Annual Report

2003 - 2004

Centre for Ecology & Hydrology

NATURAL ENVIRONMENT RESEARCH COUNCIL

The Centre for Ecology and Hydrology (CEH) is the UK's Centre of Excellence for research in the terrestrial and freshwater environmental sciences. Our parent body is the UK Natural Environment Research Council. CEH's staff have specialist skills in a wide range of environmental disciplines, ranging in scale from the gene to whole Earth systems. Our research is aimed at improving our understanding of both the environment and the processes that underlie the Earth's support systems. We are particularly interested in the impacts of human activity on natural environments.

We aim to generate workable solutions to today's pressing environmental problems, so that a healthy, wealthy and sustainable environment can be enhanced and maintained in the UK and worldwide.

Photograph R Gaunt

Annual Report 2003 - 2004

The Centre for Ecology and Hydrology is a Research Centre of the UK Natural Environment Research Council

Contents

Foreword from the Director, Prof. Patricia Nuttall OBE

The period 2003/2004 has seen the greatest changes in the Centre for Ecology and Hydrology (CEH) since its formation. From being a site-based organisation we have moved to becoming an integrated Research Centre with a single goal – to deliver our science strategy, 'Health and Wealth of the Environment'. This could not have been achieved without the hard work and dedication of all of CEH's staff, who deserve a big thank you. I would like to say a few words regarding three particular topics from this year:

Working together

Our new focus on Science Programmes has enormously improved our working together across CEH. One example has been in preparing our science and business plans for the year. For the first time we have a Corporate Business and Operating Plan, which includes outline science plans for each of our five Science Programmes (Biodiversity, Biogeochemistry, Water, Climate Change and Sustainable Economies). Planning for our next five-yearly (Quinquennial) Programme of research themes (2005-2010) has brought research staff together who often have not met before, sparking off new ideas and interdisciplinary approaches – and so realising the potential of our research capability.

As another example, Site Managers at our eight research sites are now working together under a new appointment - Head of Site Management. The managers now have clearly defined budgets with which to provide and maintain fit-for-purpose facilities for the work of the research staff, they are identifying and implementing best practice across the organisation and they are working together with research staff in new ways.

Science Management Audit (SMA)

As a condition of our public funding, CEH has to undergo Audits at 5-yearly intervals. For two weeks in March 2004, a team of 17 internationally recognised environmental scientists undertook a Science and Management Audit of CEH. It was a difficult challenge to review a complex organisation in the middle of radical changes. Thanks are due to all who presented their research, demonstrated their work and managed this demanding Audit. At the time of writing we have received the SMA's Report, which set an extremely high value on our science – we (and our parent body the Natural Environment Research Council, NERC) are of course very pleased with this outcome. The Report's recommendations will inform our activities in the next few years.

Building partnerships

CEH has a successful track record of working with others, as recognised by the SMA Report. Indeed, the delivery of our ambitious science strategy depends on strong partnerships and, with the support of NERC, we have been able to consolidate this. For example: the Lancaster Environment Centre has been strengthened by the relocation of staff and facilities from CEH Merlewood and Windermere into newly built and refurbished facilities on the campus of the University of Lancaster; the new Environment Centre for Wales is being built at University of Wales, Bangor and will house CEH Bangor staff together with University staff. A partnership in Scotland is hoping to establish the Aberdeen Centre for Environmental Sustainability, bringing together staff from CEH Banchory, University of Aberdeen and Macaulay Land Use Research Institute. In Europe, we have continued to build links within the PEER network of European environmental research institutes and within European Framework Six research collaborations.

Opening CEH Lancaster

The new structure of CEH is described in the following pages. I hope you enjoy reading this Annual report, and shall welcome any feedback you wish to send to me.

Pat Nuttall

Pat Nuttall, *directorceh.ac.uk*
tel: 01793 442516

The Changing

This year has seen some major steps towards our transformation from a site-based organisation to a science programme-led, strategy-focussed organisation. The five new Science Directors (pictured right) took up their posts on October 1st 2003 in order to prepare for full operation of the new management system before it 'went live' on April 1st 2004.

Senior members of staff from across all sites have formed Programme Colleges which meet regularly to help, advise and support the Science Directors in the strategic management and development of the programmes. In the first such meetings in late 2003 and early 2004, College members considered the implementation of our science strategy over the next 5 years. The outputs from their discussions formed the foundation of the new Quinquennial Science Programme that was submitted to NERC in June 2004 for international review and financial approval. We will report next year on the results of that review, which will be considered by NERC Council, along with the report on our Science and Management Audit, in January 2005.

Each of the Science Directors is assisted by a Science Programme Administrator (SPA), who also acts as secretary to the Programme College, and by financial and secretarial support staff. The SPAs have a key role in ensuring news and information is disseminated amongst the dispersed scientists and other staff working in their programme.

We have reorganised how we obtain external help and advice. We have created a single Programme Development Group (PDG) from the three former groups, who have the role of advising on the quality, focus and relevance of our science. Members of the PDG, primarily from UK academic institutions, are affiliated to a Programme College and can attend annual meetings to provide an external perspective. In addition, the Chairman of the PDG is a member of our Advisory Committee (see page 5). This ensures a flow of information between the policy advice and the scientific advice.

Additionally, 'CEH Swindon' the CEH Director's office within the NERC building, has been strengthened by new and replacement staff in the finance, personnel and site administration areas, and now provides centralised corporate support to all the sites.

As the Director has mentioned (page 1), CEH is forging new partnerships with Universities in Lancaster, Bangor and Aberdeen. We shall start to see the 'fruits' of these collaborations shortly, in exciting and innovative ways of using our skills and knowledge alongside those of our partners. International collaboration has been important too. CEH's staff have worked in teams with researchers from many European countries this year, including the new Accession States, and have won significant funding from the European Framework Programme 6. Further details on these activities can be found on page 35.

Using CEH's outputs

CEH's research staff are at the leading edge of natural environmental research in the UK and the scientific knowledge gained is used in

Alan Jenkins

Dan Osborn

Melvin Cannell

David Fowler

Mark Bailey

Face of CEH

different ways - helping to underpin the UK's environmental policy-making and business. We have also maintained our excellent relationships with our external research customers and funders, and this enables us to carry out relevant, specific research in areas of national concern, such as flooding and climate change impacts and how healthy natural environments can be sustained alongside the demands and impacts of an expanding human population.

Providing scientific knowledge to underpin policy

Providing science knowledge to underpin policy continues to be an important area of activity for CEH. Findings from our independent research have informed Government policy in areas as diverse as:

- increasing the effectiveness of agri-environment schemes;
- the practical application of health and safety regulatory systems;
- implementing international conventions on air pollution;
- developing emergency and risk management strategies.

Our staff commit considerable time to work on a wide range of UK government and European advisory and co-ordination committees. In the UK this includes providing independent advice as members of the Advisory Committee on Pesticides, Advisory Committee on Hazardous Substances and the Advisory Committee on Releases to the Environment. Internationally, one of our staff chairs the International Geosphere-Biosphere Programme committee and another coordinates the EU Global Monitoring for Environment and Security Programme.

Transferring scientific knowledge to business

Commercialisation of CEH's knowledge (or intellectual property), work with the private sector and both local and regional bodies are all showing signs of substantial growth. Details of developments with existing and new spin-out companies and other examples of knowledge transfer are given on pages 27-29. Knowledge transfer is increasing, and much is achieved through the internet. A current example of this is the National Biodiversity Network Gateway (see page 34) which allows interactive access to biodiversity databases across the web and is becoming applicable to a wide range of uses (such as conservation, land use planning, ecological risk appraisal).

The year has been a busy and challenging one for staff, who have had to adjust to some radical changes in management and structure. It is a credit to them all that we have achieved this transformation while maintaining the quality and volume of our scientific outputs and are now in a secure position to face the challenges of the future.

Advisory Committee

Advising CEH

The Advisory committee was established in 1998 to advise Director CEH on scientific priorities, in particular our external relationships with Government bodies and other research customers. We are extremely fortunate to have secured the time and involvement of key members of Departments and Agencies of the Government and devolved administrations, independent advisors and representatives of NERC.

The Committee, chaired by the Earl of Cranbrook, meets at least twice a year. The meetings are held at different CEH sites in turn, so that the members can see the science that is being done at each site and improve their knowledge and understanding of local as well as corporate management issues. The committee particularly enjoys scientific presentations and meeting the staff at the sites.

During 2003, the Advisory Committee met at CEH Banchory in May and CEH Bangor in November. The developing CEH business strategy and implementation of the CEH science management plan were key elements of the discussions at these meetings. At Banchory the committee reviewed the collaborations between CEH and local environmental research organisations. These early collaborations are now being enhanced in the Aberdeen Centre for Environmental Sustainability, for which CEH is seeking support from NERC. In Bangor, the committee focussed on the developing strategies for the Environment Centre for Wales, which are now nearing fruition. Just as importantly, the Advisory Committee meetings are an opportunity for CEH to look outwards to the strategic issues facing our major stakeholders. Each committee member provides a regular update of such issues and the group discuss how CEH can best transfer its knowledge to assist and underpin the stakeholders' external policy.

The Committee has seen CEH through the trials and tribulations of significant organisational change and we have greatly valued their input. Another significant activity to which the committee were able to contribute was the Science and Management Audit in March 2004. The usual spring meeting was brought forward to enable the committee to formulate a joint response to the Audit. The Chairman met with the Audit team to discuss stakeholder interactions. The resultant Audit report considered such interactions a real strength of CEH. This endorsement is something CEH is proud of and can only be improved by the support and advice provided by this committee.

Membership of CEH Advisory Committee 2003 – 2004

Committee Member	*Organisation*
The Earl of Cranbrook, MA, PhD	Chair
Dr John Holmes	University of Oxford (Independent)
Dr Havard Prosser	National Assembly for Wales
Dr David Lynn (to Dec 03)	Natural Environment Research Council
Dr John Warburton (to Apr 04)	Dept. for International Development
Mr Steve Bass (from Apr 04)	Dept. for International Development
Mr John Herrmann	Independent
Dr Camilla Toulmin (to Sep 03)	International Institute for Environment & Development
Dr Ian Bainbridge	Scottish Executive
Prof Pat Nuttall	Director, CEH
Dr Alan Apling (to Nov 03)	Office of the Deputy Prime Minister
Mr Tony Sangwine (from Nov 03)	Highways Agency
Prof Rob Marrs * (from Apr 04)	University of Liverpool
Dr John Seager (from Apr 04)	Environment Agency
Dr Jackie Hinton (to Mar 04)	CEH (Secretary)
Dr David Howard (from Apr 04)	CEH (Secretary)
* Chairman of CEH Programme Development Group (PDG)	

Top Science Achievements in 2003 - 2004

The Farm Scale Evaluations of Genetically Modified Crops

Led by Les Firbank lgf@ceh.ac.uk with staff from across CEH, plus Rothamsted Research and the Scottish Crop Research Institute

CEH and partners have completed the biggest experiment of its kind in the world, designed to test the effects of growing Genetically Modified herbicide tolerant crops on biodiversity.

Four GM crops (beet, maize, spring- and winter oilseed rape) were grown beside the same conventional crop in split fields across GB, sown and managed by farmers. Highly detailed monitoring was carried out and well over a million samples taken, to determine whether the agricultural management involved in growing GM crops has any effect on the plants and animals that would normally live in and around these crops.

The Farm Scale Evaluations demonstrated that there are potentially harmful effects of growing GM beet and spring oil seed rape on farmland biodiversity and potentially beneficial effects of growing GM maize. These effects are due to the herbicide regimes used on the crops and are not due to the method of crop breeding used. The results from winter oilseed rape are still being analysed.

The findings were endorsed by the GM Science Review Panel and ACRE (Advisory Committee for Releases to the Environment) and, as a result, are shaping Government policy in the UK and in Europe on decisions over commercialisation of these crops. We have received extensive UK and international press interest, as well as extensive academic interest.

The sixth extinction?

Led by Jeremy Thomas jat@ceh.ac.uk, Carly Stevens & Owen Mountford

CEH scientists have produced the best evidence yet that our planet is experiencing a mass extinction. In the past 20 years, about 70% of all butterfly species in Britain have shown signs of decline. About 28% of plant species and 54% of bird species also declined in areas studied over long periods. The findings come from two teams of CEH researchers, using data painstakingly amassed over the past 40 years by 20,000 skilled naturalists.

The first team (from CEH Dorset) compared, at the national scale, population and regional extinctions of birds, butterflies and vascular plants from Britain over a forty-year period. Butterflies experienced the greatest net losses, 71% of all butterfly species having declined in the last 20 years. If insects elsewhere in the world are similarly sensitive, the known global extinction rates of vertebrate and plant species have an unrecorded parallel among the invertebrates, strengthening the hypothesis that the natural world is experiencing the sixth major extinction event in its history.

A second team (from CEH Monks Wood and Open University), working on the impacts of nitrogen on grasslands across GB found that long-term, chronic nitrogen deposition has significantly reduced plant species richness. Species adapted to infertile conditions are systematically reduced at high nitrogen deposition. At the mean chronic nitrogen deposition rate of central Europe (17 kg N/ hectare/year), there is a 23% loss of species richness compared with grasslands receiving the lowest levels of nitrogen deposition.

Both teams drew extensively on the long term records of plant and animal distributions held by CEH in the UK Biological Records Centre at Monks Wood.

Even bacteria know 'it's good to talk'.....

Andrew Whiteley aswhi@ceh.ac.uk and Mike Manefield

Scientists have recently discovered that many bacterial species 'talk' to each other. Their language is not verbal, but chemical.

The bacteria send chemical signals called Acyl homoserine lactones (AHL) to each other and when other cells receive the signal they switch on a whole range of gene responses. We discovered a range of cell-to-cell communication in a community of microbes breaking down pollutants in an industrial wastewater treatment system.

We were able to 'decode' the chemical language being used, in terms of the different AHLs present.
In order to demonstrate the role of AHL in the system, we stopped the resident bacteria efficiently breaking down the wastewater by dropping the flow rate of toxic inputs (so mimicking a starvation situation for them). Then we 'challenged' them with full strength wastewater to see if they could break that down. The community could not break down the wastewater until we introduced artificially synthesised AHL, which stimulated recovery of the function. This gave clear evidence that AHL mediated communication is a significant factor for the co-operation of different members of the microbial community, and that AHL's can be used to recover breakdown functions in failing communities.

Ultimately, this technology represents a 'clean' system of keeping wastewater bacterial communities in peak condition and to recover them when they start to fail - such failures being costly for both industrialists and the environment.

What goes on inside a plant gall?

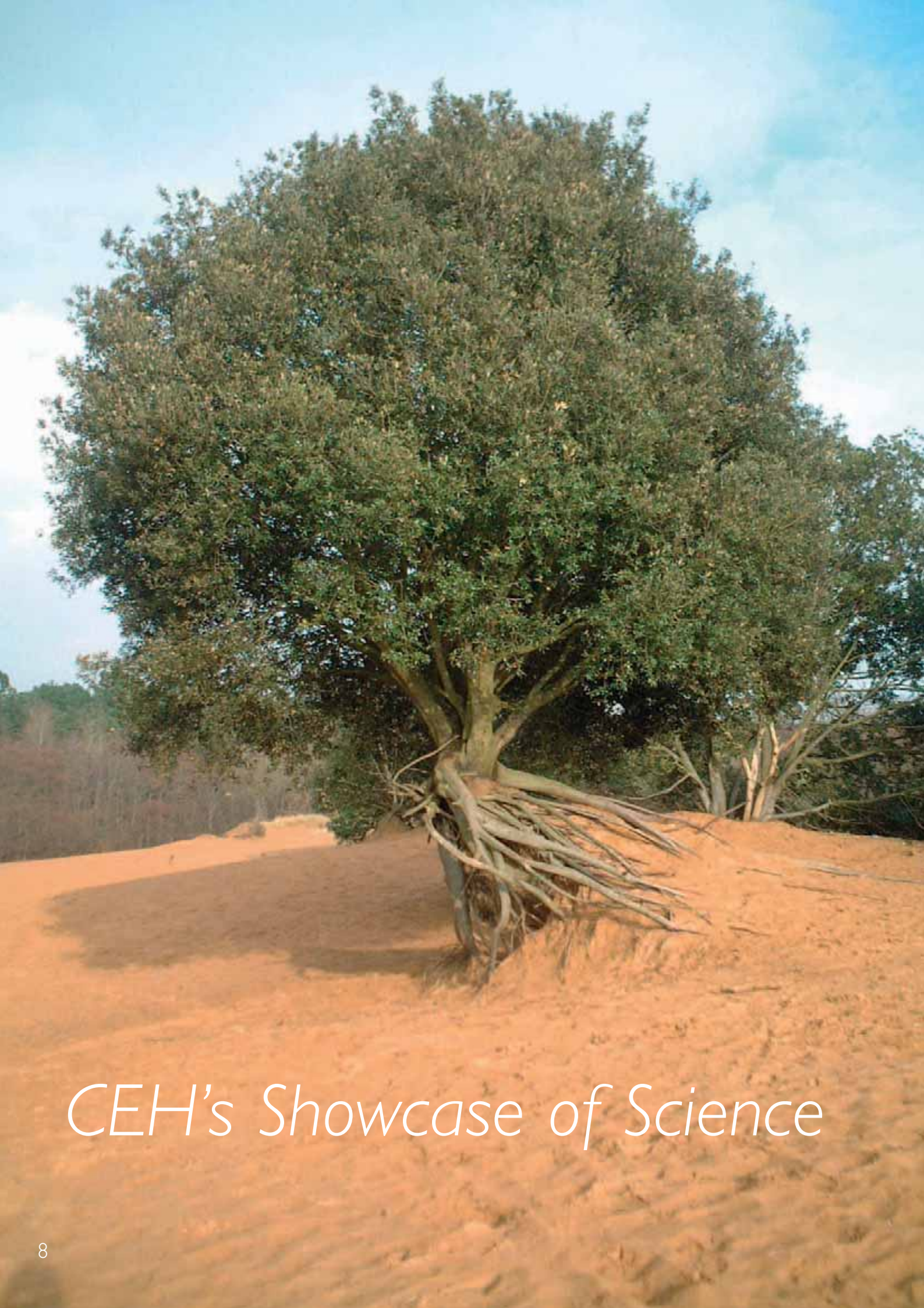
Karsten Schönrogge ksc@ceh.ac.uk and collaborators

Many insects can produce plant galls, on almost any part of a plant. Although plant galls are composed of the host plant's tissues, their development is largely controlled by insect genes, so the way in which the plant tissues adapt should be described in terms of 'impacts on insect fitness'. The ways in which gall structure can adapt between insect species, and the possible pressures driving this diversification in gall form are not well understood.

Gall wasps produce a wide variety of different gall shapes and structures in a range of plants - oak-apple galls are perhaps the most familiar. The gall provides a nutritionally rich and well-protected environment. Many of the gall wasps have complex life cycles that involve 2 generations a year (sometimes on different host plants) and each species and generation produces a characteristic gall. Other, parasitic wasps can penetrate the gall and lay eggs, which feed on the gall wasp larva, eventually killing it.

We have investigated the ecology of oak gall wasps, with particular emphasis on life cycle characteristics and the dynamics of the interactions between host plants, gall wasps and the wasps' natural enemies. We have also studied sawfly galls, to investigate the interactions of plant performance, gall induction and survival.

Our work has revealed not only the importance of gall traits but also patterns of gall wasp relatedness for the structuring of their communities, and the effects across the nutritional levels within the communities. Our study of developing galls may prove a model system for the study of 3-way nutritional interactions and the evolution of community structures.



CEH's Showcase of Science

Biodiversity

The effects of grazing on upland birds

Darren Evans dme@ceh.ac.uk and colleagues

Britain's moorland provides habitat for over forty bird species, seven of which occur in internationally important numbers. However, the grazing of moorlands (mainly by sheep) has doubled in intensity over the last fifty years and this may be connected with the deterioration of some areas used by moorland birds.

We have now completed the first year of a novel project to measure the effects of livestock grazing on upland birds. Scientists from CEH, the Macaulay Institute, the Scottish Agricultural College and the RSPB are working together to test how different numbers of sheep and cattle affect vegetation and arthropods. By studying the Meadow Pipit, we are trying to tease apart whether different numbers of sheep and cattle affect the number and type of insects and spiders that Meadow Pipits feed on, or whether it is the structure and composition of the vegetation that affects how easy it is for a bird to find food.

Impact: The results of the research will help farmers and environmental managers wishing to improve the biodiversity on their land. Our work provides a valuable input into possible changes in the policy for managing Britain's uplands.

Photograph: Ray Kennedy RSPB.com

Marine ciliates in Central Spain

Genoveva Esteban gent@ceh.ac.uk and Bland Finlay

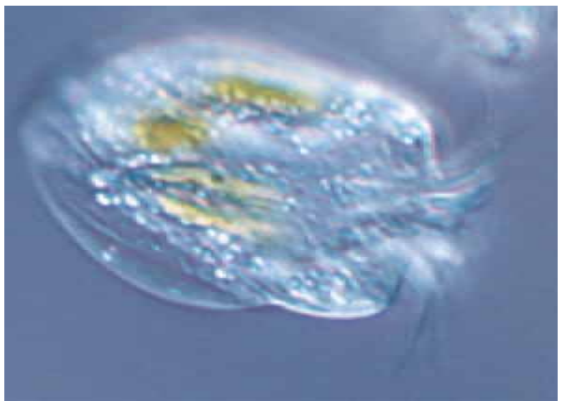
Some scientists claim that you can find free-living protozoa anywhere in the world, as long as they have their favourite habitat. We have tested this claim by searching for marine protozoa in evaporation salt pans in central Spain, roughly 300km from the coast.

We found active marine ciliate species living in communities that were typical of marine and very salty (hypersaline) habitats.

One species was *Trimyema marinum*, a small anaerobic ciliate that has not been seen or reported for 70 years.

We consistently found similar communities of marine ciliates in the different salt pans. This indicates two things - that at least some marine ciliates are dispersed across very wide geographical areas, and that specific habitat types 'select' for specific families of organisms. Our findings lend support to the idea of global dispersal of these protozoa

Impact: Free-living protozoa can be found in suitable habitats, wherever they exist, and ecosystem function is not limited by any lack of microbial diversity.



How (endangered) blue butterflies find the right host

Karsten Schönrogge ksc@ceh.ac.uk and colleagues

All five *Maculinea* blue butterfly species have a life cycle where the adult females lay eggs on a host plant and the final form of the caterpillar leaves the plant to feed as a parasite or predator. The caterpillars then pupate inside colonies of *Myrmica* red ants.

To gain access to the well-defended ant colonies, the caterpillars are known to produce a substance that mimics the oils and waxes the ants carry on their surface. These compounds are used by the ants to recognise each other as colony members and nest mates. However, at the 'infiltration' stage all *Myrmica* ants will carry all *Maculinea* caterpillars back to their nest - yet it is known that each of the butterfly species survives only with one *Myrmica* species. The caterpillars will be killed should they find themselves with the wrong ants. Our study revealed that survival depended on the physiological state of the colony and on the production of additional mimic compounds once the caterpillars are in contact with the ants.

Impact: All five Maculinea species are recorded in the International Union of Conservation and Nature (IUCN) lists of rare and endangered species, and three of them are named in the EU Habitats Directive. This study shed light on the conservation needs of rare and endangered butterflies, and also contributes to the general discussion about the evolution of host specificity.

Establishing 'refuge populations' for rare fish

Ian Winfield and colleagues ijw@ceh.ac.uk

Researchers have successfully established new refuge populations of two of the UK's rarest freshwater fish.

The vendace *(Coregonus albula)* was known from only four sites, two in the English Lake District and two in Scotland. The Scottish populations had become extinct in 1912 and 1980. In the late 1990s CEH researchers, together with colleagues from the Fish Conservation Centre, introduced young fish at two Scottish sites. Now the team has found naturally-spawned vendace of varying ages in Loch Skene, which could be invaluable if the English populations should fail.

The team also took threatened schelly eggs *(Coregonus lavaretus)* from Haweswater in the English Lake District and established a new population at nearby Small Water.

The work was undertaken as a collaborative project with the Environment Agency, the Fish Conservation Centre, Scottish Natural Heritage and United Utilities.

Impact: This work has made a significant contribution to the conservation of biodiversity in fish in the UK.

What is the link between marine physics and seabird behaviour?

Sarah Wanless swanl@ceh.ac.uk and colleagues

Typically, marine life concentrates in regions where there are strong horizontal or vertical gradients in temperature or density. So we can predict that top predators, such as diving mammals and birds, will target these concentrations of food supply or biomass. Until now, the study of the interaction between diving predators and the physical environment has been held back by the capabilities of available instruments. Currently, instruments have slow response times and cannot measure the rapid changes within the external environment whilst the animals are diving and foraging. This has now been overcome by the development of a lightweight, rapidly responding temperature-depth logger. The instrument was successfully deployed on two diving seabird species in the North Sea. A method for correcting temperature data for the remaining time lag in the response of the temperature sensor has been evolved. The technology has delivered two important benefits: in providing unparalleled information on the interaction between predators and the marine environment, and as a low-cost method of obtaining high quality oceanographic data.

Impact: This new technology will greatly enhance our understanding of the effects of ocean physics on predator-prey interactions.

Photograph: Richard Bardgett

Sequencing & analysis of Dengue 3 viruses from Cuba

Tamara Gritsun tsg@ceh.ac.uk and Ernest Gould.

A research project completed during the past year sequenced and phylogenetically** analysed isolates of Dengue 3 virus. These were obtained from a Cuban outbreak in 2000, 2001 and 2002. The phylogenetic** tree that we constructed showed us that that the virus was originally introduced into Latin America - possibly through Brazil - where it then dispersed and continued to evolve. The virus then gradually worked its way northwards through Venezuela into the Caribbean where it eventually reached Cuba. By using the phylogenetic tree we also found that an earlier Dengue 3 virus existing in Latin America was a distinct isolate, ie it was different from the introduced virus that caused the outbreaks from 2000 onwards.

Impact: The work demonstrates the spread of a pathogen virus isolate through Latin America and how knowledge of the virus' family relationships can inform the study of the spread of disease epidemics.

**Phylogenesis is the identification and understanding of relationships between different forms of life

Photograph: Eye of Science/Science Photo Library

How birds choose good nesting habitat

Shelley Hinsley sahi@ceh.ac.uk and colleagues

We have demonstrated that the conditions necessary for successful breeding in woodland birds are sensitive to large-scale as well as local climate conditions, which affect habitat structure and the timing of breeding.

Our work was based on studies of the breeding performance of Great Tits *Parus major* using nestboxes in Monks Wood National Nature Reserve. Measurements of mean chick body mass were used as an indicator of breeding performance, because the probability of survival to an adult bird (and breeding) increases with the chick's mass. The habitat structure was expressed as the mean tree canopy height in a sample area around each nestbox.

We found that when weather conditions for breeding were good, mean chick body mass increased with the mean canopy height. But when conditions were poor, the relationship was reversed, i.e. the heaviest chicks were reared in territories with a lower mean canopy height. Local weather conditions affected both the foraging behaviour and efficiency of the birds and the availability of their caterpillar food supply. The timing of breeding also affected success and was found to vary with both local climate conditions and large-scale conditions - the winter index of the North Atlantic Oscillation.

Impact: There is no single best quality habitat - the type of habitat structure that confers 'best performance' for the birds differs under different conditions.

Photograph by Dr A.G. Gosler

Water

HYRAD system now adopted within national flood warning systems

Bob Moore rm@ceh.ac.uk and colleagues

The HYRAD (HYdrological RADar) flood data processing and display system, developed by CEH, is now used operationally by the Environment Agency as its standard in flood warning offices across England and Wales. It has also been commissioned by the Scottish Environment Protection Agency and by the Belgian government.
HYRAD receives data from rainfall radar in real-time and provides database and archiving facilities. It also supports the display of rapid-replay images and shows an historical time-series of average rainfall figures for an individual river catchment. Advanced processing is available to merge the radar data and rainfall estimates - to improve accuracy and to forecast rainfall in order to give longer warning times. The average rainfall for a catchment is derived, for automated transmission to flow forecasting and modelling systems. The user is kept informed of current and future rainfall patterns - as a guide to imminent flooding.

HYRAD also supports other facilities, including numerical weather prediction models of rainfall and temperature and the production of derived information such as soil moisture estimates.

A flood duty officer will benefit from automated flood forecasting systems, which use HYRAD's catchment-average rainfalls to extend the lead-time of flood warnings. The quality assured software has been developed and is updated by CEH staff.

Impact: HYRAD provides improved support to national flood warning systems in England, Wales, Scotland and Belgium.

RIVPACS for Scottish Islands

Mike Furse mtf@ceh.ac.uk and colleagues

RIVPACS is a assessment package that allows you to determine the environmental quality of a stream. It works by comparing the invertebrate communities living in a particular stream plus the stream's environmental characteristics, against a set of freshwater invertebrate samples constructed from a wide range of high quality 'reference' stream sites.

Earlier modules of RIVPACS were developed specific to stream types in many parts of the UK. They have proved reliable and are now widely used. We have now developed a new RIVPACS prediction and stream assessment module, specifically for stream sites on Scottish islands. The new module enables the Scottish Environment Protection Agency to assess, for the first time, the biological quality of streams on Scottish islands.

Impact: The RIVPACS approach is compliant with the new EU-wide Water Framework Directive and will assist the regulatory agencies in meeting the high water quality demanded by the Directive.

The Water Poverty Index - further developments

Caroline Sullivan csu@ceh.ac.uk and Jeremy Meigh

CEH has developed the Water Poverty Index (WPI), an inter-disciplinary tool that integrates key issues relating to water resources. The WPI combines physical, social, economic and environmental

information associated with people's ability to get access to water and to use it for productive purposes.

The primary focus of the WPI is on disadvantaged people who suffer from inadequate access to water, and lack the capacity to address the problem. It was developed in consultation with a wide range of stakeholders, policy-makers and scientists in order to ensure that all the major relevant issues were included. The value of the WPI lies in its holistic approach, which can be applied at a variety of spatial scales. It is systematic and transparent, providing a powerful tool for the prioritisation of needs. It can empower decision-makers to act impartially by allowing them to justify their choices; at the same time, it gives local communities an opportunity to express their needs in a systematic way, helping them to lobby for action.

The project included pilot studies in South Africa, Sri Lanka and Tanzania and the approach is also being applied in several other parts of the world and at a range of spatial scales.

Impact: We have further developed a new methodology that has global application. The WPI has been covered widely in the international press, and continues to generate interest from many countries.

UK-wide methods for the Site Condition Monitoring (SCM) of standing waters

Iain Gunn idmg@ceh.ac.uk and colleagues

Methods have been developed, using larger water plants (aquatic macrophytes), that will allow the UK conservation agencies to reliably assess and monitor the environmental health of standing waters. It will now be possible to tell whether habitats and larger plant species within these waters are in favourable or unfavourable condition.

The methods took into account the effects of both lake area and variation over a period of time and were designed to be practical, cost-effective, repeatable, objective and measurable. The research team produced guidance too, on how the resulting data could be used in condition assessments. Mechanisms were developed to allow information on physical and chemical factors in the lakes to be combined with the plant data. This technique has allowed us to produce a more comprehensive assessment of the lake's habitat condition.

The Joint Nature Conservation Committee (JNCC) have now adopted the recommended CEH methods for the baseline monitoring of all UK designated standing water sites. The results of the monitoring will form the basis for assigning current condition categories to the sites and allow comparisons in future years.

Impact: The CEH-developed 'Aquatic macrophyte methods' will be used by all the UK conservation agencies in the 2004 baseline survey of the condition of designated standing water sites.

Southern Africa FRIEND

Jeremy Meigh jrm@ceh.ac.uk and colleagues

Southern Africa suffers from a scarcity of water resources; they are unevenly distributed and extremely variable, leading to recurrent drought and devastating floods. The region includes some of the poorest countries in the world, where many people have inadequate access to water, and suffer from the severe impacts on livelihoods and health which this brings. Consequently, water issues are extremely important.

For many years CEH has worked co-operatively with the twelve countries of the Southern African Development Community as part of the FRIEND programme (Flow Regimes from International Experimental & Network Data). FRIEND aims to promote the free exchange of data for hydrological and water resources studies; to assist co-operation between water resources managers and researchers; and to develop improved operational methods for water resources management for use across the region.

Within the project, the overall goal was sustainable management of regional water resources. Specific topics covered included: river flow modelling; implementation of drought assessment and monitoring software; development and implementation of water resources software; studies of water resources and climate change; improving capability in computer based information systems; and capacity building.

Impact: Our work contributed to increased capacity and the deployment of new operational tools for water management in 12 countries of Southern Africa.

Producing eco-hydrological guidelines for wetlands

Owen Mountford om@ceh.ac.uk

CEH has produced guidelines on the eco-hydrological requirements of wetland habitats included within Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) in eastern England, working under contract for a government Agency and in collaboration with two universities.

The CEH work focussed on swamp and aquatic vegetation, as well as making contributions to guidelines for wet grasslands and mires. The guidelines provide a concise and standard approach for Agency staff, using the output of the best available science to enable them to advise on the management of designated sites and wetlands. The guidelines contain descriptions of the plant communities in the habitat, their distribution and situation within the landscape.

Emphasis was placed on the water-regime (depth, seasonal variation and supply) for each habitat, since this is likely to be the factor that will be most affected by the Agency's activities. The guidelines also describe the nutrient conditions within which each plant community occurs and the management best suited to maintaining its extent.

To aid the Agency in decision making, CEH assessed both the vulnerability of the habitat to change (potentially damaging factors) and the potential for restoring the habitat once it is degraded or destroyed. The work has an inbuilt facility that will enable it to be updated as and when new information becomes available arising from research. It is hoped that these guidelines will be expanded to cover all of England and Wales.

Impact: The guidelines provide a concise and standard approach for Environment Agency staff, using the output of the best available science to enable them to advise on the management of designated sites and wetlands.

Biogeochemistry

Monitoring heavy metals in the UK's atmosphere

David Fowler, David Anderson dana@ceh.ac.uk and colleagues

Since heavy metals are stable and cannot be degraded or destroyed, they tend to accumulate in soils and sediments. Although emissions of heavy metals decreased significantly during the 1990s, many heavy metal substances are known human carcinogens - for which no threshold for adverse effects on human health can be identified. It is vital that we continue to monitor the concentrations of heavy metals in the environment, to ensure that levels of such pollutants are as low as reasonably achievable.

CEH has responded to this challenge by setting up a new network of monitoring sites across the United Kingdom, with support from Defra (Dept for the Environment Food & Rural Affairs). Bulk collectors are used to collect rain samples, and other collectors sample the atmosphere for airborne particles. The samples are analysed at the new laboratory facilities at CEH Lancaster using Inductively Coupled Plasma Mass Spectrometry (ICPMS). The use of the latest sampling and analytical technology enables CEH to deliver reliable and accurate measurements of concentrations of heavy metals in rain and in the air to the scientific community.

Impact: Improved measurements will allow us to make better estimates of risks to human health and the environment from heavy metals and to develop further strategies for reducing heavy metal emissions. More information at http://www.heavymetals.ceh.ac.uk/

Assessing risks to lakes from nutrient pollution

Laurence Carvalho, laca@ceh.ac.uk and colleagues

Britain has many beautiful lakes and most of them are used as sources of drinking water or for industrial processes. Unfortunately, many lakes in the UK suffer badly from nutrient pollution, derived mainly from agricultural activities and atmospheric pollution. We have developed, especially for the UK environmental agencies, specific assessment methods which can determine whether or not a lake is achieving 'good ecological status'. The assessment will make it possible to establish how many British lakes are at risk of failing to meet the EC Water Framework Directive's quality objectives. Results from work using the new methods suggest that up to 88% of lakes in England may be at risk (below the required standard), compared with 56% in Wales and only 18% of lakes in Scotland.

Impact: The methods developed are now being adopted for national risk assessment purposes, they can also be used to help develop measures to improve water quality in catchments.

Measuring and mapping ammonia emissions from UK seabird colonies

Sarah Wanless swanl@ceh.ac.uk and colleagues

Our work is the first to use a species-specific approach to accurately estimate both the quantity, and the spatial distribution of ammonia emissions from seabirds in the UK.

Atmospheric ammonia is an air pollutant that is increasingly recognized as having local, regional and global consequences for the natural environment. The size and location of these natural sources of ammonia, such as seabird colonies, have received little attention and are extremely uncertain.

Total ammonia emissions from seabird colonies are of course much smaller than those from human activities or sources. The importance lies in the magnitude of emissions from individual colonies (where there can be major local impacts) and the fact that most of the colonies are located in otherwise pristine environments where emissions derived from human activities are very small.

Impact: Our results will enable the production of more accurate ammonia emission inventories and will permit a greater understanding of nitrogen cycling in remote ecosystems.

Demonstrating the link between sulphur emissions and sulphur in stream waters

David Cooper cooper@ceh.ac.uk and colleagues

During the 1980's there was considerable concern over the impact of 'acid rain' and this led to national actions to reduce the UK's emissions of sulphur dioxide and oxides of nitrogen (the main contributors to the problem). A network of 22 upland UK stream and lake monitoring sites was established in the late 1980s, to monitor the acidity of surface waters, and track the expected decrease in acid deposition.

Now, after 15 years, sufficient data have accumulated for some conclusions to be drawn. An investigation of the 'sulphur budgets' of the 22 catchments has shown that, at most of the sites, there is a close relationship between inputs from the atmosphere and the stream water outputs. At an annual time scale we have been able to exclude the possibility that storage mechanisms in the catchments will cause a lag in response to reduced emissions. The sulphate concentrations in the stream waters have decreased rapidly and in proportion to the reduced sulphur emissions.

Impact: This provides good evidence of the success of UK emissions strategies in quickly cutting the sulphate component of surface water acidification, and the consequent recovery of waters from acidification.

What are the effects of nitrogen deposition from vehicle emissions on roadside vegetation?

J. Neil Cape jnc@ceh.ac.uk and colleagues

Cars and lorries emit nitrogen oxides, formed at high temperatures inside engines, and cars with 3-way catalysts also emit some ammonia gas. Plants growing beside roads therefore receive 'extra' nitrogen from vehicle exhausts, but vehicle exhausts are rapidly diluted by mixing with the surrounding air. By measuring the concentrations of gases from vehicle exhausts across a variety of road types in Scotland, we showed that over 90% of the emissions have dispersed within the first 15m across the verge. We also found that significant quantities of ammonia are emitted from car exhausts, but that the absolute concentrations are much smaller than those of emitted nitrogen oxides.

However, because ammonia is very soluble in water, there is a much greater uptake of ammonia than of the nitrogen oxides by plant leaves. Consequently, ammonia and nitrogen oxides contribute similar amounts of nitrogen to roadside verges.

Our results suggest that any local effects of nitrogen from vehicle exhausts are likely to occur only close to roads. However, the regional effects of traffic emissions are very important, because vehicles contribute around half of the total emissions of nitrogen oxides across the UK, which eventually reach the ground as nitric acid or nitrates in rain.

Impact: Ammonia from car exhausts contributes as much nitrogen to roadside verges as do nitrogen oxides.

Linking upland tarn water chemistry to land cover

Stephen Maberly scm@ceh.ac.uk and colleagues

There are approximately 40,000 standing water bodies in Great Britain with an area greater than one hectare. We have little or no information available on their water chemistry, especially for the upland lakes in relatively remote regions. Whilst researchers have tended to think only about the lake as the system being studied, it is clear that processes in the surrounding catchment can have a major impact on the water chemistry of lakes.

During a GANE (Global Atmospheric Nitrogen Exchange) project, data were collected from 30 upland tarns in England, Wales, Scotland and Northern Ireland, that had minimal disturbance from agriculture and sewage inputs. Analysis showed that their water chemistry and nutrient limitation could be predicted from the vegetation cover in the catchment. It also provides a way of identifying lakes that may be sensitive to particular environmental pressures, such as nitrogen enrichment or acidification.

Impact: Lake water quality may be predictable at a national scale, from available map-based information. This work involved staff from CEH, Lancaster University and the Dept of Agriculture and Rural Development for Northern Ireland.

Climate Change

Is our upland vegetation at risk of damage from ozone pollution?

Gina Mills gmi@ceh.ac.uk and Felicity Hayes

The glorious weather of summer 2003 had one draw-back - ozone pollution. Relatively high levels of this pollutant were recorded in rural and upland areas of the UK, with air quality standards being frequently exceeded. Even in the Snowdonia mountain range the ozone concentrations exceeded 60 parts per billion (ppb) on 30 days, and 90 ppb (Defra's** threshold for 'high' ozone concentrations) on 5 days during the spring and summer. Such high ozone levels could affect the health of sensitive individuals exercising in the mountains, and also some plant species may have been damaged by the pollutant.

To assess the risk of damage to vegetation during high ozone years, researchers at CEH Bangor collected over 30 plant species from Snowdonia and exposed the plants to a realistic simulated ozone regime for 10 weeks using our solardomes (dome-shaped controlled greenhouses). Almost half of the upland species responded to ozone by developing injury (fine pin-prick sized cream-coloured spots), or by having earlier die-back and/or a reduction in biomass. The consequences of such damage for current and future ecosystem health will be investigated by exposing simulated plant communities to ozone regimes representing 2003, and those predicted for 2030 and 2060.

Impact: Ozone is impacting on our most sensitive habitats and damaging plant growth.

** Defra = Dept for the Environment Food and Rural Affairs

Drivers of seabird phenology

Morten Frederiksen mfr@ceh.ac.uk and colleagues

Breeding at the right time is essential for animals in seasonal climates. They need to ensure that the energy demands of reproduction - particularly the food requirements of growing young - coincide with the peak period of food availability. Global climate change is likely to cause shifts in the timing of maximum food availability, so to adapt successfully to current and future climate change, animals need to be able to adjust the time at which they start their breeding. Many animals use environmental cues available before the breeding season to predict this seasonal food peak and can then adjust their timing (phenology).

We tested the hypothesis that regulation of the annual breeding cycle should reflect the scale at which organisms perceive their environment. We did this by comparing the phenology of three seabird species at a North Sea colony. As predicted, the phenology of two wide-ranging species, kittiwake and guillemot, correlated with a large-scale environmental cue (the North Atlantic Oscillation), whereas a resident species, shag, correlated more with local sea surface temperature. Annual mean breeding success was lower in 'late' years for European shags, but not for the other two species.

Impact: Correlations among climate patterns at different scales are likely to change in the future, and our findings have important implications for understanding how migratory animals can respond to future climate change.

Summer droughts may be permanently changing our peatlands

Alwyn Sowerby asowe@ceh.ac.uk and colleagues

A climate change experiment in the hills of Wales has demonstrated the impact of more summer droughts on the peatlands. It has also shown up the effect on their capacity to store carbon.

Peat that has been exposed to repeated summer drought for several years has a reduced ability to store water and is losing carbon more quickly - even between drought periods. This suggests that there is a fundamental change in the structure of peat that suffers repeated drought, and emphasises the importance of considering rainfall extremes and not just the total annual rainfall. There may be a real risk from the 'positive feedback' loop of climate change, which causes increased release of further greenhouse gases such as carbon dioxide and might therefore trigger further changes in our climate.

Impact: Our work emphasises the need to consider the change in rainfall pattern on our peatlands, and to include feedbacks on soil processes in Global Circulation Models.

A fisherman's lament - Climate change impact on a lake fish species

Ian Winfield ijw@ceh.ac.uk and colleagues

Although the potential life span of most fish species is at least several years, often making them the longest lived members of lake fauna, many individuals die within the first few days or weeks of hatching. Such intense early natural mortality is often the result of a mis-match between the environmental requirements of the newly-hatched fish and the ambient conditions prevailing at the time, many of which are potentially impacted by climate change.

We carried out an analysis of records of the spawning period of the perch *(Perca fluviatilis)* population of Windermere - England's largest lake - from 1946 to 2003. This has revealed that the peak of spawning activity has moved earlier in the spring by approximately 12 days over this fifty-seven year period, coinciding with an increase in the lake's annual mean temperature. This is the first demonstration in the U.K. of an impact of climate change on the ecology of a lake fish species and is likely to result in a significant shift in the pattern of recruitment of young fish to the population.

Impact: Such climate-linked effects have wide implications for the management of lake fish populations across Europe.

Map of pollution impacts on vegetation in Northern Siberia

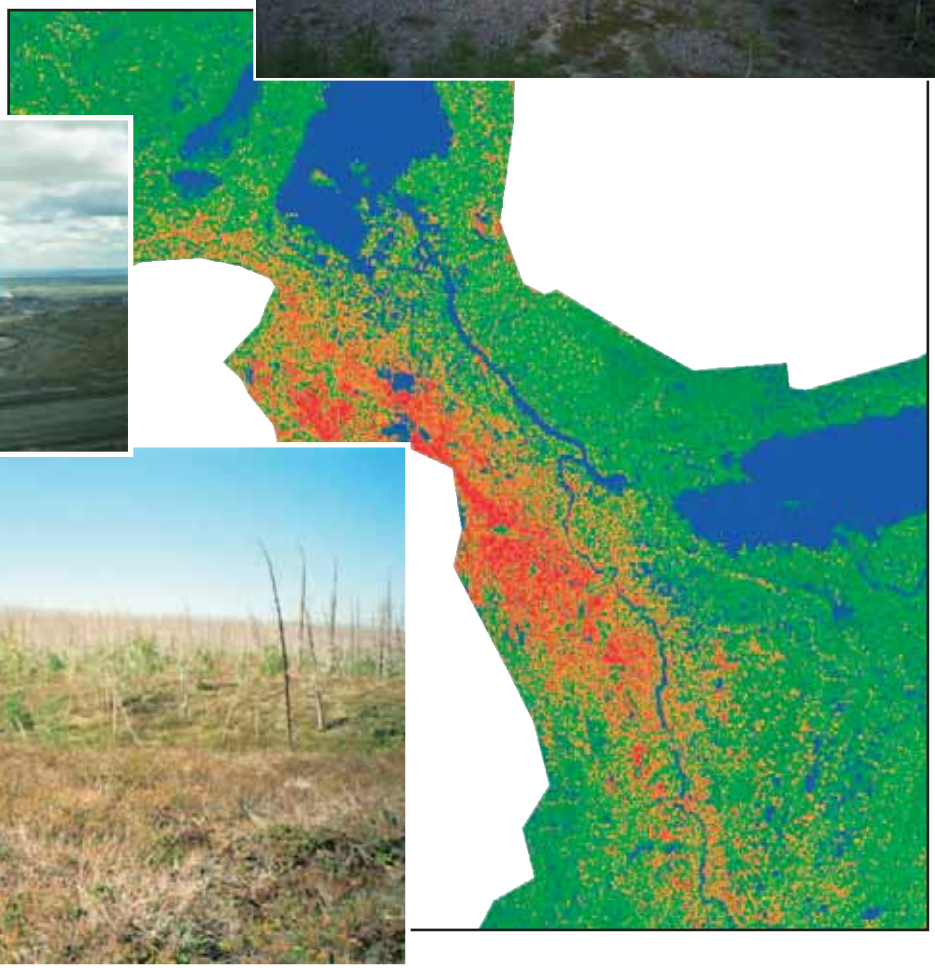
Heiko Balzter hbal@ceh.ac.uk and colleagues

Norilsk (69° 20' N, 88° 10' E) is a mining town situated north of the Arctic Circle in the tundra/taiga boundary region of Siberia. The vegetation nearby is influenced by severe climate conditions and also by high emission levels from industrial copper and nickel smelters. These smelters are working alongside the second biggest nickel sulphide deposit in the world. Heavy metal dust and sulphur dioxide depositions in the prevailing wind direction have caused severe damage to the forest, ranging from reduced growth to death of all vegetation.

CEH has used data from the European ENVISAT satellite to map the degree of vegetation damage in the region around Norilsk. Because of persistent cloud cover in the short snow-free period of 4-6 weeks in July and August, cloud-penetrating radar provides better data coverage than optical sensors. A study of a time series of radar data acquired from ENVISAT's ASAR** instrument in 2003 has produced both an account of the state of the environment in the area and a new land cover map. The new map has been compared against a previous map constructed in 1995 from Landsat data by Tutubalina and Rees. The degree of vegetation damage can be clearly seen.

Impact: We now have more accurate estimates of vegetation destruction, caused by one of the world´s biggest polluters.

** ASAR = Advanced Synthetic Aperture Radar



Does climate change shorten bird breeding seasons?

Alistair Dawson asda@ceh.ac.uk

Birds have evolved the timing of their breeding season so that the young are growing when their food resource (usually invertebrates) is most abundant. To achieve correct timing, birds use the changes in day length to prompt their annual cycle of increasing sexual maturity and then regression.

Climate change will advance the time when invertebrates are most abundant, so, if birds rely entirely on the 'trigger' of day length (the photoperiod), they will breed too late for the maximum food supply. But they may be able to compensate for this if temperature modulates the bird's responses to photoperiod. To investigate this, starlings *(Sturnus vulgaris)* were kept in two indoor aviaries with natural daylengths, and the temperature was held at either 20°C or 5°C. We found that there was no difference in the timing of sexual maturity between the two groups. However, in the group kept at 20°C, the breeding season finished three weeks earlier and the birds moulted four weeks earlier than usual. An outdoor control group showed intermediate responses.

Our findings suggest that an increase in spring temperature would not advance timing of the first clutch of eggs but may prevent the laying of later clutches.

Impact: Nationally, it has been reported that egg-laying dates are becoming earlier in spring, but our work suggests that climate change may have other consequences for bird populations.

Understanding rainfall patterns in semi-arid regions

Christopher Taylor cmt@ceh.ac.uk and colleagues

Previous observations from the semi-arid Sahel area in Africa, have shown that where an intense storm creates an area of very moist soil, subsequent storms will also tend to rain more in that area.

A numerical model of the land, surface and atmosphere has been used to study the processes in detail. The results show that plentiful soil moisture can generate a significantly moister atmosphere in the days following rainfall. Furthermore, the model also shows that subsequent storms will also be more intense, in agreement with the observations.

The reasons for this have been discovered in the detailed dynamics of the storms, and show that a cloud over moist soil can become more vigorous by restricting the growth of neighbouring clouds.

The most surprising feature of this feedback between the land surface and rainfall is that it occurs over a length of 10-20km, much smaller than had previously been considered likely. The modelling suggests that this length was naturally selected by the interaction of the component processes, each of which has a preferred length scale.

Impact: Rainfall persistence has important implications for agriculture and water resources in semi-arid regions, and also indicates a need to represent the key processes in models of weather and climate.

Sustainable Economies

Development of practical decision making tools for restoration after nuclear accidents

Brenda Howard bjho@ceh.ac.uk and colleagues

An European Framework 5 'STRATEGY' project (Sustainable Restoration and Long-Term Management of Contaminated Rural, Urban and Industrial Ecosystems) has been co-ordinated by CEH. The project has addressed the need for an holistic decision framework to address the long-term sustainable management of contaminated areas in Western Europe.

The STRATEGY partners considered various technical and social aspects of implementing restoration strategies for urban and rural environments. In addition to reducing the radioactive dose, the importance of considering socially relevant objectives was emphasised. A critical evaluation of 101 selected countermeasures was carried out, including rural waste disposal options. The partners developed a model to aid the effectiveness of countermeasure strategies, and suggested a method of carrying out participatory decision making.

As a result, detailed countermeasure sheets are now available for rural, forest, aquatic, industrial and urban situations. Outputs from STRATEGY have been well received by potential end users and stakeholders throughout Europe and will enable selection of the most robust and practicable remediation strategies. The International Atomic Energy Agency will use our outputs to assist in the production of their new guidance documentation on countermeasures.

Impact: The practical tools for use by emergency planners and in radiation protection training are now being considered for use worldwide through UN bodies and in the UK.

Managing trees to promote crop growth

Julia Wilson jwi@ceh.ac.uk and Douglas Deans

In Uganda and Kenya, on sites ranging from arid to sub-humid, the competition for water between trees and crops can be reduced by changing tree management practices. We found that by removing all the lower tree branches, it was possible to produce 2 or 3 good crops before pruning needed to be repeated. The pruning yielded good firewood and improved the timber quality as well. Root pruning was also highly effective in improving crop yield. Depending on the tree species involved, tree growth was reduced by up to a tenth.

These techniques enable farmers to manipulate the balance between perennial and annual crops grown near to each other, to meet their own economic requirements. Crops such as maize are essential for survival (but never gain high prices in local markets) and are susceptible to cyclical drought. Timber is more highly valued, it has a lower labour requirement during the production cycle and there is a good and steady demand for the wood products from pruning.

Impact: Practical management of trees growing near food crops can both improve crop yield and provide other products.

How to predict river contamination after a nuclear incident

Jim Smith jts@ceh.ac.uk and Simon Wright

In most potential nuclear explosions and accidents, radiocaesium and radiostrontium are the elements which would cause the most significant long term environmental contamination. These radionuclides were deposited in small amounts all over the earth's surface during US and Soviet testing of nuclear weapons in the 1960's. Parts of Europe were also contaminated by the accident at the Chernobyl nuclear power plant in 1986.

We studied levels of radioactivity over a 40-year period in 25 rivers, spanning an area from the South of Italy to Siberia, within the CEH co-ordinated AQUASCOPE* project funded by the EU. In the study, we used data (including land cover data from earth-orbiting satellites) to assess the influence of environmental factors on the transfer of radioactivity to the rivers. We found that the mobility of these radionuclides was the same after both the nuclear weapons testing and Chernobyl fallout events. This means that we could use data from remote sensing to predict the long-term consequences of a future radioactive fallout based on our experience from Chernobyl and the weapons testing era.

Impact: These methods could be used in management of nuclear incidents and emergencies.

* AQUASCOPE = Aquatic systems in the Chernobyl area: observations and predictive evaluation.

How much water do energy crops require?

Jon Finch jon@ceh.ac.uk and colleagues

Biofuels have been identified as an important part of meeting the Government's energy and environment objectives. These 'energy crops' are being considered as one of the ways of reducing the current increase in greenhouse gases - resulting from burning fossil fuels. Although burning these crops in power stations does release carbon dioxide into the atmosphere, the crops re-absorb it during growth so there is no net increase in the atmosphere. However, it is thought that in order to produce their high yield of biomass, these crops need a large amount of water.

There are two types of energy crops: exotic grasses and short rotation period coppice trees. Using a combination of field measurements and a numerical model, we have predicted the potential changes in the water use that will occur if these energy crops replace the current land cover, for England and Wales. We have demonstrated that short rotation coppice does, usually, use more water than the existing land cover and so it might not be appropriate to grow them in areas with low rainfall. However, the grasses do not use more water, with the result that water use is not a constraint on where they can be grown.

Impact: Our research yielded valuable information, for use by decision makers, on the environmental impact of sustainable energy solutions.

Winners and losers in tropical forests

Caroline Sullivan csu@ceh.ac.uk and colleagues

Commercialization of a natural resource is usually regarded as a process which will bring about increases in incomes, but the question is - where in the economy do these increases actually occur? In the case of open-access resources from forests, wetlands and other types of ecosystems, the major users tend to be subsistence households, who rely on these resources for their livelihoods. When these natural resources are commercialized, the benefits (and the associated costs), are not always equally shared.
The 'Winners and Losers' project has investigated different market chains based on products from two tropical species, Marula *(Sclerocarya birrea)*, in Southern Africa, and Crabwood or Andiroba *(Carapa guianensis)* in Guyana. The project has evaluated the ecological and socio-economic impacts that result from commercialization of these products, and has identified ways to help subsistence communities become winners rather than losers. If the rights of poorer people are to be protected and their livelihoods sustained, it is essential that they have better security of tenure over these important resources.

Impacts: Besides the usual project outputs, a video and other training materials have been produced, and a handbook on benefit sharing produced. A policy briefing paper has also been written for use by senior decision-makers. For more information, see http://www.ceh-wallingford.ac.uk/research/winners/

Additional photographs provided by Tony Cunningham

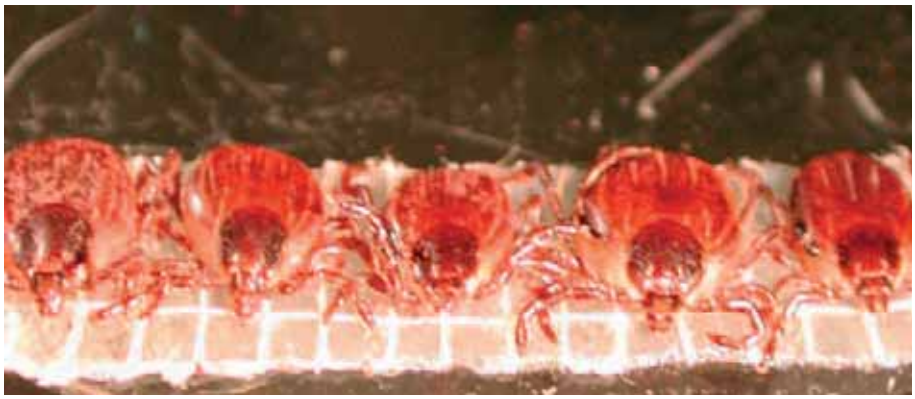
Applying our science to today's problems

Evolutec is floated on the Alternative Investment Market

Pat Nuttall pan@ceh.ac.uk

Evolutec - the CEH spin-out company exploiting the ingredients of tick saliva - has been floated on the Alternative Investment Market (AIM), raising a further £6m for investment. The company, established in 1998 and now valued at £12.7m, is based on a discovery by staff at CEH Oxford. They found that ticks produce chemical substances that allow them to bite their host (humans or animals) without irritating the host's skin. The active substance in the tick's saliva suppresses the inflammatory and immune responses in its host - so the host simply doesn't know the tick is there, and the tick can feed on the host's blood for up to a fortnight. One of the chemicals isolated, a histamine binding protein, may be useful in treating allergic reactions in humans caused by over-responsive immune systems, such as severe hay-fever, some lung diseases and rheumatoid arthritis. This is Evolutec's leading product and a synthetic version of it has now successfully completed phase 2 clinical trials. The proceeds of the flotation exercise will be used to fund further trials of the lead product.

Impact: If the trials are successful and the product proceeds to the market, a valuable new treatment will be available for patients.



Photograph taken by the late Dr Norbert Fuchsberger

Wallingford Hydrosolutions - a water resource consultancy

Andy Young ary@ceh.ac.uk

A new technology transfer company has been established within the CEH Water Programme. Wallingford HydroSolutions has been set up to maximise the technology transfer of CEH research to the user community. Focussing on the water resources area, the company will develop business services that are complementary to the research mission of CEH. These services will include:

- support and development of a range of existing software products;
- development of bespoke software solutions for the environmental sector;
- provision of a full service that encompasses software supply, installation, training and support;
- broader near market consultancy services within the environmental and allied business sectors.

There is increased demand for these services within the UK and Europe, resulting from the implementation of EU legislation such as the Habitats Directive and Water Framework Directive. Key users of research outputs and software products are Environment Protection Agencies, Water Utilities, consultants and the education sector.

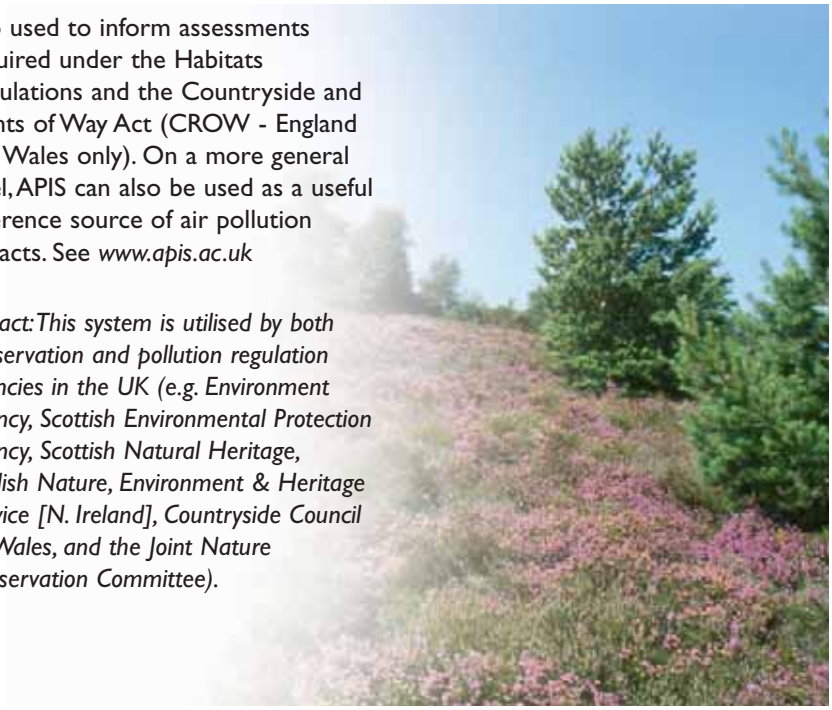
The company has had a challenging year in establishing itself but has received considerable support from CEH senior management and the NERC commercialisation group. The HydroSolutions team will ensure that the excellent research carried out by CEH is transferred to the user community to the mutual benefit of water users and the freshwater environment

A novel Air Pollution Information System (APIS)

Bill Bealey bib@ceh.ac.uk and Mark Sutton

APIS is a relational database providing information on air pollution impacts, over the web. Drawing on a vast amount of CEH research, it offers information on the types and scale of air pollution effects on habitats and individual species; information about critical loads and levels; a simple site based assessment tool for determining risk to sites and information on bio-monitoring methods. APIS also contains a series of overviews providing a simple introduction to key air pollutants, legislation and protocols, and air pollution issues.

The information in APIS is used to inform assessments of Pollution Prevention and Control (PPC) applications for both conservation agency staff and the regulators. It is also used to inform assessments required under the Habitats Regulations and the Countryside and Rights of Way Act (CROW - England and Wales only). On a more general level, APIS can also be used as a useful reference source of air pollution impacts. See *www.apis.ac.uk*



Impact: This system is utilised by both conservation and pollution regulation agencies in the UK (e.g. Environment Agency, Scottish Environmental Protection Agency, Scottish Natural Heritage, English Nature, Environment & Heritage Service [N. Ireland], Countryside Council for Wales, and the Joint Nature Conservation Committee).

Developing an Ice Geophysical Logging System

David Cooper jdc@ceh.ac.uk and colleagues

This system has been developed to measure ice density *in situ* within snowpacks. The system is a novel combination of two well-established systems. One is a neutron soil moisture probe, which can also be used to measure density of ice from a narrow borehole drilled in the snowpack. The other is a geophysical logging system manufactured by Geovista Ltd., which can record geophysical data from multiple sensors, automatically and in one pass. By combining the two instruments, ice density can be measured with high precision, both automatically and non-destructively. This reduces pressure on ice core material, which is in high demand for other investigations. The system was used for one field season in northern Canada. Although there were some teething problems, the system has allowed very detailed data to be collected, efficiently and over a wide area. Three more systems are at present being manufactured.

Impact: The new combined system allows the relation between snowfall and ambient temperature to be characterised, which is important in understanding the dynamics of climate change.

Providing an expert witness statement: effects of ammonia on natural vegetation

Mark Sutton ms@ceh.ac.uk

As part of a public inquiry regarding a planning application appeal for a poultry farm, CEH has provided evidence of the damage to a natural environment that would result from increased loading of ammonia.

Atmospheric pollution is already depositing a considerable amount of nitrogen across the UK. Proof was offered regarding the background levels of nitrogen deposition in this particular locality, which is so high that the natural heathland vegetation is already at or near its critical load - the point at which damage is apparent. Proof was also provided of the degree of extra loading of nitrogen that would result from a poultry farm of the proposed size; the nitrogen would be derived from ammonia evaporating from the chicken manure.

The expert witness also provided statements on the nature of the damage to surrounding natural vegetation from increased nitrogen deposition, and gave estimates of how far this damage might extend. (The planning application referred to land next to heathland registered as a Special Area of Conservation under the EU habitats directive.)

Impact: The provision of an expert witness helped the Inspector reach a reasoned decision, and the appeal was rejected on the grounds of environmental damage from excess nitrogen deposition. This is the first time these arguments have been put to a public inquiry and so the result will inform subsequent similar cases.

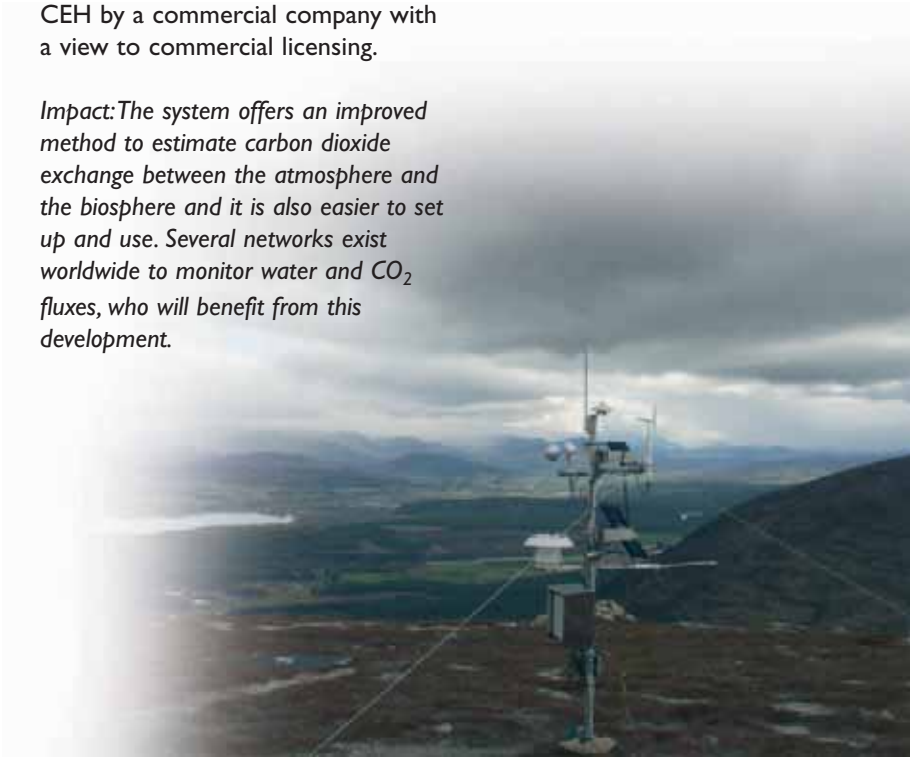
Measuring the fluxes of heat, water vapour and carbon dioxide

David McNeil ddm@ceh.ac.uk and Jonathan Evans

Currently, instruments used to measure the turbulent fluxes of heat, water vapour and carbon dioxide in the atmosphere use two commercial sensors - a gas analyser spatially separated from a wind sensor. This results in measurements that are inadequately correlated with each other in space/time as the spatial scale can be small and the frequencies high.

An integrated system has been developed and tested, which combines these two sensors so that they measure the same air sample. The system incorporates an integrated processor resulting in low power consumption, which is important for year round measurements at remote sites. They are currently being manufactured for CEH by a commercial company with a view to commercial licensing.

Impact: The system offers an improved method to estimate carbon dioxide exchange between the atmosphere and the biosphere and it is also easier to set up and use. Several networks exist worldwide to monitor water and CO_2 fluxes, who will benefit from this development.



Developments in Data Management

Data initiatives in CEH

John Watkins jww@ceh.ac.uk

The role of data in CEH has continued to gain importance with increasing volumes and sources of data available. Continuing increases in computing power, speed and intercommunication are permitting more integrated analysis and dissemination. As a result of this rising profile for data, we have reviewed CEH's data assets and current activities with a view to raising our capability through a coordinated, corporate view of data management. The post of Head of Environmental Informatics has now been appointed, who will manage the process and who will link data management and analysis with the creation and dissemination of scientific information.

CEH's review of its data holdings addressed not only the significant current digital data holdings within CEH, but also the historic data in various formats - which can form unique time-series. There are now some 1300 records of data sets that will be categorised and will then allow us to prioritise further data management activities, to increase security and access to these data. The outputs from the review have been entered into CEH Internet-based digital catalogues that are linked to the NERC Metadata Gateway, and development continues. The work will enable us to realise the scientific potential of our extensive and diverse data assets.

Effective data management is of increasing importance as part of NERC-wide preparations for new legislation: the Freedom of Information (FoI) and Environmental Information Regulations (EIR) will come into effect in January 2005.

Some examples of current data management activities in CEH

A Metadata collection system

Tim Booth tbooth@ceh.ac.uk and colleagues

A metadata collection and storage system, compatible with the data requirements for the CEH metadata survey and the NERC Metadata Gateway, is in its final stages. The metadata collection system is XML based, and storage of the data is in a Postgres database. Work is underway to collect all the appropriate data for projects funded under the NERC Environmental Genomics Thematic Programme. The methods that have been developed also have wider potential. They could be used for metadata collection in future Thematic programmes; to further the aim of smooth integration of data availability between different levels such as the CEH and the NERC Metadata Gateway; and other data centre work. The system will also be of great help in current efforts to strengthen the interactions between members of the data management community within NERC.

Data integration between BGS and CEH

Geoff Smith gesm@ch.ac.uk and colleagues

A pilot project has been completed to allow British Geological Survey (BGS) and CEH to exchange spatial data over the Internet within a Web-based mapping environment. The technology that has been demonstrated in this project will be further developed to widen the range of spatial data sets available to CEH and BGS scientists, and this aim has been identified in both organisations' 5-year development plans. The project has proven the technology for Internet-based integration and delivery of spatial data and identified routes for scientific exploitation of such combined data sets.

Developing a data processing line for NERC's Airborne Remote Sensing Facility

Andrew Wilson akw@ceh.ac.uk and colleagues

A data processing line for radiometrically calibrating and georeferencing airborne data from the NERC Airborne Remote Sensing Facility (ARSF) has been designed and prototyped at CEH Monks Wood. It has now been handed over to ARSF. The processing line enables operational processing and production of high spatial and spectral resolution, spatially referenced, remotely sensed data, to provide standard data products for the UK research community.

Development of the OpenMI architecture

Roger Moore rvm@ceh.ac.uk and Isabella Tindall

The objective of the HarmonIT project is to develop a generic interface for linking models. This interface will allow models to exchange data at run time. During 2003/04, the team developed all the basic concepts for the interface and documented them in the 'OpenMI Architecture'. The interface will allow the construction of the whole catchment models that will be required to implement the integrated water management needed for the Water Framework Directive. The work continues, with CEH scientists leading a team of 14 organisations from 7 countries.

The Bio-Linux Project

Dan Swan, dswan@ceh.ac.uk and colleagues

CEH has greatly expanded its IT Infrastructure by increasing its data storage, computing power and communications across our sites. The facilities and their provision, via Grid-based software, significantly increase the facilities available within CEH - allowing new scientific questions to be asked that could not previously be processed. The availability of Grid also starts a cultural change for scientists to view the Internet as a virtual laboratory linking collaborators with a wide range of scientific resources. The new Grid facilities not only address remote computing and data storage but also advanced video conferencing using Access Grid Nodes.

The CEH Grid Project

Steve Hindmarsh sth@ceh.ac.uk and colleagues

Bio-Linux is an integrated, bioinformatics-centred, computer system. Both standard favourite and cutting edge bioinformatics tools are provided, on a secured Linux-based system. The system combines the benefits of being powerful, configurable, and easily updatable, with the ease of use and potential for software integration required for the handling and analysis of biological data. The CEH Oxford Grid cluster runs Bio-Linux, and makes use of Bio-Linux nodes in all areas. The tools and computing power available to CEH staff have enabled many scientific questions to be approached that would not have been possible otherwise. Version 3.0 of Bio-Linux was released on Dec. 8, 2003 and has had a very positive reception.

Photograph: A Wallis

Science 'Networking' – two contrasting examples

Scientific research is not carried on in isolation, especially within such a diverse organisation as CEH. Building research relationships with scientists in other organisations - such as universities in the UK and abroad - enables a wide range of skills to be brought to any research project. It also enables a unique set of skills to be assembled to tackle a particular problem at local, national, international or global scales *(see the first example below)*.

A different kind of networking has achieved the sharing of and public access to national biodiversity datasets, previously held by many different bodies in many different ways. This success is particularly important for long-term biodiversity research and the detection of change *(see the next page)*.

CEH takes a lead role in ALTER-NET

Terry Parr twp@ceh.ac.uk and colleagues

ALTER-Net is a pan-European Network of Excellence on Long Term Ecosystem Research for Biodiversity and CEH is leading a partnership of 24 organisations from 17 European countries. ALTER-Net will develop a durable integrated research capacity in biodiversity, at a European level. Starting in April 2004, the EC is contributing 10 million euros over the next 5 years to the project.

The project will create a network for European long-term terrestrial and fresh-water biodiversity and ecosystem research, based on existing facilities. It will also develop approaches to assess and forecast changes in biodiversity, structure, functions and dynamics of ecosystems and their services. One of its main aims will be to establish a scientific framework for understanding and measuring the integrated impact of natural and human-induced drivers and pressures on biodiversity and ecosystems, on a European scale. ALTER-Net will also consider the socio-economic implications of biodiversity loss and public attitudes towards this loss. The project will draw upon strengths in biodiversity research across CEH and exploit data from long-term ecosystem research sites in the Environmental Change Network (managed by CEH).

The work of ALTER-Net will help the EU meet its commitment to 'Protect and restore habitats and natural systems and halt the loss of biodiversity by 2010'. For more information see *www.alter-net.info*

Britain's biodiversity goes on-line via the NBN Gateway

Jon Cooper jcoop@ceh.ac.uk

The National Biodiversity Network (NBN) Gateway, built by CEH's Biological Records Centre (BRC) and the Joint Nature Conservation Committee (JNCC), was officially launched in 2004 by Defra minister Ben Bradshaw MP. The Gateway is an on-line system that allows anyone to explore Britain's biodiversity through their web browser. It provides access to over 15 million biological records from almost 90 separate sources. This is the first time so many biological records for Britain have been brought together and made so easily accessible. See the gateway at *www.searchnbn.net*

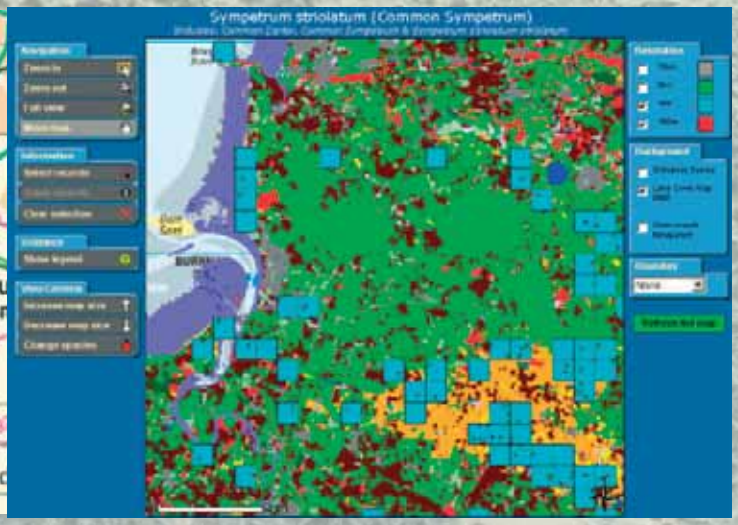
The Gateway has been built as part of the NBN's 'vision' - to bring together organisations and bodies with the common purpose of sharing biodiversity information to support conservation and research. NERC is a full member of the NBN Trust, and CEH has played a pivotal part in establishing the Network. Major recording schemes and societies, already collaborating with the BRC, have worked together to provide a set of national species datasets. We are continually adding to the list of these species datasets. Coverage is as geographically and taxonomically complete as possible.

Custom-built web pages release the potential of this huge data resource. Here are just some of the highlights:

1. Site reports that include species data and maps.

2. Species distributions. This example of the Horseshoe Vetch (*Hippocreppis comosa)* shows records overlying traditional style national maps (below left). The data can then be interrogated further.

3. Species distributions can be integrated with a range of other datasets. This example shows the Common Darter (*Sympetrum striolatum)* distribution underlain with CEH's Land Cover Map LCM2000 (below right).



CEH's European and International activities

Our European research activities are dominated by projects undertaken as part of the European Commission's Framework Programme. The Framework Programme continues to offer CEH valuable opportunities to tackle European scale environmental challenges. We can obtain access to European datasets and facilities, working closely with other leading researchers to integrate a UK perspective into European research and environmental issues. CEH is maintaining its strong role in leading European research in many core areas of science.

Major changes have taken place during 2003/04, as Fifth Framework Programme (FP5) projects reached maturity, and as the new FP6 programme has begun. CEH has benefited from a new NERC FP6 Incentive Fund, which has provided support for our involvement in the Framework Programme, and has offset some of the financial costs that come with this involvement.

The new FP6 programme has brought fresh challenges to CEH, and to our European partners - as FP6 projects are much larger in scale than previous Programmes. CEH has been strongly proactive in seeking to benefit from the opportunities offered by these large-scale research projects and networking activities. To date CEH has been very successful in FP6, and with careful development these successes may be expected to ensure that CEH will retain a key role in future European environmental research, as it moves towards a future European Research Council.

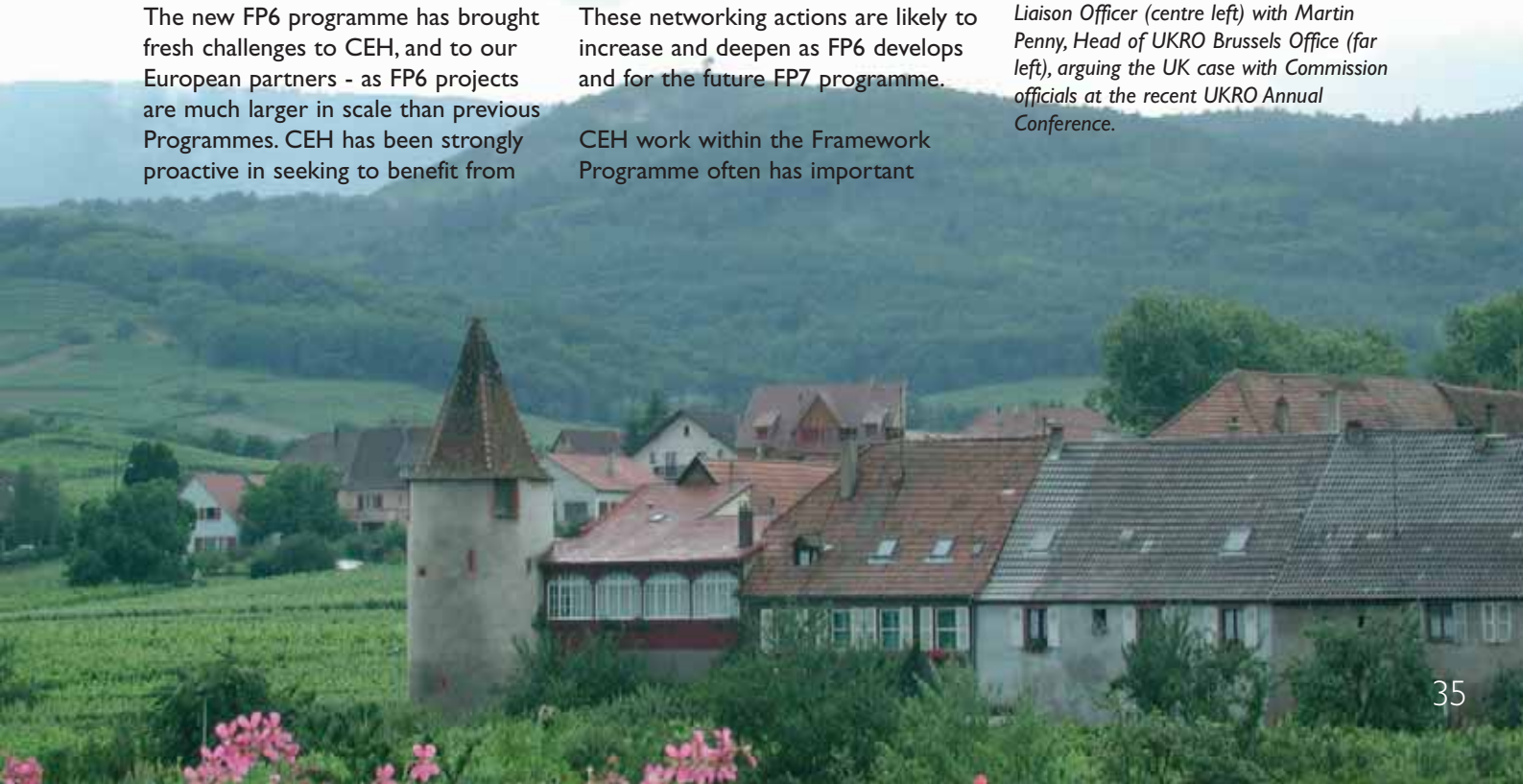
CEH's activity in European research is aided by its membership of a number of networks, including CONNECT (biodiversity conservation), Landscape Europe, EurAqua (freshwater sciences) and PEER (environmental sciences). Through these networks it has been possible to:

- build closer working relationships with other European research organizations and with the Commission;
- develop and communicate European scale research priorities;
- mobilize resources and coordinate responses to research opportunities.

These networking actions are likely to increase and deepen as FP6 develops and for the future FP7 programme.

CEH work within the Framework Programme often has important synergies with the interests of UK government departments. New opportunities have emerged as part of FP6 to bring these two areas of CEH research more closely together, for example through the new FP6 ERA-Net instrument for co-ordination of member state funded research. In addition to the increased member state involvement in the framework programme, FP6 has opened up opportunities for wider international research. Through its extensive links with international organizations, CEH has been active in building these wider linkages between the Framework Programme and the global research programme.

Neil Runnalls, nrr@ceh.ac.uk, CEH European Liaison Officer (centre left) with Martin Penny, Head of UKRO Brussels Office (far left), arguing the UK case with Commission officials at the recent UKRO Annual Conference.



Communicating our science

We communicate our science in many different ways, and at many different levels.

Our research staff communicate with:

- Other scientists, in the UK, Europe and the World, via professional journals, web and email forums, and science conferences
- Policy and decision makers, through contracted research outputs, launches of facilities and 'tools', seminars and reports, and by websites for professional and public use
- Agencies and regulators, contracted research outputs, investigations into particular problems and provision of solutions, provision of data, specialist information and decision management systems
- Business and industry, through contracted research & development, spinout companies & technology transfer (including software), regional development agency initiatives
- Press, radio and TV journalists
- The public/the taxpayer, via printed and electronic outputs, websites, public events and activities, science week events, response to written, telephone and email enquiries.
- Students of all ages. CEH's Schoolnet website for teachers and students, work experience placements, postgraduate and PhD placements, Science week events, CREST and other schemes for young scientists

The public and students of all ages contribute to many species recording schemes, managed by CEH and also the very successful UK phenology scheme. This scheme records the timing of natural events, such as bud-burst in the spring and swallow migration in the autumn.

Launching the NBN gateway. Guests from the managing oranisations and national dataset-owners discuss the potential of the Gateway

CEH Information

Our Aims

CEH has developed Vision and Mission statements, to encapsulate our aims and aspirations. These statements have been revised during 2003/4, to reflect CEH's new structure and research programmes.

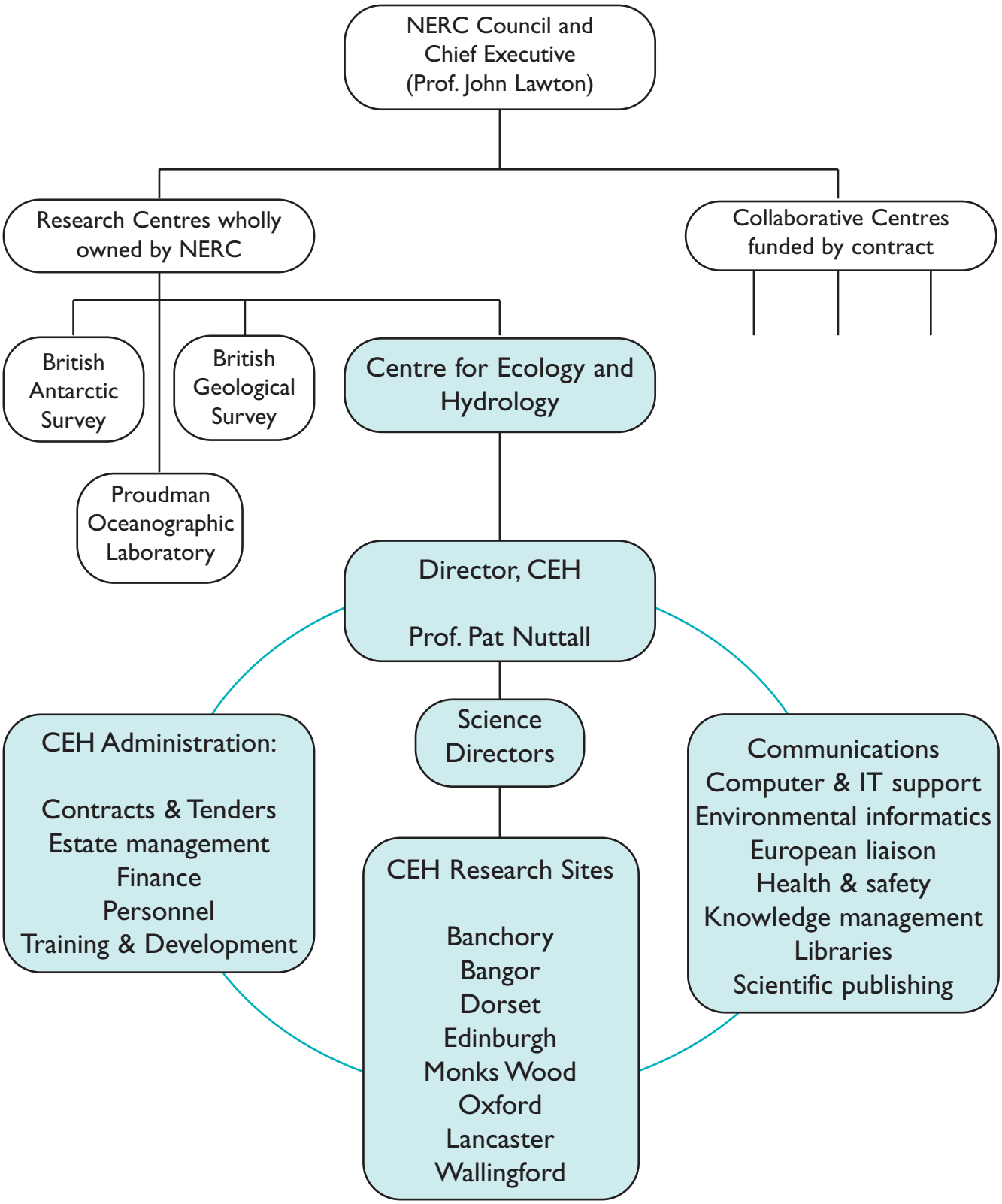
CEH's Vision Statement:

To be a world-class centre of excellence for integrated Earth system science in terrestrial and freshwater ecosystems.

CEH's Mission Statement:

- To advance knowledge in the processes governing Earth's life support systems through high quality, interdisciplinary research, survey and monitoring in water, biodiversity, and biogeochemistry.
- To provide the scientific underpinning for solutions to environmental issues arising from climate change and the need for sustainable economies.
- To secure and manage environmental data and provide access to academia, governments, industry and the public.
- To provide the knowledge base for government policies addressing environmental issues.
- To enhance the UK's industrial competitiveness through knowledge and technology transfer.
- To exploit the Centre's expertise and facilities to enhance research training in the UK and capacity building overseas.
- To promote public awareness and understanding through communication of the Centre's activities.
- To achieve and maintain the standards of an Investors in People organisation

NERC and CEH - the relationship



Managing CEH

CEH is managed internally by two Boards, the Executive Board and the Science Board, who meet at frequent intervals

Central Management

Director: Professor Pat Nuttall, CEH Swindon. 01793 442516, director@ceh.ac.uk
Head of Administration: Brian Butler, CEH Swindon. 01793 411517, bwb@ceh.ac.uk
Head of Finance: Nigel Bird, CEH Swindon. 01793 411581, nibi@ceh.ac.uk
Head of Personnel: Jaqui Dingle, CEH Swindon. 01793 442526, jad@ceh.ac.uk
Head of Site Management: Keith Rodgers, CEH Swindon. 01793 411666, kmr@ceh.ac.uk
Head of Knowledge Management: Dr Jackie Hinton, CEH Monks Wood, 01487 772519 jchi@ceh.ac.uk
Head of Environmental Informatics: Dr John Watkins, CEH Lancaster, 01524 595811 jww@ceh.ac.uk

CEH Health & Safety Adviser: Dr Jillian Binnie, CEH Edinburgh 01314 454343 jillb@ceh.ac.uk
CEH Computer Support: Roger Parsell, CEH Monks Wood, 01487 772450 rjp@ceh.ac.uk
CEH Quality Assurance: Andrea Titley, CEH Monks Wood, 01487 772435 andt@ceh.ac.uk

Science Programme Management

CEH's five science programmes are each managed by a senior scientist - the Science Director, aided by a Programme Administrator. CEH's research staff are each allocated to one of the Programmes, and these staff form the Programme's College. The Colleges meet regularly to discuss the research direction for their Programme.

The five Programmes are:

Biodiversity
Science Director: Professor Mark Bailey (CEH Oxford) 01865 281630 mbailey@ceh.ac.uk
Science Programme Administrator: Dr Sarah Turner (CEH Oxford) 01865 281630 sltu@ceh.ac.uk

Biogeochemistry
Science Director: Professor David Fowler (CEH Edinburgh) 01314 454343 dfo@ceh.ac.uk
Science Programme Administrator: Heath Malcolm (CEH Edinburgh) 01314 454343 hmm@ceh.ac.uk

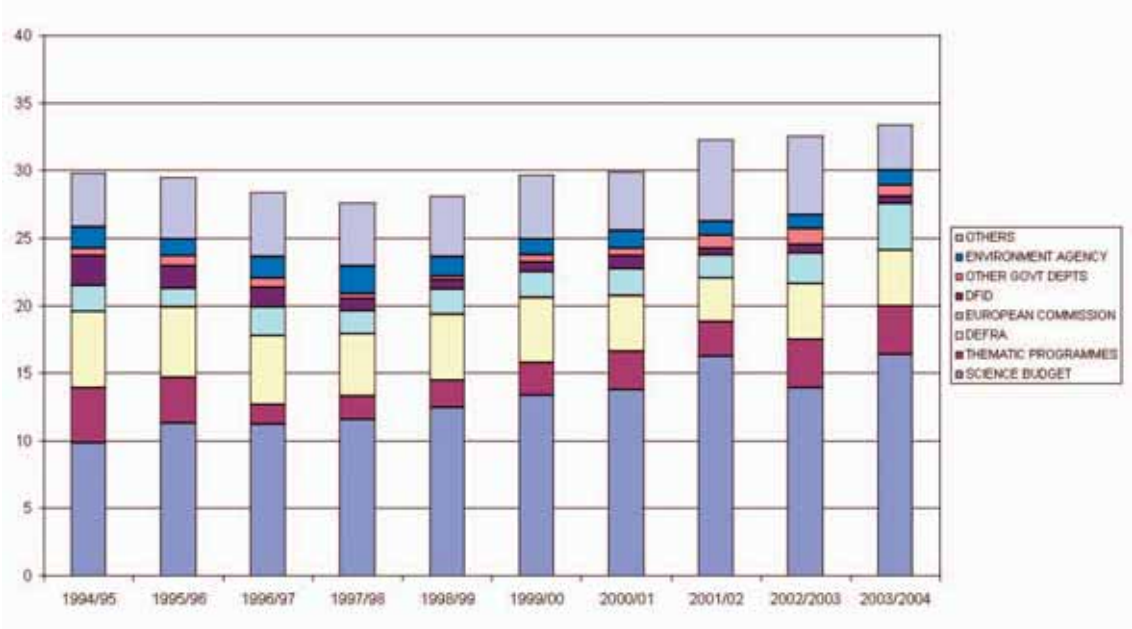
Climate Change
Science Director: Dr Peter Cox (CEH Dorset) *as from 9 December* 04 01305 213500 pcox@ceh.ac.uk
Science Programme Administrator: *(pending reappointment)*

Sustainable Economies
Science Director: Dr Dan Osborn (CEH Lancaster) 01524 595800 dano@ceh.ac.uk
Science Programme Administrator: Dr David Howard (CEH Lancaster) 01524 595800 dhoward@ceh.ac.uk

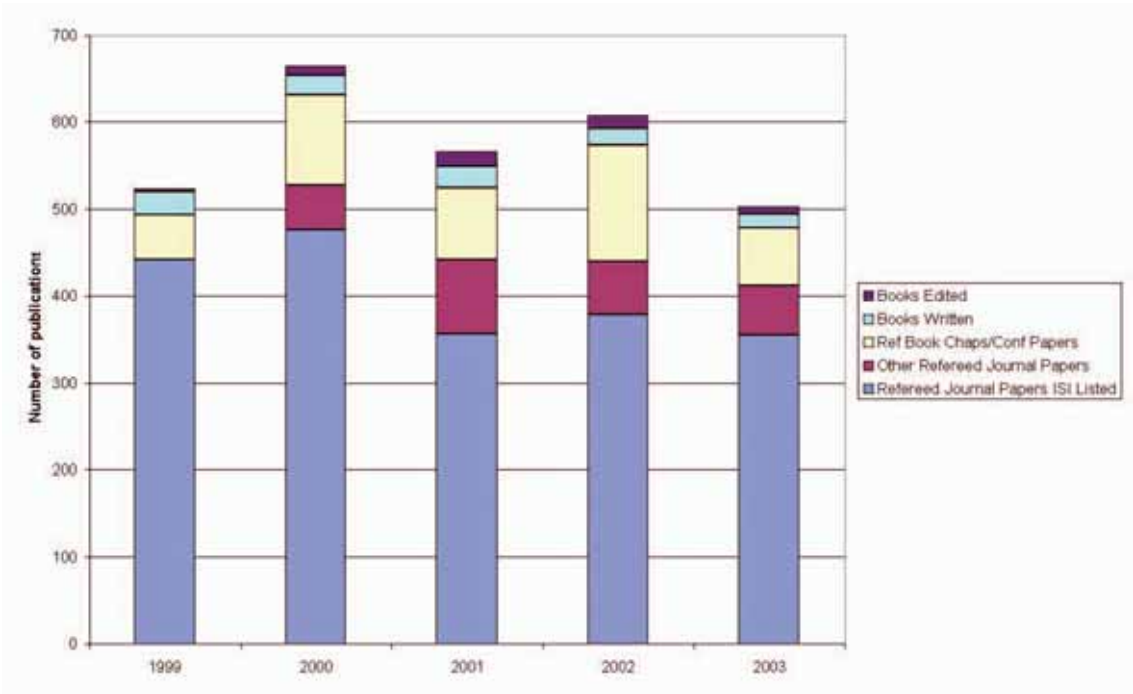
Water
Science Director: Professor Alan Jenkins (Wallingford) 01491 838800 jinx@ceh.ac.uk
Science Programme Administrator: *(pending reappointment)*

CEH Statistics

Income



Publications



Contacts

SITE	HEAD	SECTIONS	ADDRESS
CEH Swindon	Prof Pat Nuttall, Director, CEH	Administration Personnel Finance Estate Management	Centre for Ecology & Hydrology, Polaris House, North Star Avenue, Swindon, Wilts, SN2 1EU T: 01793 442516 F: 01793 442528 E: *director@ceh.ac.uk*
RESEARCH SITES			
CEH Bangor	Dr Bridget Emmett	Biogeochemistry & Ecosystem Function	CEH Bangor, Orton Building, Deiniol Road, Bangor, Gwynedd, LL57 2UP T: 01248 370045 F: 01248 355365 E: *bangor@ceh.ac.uk*
CEH Banchory	Dr Allan Watt	Biodiversity & Population Processes Ecosystem Dynamics	CEH Banchory, Hill of Brathens, Banchory, Aberdeenshire, AB31 4BW T: 01330 826300 F: 01330 823303 E: *banchory@ceh.ac.uk*
CEH Dorset	Dr Jeremy Thomas	Population & Conservation Ecology River Ecology	CEH Dorset, Winfrith Technology Centre, Winfrith Newburgh, Dorchester, Dorset, DT2 8ZD T: 01305 213500 F: 01305 213600 E: *dorset@ceh.ac.uk*
CEH Edinburgh	Dr J Neil Cape	Atmospheric Sciences Biosystems Dynamics Biosystems Management Scottish Freshwater Ecosystems	CEH Edinburgh, Bush Estate, Penicuik, Midlothian, EH26 0QB T: 0131 4454343 F: 0131 4453943 E: *edinburgh@ceh.ac.uk*
CEH Lancaster	Dr Brenda Howard	Ecological Processes in Freshwater & Soils Ecosystem Assessment & Forecasting Environmental Chemistry & Pollution	CEH Lancaster, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster, LA1 4AP T: 01524 595800 F: 01524 61536 E: *lancaster@ceh.ac.uk*
CEH Monks Wood	Dr Alistair Dawson	Biological Records Centre Earth Observation Ecological Risk Ecological Processes & Modelling	CEH Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE28 2LS T: 01487 772400 F: 01487 773467 E: *monkswood@ceh.ac.uk*
CEH Oxford	Prof Bob Possee	Molecular Microbial Ecology Molecular Virology & Parasitology Molecular Evolution & Bioinformatics Environmental Biotechnology Pathogen Population Ecology	CEH Oxford, Mansfield Road, Oxford, Oxfordshire, OX1 3SR T: 01865 281630 F: 01865 281696 E: *oxford@ceh.ac.uk*
CEH Wallingford	Dr Ann Calver	Process Hydrology Water Quality Hydrological Risks & Resources	CEH Wallingford, Maclean Building, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB T: 01491 838800 F: 01491 692424 E: *wallingford@ceh.ac.uk*

More information:
Visit CEH's web site at: *www.ceh.ac.uk*
for more information on how CEH works and what we do.

For copies of CEH publications:
Tel: 01487 772400
CEH Graphics Design Office, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire, PE28 2LS

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Photograph A Wallis

Centre for
Ecology & Hydrology

NATURAL ENVIRONMENT RESEARCH COUNCIL