



**Centre for
Ecology & Hydrology**

NATURAL ENVIRONMENT RESEARCH COUNCIL

A close-up photograph of several clear water droplets resting on a vibrant green leaf. The droplets are in sharp focus, reflecting light and showing the texture of the leaf. The background is a soft, out-of-focus green.

Meeting the Challenges of Environmental Change

Science Strategy 2014 - 2019

NERC
SCIENCE OF THE
ENVIRONMENT

90,818,657 records of **>40,000** species

£34,000,000 annual budget

8,639,300 land parcels in Land Cover Map 2007

18,778,141 days of river flow data from **1457** gauging stations

287,000 citations from 1981 onwards

8975 publications & contract reports from 2000 onwards

591 km squares surveyed in Countryside Survey 2007

311 research scientists **119** postgraduate students

180 field sites **4** research stations across England, Wales & Scotland

3 major societal and environmental challenges

- Securing the Value of Nature
- Building Resilience to Environmental Hazards
- Managing Environmental Change

1 mission

To undertake world-class research of terrestrial and freshwater ecosystems that underpins evidence-based decisions and innovation by policy-makers and businesses, and engages with people, supporting sustainable development and improving society's environmental legacy.

The Centre for Ecology & Hydrology



Who are we?

The Centre for Ecology & Hydrology (CEH) is a **world-class research** organisation focussing on **land and freshwater ecosystems and their interaction with the atmosphere**. We are a Natural Environment Research Council (NERC) Research Centre and integral to the delivery of the NERC Strategy, *The Business of the Environment*, with over 425 researchers and students based at sites in England, Scotland and Wales.

What do we do?

CEH is unique. CEH integrates UK-wide **observation systems and curiosity driven research**, from the smallest scale of genetic diversity to large-scale, whole-Earth systems. We work across disciplines and facilitate academic, public, private and voluntary sector partnerships. CEH's **extensive, long-term monitoring, analysis and modelling** deliver UK and global environmental data, **providing early warnings of change and management solutions** for our land and freshwaters. These range from evaluating the causes of change in biodiversity stock and function, forecasting floods, identifying and addressing the impacts of pollution and climate change, to safeguarding UK soils and carbon stocks. Our work also includes developing decision support tools for the sustainable intensification of agriculture and the management of ecosystem services and water resources.

Why do we do it?

Our health, security and societal development are dependent on securing the value of nature, building resilience to environmental hazards and managing environmental change. These major societal and environmental challenges drive our research. CEH's independent, impartial science **underpins UK and international environmental policies** and **innovation in the commercial sector for sustainable economic growth**. Our work is paramount in **meeting the UK's strategic research needs**, responding to emergencies and underpinning the ability of the UK to deliver world-class environmental science at the land surface.

Working with our Community

Business & Policy Innovation

Innovation is the development of new products, services and processes. Impact arises from innovation. Through engagement with businesses and policy-makers, CEH has an enviable record of creating the evidence-base for products and policies, including smarter regulation. This reflects the importance of CEH's research in establishing a green economy, which integrates the need to drive economic growth within the limits of natural systems. The ultimate goal of sustainable development, defined by Government policy, makes our work more relevant than ever.

We will: *increase the impact of CEH's research by engaging with businesses, policy-makers and environmental practitioners through co-design, co-delivery, co-location and commercialisation.*

Environmental Informatics

Understanding today's environmental challenges requires the marshalling of world-wide information and data. Scientific, commercial and societal objectives depend on high quality data and analysis tools. CEH has decades of experience in collection, analysis and dissemination of environmental information. We possess unique long-term, large-scale datasets that describe the state of the environment and, together with modelling expertise, help to predict the future. CEH's Environmental Information Data Centre (EIDC) works with the terrestrial and freshwater sciences community to ensure these datasets are secure and accessible. In concert with our data management role, we are continually advancing our informatics capabilities to address major societal and environmental challenges.

We will: *deliver innovative ways to realise the potential of our data, producing state-of-the-art management tools and knowledge systems.*

Public Engagement

Public engagement with research enriches society and informs our science. Our researchers engage with people through schools, public events and national festivals, and support informed public debate. Overall this contributes to "greater relevance, accountability and transparency" of research (*Concordat for Engaging the Public with Research*), benefiting society and our science. CEH excels in participatory engagement through citizen science, exemplified by volunteer biological recording, which enables us to deliver fundamental science and impact.

We will: *support our researchers to engage with the public, create opportunities for participation in citizen science, and plan for engagement and dialogue with the public.*

Monitoring & Observation Systems

CEH undertakes an extensive range of environmental monitoring and observation activities that underpin many areas of our research and support decision-making at local, national and international levels. But we live in an increasingly complex world in which these decisions may have wide-ranging and long-term effects on the environment and sustainable development, and which require data and information to be drawn from many sources. To meet these demanding requirements we also work in UK, European and global partnerships to establish the basis for more integrated, multi-scale observation systems that enable holistic approaches to the management and use of natural resources.

We will: *develop a flexible, long-term, UK surveillance system that informs evidence-based decisions at local to global scales, linking hydrological, biogeochemical, and ecological measurements.*

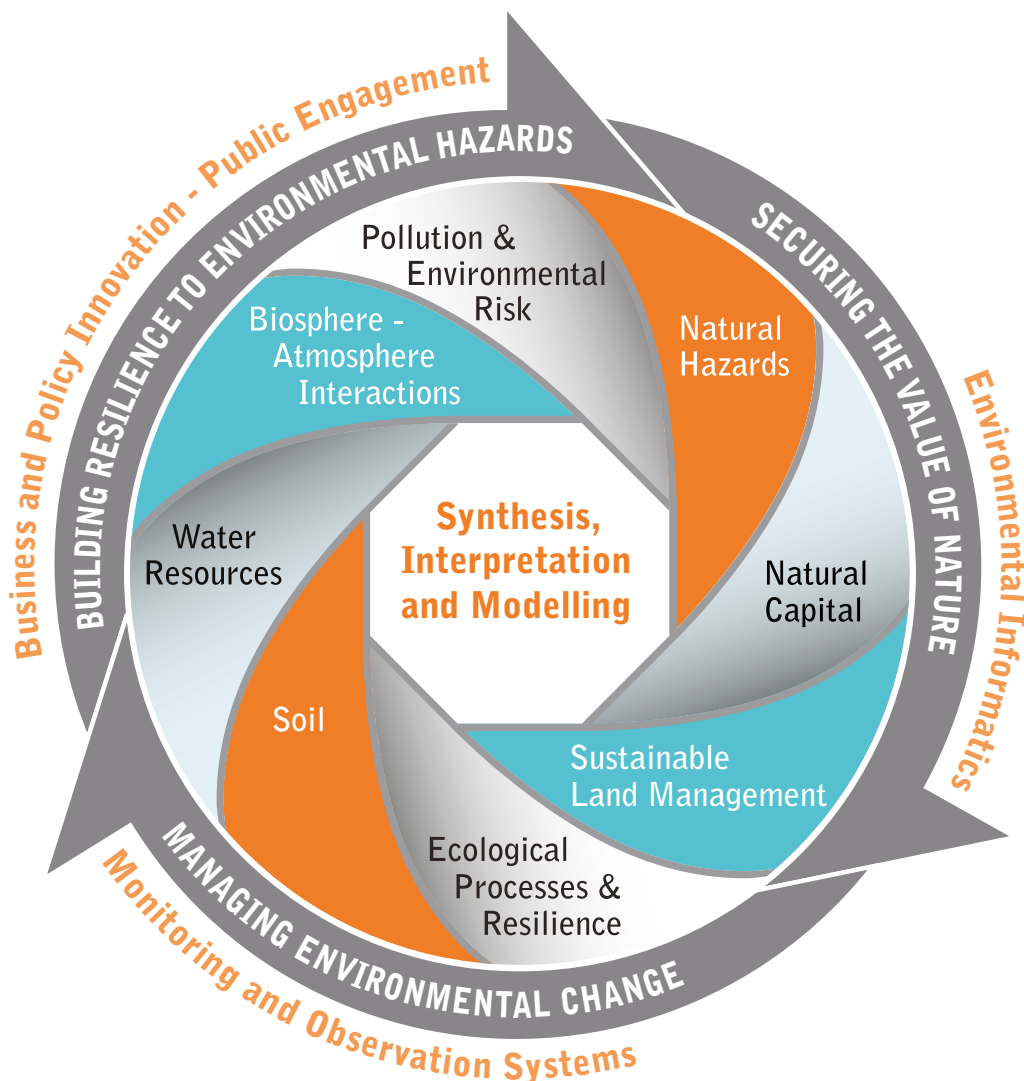
Science Strategy to Delivery

The increasing global population is making ever greater demands on limited natural resources and is driving human-mediated environmental change, including changes to our climate. Natural hazards remind us of our vulnerability and dependency on the natural and managed environment. The response, a pursuit of security and sustainability, underlines the need for a systems approach to opportunities and threats alike, where a holistic understanding supports improved decision-making for our society, economy and environment.

CEH's Science Strategy 2014-19 identifies three interdependent, major societal and environmental challenges aligned with NERC's Strategy, *The Business of the Environment*:

- Securing the Value of Nature
- Building Resilience to Environmental Hazards
- Managing Environmental Change

We will deliver our Strategy by Science Areas underpinned by Monitoring & Observation Systems and Environmental Informatics, through Business and Policy Innovation, and Public Engagement. This approach will make our researchers and science more accessible; enabling us to define, develop and deliver integrated research in partnership.



Major Societal and Environmental Challenges

Securing the Value of Nature

Our society, economy and personal wellbeing depend upon a healthy environment, encompassing natural and highly modified systems. It provides food, clean air and water, and countless other inputs to everything we produce and consume. Our environment also provides us with services including flood, pollution and climate regulation, and pest and disease control. The National Ecosystem Assessment (2011) shows that, along with biodiversity, a number of these services are in decline.

By determining the quality, quantity and risks to the resources and services provided by our environment, we will inform and develop strategies to meet the increasing demands for this 'natural capital'. CEH uniquely provides measures, assessment and mapping of natural capital and ecosystem services, alongside conservation, restoration and remediation, supporting the supply of water, food and energy.

Society has successfully exploited many aspects of natural capital to generate economic growth and improvements to our wellbeing. Yet demands on already overstretched natural systems are increasing, alongside mounting demographic pressures and environmental change. This situation cannot continue indefinitely. It requires high quality monitoring and objective assessment to provide the evidence-base for effective action, to safeguard and improve society's environmental legacy.

CEH demonstrated that half of GB's 14,000 lakes >1ha in area were unlikely to meet 'good status' as defined by the EU Water Framework Directive. Lake standards have been developed by CEH and adopted by the UK to underpin EU requirements. CEH is now piloting a lake restoration decision-support tool for practitioners, enabling effective targeting of investment.



Water resources are exploited for agriculture, industry and households, but also sustain natural ecosystems. CEH developed a decision-support tool, routinely used by regulatory bodies, to estimate river flows and underpin abstraction licensing. CEH is now establishing a knowledge-base to better define ecological outcomes of different abstraction regimes, alongside the rollout of a nationwide hydrological outlook.



The UK National Ecosystem Assessment, the first analysis of our natural environment, defined benefits provided to society and economic prosperity. CEH were coordinating, lead and/or contributory authors on 10 chapters. A key input was Countryside Survey, run by CEH in each of the last four decades. In partnership we will deliver a sixth survey, extending this unique national resource.



Major Societal and Environmental Challenges



CEH led the development of the EU portal on invasive species, DAISIE, the largest database of its kind in the world, and the GB Non-native Species Information Portal, which also incorporates an alert system, to inform statutory bodies and conservation practitioners. Invasive non-native species drive biodiversity loss and cost the British economy an estimated £1.7bn pa. CEH now leads an EU-wide integration of non-native species Information Systems, to improve early warning and response.

Building Resilience to Environmental Hazards

Environmental hazards directly affect people, businesses and wildlife. The dependence of society on agricultural production, energy supply, chemical use and transport and communication infrastructures, highlights the need for increased resilience to environmental hazards as a high priority. Hazards include floods, droughts, emerging diseases and invasive species, and pollution of soil, water and air.

The UK Review of Transboundary Air Pollution, led by CEH, demonstrated that policies to control acidification have largely succeeded, whereas policies to control nitrogen pollution have been less successful. The cost of European nitrogen pollution is estimated at £60-270bn pa. CEH is now establishing systems to improve agricultural nitrogen use efficiency and reduce its environmental impacts.



Scientific data are crucial for characterising natural and anthropogenic hazards. This forms the objective evidence-base needed to assess the threats posed and how they can be mitigated. The severity of impacts from environmental hazards depends on the hazards themselves and also on exposure and vulnerability. Quantifying the current and likely future risks from environmental hazards is an urgent and significant need. A greater challenge is understanding how hazards interact with one another and other key environmental components, such as land-use, climate change and the growing human population.

By assessing the risk of natural environmental hazards, and those caused by humankind, we will be better able to predict and develop strategies to address the threats they pose to society, the economy and our environment.



Significant European floods (1980-2009) caused estimated damage >€75bn. CEH's Grid-to-Grid model underpins operational warnings delivered by the Flood Forecasting Centre in England & Wales, and the Scottish Flood Forecasting Service. CEH is now working to improve prediction of flooding from intense rainfall as part of the Natural Hazards Partnership.

Major Societal and Environmental Challenges

Managing Environmental Change

The increasing human population and unsustainable use of natural resources are causing large-scale, rapid changes to our environment. Natural and anthropogenic changes are often interlinked and can cause unexpected impacts in physical, chemical and biological processes. Understanding the consequences of environmental change on biodiversity and natural processes and resources, including soil and water, is vital if we are to develop appropriate adaptation and mitigation strategies.

By integrating monitoring, process understanding and modelling, we can assess and respond to threats and risks, and benefit from opportunities associated with environmental change. We must identify early warnings of change and possible ecosystem tipping points, attribute causes and determine the interactions between drivers of change, such as land-use and climate. In this manner we can identify opportunities for adaptation and build increased resilience of natural and highly-managed ecosystems to change.

To achieve these ambitions policy needs to drive environmental management with approaches built on robust scientific evidence. CEH research provides this evidence.

In collaboration, CEH delivered an online tool to project the impacts of climate change on wetlands and supported wetland restoration of the Great Fen. Wetlands can regulate water quality, flooding and greenhouse gas fluxes. CEH is now applying its expertise and decision-support tool to help future-proof wetland restoration strategies.



CEH demonstrated that pollinators in farmland can be increased 12-fold through agri-environment schemes. This finding underpinned a Syngenta-led project engaging UK farmers, establishing pollen and nectar-rich habitats. The value of UK crop insect-pollination is up to £440m pa; equiv. to 13% of farming income. CEH is now the scientific lead for the Syngenta follow-on, 'Operation Pollinator', in 16 European countries and the USA.

CEH led a collaborative study of changes in seasonal timing of biological events in UK marine, freshwater and terrestrial environments. On average, from 1976 to 2005, reproduction and population growth occurred more than 11 days earlier, with accelerated change in latter decades. CEH is now examining the consequences for predator-prey relationships of phenological change to our ecosystems.





“ We will deliver our strategy by science areas underpinned by monitoring & observation systems and environmental informatics, through business and policy innovation, and public engagement. ”

Natural Hazards

Context: Natural hazards are of increasing concern for humanity because of population growth and increased societal vulnerability due to trends in urbanisation and land-use change. A key demand is to improve our prediction and estimation of natural hazard events, especially floods and droughts, and develop our knowledge to better manage and minimise their impacts on our society, economy and environment.

We will:

- *develop the science associated with the prediction of hydro-meteorological, biological and air quality hazards.*
- *facilitate the design of management systems.*
- *help to improve resilience strategies.*

Natural Capital

Context: Capital is an economic term defined as anything that can, either directly or indirectly, yield flows of benefit to people over time. Natural Capital is the stock of environmental assets that produce a flow of ecosystem goods or services into the future, including food, nutrient cycling, flood control and recreation. This concept will inform decisions on how we use our natural resources and manage the environment sustainably.

We will:

- *assess the extent, quality, trends and vulnerability of the UK's Natural Capital.*
- *define the ecosystem services that flow from our natural and managed environment.*

CEH Science Areas: Delivering our Strategy



Sustainable Land Management

Context: Ensuring adequate provision of food, fuel and water whilst conserving biodiversity and vital ecosystem functions is a key issue facing humankind. Achieving this goal requires novel land management approaches to optimise our natural resources, yet account for the effects of human-mediated environmental change.

We will:

- *develop and test economically viable solutions to conserve biodiversity and mitigate against future threats.*
- *develop practical solutions to restore and enhance ecosystem functions responsible for the delivery of goods and services crucial for human wellbeing.*

Ecological Processes & Resilience

Context: The benefits that flow from biodiversity and ecosystem services are increasingly under threat from environmental change. Threats include habitat loss and fragmentation, climate change and over-exploitation of natural resources. These threats are exacerbated by pests, diseases, alien invasive species and other drivers of global environmental change. A better understanding of ecological processes, particularly those that affect the resilience of species, is needed to maintain ecosystems and the delivery of ecosystem services.

We will:

- *identify early warnings of change, including tipping points, in freshwater, coastal, urban and terrestrial ecosystems.*
- *identify characteristics of species, communities and ecosystems that underpin ecological resilience.*

Soil

Context: Soils provide nutrients and water to grow our food, help regulate our climate, and support a large and diverse biological community. These and other societal benefits depend crucially on soil quantity and condition, both of which are currently at risk from threats such as over-exploitation, contamination and climate change. Understanding and managing the diverse, and sometimes conflicting, services provided by soils demands an integrated, multidisciplinary approach.

We will:

- *understand the linkages among soil diversity, dynamics and function.*
- *improve quantification of soil vulnerability.*
- *develop methods and platforms for observing soil change.*
- *contribute to the representation of soils within land-atmosphere and ecosystem service models.*

CEH Science Areas: Delivering our Strategy



Water Resources

Context: Water is a natural and renewable resource that sustains ecosystems which have developed in response to water availability and variability. Water resources must also serve the competing and often conflicting requirements of agriculture, industry, households, power generation, navigation, flood protection and recreation. Water resources must be allocated and used in a sustainable and equitable way whilst maintaining biodiversity and ecosystem services.

We will:

- *improve the understanding of the quantity, quality and variability of freshwaters.*
- *identify the ways in which freshwaters and their dependent ecosystems are used as a resource.*
- *assess the interactions and conflicts between these uses.*

Biosphere-Atmosphere Interactions

Context: There are crucial societal and environmental issues relating to air pollutants, greenhouse gases, and global carbon and nitrogen cycles. These include emission inventories, air quality, bioenergy and climate change effects. Developing the policy basis for addressing these issues demands the combination of monitoring and modelling of the exchange of gases, aerosols, particulate material, energy and water at land and water surfaces and effects on local, regional and global climate.

We will:

- *improve process understanding and quantification of biosphere-atmosphere exchange in major biomes.*
- *integrate our flux measurements into next-generation models.*
- *develop mitigation options to underpin atmospheric pollution policy.*

Pollution & Environmental Risk

Context: Chemicals include pharmaceuticals, radionuclides, macronutrients, trace elements, and organic and inorganic pollutants. The development, manufacture and use of chemicals contributes billions of pounds to the UK economy per annum. Yet chemicals can have hazardous properties that pose risks to human health, food production and our environment. Robust risk assessments are essential to ensure safe and sustainable chemical use and release.

We will:

- *quantify and evaluate chemical risks through an understanding of how and why they vary.*
- *assess the extent to which the environment can adapt to and tolerate chemical inputs.*
- *advise policy-makers in formulating mitigation strategies.*

Next Steps

CEH's Science Strategy addresses major societal and environmental challenges. Our world-class research and extensive long-term monitoring, in isolation, will not be sufficient to deliver our strategy. So in addition:

We will:

- *proactively engage with businesses, policy-makers and environmental practitioners.*
- *nurture robust multidisciplinary, national and international research collaborations.*
- *maximise the opportunities to access our national capability.*
- *facilitate improved integration of the terrestrial and freshwater sciences community.*
- *define the UK's terrestrial and freshwater sciences long-term needs for large-scale experimental platforms, facilities and services.*
- *provide training for the next generation of environmental scientists.*
- *encourage society to engage with our research from the outset.*

Want to know more?

CEH's Science Area Summaries are available on our website.

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