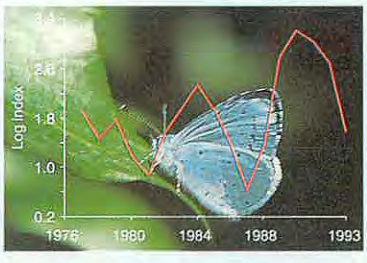
CEH data and technology development

Two of the NERC Designated Data Centres are in CEH – the Environmental Information Centre at ITE Monks Wood and the National Water Archive at IH Wallingford. The Data Centres not only provide a key link for improving the accessibility of data to the wider community, but also have their own science programmes to develop the use and interpretation of data in their own right. In particular, development in geographical information system techniques is allowing the manipulation of multiple datasets and providing new scientific insights in a number of research areas.

Much of CEH science is both specialised and responsive to emerging scientific problems, which can generate the need for new instrumentation. These new instruments are often required to perform under harsh environmental conditions in remote areas. CEH scientists have an impressive record of developing scientific instruments, specialist facilities, and new techniques in biotechnology.

Examples of CEH monitoring networks, data analysis and instrumentation development follow.

202 terrestrial variables
Meteorology
Precipitation chemistry
Atmospheric chemistry
Surface water discharge
Soil solution chemistry
Soil properties
Vegetation
Vertebrates
Invertebrates
Soil organisms
Site management



58 freshwater variables
Surface water chemistry
Surface water flow
Chlorophyll a
Invertebrates
Macrophytes
Zooplankton
Phytoplankton
Periphyton

ECN data acquired since 1993 using standard measurement protocols.

THE UK ENVIRONMENTAL CHANGE NETWORK

NERC's commitment to long-term monitoring is well demonstrated by the key role it has played in the establishment of the UK's Environmental Change Network.

ECN was given a ministerial launch in 1992 when it was established as an integrated monitoring network to detect and interpret environmental change. It is a multi-agency initiative, co-ordinated by NERC, which aims to collect, store, analyse and interpret long-term data on key environmental variables at a range of terrestrial and freshwater sites in the UK.

Monitoring began in 1993 and during its first four years ECN has:

- established a fully operational network of terrestrial and freshwater sites
- developed standard measurement protocols and quality assurance procedures to ensure that all data collected are reliable and comparable in space and time
- created a central database and developed standard data transfer, handling and validation procedures
- provided research sites for related research programmes, eg TIGER.

Contact: Dr T W Parr, ITE

THE RIVERS DATA CENTRE FOR LOIS

LOIS – the Land/Ocean Interaction Study – is one of NERC's largest Thematic Programmes, with a £30 million budget. The effective collation and manipulation of data from a variety of sources and subject areas are an important part of the programme's scientific objectives. A novel aspect of this programme is the creation of five thematic Data Centres to archive and distribute LOIS datasets.

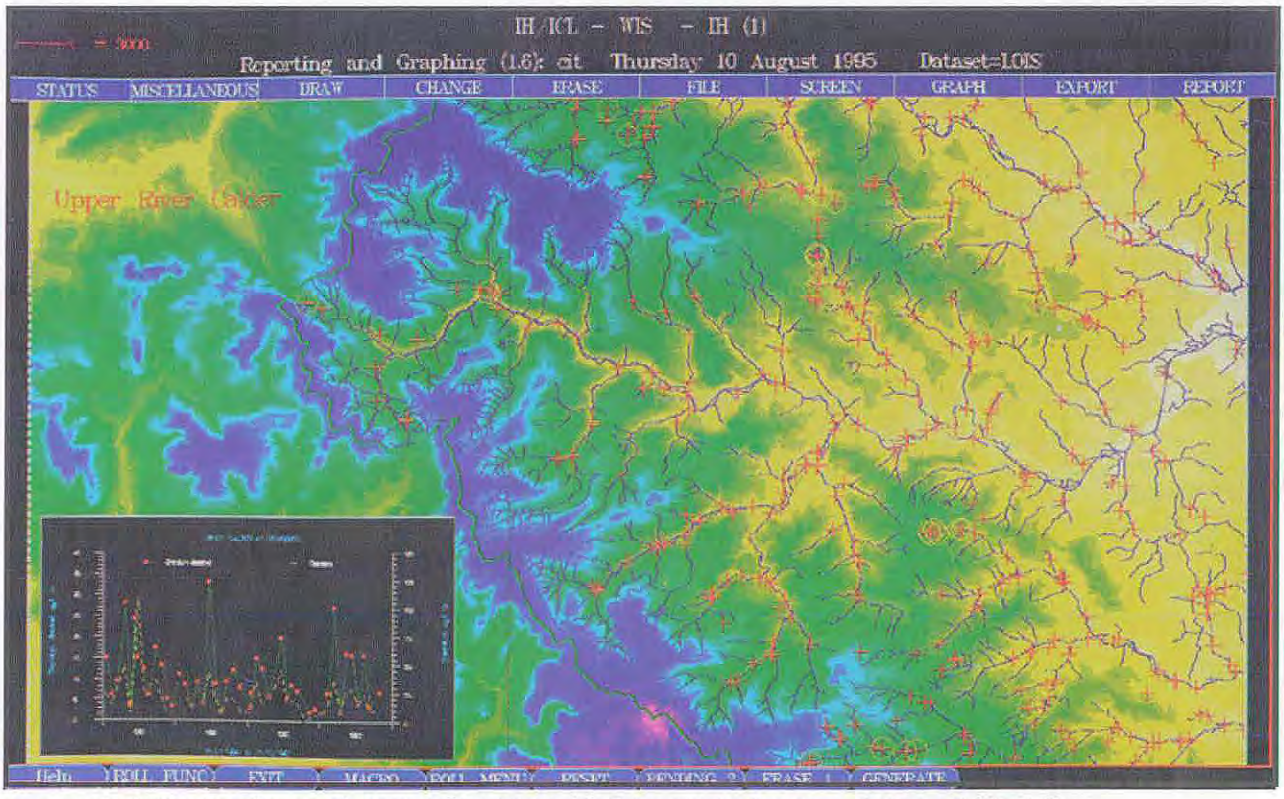
The Rivers Data Centre is at the Institute of Hydrology and is responsible for all catchment-based data – both time series and spatial. The main suppliers of the data are the Environment Agency (EA) Regions in the LOIS study area. One of the main challenges for the IH Data Centre has been the task of matching many different data types. For example, no standard encoding system for water quality data exists between the different regions of the EA, or from freshwater and marine sources.

The Rivers Data Centre is using the Water Information System (WIS), designed and developed at IH. WIS stores and manages all data required by the modellers in the rivers component of LOIS. An important aspect of this system is that it does not distinguish between spatial and time series attributes, so that the user can link and analyse spatial and time series datasets within a single integrated database.

A major LOIS objective is to develop integrated simulation models to enable better predictions over time. The LOIS Data Centres are supporting this objective by standardising their datasets. The aim is to create an integrated database which will be available, on CD-ROM, for general use after the end of the LOIS programme.

Contact Mr R V Moore, IH

The River Swale upstream of the confluence with the Ouse. This is one of many rivers flowing into the Humber Estuary which are being studied by CEH's IH staff as part of the LOIS project.



An example of WIS output from CEH's IH Digital Terrain Model of river monitoring sites in the Upper Calder Valley.

CLASSIFICATION OF THE ENVIRONMENT WITH VECTOR AND RASTER (CLEVER) MAPPING

The digital maps offer a spatial subdivision of the images, using the parcel outlines of the vector data.

Grid-based or 'raster' images derived from remote sensing can now be integrated with digital, vector information obtained from conventional cartography. A particular challenge lies in combining a diverse range of image analysis methods with the digital mapping techniques of geographical information systems (GIS).

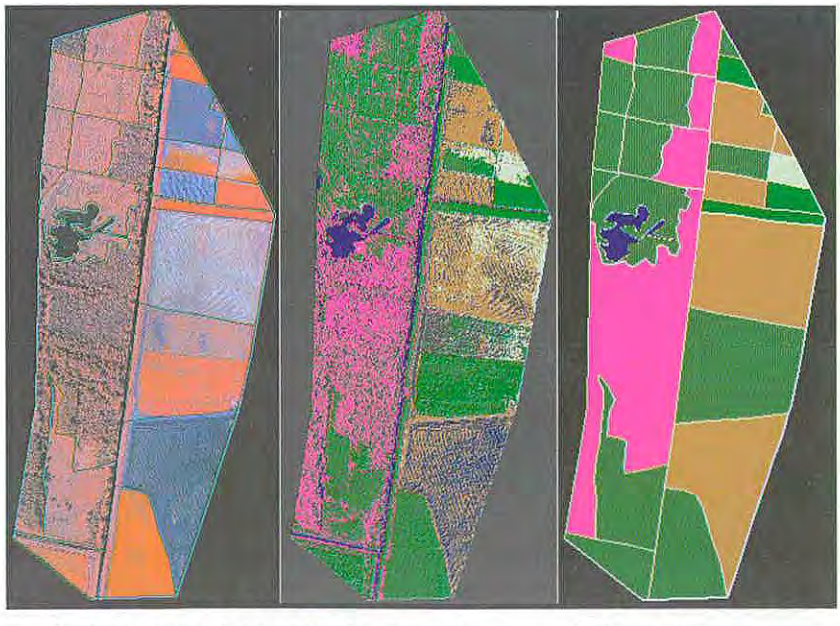
The initial development work is being centred on the Laser-Scan Integrated Geographical Information System (IGIS), which is specifically designed to integrate raster and vector data. Various enhancements to IGIS have been identified which will be developed to meet the specific requirements of CLEVER-mapping.

An image of Woodwalton Fen, Cambridgeshire, collected by airborne scanner giving a 1.25 m pixel size, has been combined with simple vector data to delimit land cover parcels. Initially the area was classified conventionally, using only the spectral information in the image. The vector data were then used to define land cover parcels, and the spectral statistics were summarised. A per-parcel classification was then applied to the summary statistics, giving a generalised map more accurately describing the distribution of broad land cover types. This new map met more closely the needs of many applications and users.

Currently the project is developing the integration of various Ordnance Survey maps and data products, combined with airborne and satellite imagery, to provide the prototype for a fully integrated CLEVER-mapping procedure, intended for long-term operational use.

This BNSC Earth Observation LINK project is being undertaken by CEH's Institute of Terrestrial Ecology, Cambridge University's Department of Geography, Laser-Scan Limited and the Ordnance Survey.

Contact: Mr R M Fuller, ITE



Woodwalton Fen, Cambridgeshire, showing an image recorded by an airborne scanner, with a 1.25 m pixel size (the display is based on red, near infrared and middle infrared wavebands) (left); a broadly-based, conventional, per-pixel, classification giving heterogeneous and frequently erroneous results (centre); and a per-polygon classification, using CLEVER-mapping, with simplified results and much improved accuracy (right).

NEW TECHNIQUES IN WATER QUALITY MONITORING

Lakes are widely regarded as ideal 'sentinels' of environmental change. They respond in a predictable way to changes in the catchment and are dominated by biological communities that are strongly influenced by changes in the weather. In recent years it has become clear that many of the long-term changes recorded in lakes are driven by climatic processes that operate on a regional or even global scale.

CEH's Institute of Freshwater Ecology has developed an automatic water quality monitoring and automatic weather station, incorporated into a buoy, which is capable of continuously recording the response of a lake system to changes in weather conditions. The station includes a full meteorological station, and a range of physical, chemical and biological data can be collected using readily available sensors. A particular attribute is a novel phytoplankton biomass sensor, which has been developed by IFE. Data are transmitted to shore where they are continuously available for retrieval via a telephone modem.

The system has been designed to be robust, to cope with extreme weather conditions. It is flexible, to allow the addition of other probes, and can be tailored to the specific requirement of the user. It has a long inter-service interval and has an inherent ability to diagnose internal faults.

The automatic water quality monitoring station has been developed with funding from the EU LIFE Programme, and additional support from the UK Environment Agency.

Contact: Mr M A Rouen, IFE

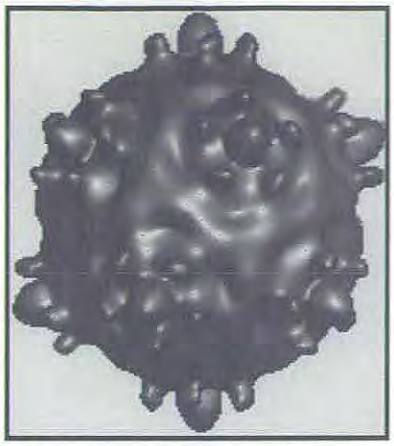
ADVANCED ELECTRON MICROSCOPY

Advanced electron microscope facilities exist in both IVEM and IFE. The facility at IVEM is one of the few centres in the UK that is dedicated to cryo-transmission electron microscopy (TEM) and comprises a Philips CM 120 cryo with an advanced cryotransfer specimen holder developed by Oxford Instruments plc.

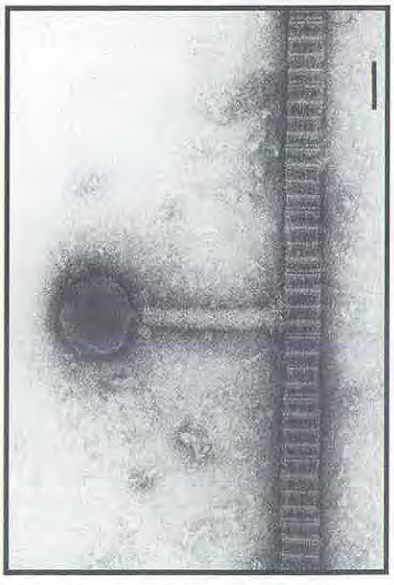
Cryo-electron microscopy is a useful technique for structural investigations of aqueous systems and is unique in that it allows direct observation of molecular structures and interactions. IVEM is using cryo-TEM to investigate the structure and function of a diverse range of viruses and microbes in the environment. Both the basic structure and function of organisms and the comparison and characterisation of different isolates of organisms are being studied.

Electron microscopy is also being used to study the microbial diversity within Priest Pot, a small hyper-eutrophic freshwater lake in the English Lake District. Fluorescence, light and electron microscopy are used to identify the total microbial community, and transmission electron microscopy is used to categorise and enumerate the variety of free viruses present. This study is part of a CEH Integrating Fund project on ecosystem diversity, described in a previous section.

Contacts: Dr T F Booth, IVEM, and Mr K J Clarke, IFE



Surface structure of cytoplasmic polyhedrosis virus using cryo-TEM. CEH's IVEM has conclusively identified the large spikes at the vertices as containing the viral RNA polymerase complex, which is a first for the Reoviridae.



A free virus (bacteriophage: Myoviridae) attached to a trichocyst ejected from a ciliated protozoon, from Priest Pot, Cumbria (bar=50 nm). CEH's IFE is studying microbial diversity within Priest Pot, a freshwater lake in the English Lake District.

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. CEH scientists are involved in both the research and management of several of the Thematic Programmes. Some examples are given below.

CEH's role in NERC Thematic Programmes

TERRESTRIAL INITIATIVE IN GLOBAL ENVIRONMENTAL RESEARCH (TIGER)

Programme Manager: Mr M A Beran, IH

The NERC TIGER programme is a five-year Thematic Programme which has addressed many important climate change issues in the terrestrial and freshwater environments. Three of its main components – dealing with carbon cycling, trace greenhouse gases, and energy and water budgets – are coming to their close. The fourth component, dealing with impacts on ecosystems, has another year to run.

A major event, the TIGER's Tale, took place on 24 October 1996 at the Queen Elizabeth II Conference Centre in Westminster, where the background and results of TIGER were presented. The Rt Hon John Gummer MP, Secretary of State for the Environment, was guest of honour. This meeting generated considerable press interest, with three national papers featuring the event and TIGER's major findings.

More detailed information on NERC's contributions to TIGER is available in the Annual Reports of the CEH Institutes. Leaflets, contact points and a key bibliography are available from the TIGER Office at CEH's Institute of Hydrology (email: tiger@ioh.ac.uk).

TIGER findings are helping address some major environmental questions

Minding the store: carbon in soils and vegetation
- Forests absorb carbon on enormous scale: are they 'missing carbon sink'?
- Carbon losses from peatland could eventually counter UK CO_2 savings
- 'Coloured' water supply problems foreseen in peat area
- Ecosystems can lose their carbon: new models to predict when
- Speed of vegetation change: the critical factor for climate and carbon

Balancing the books: towards a national budget for greenhouse gases
- DNA fingerprinting reveals unsuspected variety among methane bacteria
- Methane from UK peatlands set to double with 3° warming
- Much more nitrous oxide emitted from UK grassland than previous estimates
- Airborne sampling to check total UK greenhouse gas emissions
- Global methane emissions will grow as earth warms, but not without limit

Towards reality: improving and validating global change predictions
- Data from past millennia help refine climate understanding
- Climate prediction to benefit from new data from tropical zones
- Land surface properties crucial for accurate climate prediction
- Soil moisture holds key to explaining Sahel drought pattern

Facing the consequences: how ecosystems react to change
- New light on how plant growth is stimulated by CO_2
- Drought will be key factor for degraded environment
- Data on how species respond help predict ecosystem change
- Plant migration reduced by fragmented UK habitats
- Spread of alien plant species may be slower than expected
- Link found between biodiversity, ecosystem stability and greenhouse gases

THE LAND/OCEAN INTERACTION STUDY

River basins component
Programme Manager: Mr G J L Leeks, IH

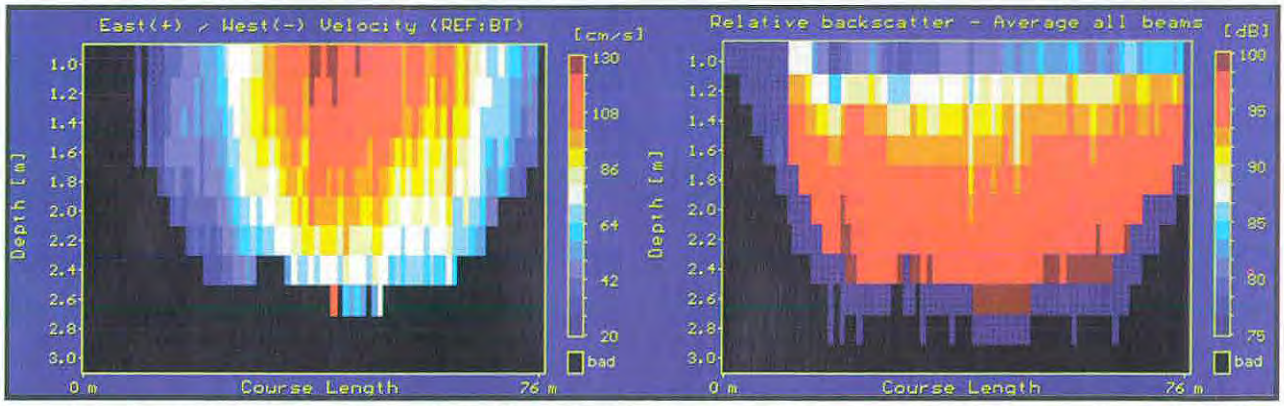
The coastal zone is an area of prime social and economic importance at the interface between land, atmosphere and the oceans. It is complex and subject to major natural and man-made change. The scientific challenges and the importance and relevance of coastal zones in global terms have led to the study of the physical, chemical and biological processes that regulate this dynamic zone being developed into a number of national and international land/ocean science programmes.

In the UK, NERC began a large-scale research initiative, the Land/Ocean Interaction Study (LOIS), in 1993. This Thematic Programme parallels and links to current international scientific interest. Intensive large-scale LOIS monitoring networks support major research, directed at improved understanding of the physical, chemical and biological processes which control land to sea fluxes. The research includes the measurement of the riverine fluxes through the full flow range, from major floods to extreme drought conditions.

CEH is a major contributor to the highly integrated LOIS programme, with substantial projects covering a wide range of rivers, estuaries and coastal research topics. Innovative technologies, such as Acoustic Doppler Current Profiling (ADCP), are providing new insights into large river and estuarine dynamics. Similarly, advanced airborne remote sensing of river corridors, including innovative applications of CASI (Compact Airborne Spectrographic Imager), is providing spatial data on catchment surface characteristics and channel water quality. The development of generic integrated river basin models to predict fluxes 50–100 years in the future is at an advanced stage. The study has also involved the development and running of a very large-scale, highly structured rivers database capable of handling large volumes of LOIS and externally supplied data, which is based at CEH's IH. GIS and visualisation facilities have been developed which are proving of value both to the scientific community and water industry. The rivers programme has involved close collaboration with the Environment Agency, Scottish Environmental Protection Agency, Yorkshire Water and other bodies.

LOIS has provided opportunity for many productive collaborative projects with a wide range of multidisciplinary university and CEH research teams.

A member of IH LOIS staff is seen in the River Ure, Yorkshire, cleaning up sensors which are used for monitoring turbidity and triggering epic bulk samplers.



A two-dimensional representation of water velocity (left) and relative backscatter of ultrasound (right) in a river section on the tidal Ouse at Drax, Yorkshire. The data were collected using an RDI river-reading Acoustic Doppler Current Profiler mounted on a boat.

There are many collaborative projects with a wide range of multidisciplinary university and CEH research teams.

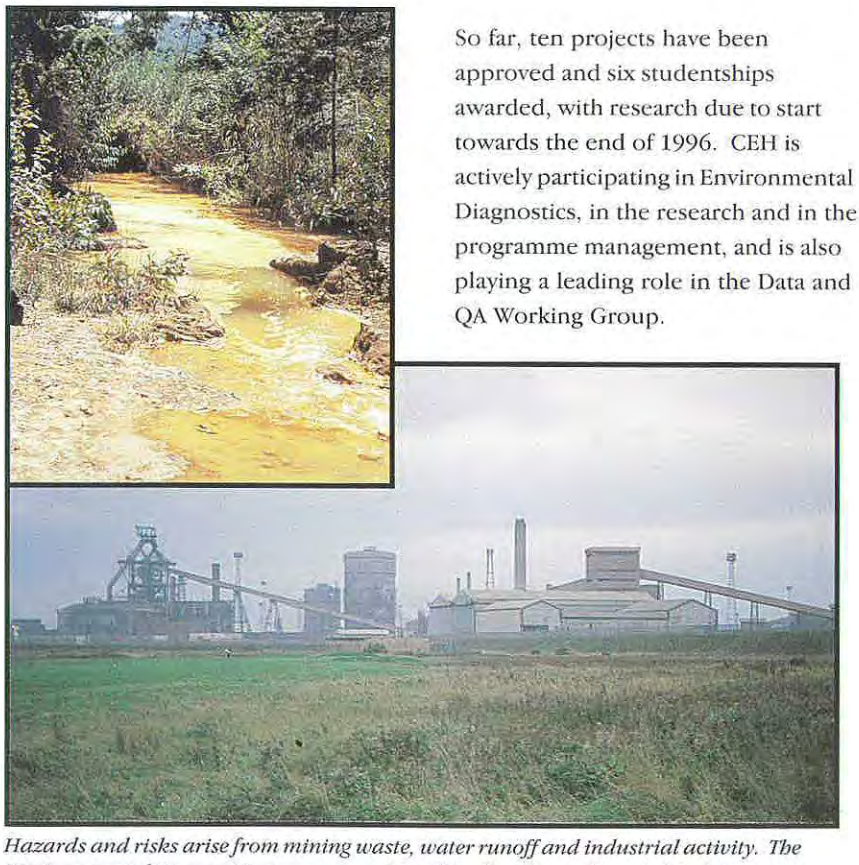
ENVIRONMENTAL DIAGNOSTICS

Programme Manager: Dr D Osborn, ITE

Environmental Diagnostics is a new Thematic Programme, running from 1995 to 2001. The Programme has attracted wide interest and is funded at £6.5 million, from a consortium of funders and users.

The programme seeks to integrate biological, hydrological and geological expertise to provide scientific underpinning for more realistic risk assessment and monitoring of waste materials, contaminants and related chemicals. The aim is to provide a firmer scientific base for environmental clean-up and remediation, and to supply industry with tools for more cost-effective and long-term decision-making on waste management, minimisation and recycling. This will help users plan and act more sustainably in future.

So far, ten projects have been approved and six studentships awarded, with research due to start towards the end of 1996. CEH is actively participating in Environmental Diagnostics, in the research and in the programme management, and is also playing a leading role in the Data and QA Working Group.



Hazards and risks arise from mining waste, water runoff and industrial activity. The Environmental Diagnostics programme is putting these hazards and risks into an ecological perspective.

LARGE-SCALE PROCESSES IN ECOLOGY AND HYDROLOGY

Programme Manager: Dr R W G Caldow, ITE

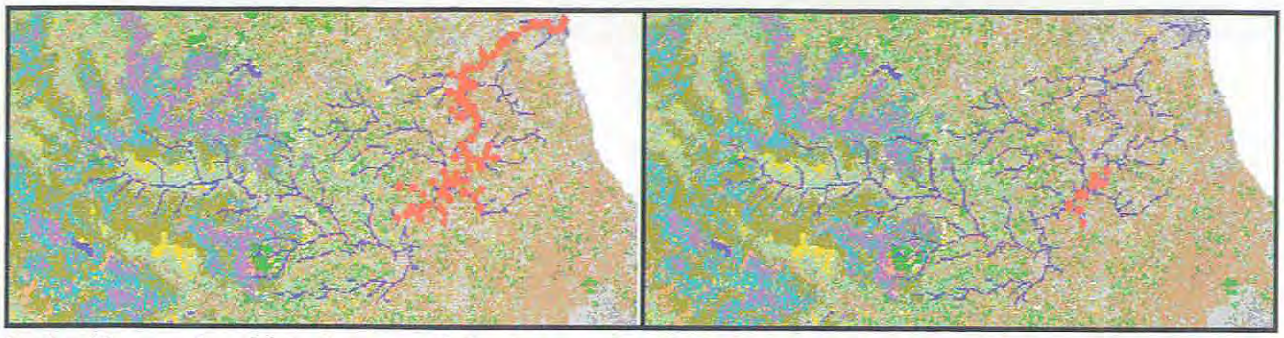
Increasing awareness of the magnitude and speed with which large-scale environmental changes are taking place has helped shape a range of recent policy documents, eg the Habitats Directive, the White Paper *Our common inheritance*, and the Biodiversity Action Plan. There is a pressing need for improved theoretical understanding to underpin such policy formulation.

The aim of this Thematic Programme is to advance understanding of processes that operate at landscape and larger scales and to generate new theoretical insights that will be of direct relevance to current conservation concerns and associated policy development.

The total budget of the programme is *c* £1500K, provided by NERC and the Scottish Office Agriculture, Environment and Fisheries Department, allocated over four financial years starting in autumn 1995 and scheduled to end in autumn 1998.

Six projects which started in autumn 1995 address a diverse array of subject areas, but have certain unifying aims that can be summarised as follows:

- to seek to quantify observed patterns of variation in measures of abundance, appropriate to the study system, at the lower end of spatial and temporal scales,
- to understand the processes producing these patterns, and the way in which they are driven by, or drive, processes operating over larger spatial and longer temporal scales.



Results of the network model simulating spread after three years for Indian balsam (Impatiens glandulifera) *in the River Wear catchment. Dispersal rate is determined by rate of movement downstream (2000 m/day) and upstream (10 m/day) and the viability of seeds in the river system. An increase in seed viability from 30 days (right) to 180 days (left) leads to a dramatic difference in dispersal rate.*

Dissemination of the findings to all users is one of the programme's most important objectives. It is planned to present the findings as a session at the winter meeting of the British Ecological Society in January 1999, and as an accompanying issue of the *Journal of Applied Ecology*.

ECOLOGICAL DYNAMICS AND GENES (EDGE)

Programme Manager: Dr R S Hails, IVEM

EDGE is a new Thematic Programme, launched in summer 1996. Outline bids were requested in September, which will result in between 15 and 20 projects being funded during 1997.

Molecular, genetic and modelling techniques are central to ecology, providing valuable new tools for addressing complex environmental questions. These approaches have provided considerable new insights into our understanding of the dynamics of populations and communities. The challenge of EDGE is to exploit new molecular and genetic techniques for solving previously intractable issues concerning the spatial and temporal dynamics of ecological processes and to develop an interdisciplinary community of scientists in this field. Projects of particular interest will be on factors influencing the exchange of genes and selection for recombinants that will produce shifts in genetic composition of populations and communities.

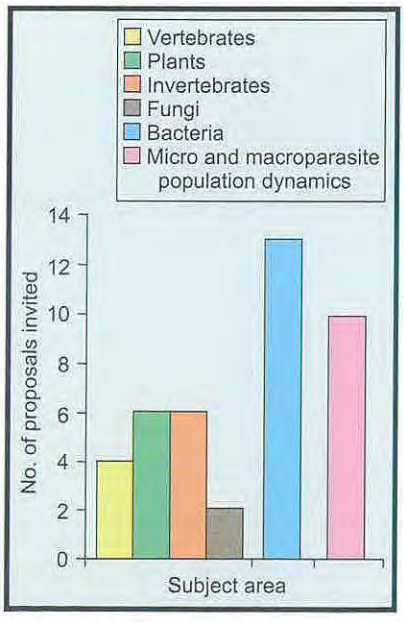
Following an initial round of outline bids, the programme has invited proposals in three main areas:

- microparasite population dynamics
- bacteria
- eukaryote populations and genetic structure.

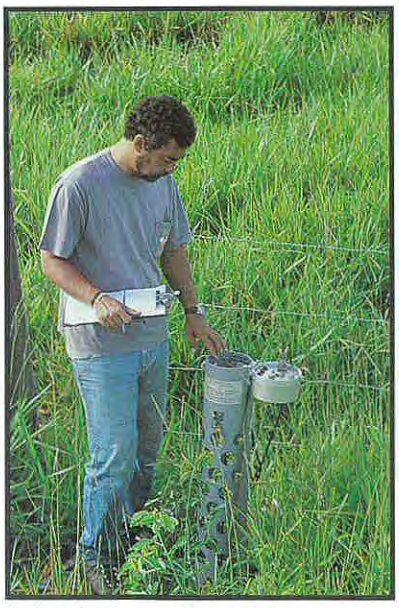
These are divided as shown in the Figure below.

It is anticipated that successful applicants will be informed by the end of July.

Molecular, genetic and modelling techniques are central to ecology, providing valuable new tools for addressing complex environmental questions.



Division of EDGE proposals by subject area.



Soil moisture measurements in Amazonian pasture, using the neutron probe developed by staff at CEH's IH.

CEH Institutes have a long history of working overseas, including involvement in large-scale international projects, collaborative projects, NERC Thematic Programmes, and overseas consultancies. Some examples of CEH's work overseas are described below.

CEH in international science

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 research. Senior CEH scientists chair the UK IHP and MAB Committees.

CEH scientists provide support to the World Meteorological Organisation's (WMO) **Hydrology and Water Resources Programme (HWRP)** and the **Hydrological Operational Multipurpose System (HOMS)** through the WMO's Commission for Hydrology. CEH manages the UK HOMS office.

DEFORESTATION IN THE AMAZON: THE ABRACOS PROJECT

Large areas of Amazonia are being deforested and the tropical forest is being replaced by pasture. This change is expected to affect both the local and regional climate. Global circulation models (GCMs) can be used to predict the climatic effects of deforestation with modelling experiments, but the realism of these experiments is critically dependent on how well the land/atmosphere surface sub-models represent the soil and vegetation. The Anglo-Brazilian Amazonian Climate Observation Study (ABRACOS), over the last six years, has improved predictions of the climatic effects of Amazonian deforestation by providing the field data needed to calibrate and validate land surface models of Amazonian pasture.

The experimental strategy of ABRACOS has been to have continuous collection of climate and soil moisture data at three pairs of forest and pasture sites in Brazilian Amazonia, complemented by a

series of six experimental missions during which intensive micro-meteorological, plant physiological and soil measurements were made.

The evaporation measurements have shown that, in the dry season, the shallower rooting depth of the pasture leads to a reduction in evaporation in response to the development of a soil moisture deficit. In contrast, the deeper rooting depth of the forest allows evaporation to continue unabated throughout the dry season, with no reduction in evaporation being observed. In the dry season, these lower evaporation rates and higher sensible heat fluxes lead to higher air temperatures in the pasture and also affect the atmospheric boundary layer at the meso-scale (>50km).

Radiosondes released over large areas of forest and pasture revealed that, during the dry season in Rondônia in Brazil, the depth of the convective boundary layer is much less over the forest than over the pasture. This observed difference in boundary layer height produces a systematic difference in dry season cloudiness. When the incoming solar radiation at the ABRACOS Rondônia forest site is compared with that at the pasture site, a plot of cumulative incoming radiation reveals a clear systematic reduction in the solar radiation received at the pasture site during the dry season when compared to the forest site. This reduction is consistent with the observation of a more rapidly growing and deeper boundary layer over the pasture reaching the condensation level earlier than the forest boundary layer and resulting in longer periods of cloud cover over the pasture. Such clear signals that the vegetation on the surface can affect climate at the meso-scale are rare.

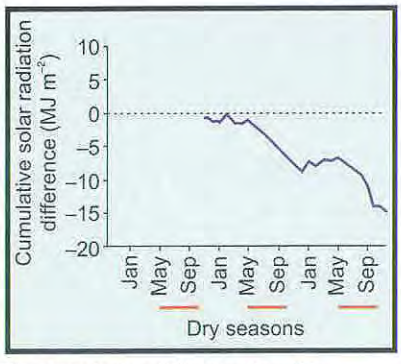
WORLDWIDE SPREAD OF ARTHROPOD-TRANSMITTED VIRUSES ANALYSED BY MOLECULAR PHYLOGENIES

Viruses that infect ticks and/or mosquitoes in the natural environment are natural pathogens of wildlife species. For example, louping ill virus infects and is transmitted by the tick *Ixodes ricinus* to grouse, rodents, deer, horses and other vertebrate species.

Until recently, sheep were considered to be the main host for amplifying ticks and louping ill virus, and thus for the persistence of the virus in the environment. Consequently, it was believed that control of louping ill as a disease could be achieved most effectively by immunising and also by applying acaricide to the sheep. However, these control methods did not curtail the losses due to louping ill. CEH's work on developing molecular methods to identify louping ill virus in ticks led to the discovery that the mountain hare (*Lepus timidus*) can also serve as a maintenance host for louping ill virus in the environment. Thus, control of the hare is also required to reduce louping ill virus persistence.

Louping ill virus is closely related to other arthropod-transmitted viruses that are distributed around the world and cause high mortality rates in wildlife, livestock and domestic species as well as humans. IVEM has carried out a systematic study of these viruses using molecular sequencing techniques. By comparative alignment of the nucleotide and deduced amino acid sequence of the gene that encodes the viral envelope protein, we have begun to reveal their population dynamics and evolutionary characteristics. The data have enabled us to predict the times of divergence between individual species and to understand the impact of man on their worldwide distribution.

Blue mountain hare (Lepus timidus) *in its natural environment. Ticks feeding on these animals become infected with louping ill virus and subsequently may transmit the disease to grouse or other susceptible species.*



The cumulative difference in solar radiation between adjacent pasture and forest shows that, in the dry season, large areas of tropical forest in Amazonia are being replaced by pasture. More radiation is received in the forest site, indicating less cloud clover over the forest.

Extensive physical and chemical variety, with rocky, stony, pebbly, sandy, silty and muddy environments, as well as the open water mass, contribute to the existence of at least 1500 species in Lake Tanganyika.

The IFE's expertise in the assessment and management of lake systems, and its understanding of the factors controlling lacustrine biota are being brought to bear in a study on the impacts of pollution on biodiversity of Lake Tanganyika – the world's second deepest lake and one of the species-richest freshwaters.

Reactor four of the Chernobyl Nuclear Power Plant enclosed in the sarcophagus to limit releases.

LAKE TANGANYIKA – DESIGNING A STRATEGY FOR ASSESSING POLLUTION EFFECTS ON BIODIVERSITY

At 1470 m, Lake Tanganyika is the world's second deepest lake. It is estimated to contain more species – including many endemics – than any lake, with the exception of Baikal in Siberia. Such an enormous waterbody can be viewed as immune to pollution in the short term. However, the very efficient retention of wind- and water-borne materials including pollutants, means that the system is likely to be susceptible in the long term. Once affected, it would be extremely difficult, if not impossible, to restore.

Although pollution need not reduce overall biodiversity *per se*, it could bring about changes in the performance and thus biodiversity of organisms at all trophic levels. Lake Tanganyika is extraordinarily dynamic, with phytoplankton species composition and fish distributions changing quickly. This can be attributed to alterations in factors that impinge on the 'whole' system, eg incident radiation, wind-induced mixing, massive nutrient upwellings and food chain interactions. These contrast with impacts such as the external inputs of nutrients and pollutants, which are important in the long term, but may have little immediate or widespread effect until a threshold level of a particular substance has been attained.

CEH's IFE is collaborating with the Natural Resources Institute and the Maritime Resources Assessment Group on a project *Pollution control and measures to protect biodiversity in Lake Tanganyika.* Along with counterparts from Burundi, Tanzania, Zaire and Zambia, IFE is supervising work establishing the effects of the following on biodiversity: eutrophication, organic enrichment, heavy metal inputs, pesticide runoff, and spillages from shipping and oil exploration. Sustainable schemes are being developed to assess pollution levels in mainly the uppermost 200 m of the water column, including inshore zones.

The overall aim of the project is to establish aquatic reserves. To do this, sites of conservation value will be investigated. Polluted and 'pristine' areas of similar topography will be studied and the water, sediments, and tissue from molluscs and fish will be assayed.

RISK ASSESSMENT OF RADIONUCLIDES FOLLOWING THE CHERNOBYL ACCIDENT

It is now ten years since the explosion of the nuclear power plant at Chernobyl on 26 April 1986. Due to the prevailing weather conditions the resulting contamination spread beyond the Ukraine and into large parts of western Europe and Scandinavia. Subsequently, not only were the intervention limits in many food products exceeded, but the ecological half-life of radiocaesium was found to be much longer than originally anticipated. Two important challenges have thus been (i) to improve our understanding of mechanisms of environmental transfer of radionuclides, and (ii) to test suitable countermeasures to reduce contamination levels. CEH's ITE is at the forefront of this work, in collaboration with the Macaulay Land Use Research Institute and the University of Nottingham.

ITE has been involved in assessing countermeasures to radionuclide contamination in both the UK and

the former Soviet Union. ITE has also identified the main factors causing contamination levels in upland sheep and grouse.

Caesium mobility in the environment is largely dependent on soil type. ITE and IFE are investigating further how this relates to spatial variation in transfer to vegetation, grazing animals and surface water bodies.

GLOBAL CHANGE AND TERRESTRIAL ECOSYSTEMS, Focus 3

For many years there has been no doubt that atmospheric CO_2 and other greenhouse gases have been steadily increasing. It is only recently, however, that 'the balance of evidence suggests a discernible human influence on global climate' (IPCC 1996). These 'drivers' of global change will have significant impacts over the next century, and, necessarily, there is a substantial, global research effort aimed at determining them. The most immediate manifestation of global change is, however, change in land use, a phenomenon that will continue for the next few decades. While this is particularly so in the tropics (driven by social, economic and population pressures), temperate regions are also undergoing significant land use change; the major re-allocation of surplus land in western Europe and North America and changing land measurement in eastern Europe and Siberian forests will all have a profound effect.

As part of the UK contribution to the International Geosphere–Biosphere Programme (IGBP), CEH hosts the Focus 3 office of the IGBP's Core Project, Global Change and Terrestrial Ecosystems (GTCE). The office co-ordinates the Focus 3 research agenda worldwide, and, by including many individual UK scientists within Focus 3 research networks, it helps to link the UK research community with numerous other national, and international, initiatives.

Research in Focus 3 of particular interest to CEH includes research on soils (which concentrates on soil organic matter dynamics, soil degradation and soil biological processes), on the physiology and productivity of managed forests, on pests, diseases and weeds, on rangelands, and on multi-species agriculture. The ability to capitalise on the beneficial effects of global change for these systems, while avoiding or reducing adverse effects, will require a strong predictive capability.

The first few years of the implementation phase have seen considerable progress, particularly in the areas of network establishment. Networks for soil organic matter, erosion, experimental forestry, wheat, rice, potato and pastures/rangelands are now all included in the GCTE core research programme and several more are now being planned. A principal network activity is the systematic comparison of models with network datasets, the follow-up analysis of the results, and the subsequent development of improved models and detailed experimentation. The worldwide network approach greatly helps in identifying suitable model/dataset comparisons for these exercises, and determines which is the most robust modelling approach for global change studies. The next phase will integrate various Focus 3 components to develop system-level studies for determining how changes in soils and in pests, diseases and weeds will affect food and forestry production.

Cereal aphids overwinter on a range of plants from which they migrate in spring to crops. Global change causing warmer winters will result in higher aphid numbers after winter, leading to greater crop losses. For each °C rise in mean winter temperature, spring migration advances by two weeks.

As part of the UK contribution to the International Geosphere–Biosphere Programme (IGBP), CEH hosts the Focus 3 office at the Wallingford site.

Using open-top chambers to manipulate the CO_2 concentration, ITE is studying the influence of climate change on trees and on their insect pests.

Being at the forefront of the ecological and hydrological sciences CEH has a responsibility to provide scientific knowledge and understanding over a broad range of environmental issues. CEH research findings are used to:

- ***underpin government policies***
- ***solve industrial problems in collaboration with businesses and industry***
- ***provide information to schools and the general public.***

The wider influence of CEH

PROVISION OF ADVICE TO GOVERNMENT

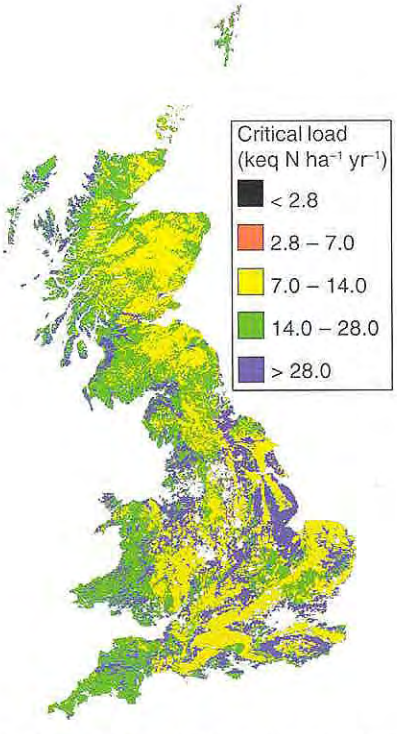
Emission control policies of the Environment Agency

The atmospheric deposition of both oxidised and reduced forms of nitrogen has increased in the UK and across Europe due to the combustion of fossil fuels (both from industry and by automobiles) and the intensification of agriculture respectively. In Europe this increase has been associated with damage to vegetation and soils and a decline in water quality.

Over the last few years CEH's ITE has led the production of critical load maps of nitrogen, in relation to both vegetation types and soil types in the UK. Work has also been undertaken with European partners to determine the contribution of nitrogen pollution to the acidification of surface water and the risk of damage to coniferous forests.

The practical value of this research has recently been demonstrated by the Environment Agency, which is using the critical loads approach to help shape national emission control policies. The ITE maps and data are being used to underpin negotiations with power generators regarding reductions of sulphur and nitrogen emissions.

Contact: Dr K R Bull, ITE Monks Wood



CEH's ITE is mapping the critical loads of nutrient nitrogen for coniferous forest, using the simple mass balance equation.

Review on the environmental use of genetically modified micro-organisms (GMMs)

GMMs are being evaluated for use in a wide range of areas, such as improving human health, biological pest control, the degradation of recalcitrant pollutants, the improvement of soil fertility, and waste water treatment. Despite the promise of benefits to be gained from the environmental release of GMMs, there are concerns associated with the potential risks they may pose to public health and safety and their ecological impact on ecosystems.

CEH's IVEM has recently advised the Department of the Environment on the status of research and field experimentation in the use of genetically modified micro-organisms, drawing on expertise within CEH and in other UK and international organisations. The objectives were to compare current and proposed developments in biotechnology with regard to the exploitation of bacteria.

Detailed comparisons of procedures required by European and North American regulators for gaining consent for the open release of GMMs were conducted. The feasibility of simplifying procedures and the concept of a handbook for GMM releases were also explored.

The feasibility study revealed, for the first time, common approaches to regulation and similar requirements for information to address safety. The study indicated the common approaches taken by OECD member countries to the regulation of GMMs and established the basis for moving towards harmonisation.

Contact: Dr M J Bailey, IVEM

CEH LINKS WITH INDUSTRY

CEH has a wide range of links and contacts with organisations in the industrial and commercial sectors (see Appendix 5). Four recent examples are given below.

Bacterial degradation of metal cutting oils

Applied studies in CEH's IVEM have led to the detection of microbial communities with the ability to neutralise the toxic effects of important environmental pollutants. Complex oil mixtures used as metal cutting fluids, which are chemically complex, carcinogenic, toxic and have a high cost of disposal, have been found to be broken down by a bacterial community of aerobic heterotrophs.

This work is being undertaken in collaboration with Viridian Bioprocessing Ltd and has potential applications at an industrial level.

Contact: Dr I M Jones, IVEM

Freshwater surfactants

GREAT-ER: Geographically referenced regional exposure assessment tool for European rivers

CEH's IH is leading an international collaborative study, funded by a consortium of industrial partners and the UK Environment Agency, to develop and validate exposure prediction software for use within European environmental risk assessment schemes. The focus of the project is the fate of 'down the drain' chemicals in the aquatic environment.

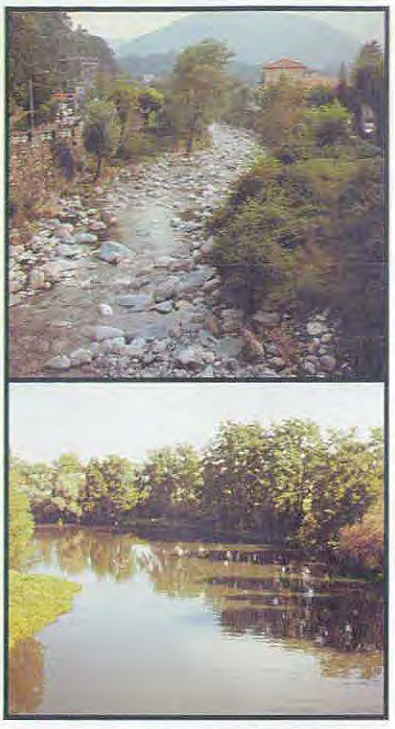
The aim is to produce a prototype powerful and accurate multi-scale exposure prediction tool. The modelling framework is being developed within two case study catchments, the Yorkshire rivers in the UK and the River Lambro, a sub-basin of the River Po in Italy. A key component of the work programme will be the development of techniques for the up-scaling of catchment models to the regional/pan European scale.

GREAT-ER has the objective of developing and validating a powerful and accurate aquatic chemical exposure prediction tool for use within the EU environmental risk assessment schemes. The target chemicals for the current phase of the project are the surfactant linear alkyl sulphonate (LAS) and boron. These chemicals are common constituents of domestic washing powder. CEH'S Institute of Hydrology is contracted to develop a robust regional hydrological model for predicting river flows and flow velocities within the case study catchments.

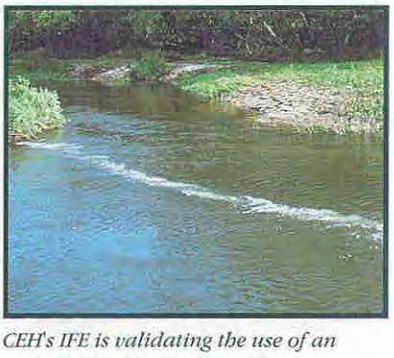
Contact: Dr A Gustard, IH

Testing of bubble screens

At the IFE River Laboratory acoustic bubble screens are being used to deflect migrating salmon smolts through a novel 'hands off' counting system. The acoustic bubble screen being used is the Bioacoustic Fish Fence (BAFF), a completely original system developed jointly and patented by two private companies. The screens are available from Fish Guidance Systems Ltd.



Top: River Lambro below the source in the foothills of the Alps. Bottom: the Lambro downstream of Milan. The latter photograph clearly demonstrates the suspended organic solids and algal content of the water which is directly attributable to the pollutant load from Milan.



CEH's IFE is validating the use of an acoustic bubble screen as part of a system for counting migrating salmon smolts.

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.

Nuffield Science Foundation's Bursary students at work.

The BAFF uses a sound generator in conjunction with an air-bubble sheet to create a 'wall of sound' designed to deflect fish. The sound field can be precisely controlled. One great advantage of the system is that it is highly effective in the dark and in turbid conditions. Even though the fish cannot see the bubbles, the acoustico-lateralis and auditory system permits them to sense their surroundings accurately.

The BAFFs form an integral part of the IFE-designed smolt counting system. IFE has validated the system on behalf of the Environment Agency. As a result of this work, IFE and Fish Guidance Systems now have a formal agreement whereby IFE endorses the BAFF. In addition, IFE will provide the test site for future products in this range. The test site will be developed as a demonstration station for the company.

Contact: Dr M Ladle, IFE Wareham

CEH drought seminar

On 21 June 1996 CEH held a seminar on the *Assessment and monitoring of droughts*. The delegates came mainly from the Water Utilities, the Environment Agency and the DoE, as well as representatives from the Office of Water Services and the House of Commons Environment Committee.

The seminar was organised to target both a specific topic and specific relevant organisations. It concentrated on the practical deliverables and expertise available within CEH which could address the specific needs of the water industry. Presentations covered climate change impact, historical trends, assessment of drought severity, economic consequences, the effects on water quality and biota, the effect of land use, and practical demonstrations of computer models.

EDUCATION AND TRAINING

School liaison activities

Schools activities in CEH have the overall aim of encouraging young people to take an active interest in the environmental sciences. In support of this aim, there is a network of Schools Liaison Officers throughout CEH, supported by the NERC Schools Programme from Swindon.

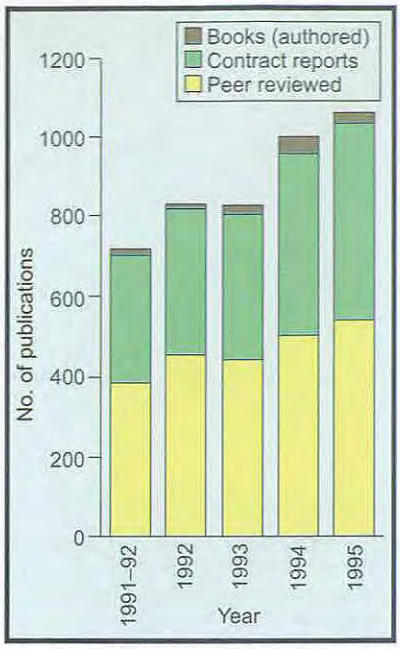
Work experience schemes tend to be the most popular activities, eg the Nuffield Science Foundation's Bursary Scheme, for students in the 16–18 year age group. The aim of the Scheme is to give students at Advanced GNVQ, 'A' level or Scottish Higher level the opportunity to participate in research projects, to experience for themselves the joys and pitfalls of science in practice and to contribute to the work of scientific institutions. ITE participated in the Scheme in 1995 and 1996.

In 1995, six student placements of six weeks' duration were offered, three funded by Nuffield and three by ITE. The projects were designed to ensure that the student would benefit by undertaking a worthwhile study, from learning new techniques and skills, and by completing a report on their project. ITE benefited from the work of the students in that it complemented and extended existing research programmes. Building on the successes in 1995, seven students (funded by both Nuffield and ITE) are now completing projects for 1996 within four of ITE's research stations.

Several students have used their Nuffield work as the basis of their 'A' level practical projects, and one student won a prize for her project in the AMOCO Science Competition 1996.

Contact: Mrs S Wallis, ITE Monks Wood

CEH output and performance indicators



CEH staff publications.

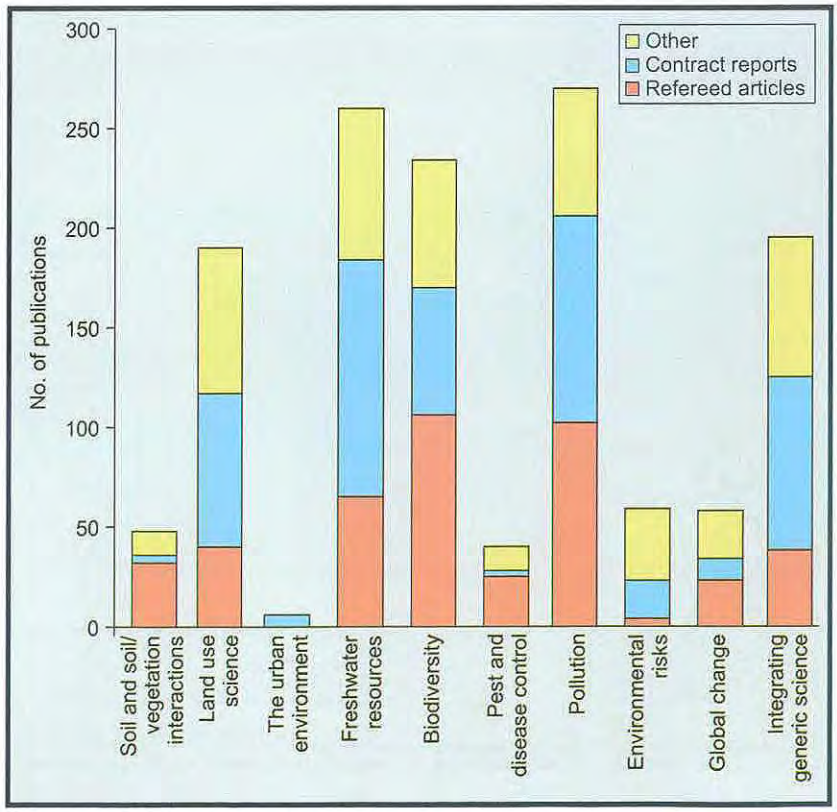
PUBLICATIONS

The output of publications, contract reports and other qualitative and quantitative indicators remains an important priority within CEH and has been held at a high level. The rising trend in recent years in the numbers of peer-reviewed publications, contract reports and authored books has been maintained.

With the development of the CEH Core Strategic Programme, more attention has been paid to the volume of publications relating to projects in each of the newly classified programme areas. Publication levels are particularly strong in scientific disciplines traditional to CEH Institutes, but the Centre also makes a significant contribution in a number of emerging priority areas.

LINKS

Links between CEH Institutes, the Higher Education Sector and other organisations remain strong (Appendix 3). The range of CEH representation on key external scientific and decision-making committees demonstrates the variety of scientific interests across CEH and the regard in which CEH scientists are held in the wider scientific community. Some 72 places, as chair, convenor, leader or member, are held on 29 UK, 10 European and 25 international committees (Appendix 4). CEH also has strong interaction with industry and commerce, as demonstrated in Appendix 5.



CEH staff publications by Core Strategic Programme.

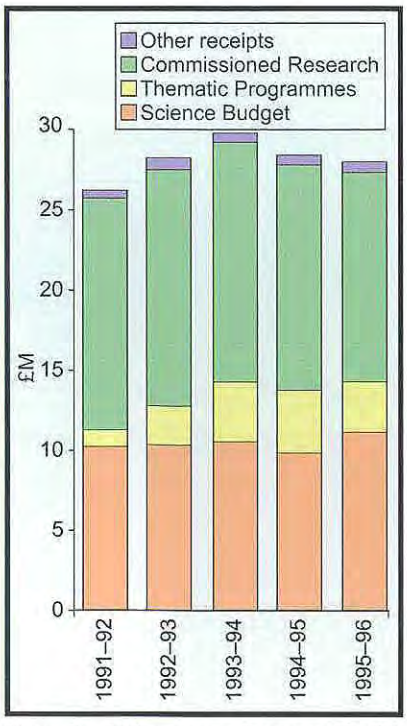


Figure 1. CEH sources of income 95–96.

Finance and staffing

FINANCE

Science Budget

In the first full year of operation of CEH, the value of the baseline Science Budget, which maintains the CEH Core Strategic Programme and contributes towards the Centre's infrastructure costs, was slightly reduced below the 1994–95 level. This reduction is not, however, evident from the figures in the year-on-year summary (Figure 1) as these also show the effects of borrowing from central NERC funds, for both an internal loan and cash flow assistance in respect of slipped Commissioned Research receipts.

During the course of the year considerable progress has been made in reshaping science programmes within CEH.

During the course of the year considerable progress has been made in reshaping science programmes within CEH as a result of the development of the New Funding Model (NFM) for NERC. The Science Budget and Thematic Programme divisions in Figure 1 are as they will appear under the NFM. Although the full effects on resources and management will not be felt until the new CEH research programmes are actually in place (in 1997–98), a broad analysis of expenditure on projects in 1995–96 under the new Core Strategic Programme has been prepared for planning purposes (Figure 2).

Prior to the formation of CEH, a number of collaborative projects existed in Institutes, mainly in respect of externally funded activities. The CEH Integrating Science Fund was established in 1995 for specific funding of three-year projects within the Core Strategic Programme regarded as suitable for full collaboration between two or more component Institutes. Seven projects, described elsewhere in this Report, were supported in 1995–96 at a cost of £520K through redirection of existing activities. All CEH Institutes are involved in these projects and the initiative has been rolled forward into 1996–97.

Thematic Programmes

CEH Institutes have continued to compete successfully for NERC Thematic Programme funds and in 1995–96 received support of £3.15M under the following programmes:

- Terrestrial Initiative in Global Environmental Research (TIGER)
- Terrestrial Initiative in Global Geological Environmental Research (TIGGER)
- Land/Ocean Interaction Study (LOIS)
- Pollutant Transport in Soils and Rocks
- Wildlife Diseases
- Hydrological Radar Experiment (HYREX)
- Large-Scale Processes in Ecology and Hydrology
- Environmental Diagnostics

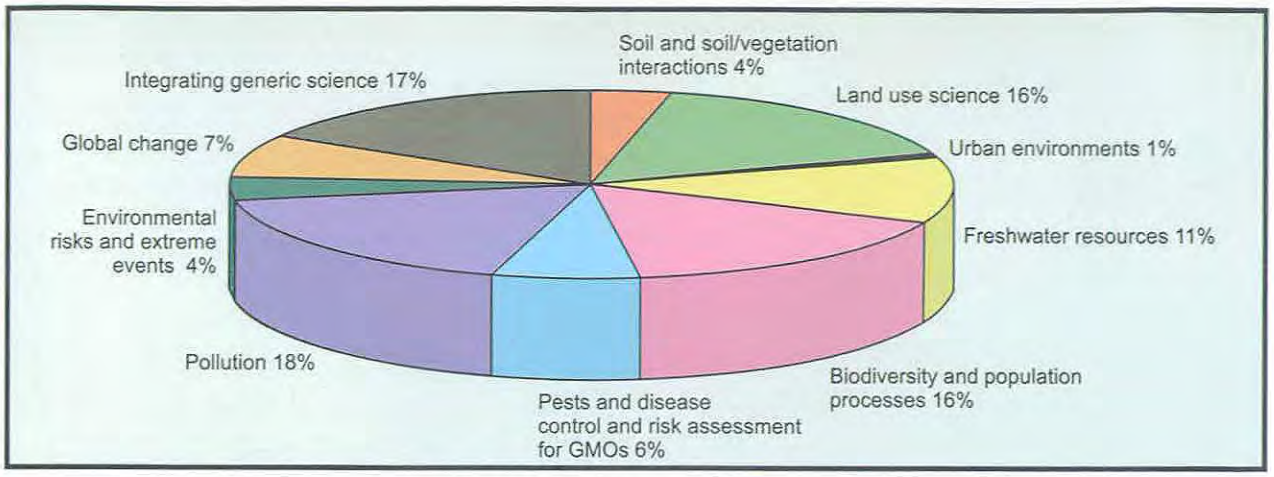


Figure 2. Breakdown of core strategic expenditure by programme.

- Testable Models of Aquatic Ecosystems
- Along Track Scanning Radiometer
- Atmospheric Chemistry Studies in the Oceanic Environment
- Instruments for Field Measurements in the Atmosphere.

Commissioned Research

Actual receipts from external customers were lower in 1995–96 than in previous years, but the picture was distorted by a significant slippage of payments from major customers into 1996–97. After taking these into account, the overall level of Commissioned Research activity has been maintained. Figure 3 shows receipts from major customers in 1995–96, with the receipts in earlier years revalued to current prices for the purposes of comparison.

STAFFING

The emphasis in CEH continues to be on recruiting and retaining high-quality, well-qualified, well-trained and motivated staff as the key resource of the organisation. On 31 March 1996, 624 staff were in post in CEH, a net reduction of five compared with 31 March 1995. Of these, 196 are on fixed-term appointments. Total staff numbers in each of the CEH Institutes are contained in Appendix 6.

The numbers do not, however, reflect the significant numbers of students working with CEH scientists, or the visiting workers on the Institute sites. In all, these totalled in the region of 310 in the course of the year, with resources being found from within Institute budgets to support their activities. In some instances these included additional cash contributions, particularly towards CASE awards, and in others calls on staff time for supervision. Some 90 staff from other parts of NERC (mainly British Geological Survey and NERC Computer Services) are also based on CEH sites. The total number of workers supported by the CEH infrastructure is therefore over 1000.

The emphasis in CEH continues to be on staff as the key resource of the organisation.

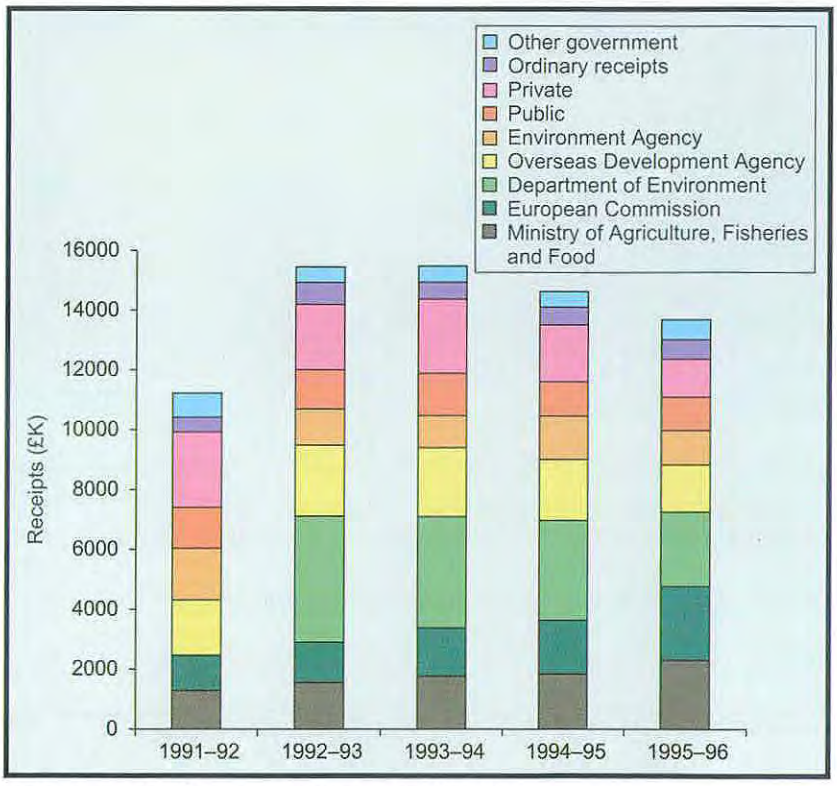


Figure 3. Receipts from major customers in 1995–96.

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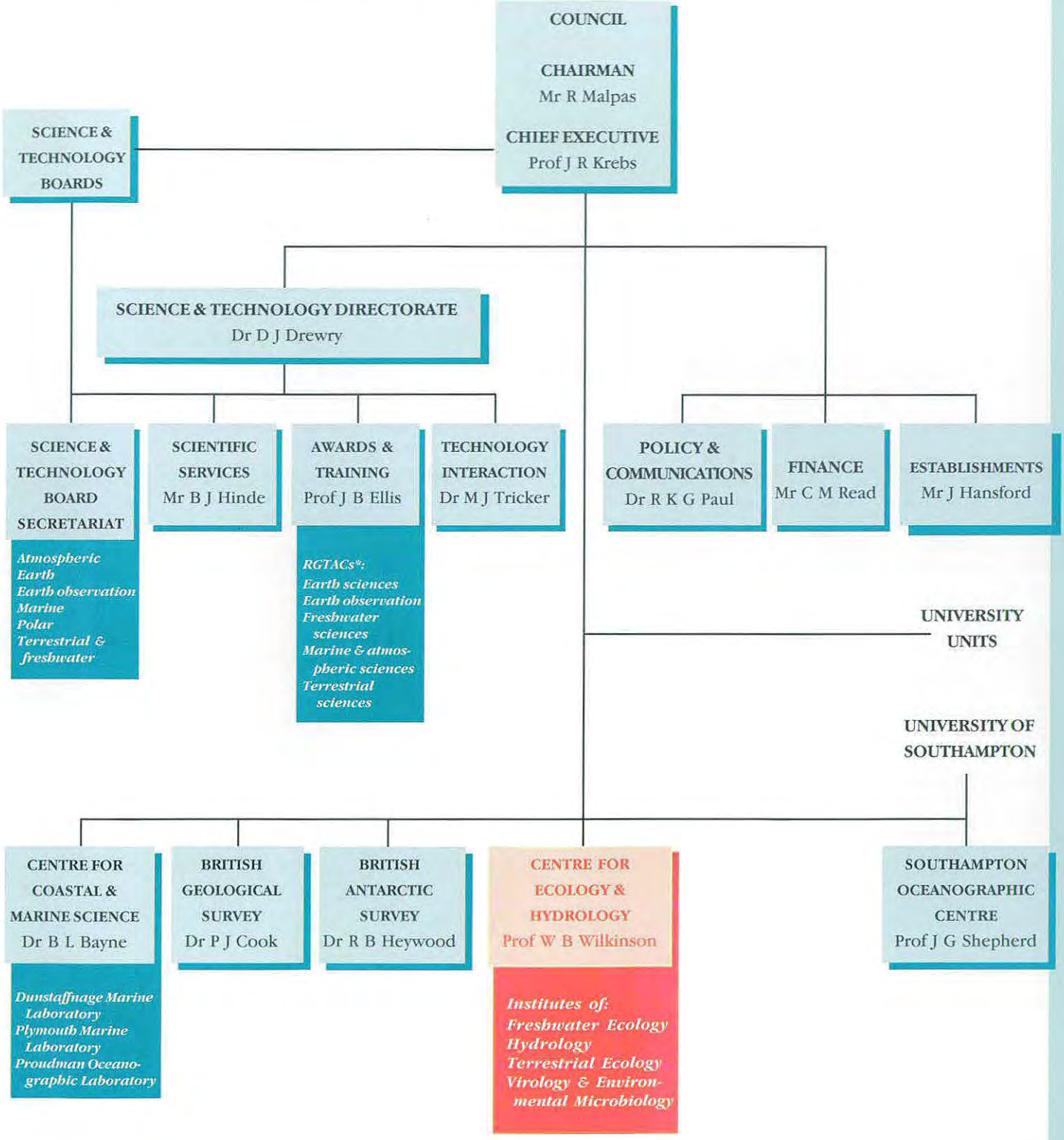
APPENDIX I

NERC structure



** RGTACs – Research Grant and Training Award Committee*

APPENDIX 2

Membership of CEH Programme Review Groups

Land and water resources

CEH Programmes
Soil & soil/vegetation interactions
Land use science
Urban environment
Freshwater resources

Prof H S Wheater (Chair)	*Engineering hydrology*	Imperial College London
Dr A M C Edwards	*Water quality*	Environment Agency, Leeds
Prof K Killham	*Soil microbiology*	University of Aberdeen
Prof R H Marrs	*Land use*	University of Liverpool
Dr J Mulder	*Soil-water science*	NISK, Norway
Prof G E Petts	*Land/river interactions, ecology*	University of Birmingham

Biodiversity

CEH Programmes
Biodiversity
Pests and disease control

Prof C C Payne (Chair)	*Virus biotechnology*	Horticulture Research Int
Dr V K Brown	*Invertebrates*	Int Inst Entomology, London
Prof C Gliddon	*GMOs*	University of Wales, Bangor
Prof D A Ritchie	*Microbial genetics*	University of Liverpool
Prof M B Usher	*Ecology*	Scottish Natural Heritage
Prof K Vickerman FRS	*Zoology*	University of Glasgow

Pollution, risks, global change

CEH Programmes
Pollution
Environmental risks
Global change

Prof R W Battarbee (Chair)	*Limnology, palaelimnology*	University College London
Dr C W Anderson	*Statistics*	University of Sheffield
Prof C Cunnane	*Flood hydrology*	University of Galway
Prof J Grace	*Climate change*	University of Edinburgh
Prof J A Lee	*Pollution*	University of Sheffield
Prof C H Walker	*Ecotoxicology*	University of Reading

Monitoring, data, assessment, valuation

CEH Programmes
Integrating generic science

Dr J C Rodda (Chair)	*Hydrology*	President of IAHS
Prof T A Burke	*Genetic fingerprinting*	University of Leicester
Prof P J Curran	*Remote sensing*	University of Southampton
Dr R H Haines-Young	*GIS*	University of Nottingham
Mr J Murliss	*Atmospheric pollution*	University College London
Prof C Perrings	*Environmental economics*	University of York
Dr P A S Rae	*Environmental planning*	British Gas

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 22 universities, including those through co-location:

Aberdeen	Kent	Reading	Aarhus
Brunel	Lancaster	Southampton	Alabama
Cardiff	Leeds	York	Buenos Aires
Cork	Leicester	Wales	Cordoba
Edinburgh	Oxford	Warwick	Tromso
Imperial College			Wageningen

Twenty-one members of CEH staff acting as **Visiting Professors**

T W Ashenden	Newcastle	I Newton	Oxford
I R Calder	Birkbeck College, Loughborough	P A Nuttall	Oxford
M G R Cannell	Edinburgh	A D Pickering	Brunel
J M Elliott	Tromso	R D Possee	Oxford Brookes
D Fowler	Nottingham	C S Reynolds	Buenos Aires, Reading
A J Gray	Southampton	T M Roberts	York
M P Harris	Glasgow	J Sheail	Loughborough
J Hilton	Reading	B W Staines	Aberdeen
M Hornung	Lancaster	E W Tipping	Lancaster (Readership)
J G Jones	Liverpool	W B Wilkinson	Reading
S C Maberly	Aarhus		

195 **students** (including sandwich course and CASE students) at CEH Institutes from both UK and overseas universities

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

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

Collaborative research with 95 university departments through EU, Non-Thematic and Thematic Programmes such as TIGER, LOIS, Environmental Diagnostics, etc (see Appendix 3) 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 £1.2M in university subcontracts for UK Government departments involving 25 university departments
- IVEM collaborates closely with the Universities of Edinburgh, Exeter, Oxford and Wales

APPENDIX 4

CEH representation on key external scientific and decision-making committees

	Committee	*CEH Representatives*	
UK	MAJOR LEARNED SOCIETIES		
	British Ecological Society	Prof I Newton	Past-President
	British Ecological Society	Prof A J Gray	Vice-President
	British Hydrological Society	Mr F M Law	President designate
	British Hydrological Society	Mrs C Kirby	
	British Mycological Society	Dr J C Frankland	
	British Phycological Society	Dr S C Maberly	
	Institution of Hydrological Sciences	Dr H R Oliver	
	Royal Society Biological Assessment Committee	Prof I Newton	Chair
	Royal Society of Edinburgh	Prof M G R Cannell	
	Society for General Microbiology		
	– Environmental Microbiology Committee	Dr R W Pickup	Convenor
UK	GOVERNMENT DEPARTMENT AND OTHER PUBLIC SECTOR		
	Advisory Committee for Dangerous Pathogens	Dr E A Gould	
	Advisory Committee for Genetic Modification	Prof T M Roberts	
	Advisory Committee for Genetic Modification	Ms D Carey	
	Advisory Committee for Hazardous Substances	Prof T M Roberts	
	Advisory Committee on Pesticides	Prof T M Roberts	
	Advisory Committee on Pesticides	Dr S Dobson	
	Advisory Committee on Release of (GMOs) into the Environment	Prof A J Gray	
	Advisory Committee on Toxic Substances	Dr S Dobson	
	Biodiversity Steering Group	Prof T M Roberts	
	Bio-resources Committee	Dr E A Gould	
	Critical Loads Advisory Group	Dr K R Bull	
	Critical Loads Advisory Group	Prof D Fowler	
	Critical Loads Advisory Group	Prof M Hornung	
	Critical Loads Advisory Group	Dr A Jenkins	
	Environment Agency Toxic Algal Task Group	Prof C S Reynolds	
	Forestry Research Coordinating Committee	Prof M G R Cannell	
	Interdepartmental Committee for Hydrology	Mr F M Law	Chair
	ODA Environmental Research Programme Science Committee	Prof T M Roberts	
	Photochemical Oxidants Review Group	Prof D Fowler	
	Radioactivity and Environment Committee	Dr B J Howard	
	Red Deer Commission	Prof B W Staines	
	Plant Disease Programme Review Committee	Dr J I Cooper	
	Scottish Office Health Dept. Working Party on Blue-green Algae	Dr A E Bailey-Watts	
	Technical Committee on Detergents and the Environment	Dr A House	
	UK Round Table on Sustainable Development (Water Subgroup)	Prof W B Wilkinson	

UK

Other

British Consultants Bureau - Water Engineering Committee	Mr F H Farquharson	
BSI Biological Methods Committee	Dr P D Armitage	
CIWEM Membership Panel	Dr F H Dawson	
FWR Algal Toxin Research Forum	Prof A D Pickering	
Land Use Research Coordination Committee	Dr L G Firbank	
UK Federation of Culture Collections Committee	Dr J Day	
UKFCC	Dr J Day	

EUROPEAN

EurAqua	Prof W B Wilkinson	UK leader
EC Biotechnology Research Grant Committee	Dr R W Pickup	
European Conservation Research Institute Network (CONNECT)	Prof T M Roberts	
EEA Nature Topic Centre Board	Dr D Moss	
European Forestry Initiative	Prof M G R Cannell	
European Forestry Institute Management Committee	Prof M G R Cannell	
European Inland Fisheries Advisory Committee Working Party	Dr I J Winfield	
Natural Hazards Section – European Geophysical Society	Mr R Moore	Convenor
UNESCO International Hydrological Programme FRIEND - N Europe	Dr A Gustard	Chair

INTERNATIONAL

Africa Committee	Dr A E Bailey-Watts	
IAHS Programme Committee for IUGG 1999 Conference	Prof W B Wilkinson	Chair
IAHS International Commission for Surface Water	Dr A Gustard	Vice-President
IAWQ UK National Committee	Dr J S Wallace	
International Commission for Irrigation and Drainage	Dr R Ragab	
IDNDR Committee on Droughts	Dr J R Meigh	
IDNDR Coordinating Committee	Dr J S Wallace	
IDNDR Working Group	Dr L S Anderson	
International Geosphere–Biosphere Programme, GTOS	Mr M A Beran	
IGBP, BAHC Committee	Dr J H C Gash	
IGBP, GCTE Focus 3 Committee	Dr J I Ingram	
Intergovernmental Panel on Climate Change	Prof M G R Cannell	
International Committee on Atmosphere–Soil–Vegetation Relations	Dr J S Wallace	Vice-President
International Council for Research on Agro-Forestry	Dr R R B Leakey	
International Humic Substances Society	Dr E Tipping	
IUCN - Advisory Committee on Wetlands	Dr M C Acreman	
IUCN/Species Survival Commission	Dr I J Winfield	
ONECE Convention on Long Range Transboundary Air Pollution	Dr K R Bull	
UNESCO International Hydrological Programme – UK Committee	Mr F M Law	Chair
UNESCO International Hydrological Programme (S Africa FRIEND)	Dr A Bullock	Advisor
UNESCO International Hydrological Programme Project 1. FRIEND	Dr A Gustard	Chair
UNESCO MAB UK Committee	Prof T M Roberts	
WMO Commission for Hydrology	Prof W B Wilkinson	UK Leader
WMO Commission for Hydrology	Mr M A Beran	
WMO Commission for Hydrology	Mr F M Law	
WMO GWEX Canadian Advisory Panel	Prof W B Wilkinson	
WMO/UNESCO Freshwater Assessment Committee	Prof I R Calder	

APPENDIX 5

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:

AEA Technology
Albright & Wilson
Aromascan
British Trust for Ornithology
Calladonian Partnership
Laserscan
National Trust
Natural Resources Institute
North West Water plc
Ordnance Survey
Zeneca Ltd

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

Ash Consulting Group
Aquater
BIOSS
Baker Associates
Binnie, Black & Veatch
British Gas
CSL
Cairngorm Chairlift Co
DSFIA
ERM
Ecosystems (Asia) Ltd
Ensis
Frank Graham Associates
Game Conservancy
Halcrow Fox
ICL
Joss (Aberdeen) Ltd
Laurence Gould
Logica
Magnox Electric plc
Mott Macdonald
NRPA
National Power
Nevis Range
Pieda Ltd
South East Water plc
WCMC
Wallingford Water
Water Research Centre
Water Training International
Wessex Env Association
Wilmot Industries Ltd
Wilson Associates
etc

In total, CEH has subcontracted research work to or from some 84 industrial/commercial organisations during the year.

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

APPENDIX 6

CEH organisation as at 31 March 1996

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, Institute of Hydrology *(Dr J S Wallace from Nov 1996)* Professor P A Nuttall, Director, Institute of Virology & Environmental Microbiology Mr P Williams, Head of Administration, CEH
Total staff	624 (1000 including students and visiting workers)

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 *(Mrs K Vann from Dec 1996)*

Administration	
Head of Administration	**Mr P Williams** (based at NERC Swindon Office and Wallingford)
Finance Officer/Deputy Head of Admin	Mrs H M Wood
Contracts Officer	Ms L A Aspinall
Administration	Miss L Jennings
Science and Marketing	
Science policy and co-ordination	Dr J C Metcalfe
GCTE Project Office	Mr J I Ingram, Miss J Gaskin
Marketing and science administration	Dr W D Graham
Information	
Information services	Mrs P A Ward (based at ITE Merlewood)
Technical	
Safety technician	Mr C Hankinson (based at ITE Merlewood)
Staff	12

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** (to May 1995)	Salmonids in upland streams Impacts of impoundments Afforestation and the aquatic environment
Staff	95	

INSTITUTE OF HYDROLOGY
Wallingford Laboratory
Crowmarsh Gifford
Wallingford, Oxon OX10 8BB
Tel: 01491 838800 Fax: 01491 692424

Director **Mr A G P Debney**

Head of Division	**Dr J S Wallace** *(Director IH from Nov 1996)*	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	193	

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*	**Prof 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*	**Prof 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: 01248 370045 Fax: 01248 355365*	**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	277	

INSTITUTE OF VIROLOGY AND ENVIRONMENTAL MICROBIOLOGY
Mansfield Road
Oxford OX1 3SR
Tel: 01865 512361 Fax: 01865 559962

Director **Prof 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 of baculoviruses Orbivirus research of baculoviruses
Staff	47	

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