



UK Centre for
Ecology & Hydrology



Annual Review **2020**

2020

The year in numbers

These numbers indicate the size, scale and excellence of the science we deliver in support of a world where people and nature prosper


1,000+
datasets are now freely available via the Environmental Information Data Centre



Over **3/4 million** updates were made to the data in the National River Flow Archive



1.77 million records were received by the Biological Records Centre from over **20,000** contributors covering over **24,000** species




3/4 of our outputs were rated world-leading or internationally excellent



We won **23** bids across **17** countries



4 UKCEH scientists were named on the Highly Cited Researchers 2020 list



Our researchers published over **400** papers



Our scientists jointly supervised **170** doctoral researchers



We won **150** bids worth **£18.9 million**

Contents

06

INTRODUCTION FROM THE CHAIR

07

INTRODUCTION FROM THE DIRECTOR

08

OBJECTIVES & ACTIVITIES

10

PERFORMANCE & ACHIEVEMENTS

30

NATIONAL CAPABILITY

31

OUR PEOPLE



Front cover image: © Matthias Tschumi.
 Inside cover images: top centre - photo by Nanang Sujana/CIFOR. (CC BY-NC-ND 2.0);
 Top right and centre - Shutterstock;
 Centre left, centre right and bottom centre: © Simon Butterworth.



LORD CAMERON OF DILLINGTON, CHAIR

Letter from the chair

Having worked with the UK Centre for Ecology & Hydrology (UKCEH) for some years and become its first Chair in 2019, I have been consistently impressed by the organisation's focus on delivering world-class science which has an impact on the world's major environmental challenges. In this Annual Review, you will see numerous examples of how UKCEH has furthered knowledge, informed policy, and supported innovation around the world, not least through its contributions towards realising 11 of the 17 UN Sustainable Development Goals.

Of course 2020 has been dominated by the global pandemic and the many challenges this created. I am pleased to report that, despite the many difficulties, the Centre succeeded in delivering against its Strategy 2025, adapting rapidly to changing circumstances and finding new ways to work, while caring for the safety of staff, partners and the public. The Centre's

directors and staff deserve huge credit for the extra effort they put in throughout the year to achieve this.

I was particularly proud that UKCEH was able to contribute proactively to the UK's emergency response to COVID-19. Our scientists led national work to detect the virus SARS-CoV-2 in wastewater, they lent their modelling expertise to efforts to identify optimum strategies for easing lockdowns, and they maintained national air pollution monitoring networks throughout the pandemic, providing vital information on emissions. The organisation donated thousands of pairs of gloves, suits, aprons, and other essential equipment to key workers based near our sites in Bangor, Edinburgh, Lancaster and Wallingford, and provided a DNA sequencing machine for use at a COVID-19 diagnostic testing centre in Milton Keynes.

The Board of Trustees has seen some changes during the course of the year. We regretfully said goodbye to Fiona Evans, formerly HR Director of ZSL, and Professor Paul Leinster CBE, formerly Chief Executive of the Environment Agency. I am

very grateful to Fiona and Paul for their valuable contribution to the governance of UKCEH during difficult times, as well as to the remaining trustees for their diligence.

We look forward with optimism, knowing that the organisation has survived this challenging year, and is in a strong position to thrive in 2021, while enabling governments, NGOs and businesses to "build back better". After all, the pandemic has also shown us that real change is possible when there is the will to achieve it.

"We really cannot thank you enough for helping protect our crew during these unprecedented times. This PPE does not just mean that our crew are better protected, it also reduces the risks of transmission of the virus to the patients we are treating, as well as the families of crew, who they return home to."

Samantha Collier,
Corporate Partnerships
Manager at Thames
Valley Air Ambulance



PROF MARK J BAILEY, EXECUTIVE DIRECTOR

Letter from the director

This Review marks the completion of my first full year as Executive Director of the newly independent UK Centre for Ecology & Hydrology. We always knew that our first year of independence from UK Research and Innovation (UKRI) would be demanding, but in practice, it has been difficult in ways we could never have dreamt at the outset. But, while the pandemic has presented us with numerous challenges, I firmly believe we have emerged from the year more flexible and more focused.

With staff based across four sites, working with partners all around the world, involved in extensive laboratory and field work, adapting to the restrictions of the pandemic was hugely complex. That we not only maintained much of our normal service, but also delivered the impressive range of achievements set out in this document, is due largely to the extraordinary efforts of our staff and the flexibility of our funders and partners, to all of whom I am immensely grateful. We were also fortunate to be in a strong

enough financial position to be able to retain all our staff on full pay throughout the year.

In April, we published our Strategy 2025, setting out our direction as an independent organisation for the next five years. And throughout the pandemic, we have continued to deliver against this strategy. This Annual Review gives you a flavour of the holistic approach that UKCEH takes to tackling environmental challenges, integrating different disciplines within and beyond environmental science, and balancing environmental needs with economic and social needs.

We were terribly saddened this year to lose Professor Richard Shore, who died suddenly in July. Richard joined the Institute of Terrestrial Ecology, a forerunner of UKCEH, in 1988, and had been with us ever since, most recently as Science Area Head for Pollution and Head of Site for UKCEH Lancaster. He made a huge contribution to pollution and wildlife science worldwide, and we miss his humour, kindness and wisdom greatly.

Throughout all the ups and downs of this strange year, I have been constantly impressed by the commitment and flexibility of UKCEH's leadership team, Board and, of course, our staff. I am humbled by their dedication.

We remain a strategic delivery partner for the Natural Environment Research Council, part of UKRI, and much appreciate their funding of our National Capability Awards and research grants that make up a major proportion of our annual income.

2020 has been a challenging but productive year, and for 2021, working with our collaborators, we will continue to demonstrate that our science makes a difference.

Who we are

The UK Centre for Ecology & Hydrology is an independent, not-for-profit research institute carrying out excellent environmental science with impact.

Our 500 staff work to understand the environment, how it sustains life, and the human impact on it. We provide

the data and insights that governments, businesses and researchers need to create a productive, resilient and healthy environment.

This Annual Review covers the 13-month period since the UK Centre for Ecology & Hydrology became independent from UK Research and Innovation.

How we work

Underpinning UKCEH's research and innovation are large research infrastructures and our capabilities in monitoring, measuring and observation, experimentation, data science and modelling.

Monitoring, measuring and observation

We provide flexible, long-term, large-scale monitoring and surveillance networks essential to allow us to identify and measure environmental change, and determine the factors that drive that change.

Experimental platforms and research facilities

Our research facilities enable us to test the role of different drivers of environmental change and the outcomes of novel

interventions to manage the environment. We provide and operate experimental platforms and research infrastructures supporting national and international collaborations.

Data science and modelling

We have developed models to forecast and predict aspects of the environment at different spatial and temporal scales. They include models of national and international importance for assessing air quality; GHG emissions inventories; land use and environmental impact modelling; the UK's sole land surface model; nationwide, real-time flood forecasting; and water resource outlooks.

Our ambition

We seek to understand the environment, how it sustains life, and the human impact on it – so that together, people and nature can prosper



Our charitable objects

- To carry out pure and applied scientific research in terrestrial and aquatic environments, including their interactions with the atmosphere.
- To deliver scientific expertise in terrestrial and aquatic environments, including their interactions with the atmosphere.
- To advance education in the environment and environmental sciences, and sustainable development.
- To promote sustainable development for the benefit of the public by promoting the preservation, conservation, protection and improvement of the environment and the prudent use of natural resources.
- To promote sustainable means of achieving economic growth and regeneration.

Our strategy

In April 2020, we published Our Strategy 2025: Research and Innovation

Our strategy sets out the role of UKCEH in addressing three major environmental and societal challenges:



1 Creating and enhancing sustainable ecosystems

2 Reducing and preventing pollution

3 Mitigating and building resilience to climate and environmental change

Our specific contribution to these challenges focuses on ten integrated issues:

Biodiversity

Chemical risks

Clean air

Climate and land

Ecosystem restoration and resilience

Flood and drought impacts

Net-zero greenhouse gas emissions

Soil health

Sustainable agriculture

Water quality and resources

Biodiversity



The challenge

Biodiversity is under threat with species declining at the fastest rate ever recorded. The biggest threats include habitat loss and fragmentation, climate change, pollution, invasive species and pathogens.



Our commitment

- To better understand the response and interactions between biodiversity and environmental change.
- To define the impact of the many drivers of change, including climate, land use, invasive species and globalisation.
- To develop effective, evidence-based mitigation strategies that inform and improve biosecurity preparedness, and halt and reverse the decline in biodiversity.

Examples of progress in 2020

Supported by National Capability funding, our Biological Records Centre received 1.77 million records from over 20,000 contributors covering over 24,000 species. Our analysis of species trends contributed to the publication of annual UK Biodiversity Indicators, led by the JNCC (Joint Nature Conservation Committee). These indicators inform policy and form a major part of the UK's international reporting on biodiversity. www.brc.ac.uk

We worked with Network Rail on a Biodiversity Action Plan, which supports the organisation's goal to increase biodiversity across its estate, which covers 52,000 hectares and comprises 20,000 miles of track.

Nitrogen pollution from agriculture, industry and road traffic is a major driver of biodiversity loss in the UK.

A UKCEH-led project for the JNCC showed that habitats threatened by nitrogen pollution are best protected by targeted local measures. The modelling study indicated that while national measures have an important role to play in reducing background pollution levels that can harm sensitive habitats, it is also important to implement local mitigation measures to protect sites close to pollution sources.

Photo: Lucy Hulmes, UKCEH

“Collaborating with UKCEH on the development of its new biodiversity action plan has enabled Network Rail to work with experts in the fields of biodiversity and remote sensing. This work will help Network Rail to become recognised as leaders in land management and to achieve ambitious targets of biodiversity net gain by 2035.”

Dr Neil Strong,
Biodiversity Strategy Manager,
Network Rail

A ‘tool-box’ approach where you can choose the most effective measures for a particular area will not just maximise benefit to each site, but also be most cost-effective.

1,200 beekeepers signed up for our National Honey Monitoring Scheme in 2020, and 800 samples were processed. Our Analytical Chemistry Group developed methods for detecting up to 100 pesticide compounds in a single extraction. This citizen science programme uses plant eDNA to tell us what bees are feeding on in different parts of the country and at different times of year, helping to identify possible threats to the habitat of pollinating insects. <https://honey-monitoring.ac.uk>

Our annual survey of Windermere indicated the continued presence of a non-native fish species, the ruffe, first detected by our monitoring last year. Arctic charr were also observed – a species in dramatic decline and with great cultural importance locally.

Professor Helen Roy MBE led the IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) thematic assessment on Invasive Alien Species (IAS), which defines the impact of the drivers of IAS, including climate, land use, invasive species, and globalisation. A first order draft was circulated for review in September 2020.



1,200 beekeepers signed up for our National Honey Monitoring Scheme in 2020, and 800 samples were processed.

Photo: UKCEH



Forward look for 2021

- Welsh Government uses a set of national indicators to monitor and assess progress against their well-being goals. We will lead work in 2021 to define, agree and calculate a biodiversity indicator, taking account of the need for reliable, repeatable data, the meaning of the indicator to society, and its relevance as a measure of biodiversity.
- We will scope the incorporation of data from the National Honey Monitoring Scheme into Defra's indicator for 'chemicals in the environment', by which the UK Government will measure progress against its 25-year Environment Plan.
- As part of a UKRI Insect Declines Highlight Topic project, we will undertake a comprehensive analysis to identify how different drivers of declines in the diversity and abundance of insects interact across the UK, including habitat loss, climate change, pollution and disease.
- Under the NERC ERCITE project ChemPop, we will identify the most important chemical and landscape drivers of aquatic biodiversity in rivers over the past 30 years, and review the impact of agriculture over time on populations of different groups of aquatic and terrestrial invertebrates.

Chemical risks



The challenge

Chemicals are integral to human life and generate billions of pounds for national economies. However, chemicals released during production, use and the waste process can degrade the environment, affecting the health of humans and wildlife.



Our commitment

- To advance the measurement and assessment of chemical hazard pathways across water, land and air.
- To develop novel emissions-fate-transfer models that deliver explicit descriptions and predictions of environmental chemical exposure in space and time.
- To make a major contribution to sustainable chemical use through an enhanced understanding of environmental exposure and effects.

Examples of progress in 2020

We carried out work for Defra and the Environment Agency to help develop an indicator which will be used to track exposure to and the adverse effects of chemicals on wildlife in the environment. This indicator will form part of the metrics for Defra's 25-year Environment Plan.

A major EU project led by UKCEH is enabling researchers and regulators to better assess the potential risks that man-made nanomaterials may pose to the environment and humans. The research, published in *Nature Nanotechnology* in August, sets out ten key principles for improving predictions of how nanomaterials transform and dissolve as they pass through air, water, soil and living organisms.

We modelled changes in zooplankton species richness across a series of lakes in Ontario, Canada that are recovering from past acidification and metal

inputs. We used a state-of-the-art modelling approach to understand the impacts of chemical mixtures and bioavailability together. The results demonstrate that, in the long term, such an approach may be highly valuable in site-specific risk assessment of metal contamination.



Photos: Shutterstock



Forward look for 2021

- We are planning a major update of the ERICA Tool, a radiological environmental assessment model, used by regulators and industry worldwide.
- We will develop the NanoFASE spatio-temporal model for predicting the fate and exposure of nanomaterials in the environment further as part of an ongoing project which will inform sustainable product development.
- With UK Water Industry Research funding, we will collect data on the fate and behaviour of different microplastic polymers in a range of different wastewater treatment plants, and develop new methodology to identify whether nanoplastics are present in tap water.
- Our modelling expertise will be applied to predict the impact of rodenticides on sparrowhawks at a population level.



Supporting the safe use of rat poisons across the UK through policy and a stewardship scheme

Controlling rats is essential to protect food quality, human health and infrastructure. Second-generation anticoagulant rodenticides (SGAR) are very effective rat poisons but present a significant risk to other wildlife. Through its Predatory Bird Monitoring Scheme (PBMS), UKCEH has underpinned the development of voluntary SGAR initiatives by UK industry, as well as national and international SGAR regulations. Under these regulations, a UK-wide rodenticide stewardship scheme has been introduced, with monitoring provided by PBMS. This scheme will prevent potential damage costing hundreds of millions of pounds.

Photo: Shutterstock

"PBMS is the best example of wildlife monitoring and exposure that measures changes to the environment as a result of policy intervention. It's hard to think of an alternative that gives a measure of chemicals in the environment. Because we have PBMS, we have evidence-based decision making based on outcomes."

**Principal Specialist,
Natural England**

Clean air

The challenge

Air pollution is a major risk to human and environmental health. Around the globe, the adverse health effects of air pollutants are most prominent in urban areas, notably in African and Asian megacities. Air pollutants also contribute to ecosystem damage and biodiversity loss, and impact food security by reducing crop yields.



Our commitment

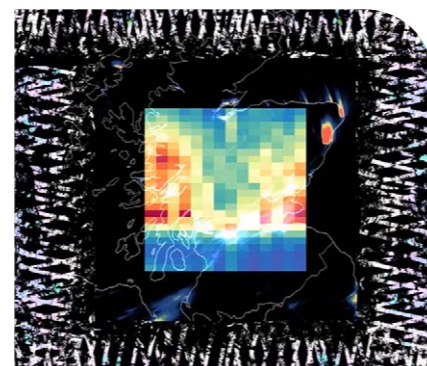
- To quantify emissions, atmospheric dispersion and chemical transformation, and assess ecological and human health impacts.
- To improve the way we assess the contribution of nature-based solutions and ecosystem services to improving air quality.
- To provide the evidence and solutions required for effective clean air policy actions.

Examples of progress in 2020

During the pandemic, we put in place plans, with the support of Defra and the Environment Agency, to maintain the operation of our UK air quality monitoring sites because of the potential impact of air pollution on respiratory illnesses. This included investing in new equipment to maintain our operation of the BT Tower Atmospheric Observatory in order to quantify CO₂ emissions in London.

The South Asian Nitrogen Hub, led by UKCEH, informed the UN Environment Assembly's first ever Resolution on Sustainable Nitrogen Management. This involved close collaboration among all eight countries of South Asia through our partners, the South Asia Cooperative Environment Programme (SACEP).

New guidance developed by UKCEH and adopted by UNECE in December will give governments and farmers the evidence needed to reduce nitrogen losses that pollute air and water. The guidance includes 76 detailed measures for reducing agricultural-based emissions of ammonia, nitrogen oxides, nitrous oxide to air, plus nitrate and other leaching to water.



Air quality data from between March and May 2020 was used in a digital artwork which visualised changes in nitrogen dioxide concentration in Scotland.

Photo: UKCEH



Forward look for 2021

- In 2021, we will continue to build the first UK Community Emission Modelling System as part of the UKRI Strategic Priorities Fund on Clean Air with the UK Met Office and several UK academic and research partners.
- We will quantify the contribution of agricultural emissions to UK air quality and public health impacts as part of a National Institute for Health Research funded study, and identify the role of future changes in emissions and diets on reducing such impacts.



Establishing sustainable nitrogen management globally in support of multiple Sustainable Development Goals

About 80 per cent of manufactured nitrogen compounds, worth about US\$200 billion, are lost to the environment each year, causing damage to the environment and making a large contribution to climate change. UKCEH work on nitrogen emissions and effects has underpinned United Nations conventions and resulted in the adoption of national emission level ceilings. The UKCEH-led European Nitrogen Assessment has inspired other countries by providing an exemplar assessment framework. UKCEH leads the establishment of the International Nitrogen Management System. The resulting insights have formed the basis

for the UN Environment Assembly Resolution (UNEP/EA4/Res14) and for 14 countries to agree the Colombo Declaration, which aims to halve nitrogen waste by 2030 offering a saving of US\$100 billion per annum globally.

"The whole campaign is informed by science. You have managed to mobilise through your networks not only the scientific data but the scientists as a network to support the global launch."

Deputy Executive Director of the UN Environment Programme

Photo: Shutterstock

Climate and land



The challenge

Changes in climate, involving interactions of physical, chemical, and biological processes of the atmosphere, ocean, and land surface, are having widespread impacts on societies and ecosystems.



Our commitment

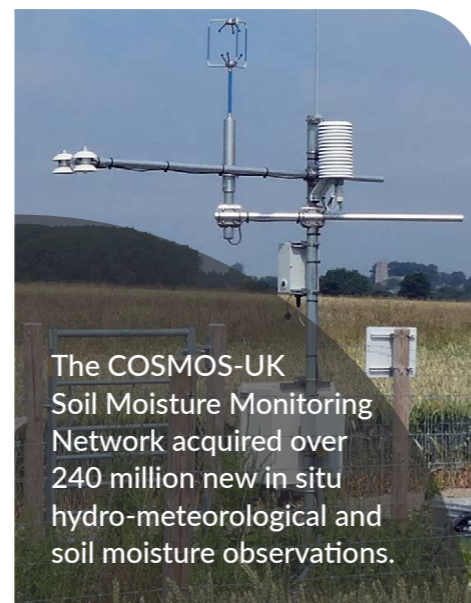
- To improve forecasting of extreme weather events, enabling society to better prepare and respond.
- To advance land surface models, by improving representation of groundwater, irrigation, evaporation, large-scale fires, and the nitrogen cycle.
- To better represent the Arctic system in land surface modelling, given the rapid climate-driven changes in this ecosystem, and understand its role in exacerbating change.

Examples of progress in 2020

The COSMOS-UK Soil Moisture Monitoring Network acquired over 240 million new in situ hydro-meteorological and soil moisture observations. Five years of observational data are now freely available for public download from the Environmental Information Data Centre, advancing weather and climate science with a wide range of applications.

We delivered a major report to the Climate Change Committee on non-linear responses of ecosystems and society to climate change. The report provides evidence of climate risks in the natural environment that do not follow linear patterns of change. It calculates the resulting environmental, societal and economic impacts, identifies key risks, and assesses the extent to which current and

future adaptation strategies could address these risks. This is one of several research reports which underlie the UK Government's 3rd Climate Change Risk Assessment, due to be published in 2022.



The COSMOS-UK Soil Moisture Monitoring Network acquired over 240 million new in situ hydro-meteorological and soil moisture observations.

Photos: UKCEH



Forward look for 2021

- We will assess the vulnerability of water resources in Brazil to climate extremes, including floods and droughts, using a version of the JULES land surface model that has been extended to represent human management of water through dams, reservoirs and other infrastructure.
- Through the ULYSSES project, we will develop a multi-model hydrological seasonal prediction system using state-of-the-art hydrological models at a spatial resolution of 0.1° globally.

Photo: Shutterstock

CASE STUDY

Mitigating the impacts of climate change in West Africa

Over the last 30 years, UKCEH research has produced fundamental new understanding of land surface atmosphere interactions in West Africa which has strengthened understanding of climate change among policymakers. The work has enabled the governments of Burkina Faso and Senegal to reshape policy on agriculture and flooding. It has improved the evidence base of National Adaptation Plans and built capacity within those countries. Estimates of resulting potential savings are in the hundreds of millions of US dollars.

"It was very challenging for our project to get good data on climate change, specifically high quality of projection and impacts for a local level. Now, AMMA's output [a project led by UKCEH] has been used at national level: Senegalese National Adaptation Plan process, climate policies, and sectoral (coastal zone, agriculture, water resources) strategies or plans and at local level, integrated in local development plans."

Climate analytics adaptation expert coordinating PAS-PNA in Senegal

Ecosystem restoration and resilience

The challenge

The UN Decade of Ecosystem Restoration to 2030 recognises that ecosystem degradation undermines the well-being of 3.2 billion people. The resultant loss of species and ecosystem services across the world equates to a 10 per cent annual reduction in gross productivity.



Our commitment

- To focus on solutions that allow species to thrive or re-establish where their numbers have been depleted.
- To model the impact of climate and land-use change on genetic diversity and provide early warning signs of ecosystems in danger of collapse.
- To create accurate habitat maps, land-use projections and decision-support tools to inform landscape-scale restoration for biodiversity net gain, water and soil security, and poverty alleviation.

Examples of progress in 2020

Under the UN Convention on Biological Diversity, nations are required to safeguard their genetic diversity (Aichi Target 13). We co-developed a world-leading approach to achieving this target in practice. The approach was developed for Scotland and won the Nature of Scotland Innovation Award 2020. We expect to adapt the approach for other countries in future.

We developed a new tool for exploring the genome of the Scots pine, more quickly, cheaply and in greater depth than ever before. We established 16 new Genetic Conservation Units for six UK

native tree species - silver birch, ash, Scots pine, rowan and the oaks; and we delivered a pan-European database of trait data (measurements of all parts of the tree including stem cores, and genetic data) for 3,600 trees across 12 tree species.

July saw the start of the Woodland Survey of Great Britain. Despite the pandemic, 18 sites were safely surveyed. This is the third such survey, the baseline having been recorded in 1971, with a repeat in 2002. The results will contribute to the Woodland Trust's report assessing the state of Britain's woodlands and trees.

Photo: Shutterstock



Forward look for 2021

- We will produce national maps showing the potential for restoring all terrestrial Priority Habitats to support the delivery of the Nature Recovery Network, a major commitment in the UK Government's 25 Year Environment Plan.
- We will carry out a major survey of restored habitats across Great Britain, which will inform future restoration priorities.
- We will create a prioritised list of sites suitable for new populations of the rare plant Slender Naiad (*Majas flexilis*) and for translocation of threatened populations.



Informing decision-making by mapping how land is used across the UK

Land Cover Maps (LCM) are maps of the physical coverage of the Earth's surface, derived from satellite data. With National Capability funding, UKCEH has produced Land Cover Maps of Great Britain since 1990, and the LCM family includes products incorporating other data sets such as crops and pesticides. These maps have a wide range of applications across business, policy and infrastructure. Specific case studies across sectors show that LCM has been used to save millions of pounds in costs as well as helping to protect protected species habitats.

"Land Cover Map underpins all the Natural Capital accounting in the UK... because it gives universal, standard coverage across the UK at the appropriate scale. All this allows the UK to make better, more informed decisions for our long-term management of the environment."

**Head of Natural Capital,
Office for National Statistics**

Photo: Loch Druidibeg by Gordon Hatton (CC BY-SA 2.0.)

Flood and drought impacts



The challenge

Floods and droughts have the potential for immense destruction of homes, crops, wildlife and infrastructures. Since 2017, water crises and extreme weather events have been consistently identified in the World Economic Forum's top five global risks by impact.



Our commitment

- To better predict and evaluate the risks and impacts of floods and drought.
- To improve models in support of hydrological research and thereby underpin a range of climate and meteorological projections and forecasts.
- To predict hydrological conditions over near and decadal timescales in order to mitigate and reduce the economic and social impacts of extreme weather events.

Examples of progress in 2020

The Surface Water Flooding Hazard Impact Model, developed by UKCEH, the Health and Safety Laboratory, Environment Agency and Met Office under the Natural Hazards Partnership (NHP), was launched as an operational service across England and Wales by the Flood Forecasting Centre (FFC) in April 2020. The model forecasts hazard, impact and risk information based on predictions of likely rainfall.

The National River Flow Archive released an update to its Peak Flow Dataset (version 9), which provides improved data for flood estimation anywhere in the UK. The dataset provides flood data for 935 river flow gauging stations around the UK, and has been shown to provide net economic benefits of almost £5.4 million per year in terms of

costs saved by environmental consultants and regulators.

UKCEH collaborated with the World Meteorological Organization (WMO) to develop a demonstration portal, trialling integration of diverse hydrological information as part of the HydroSOS project.

"During spring 2020, the Surface Water Flooding Hazard Impact Model was fully implemented operationally at the Flood Forecasting Centre. This was the culmination of many years of hard work and strong collaborative working between UKCEH, the Health & Safety Executive, ourselves and others through the Natural Hazards Partnership."

**Robert Cowling,
Senior Hydrometeorologist,
Flood Forecasting Centre**

Photo: © Simon Butterworth

When implemented, HydroSOS will be the first global operational system to integrate hydrological status assessments and outlooks from and for National Meteorological and Hydrological Services (NMHSs) and will enable them to develop targeted information products for their users including the agricultural, industry, energy and water supply sectors, as well as the general public.

We developed a new drought declarations explorer app in collaboration with the Indian National Institute of Hydrology, as part of the National Capability SUNRISE

programme. The app will allow decision-makers to understand the likely influence of their decisions on drought declarations.

We delivered a new rainfall and flood risk nowcasting tool to ANACIM, the national Meteorological Agency of Senegal, along with training for forecasters. The tool was co-developed with in-country partners and used by forecasters to predict rainfall and flood risk during the September 2020 floods, which affected 17,000 people.



Forward look for 2021

- Through a wide consultation we will identify and prioritise community requirements, providing UKRI and NERC with the evidence they need to develop a full business case for an investment in a transformative Flood and Drought Research Infrastructure (FDRI).
- In partnership with the Open University, we will carry out work for Defra, the Environment Agency and the Welsh Government to review current approaches to communicating drought risk and to develop and test alternative approaches.
- We will deliver Good Practice Guidance for nations to report on progress towards the UNCCD's Strategic Objective 3 "to mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems".
- The new nowcasting system for predicting extreme rainfall over Senegal and flood risk in Dakar (see above) will be trialled through the full 2021 rainy season ahead of intended future operationalisation.



Photo: Shutterstock

Net-zero greenhouse gas emissions

The challenge

Many countries, including the UK, have committed to a net-zero emissions economy. To find solutions to reduce or minimise carbon and other greenhouse gas (GHG) emissions, it is essential that sources are identified and the processes and biogeochemical cycles involved are fully understood.



Our commitment

- To improve the quantification of GHG fluxes across the UK and identify drivers of change.
- To develop and test practical approaches for enhanced soil carbon sequestration.
- To address a range of questions from the role of bio-fuels in mitigating climate change to the risks of large releases of carbon from permafrost, informing policy at national and international scales.

Examples of progress in 2020

We modelled land-use mitigation options and their impact on GHG emissions, agricultural land availability, and timber and bioenergy crop production for the Climate Change Committee (CCC). This modelling underpinned CCC advice to UK Government for the 6th Carbon Budget published in December 2020.

With partners, we published a series of reports that together make up the National Forest Evidence Review for the Welsh Government. This comprehensive review of the scientific evidence relating

to the impacts, benefits and disbenefits of forestry and afforestation in Wales offers expert evidence to inform the National Forest for Wales programme.

As part of the ASSIST National Capability programme, we are investigating options to mitigate agricultural GHG. Through new experimental data and evaluation of past literature, we found compelling evidence that soil nitrous oxide emission can follow diurnal patterns. Our findings have profound implications for agricultural GHG reporting.

Photo: iStock.com

“The National Forest Evidence Review is an astonishing achievement which demonstrated the value of cross-organisational collaboration. The first class evidence displayed in the Evidence Review has been instrumental in the development of the National Forest for Wales strategy.”

Lloyd Harris,
Forestry Evidence Lead,
Welsh Government



Forward look for 2021

- Through observation and modelling we will quantify the benefits of improved hydrological management of agricultural peatlands to realise the maximum GHG mitigation potential.
- We will enable emissions from organic soils to be included in the UK’s GHG inventory, making the UK one of the first countries in the world to report emissions and removals arising from wetland drainage and rewetting.

CASE STUDY

Reducing greenhouse gas emissions from peatlands

UKCEH-led research has shown the UK’s peatlands emit over 20 Mt CO₂-equivalent of GHGs per annum, mostly from agriculturally drained systems, which equates to around 4 per cent of the UK’s entire GHG emissions. Our work on peatlands has contributed to national Kyoto Protocol emissions reporting, the development of emissions mitigation strategies embedded in Defra’s 25-year Environment Plan, and UK government net-zero emissions planning. Our work has underpinned £10s of millions of public and private sector investment in peat restoration, both in the UK and internationally, notably in Indonesia where degraded peatlands are major contributors to global climate change.

“UKCEH’s work has enabled a realistic perspective on peatland emissions and their mitigation potential on the pathway to net-zero.”

Head of Land Use and Bioenergy Science,
Department for Business, Energy and Industrial Strategy,
UK Government

Peatland forest in Parupuk village, Katingan, Central Kalimantan. Photo by Nanang Sujana/CIFOR. (CC BY-NC-ND 2.0)

Soil health



The challenge

Healthy soils and peatlands are critical for life. They produce 95 per cent of our food and are the source of many of our antibiotics. They store more carbon than the world's forests, mitigate climate change, recycle nutrients and waste, and clean our water. Yet they are vulnerable to pollution, unsustainable exploitation and erosion.



Our commitment

- To determine the status, trends and drivers of change in soil health, including change of biodiversity and carbon stocks in British soils and peats.
- To develop a new generation of soil system models that accurately represent biogeochemical cycling and soil function from local to global scales.
- To ensure these new models can predict the impact of land use and climate change on soils at the landscape scale.

Examples of progress in 2020

Despite the pandemic, we were able to continue the UKCEH Countryside Survey soil health monitoring programme, the only soil monitoring programme for Great Britain. The Survey provides an ongoing record of soil health data going back to 1978 and is contributing to the development of new free global soil products such as soilgrids. www.isric.org/explore/soilgrids

In September, the EU Mission Board launched a Proposal for a Soil Health Mission: Caring for Soil is Caring for Life. Professor Bridget Emmett was one of the 15 Mission Board members who made a significant contribution to this Proposal, which recommends that countries adopt national soil monitoring programmes such as UKCEH's Countryside Survey programme.



Photo: Shutterstock

Photo: UKCEH

To facilitate citizen engagement with the issue, UKCEH led the launch of a new online community initiative 'uksoils' to inspire us all to learn more about soil.

<https://uksoils.org>

We contributed to global soil erosion studies that showed that climate change will increase soil erosion by water; moreover, that soil erosion by water will

contribute to 50 per cent of total soil phosphorus depletion. Africa, South America and Eastern Europe were found to be at greatest risk with high costs of chemical fertiliser and inefficient organic phosphorus management.

More than a third of soil's organic matter is made up of dead microbes and the residues of these organisms, called necromass. In work

funded by NERC, a team of soil scientists from UKCEH and collaborators studied soil microbial necromass and its importance in soil nutrient cycling and carbon storage. In 2020, this resulted in the publication of a series of research papers explaining the central role the microbial necromass has in soil carbon cycling.



Forward look for 2021

- We will produce a new web app exploiting UKCEH Countryside Survey soil data to help farmers and landowners benchmark the health of their soil and identify if changes in management are needed.
- Working with the dairy industry, we will assess the current status of carbon storage in grazed grasslands and determine their potential for increased carbon sequestration.
- Building on the launch of the 'uksoils' website, in 2021 we will launch an online community forum to support the exchange of ideas and information and encourage action in support of soil health.

© Natural England/Giles Rickard (CC BY-NC-ND 2.0)

Sustainable agriculture



Our commitment

- To work with the farming industry to test innovative, regenerative agricultural systems that are productive and resilient to future environmental shocks.
- To provide tools and data for planning future land use that optimise benefits to food production while minimising conflicts with provision of other ecosystem services.
- To provide the evidence-base for the design of resilient environmental and management policies and practices, nationally and internationally.

The challenge

Meeting the need for increased food production and nutrition without degrading our environment, is one of the greatest challenges facing society today.

Examples of progress in 2020

As part of the ASSIST National Capability programme, we developed a free web-based environmental planning tool to enable farmers across Great Britain to deliver environmental improvements to their land. The new E-Planner helps farmers to decide which agri-environmental options to introduce and where, and will support the implementation of national schemes to replace the Common Agricultural Policy (CAP).

<https://assist.ceh.ac.uk/e-planner>

We used a rapid modelling approach to quantify the potential effects of Brexit trade deals on the pig and poultry sector for jobs and the environment in Wales. The small

sectors report was circulated throughout Welsh Government and the results were used in joint Brexit planning meetings of the four UK nations.

New satellite-derived Land Cover Maps for 2017, 2018 and 2019 for the UK were launched in July 2020, as well as a change product, which revealed changes in the British landscape over 25 years (1990-2015). Knowing what we have on our land surface is crucial when it comes to planning developments and environmental improvements, and our maps are valuable tools for government agencies, water companies, land managers, NGOs and researchers.

Photo: © Simon Butterworth



Forward look for 2021

- In 2021, we plan to release a new and improved version of the E-Planner for farmers in Great Britain, with enhanced functionality, including the potential for wet grassland creation and the facility for users to access their own rural payment data.
- We will release a complementary E-Surveyor, a mobile app backed by the latest AI, which will enable farmers to easily assess the quality of wildlife habitats on their land and learn more about the biodiversity these habitats support.

Image from ASSIST E-Planner, UKCEH. E-Planner contains third party data, © their respective licensors. Background mapping © OpenStreetMap and contributors

CASE STUDY

Supporting agricultural and environmental policy in Wales

The Welsh Government has enshrined the UN Sustainable Development Goals into policies to support a more sustainable, resilient and ethical future for Wales. To support the evaluation of these policies, the Welsh Government commissioned UKCEH to implement a series of environmental monitoring and modelling research activities. The outputs of this work have led to policy developments including support for EU Exit preparations and an evidence base for the new Welsh Sustainable Farm Scheme.

“The UKCEH-led GMEP and ERAMMP projects represent a significant and central evidence programme for Welsh Government. The return on this investment is a rich and highly valued evidence base. It is robust, wide reaching and insightful.”

Head of Environmental Modelling and Monitoring, EU Exit and Strategy Division, Department of Environment and Rural Affairs, Welsh Government



UKCEH

Water quality and resources



Our commitment

- To advance our understanding of catchments, rivers, wetlands and lakes by integrating technical innovations for near real-time large-scale monitoring and reporting.
- To develop our Hydrological Summary and Outlook through model improvement, providing information for improved water management across all sectors.
- To support the restoration of over-exploited freshwater resources and ecosystems, underpinning social and economic development for local communities.

The challenge

Water is a resource on which all life depends. Yet, across the planet, 30 per cent of people do not have access to reliable supplies of clean water. Efficient management of water is critical to addressing the competing demands of industry, agriculture and energy production while sustaining flows and quality for natural ecosystems.

Examples of progress in 2020

In March, we launched the UK Water Resources Portal – an interactive web portal which provides the most up-to-date available data on river flows, rainfall, soil moisture and groundwater levels, for users to interrogate via an interactive map. The portal is designed for use by government agencies, water companies, farmers, river trusts, local interest groups, local authorities, and researchers to help predict imminent floods and droughts and compare them to similar events over the past 50 years.

We developed The Freshwater Data Explorer, a portal created in collaboration with Earthwatch. Citizens can interrogate data via an interactive map and then work with the Environment Agency and with one another to protect and improve the environment. The portal contains data about pressures on the environment as well as the way wildlife is responding to those pressures.

Pioneering research led by the UKECH devised the first global lake temperature classification system, which categorises lakes

Photo: Shutterstock

into one of nine thermal regions. Combining satellite data of more than 700 lakes with climate change models, our scientists predict that by the year 2100, for the most extreme climate change scenario, average lake temperature will be around four degrees Celsius warmer. Even small changes in temperature can have a significant impact on aquatic wildlife, including important fish species.

Through the FREEDOM-BCCR project, our scientists have worked with water industry partners to determine the threats posed to the quality and treatability of water sources from climate change, and the options open to the industry to adapt to or mitigate these threats, through catchment, reservoir or water treatment management.

Our data analysts integrated data on water quality, weather and algal blooms to determine the key environmental thresholds that trigger algal blooms in the Thames. This enables us to predict the impact of various inter-basin water transfer options being considered by Thames Water, supporting future water security for London and the south east of England.



Forward look for 2021

- We will assess the technical and commercial feasibility of the Floating Weed Manager – a satellite-based service for monitoring invasive floating aquatic plants – for the European Space Agency.
- We will develop a Climate Service that will help the water sector manage and plan the UK's water resources to be resilient to drought under climate change, drawing on a high-quality enhanced dataset on future river flows, groundwater levels and recharge.

Algal bloom. Photo: UKCEH

National capability

National Capability programmes

National Capability programmes rely on UKCEH's fundamental capabilities in water, land and air science. These include measurement, monitoring and observation, the generation, management and dissemination of large-scale, long-term data sets, and expertise in data analytics and modelling. These capabilities in turn support researchers, governments, business and society. Many of the achievements highlighted in this report were realised through National Capability funding under the following programmes:



In our role as a strategic delivery partner for the NERC, part of UKRI, UKCEH provides National Capability for freshwater, terrestrial and near atmosphere science. This enables the UK to stay at the forefront of environmental science globally and to deliver national strategic research. Through it, we provide the knowledge, data and insights that researchers, governments, and businesses need to create a productive, resilient and healthy environment.

Environmental data

Our National Capability generates publicly available environmental data sets, software models and decision-support tools, enabling world-class environmental research, resource management and policy development. It underpins and enables the wider community of environmental scientists to carry out research that addresses a range of challenges that improve human and environment health, mitigate climate change and support economic development. These are science-led initiatives designed to improve our quality of life while living within Earth's limits. By the end of 2020, we had made over 1,000 data sets freely available.

The Environmental Information Data Centre

The Environmental Information Data Centre (EIDC) is one of NERC's network of environmental data centres. Delivered by UKCEH, it is a focal point for the terrestrial and freshwater sciences community, enabling the UK's researchers to make their data available and safeguard it for future application. In 2020, EIDC was certified as a trusted repository by CoreTrustSeal, giving researchers the assurance that their research results will be managed, curated, and archived in such a way to preserve the initial investment in collecting them.



Our people

Postgraduate & early career research

Over the past year, more than 100 of our scientists have been involved in supervising 170 postgraduate researchers, who benefit from access to our laboratory facilities, field sites and data centres. Postgraduate training and development has been carried out in partnership with 16 NERC-funded Doctoral Training Partnerships and Centres for Doctoral Training.

UKCEH has also supported 61 Research Associates in specialist posts where around 10 per cent of their time is dedicated to individual professional and career development. Looking forward, we are one of the institutes that will be involved in a new ecotoxicology PhD programme.

Investment in people & skills

In 2021, we will invest in new science posts and skills to help meet our strategic goals and support our impact, including in data science, modelling, air pollution and biological risks for human health, molecular expertise including bioinformatics, quantitative ecology, Earth observation expertise, analytical chemistry with specialisms in organic analysis, and project management. We will also create exciting new opportunities for skilled engineers, mathematicians, statisticians and physicists as we seek to expand our existing technical capability in environmental data collection and analysis.

Environmental sustainability

UKCEH sets high organisational standards to reduce direct environmental impacts associated with our activities which is underpinned by our ISO14001:2015 certified Environmental Management System. In 2020, UKCEH renewed its Environmental Policy and set strategic objectives to ensure our future planning and operations will support biodiversity, enhance ecosystem services, prevent pollution, procure sustainably and ultimately achieve net-zero by 2040. For 2021, we will further develop and implement the supporting action plans to ensure our estate and operations achieve these objectives.

Investors in People

UKCEH participates in the Investors in People programme as part of our commitment to excellence in people management. In 2020, we were accredited with the Investors in People Silver Award, in recognition of the priority we give to leading, supporting and developing our people. The feedback we received will inform improvements to our working culture for the future.



Equality, diversity and inclusivity

In 2020, UKCEH published a Black Lives Matter response statement, provided mandatory EDI e-learning to all staff and students, and carried out an EDI consultation through our staff representative panel to inform our new EDI action plan. We attained Disability Confident Employer status renewal and added EDI questions to our Investors in People staff survey and annual postgraduate student survey.



UK Centre for Ecology & Hydrology

BANGOR

UK Centre for Ecology & Hydrology
Environment Centre Wales
Deiniol Road
Bangor
Gwynedd
LL57 2UW
United Kingdom
T: +44 (0)1248 374500

LANCASTER

UK Centre for Ecology & Hydrology
Lancaster Environment Centre
Library Avenue
Bailrigg
Lancaster
LA1 4AP
United Kingdom
T: +44 (0)1524 595800

EDINBURGH

UK Centre for Ecology & Hydrology
Bush Estate
Penicuik
Midlothian
EH26 0QB
United Kingdom
T: +44 (0)131 4454343

WALLINGFORD

UK Centre for Ecology & Hydrology
Maclean Building
Benson Lane
Crowmarsh Gifford
Wallingford
Oxfordshire
OX10 8BB
United Kingdom
T: +44 (0)1491 838800

enquiries@ceh.ac.uk

www.ceh.ac.uk

@UK_CEH

The UK Centre for Ecology & Hydrology (UKCEH) is a registered Charity in England & Wales (number 1185618) and in Scotland (number SC049849), and a registered Company Limited by Guarantee in England & Wales (number 11314957).

The Centre owns a registered trading subsidiary, the UK Centre for Ecology & Hydrology Enterprise, a Company Limited by Shares (number 12251749), which supports our charitable purpose.

The registered office of the UK Centre for Ecology & Hydrology is at the Maclean Building, Benson Lane, Crowmarsh Gifford, Wallingford, Oxfordshire, OX10 8BB, UK.

