

**Institute of
Terrestrial
Ecology**

Scientific Report 1996-97

Centre for Ecology and Hydrology
Natural Environment Research Council



ITE's mission statement

The Institute of Terrestrial Ecology will develop long-term, multidisciplinary research and exploit new technology to advance the science of terrestrial ecology, leading to a better understanding and quantification of the physical, chemical and biological processes of the land.

Priority is placed on developing and applying knowledge in the following areas:

- the factors which determine the *composition, structure, and processes* of terrestrial ecosystems, and the *characteristics* of individual plant and animal species
- the dynamics of *interactions* between atmospheric processes, terrestrial ecosystems, soil properties and surface water quality
- the development of a sound scientific basis for *monitoring, modelling and predicting* environmental trends to assess past, present and future effects of natural and man-made change
- the securing, expansion and dissemination of ecological data to further scientific research and provide the basis for impartial advice on environmental protection, conservation, and the sustainable use of natural resources to governments and industry.

The Institute will provide training of the highest quality, attract commissioned projects, and contribute to international programmes.

ITE will promote the use of research facilities and data to enhance national prosperity and quality of life.

**Scientific Report of the
Institute of Terrestrial Ecology
1996–1997**

Centre for Ecology and Hydrology

Natural Environment Research Council

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The Institute welcomed the Prior Options Review endorsement that the future delivery of excellent, relevant and independent science in the public sector was secure.

Introduction by ITE Director

1996–97 has been another very successful year, with the Institute's reputation for high-quality research, survey and monitoring enhanced.

The *1996–97 Scientific Report* of the Institute, and those of ITE's sister Institutes within the Centre for Ecology and Hydrology (CEH), mark a departure from the format of previous annual reports by focusing purely on the year's scientific achievements and resultant contributions to the research programme of the Centre. The broad development of the research programme, links with the Natural Environment Research Council (NERC), partnerships with public and private sector organisations, financial information and performance measures will be covered by the *1996–97 CEH Annual Report*, which thus complements the scientific reports of the Institutes.

1996–97 has been another very successful year for ITE, with performance sustained across a range of key areas. They include:

- high-quality research, based on extensive collaboration with the academic sector;
- links to the industrial sector, with improved opportunities for commissioned research; and
- the integration of interdisciplinary teams to enhance national survey and monitoring projects.

ITE staff have utilised NERC's

responsive and thematic funding modes to strengthen the underpinning research activity. Links across Europe have been enhanced through successful joint bids under the European Commission's Fourth Framework Programme and to the European Environment Agency.

Since the formation of CEH, collaboration across the component Institutes has been stimulated by the CEH Integrating Fund. This initiative has been running for two years, and ITE is involved in a number of co-operative projects concerning, for example, socio-economic models of land use, microbial diversity and ecosystem function, and urban environments.

The period of uncertainty created by the Prior Options Review process has now ended and the outcome provides recognition by Government of the past record of achievement of NERC and its Centres/Surveys, as noted in the *1996–97 CEH Annual Report*. The conclusions of the Review endorse the future delivery of excellent, relevant and independent science in the public sector, and the integrated environmental research capability of



The ITE Management Group, meeting in March 1997: Professors Melvin Cannell, Mike Hornung, Alan Gray, Mike Roberts and John Good, Mrs Jane Parsell, Drs Steve Albon, Barry Wyatt and Lloyd Anderson (L–R)

ITE's success ... is attributable to the commitment, flexibility and resilience of staff at all levels in the Institute.

CEH. The resources provided for rationalisation and restructuring will give an opportunity to further strengthen interdisciplinary research in which the Institute will play a lead role.

ITE's success during this period is attributable to the commitment, flexibility and resilience of staff at all levels in the Institute. The success also vindicates the management strategy which has been implemented since 1990, namely to:

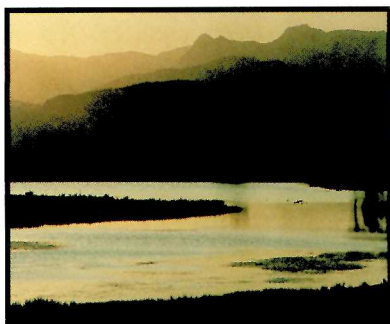
- maintain a national distribution of sites to sustain detailed studies of regional landscapes;
- maintain a breadth of disciplines and the flexibility to form interdisciplinary teams;
- increase collaboration through larger interdisciplinary projects;
- diversify the customer base and increase the quality of commissioned research;
- use replacement posts to strengthen key areas (molecular ecology, mathematical modelling and information technology).

The challenges to management have intensified, however, as the customer base continues to diversify and fragment. Coupled with the need to realign ITE's activities to the New Funding Model introduced by

NERC for the allocation of its science budget, and the relatively short lifespan of NERC thematic programmes, the difficulty has been to match scientific expertise to the changing profile of funding.

The creation of ten CEH core strategic programmes, as part of the necessary realignment of research activities under the New Funding Model, has been a major exercise during the year. Four programme review groups, whose members were drawn from a wide scientific community including academia, industry and UK Government departments, were asked to assess the merit of the new research programmes in 1996–97. Following their endorsement, the ten programmes became effective on 1 April 1997. The breadth of the science covered by these programmes, and their relevance to regional, national and global environmental issues, is considerable. The following section reports on scientific research carried out by ITE staff during 1996–97 which contributes to six of the ten programmes. The contributions of ITE's sister Institutes to the core strategic programme are detailed in their scientific reports.

Prof T M Roberts



CEH is undertaking ten NERC Core Strategic Programmes which provide a science base that underpins both national and international requirements in the terrestrial and freshwater sciences. The ten component programmes cover a wide range of topics. They are also dynamic and can be changed to incorporate new and emerging environmental issues.

CEH Core Strategic Programme

1: Soils and Soil-Vegetation Interactions

This programme is designed to improve our understanding and ability to model key soil processes controlling the transformations of materials within soils and the flux of water through the soil-vegetation-atmosphere continuum.

2: Land Use Science

This is aimed at promoting an integrated approach to land use science that is applicable to the wide range of user community requirements. The programme's themes will be developed to provide the basis for large-scale, long-term analytical studies of major land use change.

3: The Urban Environment

This relatively new programme aims to extend the interdisciplinary knowledge base and to understand the key environmental patterns and processes in urban situations and particularly change due to human activities. This knowledge is required to plan more sustainable urban environments.

4: Freshwater Resources

Increasing demands on freshwater resources have resulted in the need for a scientific basis for the effective strategic and sustainable management

of freshwater resources. This programme will address this by integrating CEH research in the areas of water quantity, water quality, and the ecological aspects of freshwater systems.

5: Biodiversity

Aimed at improving our understanding of microbiological and biological resources at a range of spatial scales. The research considers the underlying processes and resulting functions, and directs knowledge to the sustainable management of biodiversity.

6: Pest and Disease Control and Risk Assessment for GMOs

The primary aim of this programme is to undertake research in the provision of novel pest and disease control strategies whilst addressing any possible risk to the environment. The use of molecular biology is essential to maintain a novel and progressive approach to the themes of pest control and animal disease control.

7: Pollution

This programme is aimed at developing a better understanding of generic processes such as atmospheric transport, fluxes of

pollutants and the fate of pollutants, in order to predict more accurately the likely impacts on environments and organisms.

8: Environmental Risks and Extreme Events

This research programme will develop understanding of how environmental extremes affect mankind and the natural environment, developing quantitative, predictive tools to describe these effects, and contributing to mitigating measures.

9: Global Change

This programme will help to reduce uncertainty in the magnitude of global change and its impacts. The research is focused on improving the accuracy of global change predictions through measurement programmes, the development of scaling-up methods and models, and the identification of ecosystem responses.

10: Integrating Generic Science

Programme 10 has been designed to provide a research framework for those areas of CEH science which underpin the nine other programmes (eg providing the data and technological support), as well as conducting its own fundamental research.

The following section of this Scientific Report describes research which is currently being carried out in six of the ten programmes by the Institute of Terrestrial Ecology. Further details of the projects and issues that make up each of the ten Core Strategic Programmes are listed in Appendix 3 of the CEH Annual Report.

The year's scientific highlights, major events and staff news are detailed below, together with an account of the Institute's database and network activities. Juxtaposed to these successes have been a number of major challenges arising from realignment of ITE's activities under CEH's core strategic programmes, the Government's Prior Options Review process, and continuing implementation of the recommendations of the 1994 Science Management Audit.

Institute overview

Output levels have been maintained at last year's peak, and commissioned research activity sustained across a broad user community.

The year's highlights

The Institute's work is designed to support the delivery of NERC's seven strategic aims, namely

- high-quality science, engineering and technology (SET),
- facilities for SET,
- working in partnership,
- the data resource,
- education and training,
- an independent voice, and
- public understanding of science

The year's highlights are reported here in the context of these strategic aims. Overall, and as noted in the Introduction, 1996–97 has been a highly productive year for the Institute, with output levels maintained at last year's peak across a range of performance measures, and commissioned research activity sustained across a broad user community.

High-quality science

The 1992 Earth Summit in Rio de Janeiro, with its focus on issues relating to sustainable development, resulted in the signing of a number of important international Conventions. This has now had a significant impact on ITE's research in biodiversity in particular. In 1994

the UK Government published its Biodiversity Action Plan (BAP), a programme for implementation of the UN Convention on Biological Diversity (CBD). ITE has played a full part in this implementation through representation on the relevant BAP committees and inputs to the selection of priority species and habitats.

The CEH biodiversity core strategic programme has been structured to address the underpinning research needs identified by the UNEP Expert Research Panel to the CBD. This programme has supported commissioned research on ten priority species (eg the bittern and the capercaillie) and six priority habitats (including species-rich hedgerow, moor-grass/rush pasture, lowland heath, fen and native pinewood). ITE also carried out a Europe-wide assessment of national programmes dealing with implementation of the CBD, for the European Environment Agency. Further, the Institute is an active participant in the Darwin Initiative, which seeks to assist poorer countries meet their obligations as signatories to the CBD, with projects in Uganda, Tanzania and Russia.

Research under the **land use core strategic programme** has focused on the development of techniques to monitor ecological aspects of land use and to assess the impacts of land use change. Drawing on this underpinning programme, ITE has been increasingly involved in evaluating the effectiveness of existing agri-environment schemes. Studies of the causes of ecological changes recorded by the ITE Countryside Surveys (in 1978, 1984 and 1990) have revealed strong links between agricultural practices and botanical diversity. This information is being linked to socio-economic models of land use change, to inform the debate regarding reform of the Common Agricultural Policy.

In the **pollution core strategic programme**, research has focused on resolving uncertainties in the temporal fluxes and spatial dynamics of pollutant deposition and transport. A major study was completed on the rate of recovery of acidified surface waters following abatement of sulphur emissions over the last decade. Impact studies have been redirected towards understanding the effects of excess nitrogen deposition and photochemical oxidants. These studies have played an important role in the development of protocols for pollution abatement in the United Nations Economic Commission for Europe and for critical appraisal of the European Commission's new 'acidification strategy'. Research on radionuclides has been extended to assess the human dose parameters in heavily impacted regions of the Ukraine and Russia. In addition, ITE staff played a key role in the 'Arctic Mapping and Assessment Programme' (AMAP) in which geographical information system (GIS) techniques were used to assess the regional variation in radioactivity across the Arctic.

ITE's 'pollution' research capability has been significantly enhanced by six successful applications to the NERC's Environmental Diagnostics thematic programme. In addition to providing the programme management team and co-ordinating the data management component, ITE staff were partners in consortia that will study freshwater acidification and heavy metal deposition, as well as fluxes and degradation of organic pollutants.

In the **global change core strategic programme**, ITE continues to provide research to underpin the Climate Change Convention. NERC's thematic programme 'Terrestrial Initiative in Global Environmental Research' (TIGER) came to an end in 1996–97, and ITE contributed in full measure to the success of the programme and to the final TIGER conference (Plate 21). Since then, ITE has had considerable success in sustaining global change research with funding under the European Commission's Fourth Framework Environment and Climate Programme (ITE currently holds ten awards). The results of this work have been fed into the Inter-Governmental Panel on Climate Change (IPCC) review process,

ITE staff played a key role in the 'Arctic Mapping and Assessment Programme' (AMAP) in which geographical information system (GIS) techniques were used to assess the regional variation in radioactivity across the Arctic.



Plate 21. Professors Alistair Fitter, John Lawton, David Fowler and Mike Roberts (L–R) at the TIGER closing conference, held in London

It emerged that, contrary to prior expectations, the forests of the Legal Amazon form a large sink for atmospheric carbon, taking up about 2 gigatonnes per year. This conclusion indicates that these forests are a significant component of the so-called global 'missing sink' of carbon.

which will culminate in a major assessment in 2000

Scientific achievements

In 1996–97 the Institute's major scientific achievements in the core strategic programmes included the following

Carbon sinks in the Amazon

This study had the objective of modelling the distribution of carbon flux across the area known as the 'Legal Amazon' using GIS methods, in order to determine the importance to global carbon sequestration of the forests within this region. The model structure used remotely sensed mapping of different forest types, calibrated against field measurements of carbon flux provided by collaborators in the TIGER consortium. It emerged that, contrary to prior expectations, the forests of the Legal Amazon form a large sink for atmospheric carbon, taking up about 2 gigatonnes per year. This conclusion indicates that these forests are a significant component of the so-called global 'missing sink' of carbon.

Radioactivity in the Arctic

A report on the state of the arctic environment, delivered to Ministers of the arctic countries in June 1997, resulted from an international co-operative effort over six years involving scientists largely from arctic countries. ITE staff were members of the team responsible for producing the part of the report dealing with radioactivity. The report reviewed all currently available information on radioactivity in the Arctic, including past, present and potential sources, and assessed how radiation doses might affect the health of people living in the Arctic. It concluded that arctic terrestrial ecosystems are more vulnerable to radioactive contamination than temperate areas due to high transfer rates, the

consumption of many wild foods, and the diet of indigenous peoples (especially the ingestion of reindeer meat, freshwater fish, goat cheese, berries, mushrooms and lamb). The major sources of radioactive contamination are global fallout from atmospheric weapons testing, liquid discharges from Sellafield, and fallout from the Chernobyl accident. Of these sources, global fallout from weapons testing has provided the largest dose to arctic peoples.

Measuring UK greenhouse gas budgets directly using aircraft

The relatively long atmospheric lifetimes of the greenhouse gases methane and nitrous oxide provide opportunities to obtain large-area emission measurements using aircraft. ITE scientists have pioneered a technique which establishes a mass budget for the gases in the atmospheric boundary layer under conditions with a well-defined capping inversion and steady airflow across the country. In collaboration with the UK Meteorological Office research flight using a Hercules C-130, measurements of CH₄ and N₂O upwind and downwind of the coastline have been made in westerly airflow for the entire UK coastline to provide total emissions of these gases in winter conditions.

Acid waters survey of Wales

In order to assess the ecological benefits of reduced emissions of acid pollutants, a major survey of acid waters in Wales was carried out between 1994 and 1996. This large collaborative project, which repeated a survey undertaken in 1984 by the Welsh Water Authority, was funded by the Welsh Office, Environment Agency, Countryside Council for Wales (CCW) and the Forestry Authority. The 1995 survey involved extensive chemical and biological sampling of 102 streams and 16 lakes in acid-sensitive areas of

Wales, together with measurement of atmospheric deposition. The 1995 survey has confirmed and extended many of the relationships previously established between stream chemistry, biology and catchment attributes. Atmospheric deposition of sulphur to Wales has decreased since the 1984 survey and there is evidence that some chemical components of freshwaters, such as pH and sulphate, have responded. For a variety of reasons there is, however, no evidence of a response from biological indicators of acidification, such as stream invertebrates, fish and dippers.

Decline of biodiversity in arable areas

ITE scientists have established a strong link between the decline in biodiversity of farmland birds, invertebrates, and reductions in plant diversity resulting from changing agricultural practices. The link was established by matching individual bird and butterfly species with their associated foodplants, and then looking at the changes in these plant species within the landscape between 1978 and 1990. The correlation between plant and animal decline is particularly strong for butterflies, and also applies to many bird species.

Facilities for science, engineering and technology

A significant element of CEH's mission is to maintain well-found laboratories and, in particular, to support large-scale facilities. Recent investments in ITE to provide leading facilities are as follows.

Monitoring fluxes of trace gases and pollutants

Until recently the deposition monitoring networks in Europe were restricted to wet deposition. Dry deposition was considered too difficult and expensive to monitor, and consequently left as a research activity for micrometeorologists.

Annual dry deposition inputs were (and still are) calculated for Europe and North America using models. Within the EU LIFE initiative, a consortium of UK, Dutch and German research groups developed a measurement station to continuously monitor dry deposition fluxes of sulphur dioxide, nitric oxide, nitrogen dioxide and ozone.

The stations that have been constructed and tested include an upland site at Auchencorth Moss in Scotland, developed and operated by ITE Edinburgh. The Dutch operate a similar site over the Speuld forest in The Netherlands, while the Germans operate a site over agricultural land close to Leipzig. Measurements at Auchencorth have now produced almost three years of continuous fluxes of SO₂, NO, NO₂ and O₃, and one year of ammonia fluxes.

Reorganisation of air pollution chamber facilities

A major focus for research at ITE Bangor is the study of air pollution effects on plant species and communities. In collaboration with the University College of Wales, Bangor, a range of controlled environment and outdoor plant exposure chambers have been constructed at the University Farm. The controlled environment facility consists of six 'walk-in' rooms with regulated control of light, temperature and humidity. The outdoor facilities consist of eight climate change solardomes (with control of CO₂ and temperature) as well as eight smaller solardomes (with control of the pollutant gases SO₂, NO_x and O₃). In addition, there are six chambers in which wet deposition can be simulated. This collection of experimental facilities, unique in the UK, supports a wide range of ecological and physiological studies carried out jointly by ITE scientists and staff and students from a number of universities.

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Substantial progress has been made on a LINK project to develop a world-leading method for land cover mapping, using remotely sensed data from satellites.



Plate 22. Animal tagging systems are being tested in studies on the transfer of radionuclides to sheep

Molecular microbiology laboratories

This year has seen the refurbishment of a suite of laboratories for soil microbiological work at ITE Merlewood. The laboratories have been designed to provide a safe environment for work on Class I and II micro-organisms, and they also satisfy regulations covering work on genetically manipulated organisms, with Advisory Committee on Genetic Modification (ACGM) containment level 2. They are currently the focus of a project which combines culture and DNA-based methods to study the ecology of methane-oxidising bacteria in soils.

Molecular genetics in ecology initiative

ITE Banchory and the University of Aberdeen have been collaborating on a NERC-funded project to apply molecular techniques to long-term studies of animal population dynamics. The NERC Advisory Board has reviewed the programme and commended the group for their progress in developing appropriate molecular techniques. The methods are currently being applied to advance knowledge about the role of population structure in the dynamics of three vertebrates in NE Scotland (grouse, otters and water voles). Microsatellite and mitochondrial polymorphisms are used to characterise individuals, and assess levels of local population structure, dispersal and relatedness. The laboratory that has been established will provide the focus for more extensive applications in the future.

Working in partnership

In partnership with the user community, ITE scientists are working in the following areas:

- developing new techniques for mapping land cover using remote sensing data;
- evaluating applications of new

environmental monitoring systems developed by the industrial sector;

- developing decision support systems to improve access to national data on biodiversity and habitat management;
- improving networking between the science base and industry through seminars and workshops.

New techniques for mapping land cover

Substantial progress has been made on a LINK project to develop a world-leading method for land cover mapping, using remotely sensed data from satellites. The project involves collaboration with the Ordnance Survey and Laserscan and will produce innovative semi-automated mapping procedures within an integrated GIS. The key technical innovation has been to segment the images into vector maps prior to classification of the within-segment pixels.

Evaluating environmental monitoring systems

ITE Merlewood is involved in a collaborative programme with the Cumbria-based electronics company, Oxley Developments Ltd, to test environmental applications of new sensor and tagging systems. Novel solid-state water quality sensors developed by the company are being tested alongside existing monitoring equipment at the Moor House–Upper Teesdale site of the Environmental Change Network and, in collaboration with the Institute of Freshwater Ecology, in Esthwaite Tarn in the Lake District. Animal tagging systems are being tested in studies on the transfer of radionuclides to sheep (Plate 22) and are being used to facilitate automation of data collection and recording on each individual animal. The collaboration is supported under EC Area 2 funding.

In addition, ITE scientists have received a NERC grant (under the

CONNECT scheme) to assess ecological applications of an instrument designed to provide a fingerprint of compounds from the volatile components released into the atmosphere. It could be described as an 'artificial nose'. In a collaborative study between the Aromascan company and staff at ITE Merlewood, the potential of the technique has been tested in the identification of bacteria and fungi. The fingerprints of pure cultures of selected micro-organisms were derived and then used to identify the organisms present in mixed cultures. The results of the exploratory study are currently being analysed.

Developing environmental information systems

The use of information technology and especially computerised decision support tools will improve the way we tackle complex environmental problems, by providing ready access to a wide variety of data sources and the facility to interact with them through predictive models. This technology is relevant to habitat management and restoration, environmental diagnostics, ecotoxicology, and pollution studies.

ITE scientists have developed a computerised database system which provides all the available information required to prescribe appropriate management techniques for habitat restoration. The information system identifies the key species needed for restoration and supplies details of their ecological characteristics, habitat requirements and biogeographical distribution. The software contains expert information on the 'best practice' restoration, and the management techniques to achieve these objectives, for a variety of secondary successional habitats including lowland heath, wet meadows and chalk grassland.

Improving networking with the industrial sector

Effective communication is the key to practical applications of science for maintaining and restoring the environment. This is particularly the case with regard to the control and mitigation of contaminated land. A NERC grant (under CONNECT) enabled the University of Liverpool in association with ITE Merlewood to undertake a wide consultation on the potential for microbiological degradation of contaminants in soils. This culminated in a workshop which brought together microbiologists from HEIs and research institutes with representatives of the potential user communities, drawn from the chemical industry, agricultural sector, the water industry, the Environment Agency, the waste management industry and UK Government departments. The output from the workshop established the major gaps in knowledge as seen by both the research community and the problem holders, and identified the priority areas for future research.

Efficiency and effectiveness

This was an excellent year for achieving financial targets, outputs of publications, and expansion of links to the user community and the academic sector. The support for science programmes declined slightly to 45% of the annual income (31% from the science budget

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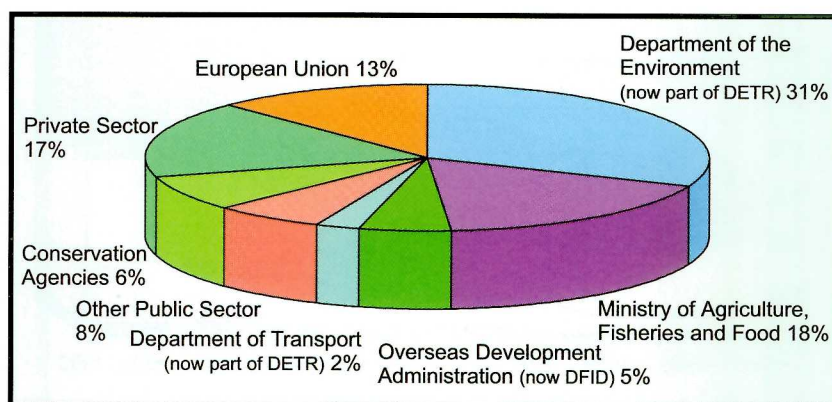


Figure 33. ITE commissioned research receipts in 1996-97

The Institute's high-quality research, survey and monitoring generated over 400 scientific papers and 20 books.

baseline and 14% from NERC's thematic programmes). The decline in thematic programme funding from TIGER and the 'Land–Ocean Interaction Study' (LOIS) was substantially offset by success in the Environmental Diagnostics programme. The science base was further strengthened by three awards under NERC's non-thematic (responsive) funding mode. The successful projects concerned behavioural ecology, invertebrate population regulation, and pollution degradation in soils. Commissioned research increased to 55% of the Institute's core strategic budget. The user community continued to diversify with the decline in support from the Department of Environment, Transport and the Regions being counterbalanced by increases from the Ministry of Agriculture, Fisheries and Food and from the European Union (Figure 33).

ITE's output indicators were sustained at the high level established in recent years (Figure 34). The Institute's high-quality research, survey and monitoring

generated over 400 scientific papers and 20 books. Contributions to the public understanding of science included more than 100 general articles. Over 200 contract reports were produced from the research commissioned by the user community.

Databases and networks

The Environment Information Centre (EIC) at ITE Monks Wood is custodian of a number of key national and European environmental datasets, covering land characteristics and the distribution of flora, fauna and habitats. The Centre is home to the UK National Critical Loads Mapping Centre, and is a component of two European Topic Centres (on Nature Conservation and on Land Cover) within the European Environment Agency. EIC also undertakes research into the methods of environmental data acquisition, analysis and use, particularly the application of information technologies like GIS.

Outside EIC there are other research programmes developing large spatial and/or temporal databases, linked into an ITE data network (which is responsible for maintaining standards of data management and accessibility within the Institute). These include datasets for the ITE Land Classification, Countryside Survey, and Environmental Change Network (based at ITE Merlewood), and the Scottish Centre for Ecological Data (based at ITE Banchory). Work on the stewardship and exploitation of environmental data has been enhanced by increased support from NERC. The following describes the development of these databases.

Database of the Biological Records Centre (BRC)

The database comprises distributions of biological species in the British

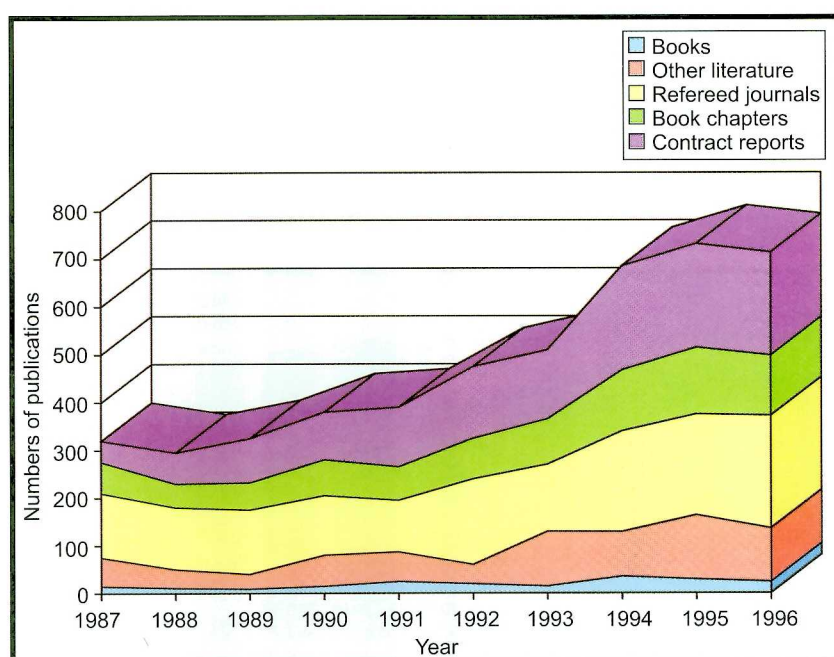


Figure 34. Trends in output of ITE publications in 1996–97

Isles (Figure 35), and holds over six million records covering 15 000 species. The Centre is assisted in its core activities and database functions by the statutory Conservation Agencies through a support contract administered by the Joint Nature Conservation Committee.

BRC has been successful in leading a bid with the Botanical Society of the British Isles to resurvey and compile an updated database of vascular plants. Work has just begun and a new *Atlas of the flora* will go to press at the end of 2000. This ambitious programme and other initiatives, such as the 'Butterflies for the new millennium' project with Butterfly Conservation, have been developed in partnership with the leading national voluntary organisations and the statutory Conservation Agencies.

The BRC is also at the core of the National Biodiversity Network which has been established to strengthen the accessibility of biodiversity data. Over the last three years the BRC Oracle database has been restructured to become fully relational. This has improved the day-to-day accessibility of the data, and additional enhancements to the management and accessibility of data are continuing, subject to available resources. These improvements have resulted in greater integration of BRC's species data with other environmental datasets in ITE.

Database of the UK Environmental Change Network

ECN is a multi-agency, long-term monitoring programme for identifying and quantifying environmental changes associated with man's activities. It aims to distinguish man-made changes from natural variations and trends, and to give early warning of undesirable effects. ECN measurements are

collected regularly at a growing number of network sites (currently ten terrestrial and 37 freshwater) throughout the UK using standardised protocols. ECN has been at the forefront of research to develop indicators of environmental change. In addition, ECN led a successful bid to the EC for a Concerted Action project to co-ordinate the monitoring of environmental change across Europe.

Database of critical loads of atmospheric pollutants

The database comprises estimates of the vulnerability of the land surface of Great Britain to the effects of atmospheric pollution (particularly acid deposition), on the basis of air quality and the sensitivity of receptor soils, geology, freshwaters and vegetation (trees, semi-natural vegetation and crops). Research on the uncertainties in the critical loads database has been enhanced by awards from the Environmental Diagnostics thematic programme.

Ecological surveys of Great Britain

The database consists of information collected in field surveys of selected one km squares of the British National Grid, representative of 32 distinct land classes (classified according to environmental characteristics such as geology, altitude and climate). Information includes botanical data (occurrence and cover within quadrats), soil type and strata, and land cover. The data have been collected from up to 508 sample squares, surveyed in 1978, 1984 and 1990. Information from the database has been analysed to assess the causes of changes in landscape features and biodiversity.

The Countryside Survey 1990 included the production of a national Land Cover Map from the

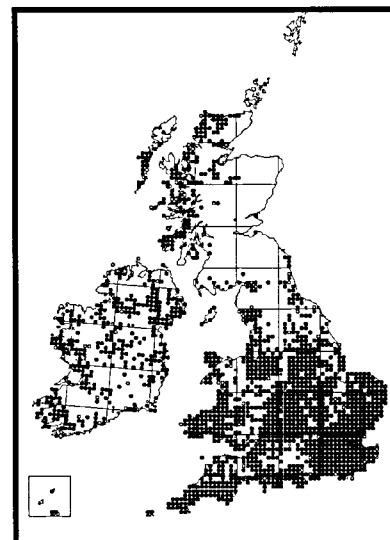


Figure 35 Sample species' distribution map produced by the Biological Records Centre





Countryside Information System

classification of satellite images provided by the LANDSAT Thematic Mapper. By 1996–97, over 150 organisations held licences for use of the land cover data. Research was initiated in 1996 to develop a more accurate Land Cover Map under the British National Space Centre/NERC LINK programme. Data from the Countryside Surveys have been made available through the PC-based Countryside Information System (CIS). Several new one km square datasets were added to the CIS in 1996 to create the largest single repository of national environmental information.

ITE's capability in ecological surveys has been enhanced by several commissioned research projects to monitor the effectiveness of Agri-Environment Schemes. These include ESA monitoring in Scotland, the Tir Cymen Scheme in Wales, and the Countryside Stewardship Scheme in England. A repeat of the Countryside Survey is planned for 1998 and will be published in 2000.

Events and staff news

The then Minister for Rural Affairs, the **Right Hon Tim Boswell MP**,

and the recently appointed Chairman of NERC, **Mr James Smith CBE**, visited ITE Monks Wood in February 1997. The visit was hosted by Professor Mike Roberts, and the Head of ITE Monks Wood, Dr Barry Wyatt (Plate 23). The visitors saw some of Europe's most innovative land use research, including presentations on the effects of agriculture on bird populations, habitat management, risk assessment of genetically modified crops, and the effects of UV-B radiation on plants.

The European Conservation Research Institute Network (CONNECT) held the annual meeting of its Management Board at ITE Banchory in October 1996. The meeting brought together the Directors of all the major ecological research institutes in northern and central Europe. The meeting was hosted by Professor Roberts and Professor Brian Staines (then Head of ITE Banchory) (Plate 24).

Mr Terry Wells (ITE Monks Wood, retired) was awarded the OBE for services to botany and conservation. The award was in recognition of his pioneering research on habitat management and restoration, along with his extensive voluntary work in support of local nature reserves. **Dr Jeremy Thomas** (ITE Furzebrook) was awarded the Zoological Society of London's Marsh Award for Conservation Biology. The award cites his 'outstanding work in conservation ecology and, in particular, his classic study on the conservation of the large blue butterfly and the way in which he has underpinned this work with excellent science'.

Dr Roger Leakey (ITE Edinburgh) was elected as a Fellow of the Institute of Biology and **Dr Ronnie Milne** (ITE Edinburgh) was elected as a Fellow of the Institute of



Plate 23. Visit of the Rt Hon Tim Boswell MP (seated) to ITE Monks Wood in February 1997, with Mr James Smith CBE, Chairman of NERC (centre), Professor Mike Roberts, Director ITE (R) and Dr Barry Wyatt, Head of ITE Monks Wood (L)

Physics. **Professor Ian Newton** (ITE Monks Wood) was elected to the Council of the Royal Society for the Protection of Birds. **Mr Brian Eversham** (ITE Monks Wood) was appointed Vice President (and President Elect) of the British Entomological and Natural History Society. **Professor David Fowler** (ITE Edinburgh) gave the Caledonian Research Foundation Lecture to the Royal Society of Edinburgh.

The number of ITE staff with Honorary Professorships increased to 12 with the appointments of **Professor Nigel Webb** (to the University of Liverpool) and **Professor Keith Bull** (to Nottingham Trent University). **Dr Chris Preston** (ITE Monks Wood) was awarded the Doctorate of Philosophy by the University of Cambridge. **Mr Paul Howe** (ITE Monks Wood) graduated as a Bachelor of Philosophy with the Open University.

The paper *Modelling ecological change on set-aside arable land using a GIS approach*, by **Ms Ruth Swetnam**, **Dr Les Firbank**, **Ms Noranne Ellis** and **Dr Mark Hill**, was voted to be the best ecological and agricultural application at the 1997 International Society of Environmental Software Systems conference in Whistler, Canada.

ITE staff co-supervised over 100 research students and two achievements by associated students were notable. **Mr Claus Svendsen** (University of Reading) received the 'best first paper' commendation by the European Society for Environmental Toxicology and Chemistry.

Mr David Conway (University of Liverpool) was invited to present a display of his joint research with ITE Merlewood at the House of Commons.



Plate 24. Professors Mike Roberts (3rd from L) and Brian Staines (5th from R) with the Directors of the European Conservation Institutes Research Network (CONNECT) at ITE Banchory, which hosted the annual Management Board meeting

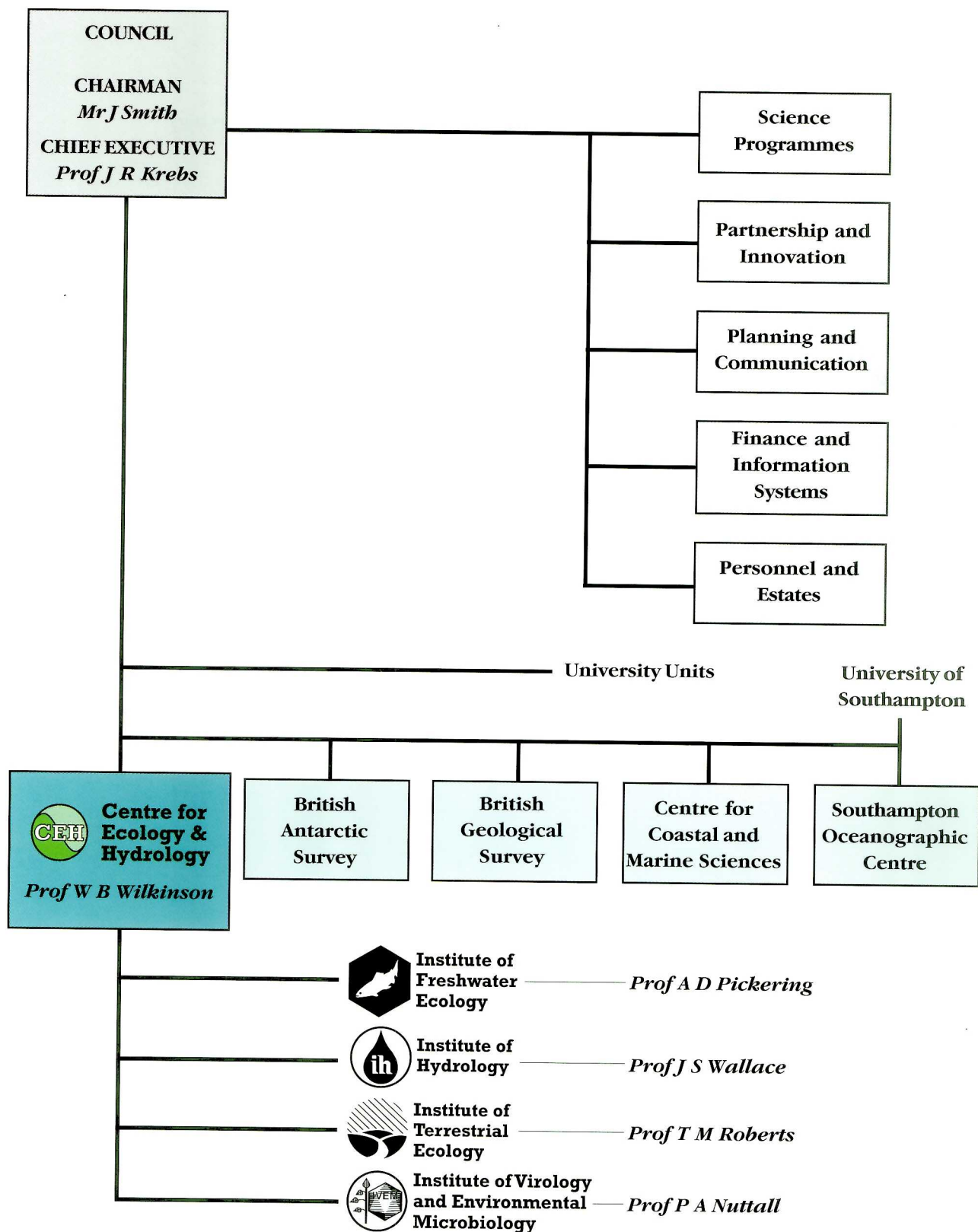
The Institute continued to raise the public awareness of science through extensive support for school projects. **Mr Colin Barr** (ITE Merlewood) and **Mr Robin Fuller** (ITE Monks Wood) assisted by **Mrs Sue Wallis** (ITE Monks Wood) co-ordinated a nationwide survey by schools of land use in England. The Geographical Association published a book on the survey, which was launched at the Royal Geographical Society in London in November 1996.

ITE continued to support the Nuffield Bursary Scheme and six 'A' level students completed projects in 1996. **Ms Lucy Webster** won a prize in the AMOCO science competition 1996 for her project work carried out at ITE Banchory.

It is evident from the extent of these individual highlights that ITE continues to take a leading role in British ecological research. Nevertheless, one should not focus purely on the individual contributions; the high standing of ITE's science is based upon the contributions of staff at all levels of the organisation.

**ITE staff co-supervised
over 100 research
students.**

NERC structure



Location of CEH sites



Director:
T M Roberts

Institute structure

Address	Head of Station	Research sections	England			Scotland		Wales															
			Monks Wood Research Station	Merlewood Research Station	Furzebrook Research Station	Edinburgh Research Station	Banchory Research Station	Bangor Research Unit															
Abbots Ripton Huntingdon Cambridgeshire PE17 2LS	B K Wyatt	Animal ecology Earth observation Ecological processes & management Pollution & ecotoxicology Environmental Information Centre	01487 773381 01487 773467 monkswood@ite.ac.uk	Windermere Road Grange-over-Sands Cumbria LA11 6JU	M Hornung	Environmental chemistry Land use Radioecology Soil ecology Environmental Change Network	015395 32264 015395 34705 merlewood@ite.ac.uk	Furzebrook Road Wareham Dorset BH20 5AS	A J Gray	Invertebrate ecology Plant ecology & genetics Vertebrate & trophic ecology	01929 551518 01929 551087 furzebrook@ite.ac.uk	Bush Estate Penicuik Midlothian EH26 0QB	M G R Cannell	Ecosystem modelling Trace gas fluxes & air pollution Tropical ecology	0131 445 4343 0131 445 3943 bush@ite.ac.uk	Hill of Brathens Glassel, Banchory Kincardineshire AB31 4BY	S D Albon	Applied ecology Upland community ecology Vertebrate population ecology	01330 826300 01330 823303 banchory@ite.ac.uk	University of Wales, Bangor, Deiniol Rd Bangor, Gwynedd LL57 2UP	J E G Good	Air pollution & climate change impacts Biogeochemistry & land use Upland ecology	01248 370045 01248 355365 bangor@ite.ac.uk

Further information is available on the ITE homepage of the World Wide Web - <http://www.nmw.ac.uk/ite>

APPENDIX 3

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Miss	R	Cooper	8(A)
Mrs	JL	Green	6(A)
Mrs	D	Harman <i>Personal Secretary to Director</i>	8(A)
Mrs	JV	Kimber	9(A)
Mrs	J	Knight	7(A)
Mrs	JS	Parsell <i>Head of Administration</i>	5(A)
Miss	SL	Stapleford	7(A)
Mrs	S	Stefanelli	7(A)pt

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Mr	NJ	Brown	6(S)
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Ms	H	Chamberlain	4(S)
Miss	R	Cox	6(S)
Mrs	JM	Croft	7(S)
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Ms	C	Davies	7(S)pt
Dr	AS	Dawson <i>Head of Animal Ecology Section</i>	4(S)
Dr	S	Dobson	3(S)
Miss	H	Dyke	7(S)
Dr	JE	Eastwood	6(S)
Mr	BC	Eversham	5(S)
Miss	J	Finnie	7(S)
Ms	WA	Forrest	9(A)
Mrs	J	Francis	8(A)pt
Mr	P	Freestone	6(S)
Mr	RM	Fuller <i>Head of Earth Observation Section</i>	4(S)
Mr	RA	Garbutt	7(S)
Mr	J	Gascoigne	7(S)
Mrs	JM	Gaunt	9(A)
Ms	F	Gerard	6(S)
Mr	A	Glasscock	6(S)
Mr	N	Greatorex-Davies	6(S)
Mr	PD	Greenlade	7(S)
Mrs	EM	Guerin	9(A)

Miss	JR	Hall	6(S)
Mr	PK	Hankard	7(S)
Mr	PT	Harding	4(S)
Dr	MO	Hill <i>Head of Ecological Processes & Management</i>	4(S)
Dr	SA	Hinsley	6(S)
Mr	PD	Howe	6(S)
Mrs	M	Jolly	9(T)
Mrs	MJ	King	8(A)
Miss	N	Maguire	8(S)
Mr	HM	Malcolm	6(S)
Miss	S	Manchester	7(S)
Ms	J	Mann	8(A)
Dr	A	McLeod	5(S)
Miss	S	McNally	7(S)
Dr	A	Meharg	5(S)
Dr	TJ	Moffat	6(S)
Dr	D	Moss	4(S)
Mr	JO	Mountford	6(S)
Mr	DG	Myhill	7(S)
Dr	K	Newsham	6(S)
Prof	I	Newton	2(I)
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Dr	RF	Pywell	6(S)
Mrs	C	Richards	8(A)pt
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Mr	P	Rothery	4(S)
Mr	DB	Roy	7(S)
Prof	J	Sheail	3(I)
Dr	RF	Shore	5(S)
Dr	G	Smith	6(S)
Mrs	AS	Southwood	8(T)
Mr	TH	Sparks	5(S)
Mr	MR	Spendlove	9(T)
Ms	R	Swetnam	7(S)
Mr	AG	Thomson	6(S)
Mr	A	Turk	8(S)
Mrs	H	Turk	9(T)
Mrs	JM	Ulliyett	7(S)
Mrs	D	Wade	8(A)
Dr	R	Wadsworth	6(S)
Mr	K	Walker	7(S)
Mrs	S	Wallis <i>Assistant to Head of Station</i>	7(S)
Miss	EA	Warman	7(S)
Dr	JM	Weeks	5(S)
Mr	J	Wright	7(S)
Miss	CL	Wyatt	7(S)
Mr	I	Wyllie	5(S)
Mrs	IS	Wyllie	8(T)
Mr	MG	Yates	6(S)
Mrs	TJ	Yates	6(S)

APPENDIX 3

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Mr	NA	Beresford	5(S)
Dr	HJ	Black	6(S)
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Dr	RGH	Bunce <i>Head of Land Use Section</i>	4(S)
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Mr	ASC	Culling	8(S)
Mrs	J	Delve <i>Personal Secretary to Head of Station</i>	8(A)
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Miss	JS	Garnett	8(S)
Miss	MK	Gillespie	6(S)
Mrs	K	Goodsir	8(C)
Ms	J	Grimshaw	9(A)
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Dr	BJ	Howard <i>Head of Radioecology Section</i>	4(S)
Dr	DC	Howard	6(S)
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Dr	P	Ineson	4(S)
Dr	HE	Jones	5(S)pt
Mrs	VH	Kennedy	6(S)
Ms	AJM	Lane	6(C)
Mr	R	Lethbridge	TG2
Mr	DK	Lindley	4(S)
Dr	N	Parekh	6(S)
Mr	JA	Parkinson	5(S)
Dr	TW	Parr <i>Head of Environmental Change Network</i>	4(S)
Mrs	J	Parrington	7(S)pt
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Miss	R	Pounder	8(A)
Mr	C	Quarmby	5(S)
Mrs	L	Raine	9(A)pt
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Miss	SMC	Robertson	7(S)
Mr	MJ	Rossall	8(S)
Mr	AP	Rowland <i>Head of Environmental Chemistry Section</i>	5(S)
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Mr	R	Scott	6(S)
Dr	WA	Scott	4(S)
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Mr	D	Sleep	7(S)
Mr	SM	Smart	7(S)
Mr	GJ	Stark	6(S)
Miss	HM	Van der Poll	6(S)
Mr	JW	Watkins	6(C)
Mrs	D	Whittaker	8(T)
Mr	DL	Williams	7(S)
Mr	D	Wilson	8(S)
Mr	C	Woods	6(S)
Mr	SM	Wright	7(S)
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Mr	C	Hankinson	7(T)
Mrs	PA	Ward	6(A)
<i>ECN staff located at Wytham</i>			
Dr	MD	Morecroft	6(S)
Miss	M	Taylor	8(S)

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Mrs	J	Binnie	7(S)
Mr	TAW	Brown	7(S)
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Ms	M	Coyle	7(S)
Dr	A	Crossley	5(S)
Mr	JD	Deans	4(S)
Dr	JM	Dick	6(S)
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Mrs	MJ	Ferguson	9(A)
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Dr	AD	Friend	5(S)
Dr	ACM	Gillies	6(S)
Dr	KJ	Hargreaves	6(S)
Mr	FJ	Harvey	6(S)
Mr	A	Horsburgh	9(T)
Mr	K	Ingleby	6(S)
Mrs	DS	Innes	8(A)
Mr	GJ	Lawson	5(S)
Dr	RRB	Leakey	4(S)
Mr	ID	Leith	6(S)
Dr	PA	Mason	5(S)
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Mr	DA	McEwan	9(T)
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Mr	RC	Munro	6(S)
Mrs	MB	Murray	6(S)
Mr	TD	Murray	6(S)
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Mr	RL	Storeton-West	7(S)
Dr	MA	Sutton	5(S)
Mr	J	Wallace	9(T)
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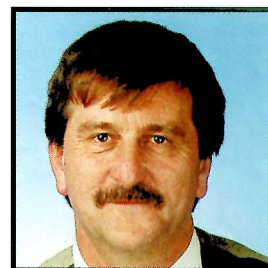
Dr	SL	Brown	6(S)
Dr	JM	Bullock	6(S)
Dr	RWG	Caldow	6(S)
Mrs	IM	Chester <i>Library Services</i>	8(A)
Mr	RT	Clarke	4(S)
Dr	RE	Daniels	4(S)
Dr	GW	Elmes	3(I)
Dr	JD	Goss-Custard <i>Head of Vertebrate & Trophic Ecology Section</i>	3(I)
Ms	K	Hodder	7(S)
Mrs	MC	Jones <i>Station Secretary</i>	7(A)
Dr	RE	Kenward	4(S)
Mrs	S E A	Le V dit Durell	6(S)pt
Miss	LC	Maskell	7(S)
Dr	S	McGrorty	5(S)
Miss	R J	Mogg	7(S)
Miss	IL	Moy	7(S)
Mr	B	Pearson	6(S)
Mrs	MK	Perkins <i>Personal Secretary to Head of Station</i>	8(A)

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Mr	RJ	Rose	6(S)
Mr	RG	Snazell	5(S)
Dr	RA	Stillman	6(S)
Dr	JA	Thomas <i>Head of Invertebrate Ecology Section</i>	3(I)
Dr	LK	Ward	4(S)
Mrs	JC	Wardlaw	6(S)pt
Prof	NRC	Webb <i>Head of Plant Ecology & Genetics Section</i>	4(S)
Mr	A D	West	7(S)

Banchory Research Station

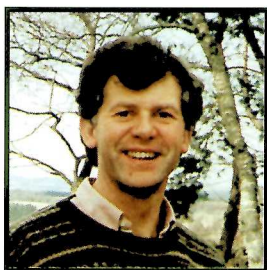
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Head of Station

Prof B W Staines (3S)

**Head of Station as from 1 March 1997**

Dr S D Albon (3S)



Dr	IM	Alonso	5(S)
Mrs	PM	Andrews	9(A)
Dr	PJ	Bacon	4(S)
Dr	NG	Bayfield <i>Head of Applied Ecology Section</i>	4(S)
Dr	DN	Carrs	6(S)
Mr	JWH	Conroy	6(S)
Mr	RP	Cummins	5(S)
Mr	DD	French	5(S)
Mrs	M	Gash	8(A)pt
Prof	MP	Harris	4(S)
Dr	SE	Hartley <i>Head of Upland Community Ecology Section</i>	5(S)
Mr	J	Irvine	7(S)
Dr	H	Kruuk	3(I)
Mr	AD	Littlejohn	9(T)
Dr	M	Marquiss	5(S)
Dr	G	Massei	5(S)
Mrs	GM	McGowan	6(S)
Dr	R	Moss <i>Head of Vertebrate Population Ecology Section</i>	4(S)
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Miss	I	Pearce	7(S)
Mr	N	Picozzi	5(S)
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Mr	A	Webb	7(S)
Mr	D	Welch	4(S)

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Mrs	A	Brittain		7(S)
Dr	A	Buse		5(S)
Mrs	JR	Cooper		9(A)pt
Dr	BA	Emmett		5(S)
Mr	S	Hughes		6(S)
Mrs	G	Langhorne		8(A)pt
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Mr	DA	Norris		7(S)
Miss	DE	Owen	<i>Unit Secretary</i>	7(A)
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Mr	W	Slade		5(C)
Mr	PA	Stevens	<i>Head of Upland Ecology Section</i>	4(S)
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Research projects at 31 March 1997

Soils and soil-vegetation interactions

- Project 1 1** Physicochemical processes affecting soil-water interactions
 Issue 1 1 2 Organic matter decomposition and the production of humic substances
- Project 1.2** Biologically mediated soil processes
 Issue 1 2 1 Activity and diversity of key functional populations
 Issue 1 2 2 Trophic interactions in soils and their influence on soil organic matter production and degradation

Land use science

- Project 2 1** Long-term and large-scale monitoring of land use
 Issue 2 1 1 National-scale survey of land use and cover
 Issue 2 1 2 Remote sensing of land use and cover
 Issue 2 1 3 Monitoring and evaluation of land use policies
- Project 2.2** Land use systems
 Issue 2 2 1 Environmental impacts and management of farming and forest systems - uplands
 Issue 2 2 2 Environmental impacts of farming systems - lowlands
 Issue 2 2 3 Land use manipulation to minimise adverse impacts
 Issue 2 2 5 Holistic catchment studies
 Issue 2 2 6 Development of water resource management strategies
 Issue 2 2 7 Coastal zone survey and management
- Project 2.3** Management of ecosystems in tropical regions
 Issue 2 3 1 Management and restoration of forests and drylands
 Issue 2 3 2 Agroforestry
- Project 2 4** Landscape function and modelling
 Issue 2 4 1 Modelling spatial processes
 Issue 2 4 2 Applied landscape ecology
 Issue 2 4 3 Integrated modelling of land use processes including social and economic variables

The urban environment

- Project 3 1** Patterns of urban land/water use and associated habitats
 Issue 3 1 1 Pattern and distribution of urban habitats in relation to past and present land/water use

Biodiversity and population processes

- Project 5.1** Biodiversity characterisation, pattern and monitoring
 Issue 5 1 1 Species richness in relation to environmental factors
 Issue 5 1 2 Methodologies for biodiversity assessment in Europe
 Issue 5 1 5 Biodiversity in forests
- Project 5 2** Ecosystem function and biodiversity
 Issue 5 2 1 Trophic interactions and ecosystem function insect-plant interactions
- Project 5.3** Population processes underlying biodiversity
 Issue 5 3 1 Environmental determinants of population processes
 Issue 5 3 2 Interactions between demes, local populations and greater populations
 Issue 5 3 3 Interactions between populations of different species
 Issue 5 3 5 Within- and between-species comparative population and community processes
- Project 5 4** Conservation and restoration of biodiversity
 Issue 5 4 1 Single-species conservation programmes monitoring and evaluation
 Issue 5 4 3 Habitat creation and restoration
 Issue 5 4 4 Community attributes of restored ecosystems
 Issue 5 4 5 Wetland management and restoration

Pest and disease control

- Project 6 3** Environmental impact of GMOs and potentially invasive species
 Issue 6 3 1 Gene flow in natural plant populations

Pollution assessment and control

- Project 7 1** Radionuclides
 Issue 7 1 1 Parameterisation of radionuclide contamination and transfer
 Issue 7 1 2 Incorporation of spatial variability
 Issue 7 1 3 Extending the range of radionuclides (and applications to heavy metal transfers)
 Issue 7 1 4 Improving estimation of radiation doses

Issue 7 1 5 Development of countermeasures
Issue 7 1 6 Collaboration

Project 7.2 Acidifying pollutants

Issue 7 2 1 Emissions
Issue 7 2 2 Atmospheric chemistry and transformations
Issue 7 2 4 Impacts on soil-plant systems
Issue 7 2 5 Surface water and catchment-scale impacts
Issue 7 2 6 Modelling
Issue 7 2 7 Critical loads

Project 7.3 Photochemical oxidants

Issue 7 3 1 Atmospheric transformations and transport
Issue 7 3 3 Impacts on vegetation, materials and human health

Project 7.4 Toxic metals

Issue 7 4 1 Transport and deposition
Issue 7 4 2 Soil processes and soil-plant transfers
Issue 7 4 3 Transfer to animals
Issue 7 4 4 Ecotoxicology and environmental standards

Project 7.5 Organic pollutants

Issue 7 5 1 Monitoring
Issue 7 5 2 Transport and food-chain transfer
Issue 7 5 3 Biological degradation and transformation
Issue 7 5 6 Ecotoxicology and environmental standards

Project 8.3 Understanding and modelling the role of rare events on ecological systems

Issue 8 3 1 Rare events and ecological processes
Issue 8 3 3 The ecological repercussions of floods and droughts

Project 9.1 Greenhouse gas budgets and cycles

Issue 9 1 1 Global atmospheric CO₂ monitoring
Issue 9 1 3 Net CO₂ fluxes for UK vegetation and soil
Issue 9 1 4 Exchange mechanisms in high-latitude wetlands
Issue 9 1 5 Greenhouse gas emissions for the whole UK
Issue 9 1 7 Soil sinks of methane
Issue 9 1 8 Mid-latitude sources of N₂O and NO

Project 9.2 Land-atmosphere-ocean interactions

Issue 9 2 5 Dynamic ecosystem models for GCMs

Project 9.3 Forecasting and detecting the impacts of global change

Issue 9 3 2 Colonisation, dispersal and extinction of species
Issue 9 3 4 Species responses to elevated CO₂
Issue 9 3 5 Ecosystem responses to elevated CO₂
Issue 9 3 6 Ecosystem responses to elevated UV-B radiation

Project 10.1 Environmental assessment, economics and history

Issue 10 1 1 Improved methodology for quantitative prediction of environmental impacts
Issue 10 1 3 Environmental valuation
Issue 10 1 7 Impacts of historical land use change

Project 10.2 Remote sensing

Issue 10 2 1 Algorithm development
Issue 10 2 2 Ground reference and scaling up
Issue 10 2 3 Data integration

Project 10.3 Instrumentation

Issue 10 3 1 Intelligent sensor clusters

Project 10.4 Biotechnology development

Issue 10 4 1 Virus replication

Project 10.5 Analytical chemistry

Issue 10 5 1 Determination of organic pollutants and metabolites
Issue 10 5 5 Sample matrices
Issue 10 5 6 Field analytical techniques
Issue 10 5 7 Chemical databases
Issue 10 5 8 Stable isotope facility

Project 10.6 Databases and reference collections

Issue 10 6 1 Integrity and accessibility of databases and collections within CEH
Issue 10 6 2 Monitoring environmental change
Issue 10 6 3 Environmental management

Project 10.7 Biometrical applications, research and development

Issue 10 7 1 Biometrical collaboration
Issue 10 7 2 Application and development of biometrical methods
Issue 10 7 3 Statistical training

Environmental risks and extreme events

Global change

Integrating generic science

Publications by ITE staff

- Refereed papers in journals
- Books, book chapters, conference proceedings, papers and summaries
- Contract reports

ITE publications for sale

Titles published in 1996–97

APPENDIX 5

Publications by staff at 31 March 1997

Refereed papers in journals

(Aarkrog, A., Baxter, M S., Bettencourt, A.O., Bojanowski, R., Bologa, A., Charmasson, S., Cunha, I., Delfanti, R., Duran, A., Holm, E., Jeffree, R., Livingston, H D., Mahapanyawong, S., Nies, H., Osvath, I., Li Ping Yu, Povinec, P P.), Sanchez, A., (Smith, J.N. & Swift, D.) 1997 A comparison of doses from ^{137}Cs and ^{210}Po in marine food a major international study *Journal of Environmental Radioactivity*, 34, 69-90

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APPENDIX 5

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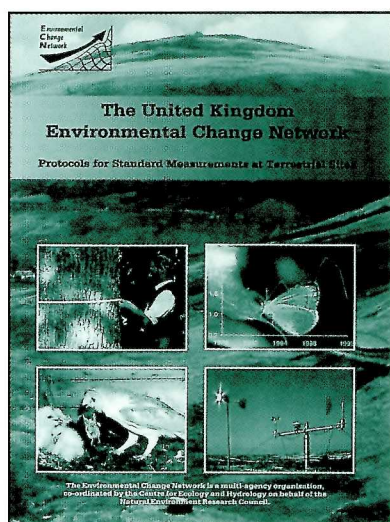
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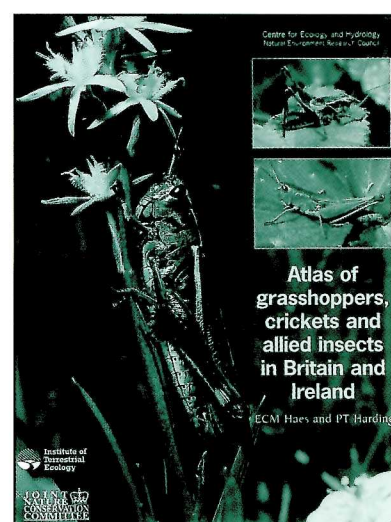
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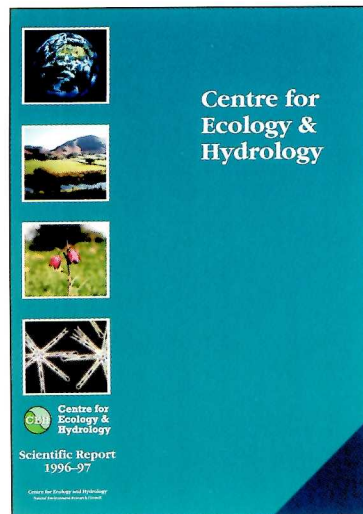
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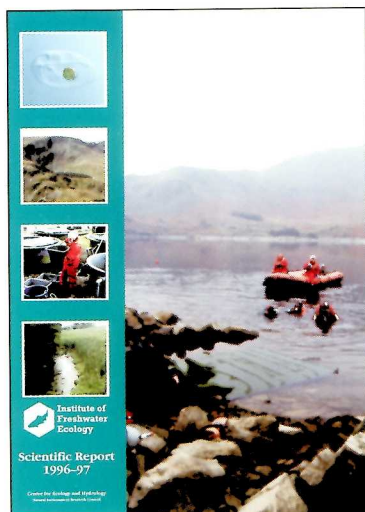
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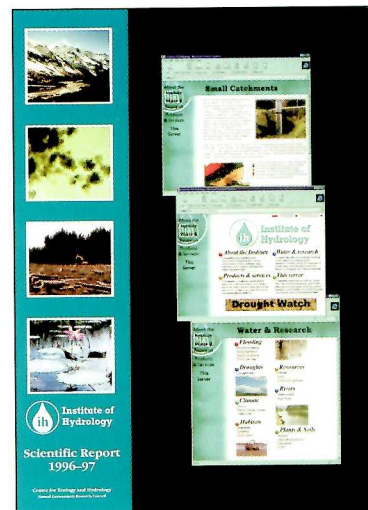
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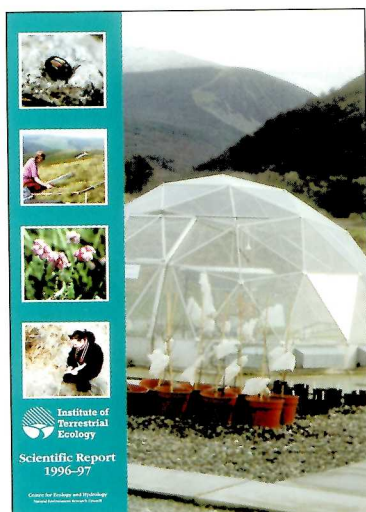
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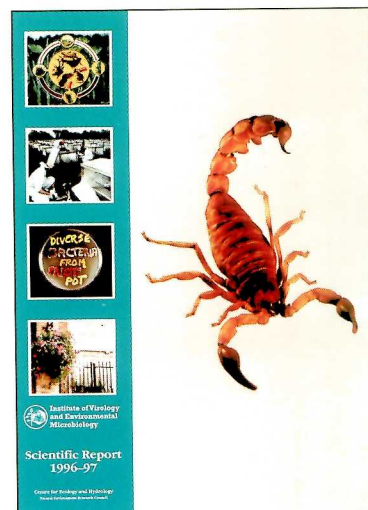
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