UKCEH

Science for net zero and beyond

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Increasing carbon sequestration

Reaching the UK-legally binding Net Zero GHG emissions target by 2050 requires emission sources to be balanced by sinks. The UK Centre for Ecology & Hydrology's research not only tackles the decarbonisation challenge, but also explores co-benefits for habitats and species.

The decarbonisation challenge

In the Seventh Carbon Budget, the Climate Change Committee advises that by 2040, UK emissions should be cut to 13% of their 1990 levels to stay on track for net zero by 2050. Land use changes, including peatland restoration and woodland creation, are key to make this happen. That's where we come in!

The UK Centre for Ecology & Hydrology (UKCEH) monitors and models environmental change across land, water and air, which supports the UK's journey to net zero. Managing a UK-wide network of flux towers that track carbon and greenhouse gas movements year-round, UKCEH locates emission hotspots and carbon sinks. This data informs practical, science-based approaches to decarbonisation across sectors.

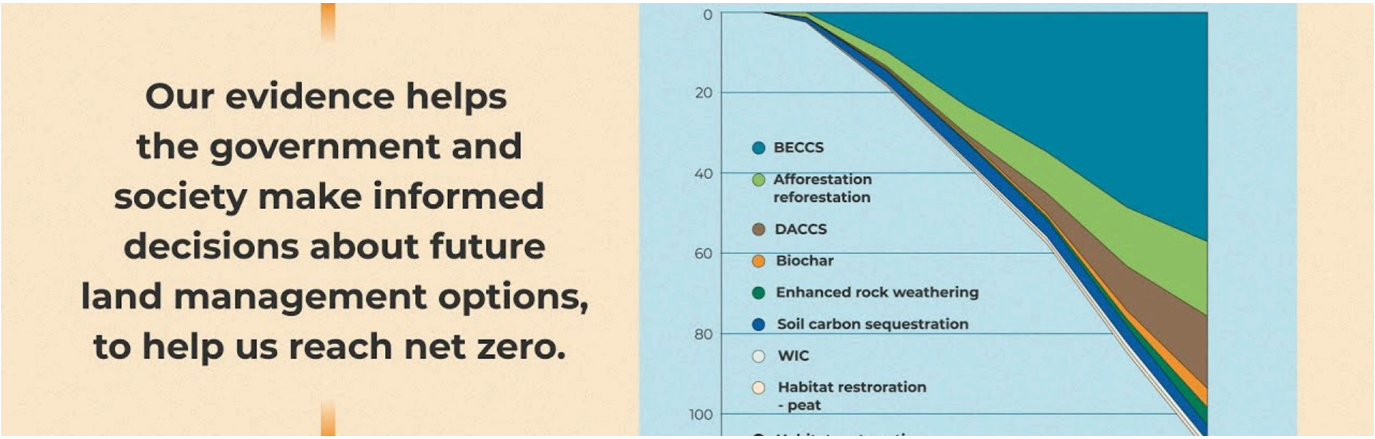
Let's explore a few ways UKCEH's research is developed and applied to overcome the decarbonisation challenge.

Peatland nitrogen pollution experiment in Edinburgh. Photos: Jo Hanley

The importance of peatlands

Peatlands are waterlogged ecosystems where slow decomposition allows organic matter to accumulate over millennia. They help capture carbon dioxide and support plant species, with the UK home to some of the world's largest areas of rare blanket bog. However, around 80% of UK peatlands have been altered by human activities such as drainage, burning, afforestation, grazing, and pollution, often to make the land suitable for crops or other uses. This has turned them into carbon dioxide emission sources.

Peatland restoration



UKCEH led the development of a national peatland greenhouse gas (GHG) flux monitoring network in the UK, which has enabled greater understanding of the interacting effects of climate change, land-use change and GHG exchange. We also manage the land-use component of the GHG emissions inventory for the UK, which is reported to the United Nations. UKCEH elaborated methods to include peatland in the national inventory and showed that they generate around 4% of the UK's total GHG emissions. Our research continues to support the improvement of national emissions reporting.

We increasingly work with government, farmers, NGOs and the private sector to develop ways to mitigate these emissions, particularly in emissions hotspots in lowland agricultural areas that are important to the UK's economy and food security. Through the NERC GHG Removal Demonstrator programme, we also create new forms of peatland management to harness their unique potential to act as efficient and permanent carbon sinks.

Technology development

All Woodland Carbon and Peatland Code sites must record the amount of carbon dioxide they remove from or stop entering the atmosphere. Yet, current measurement, reporting and verification (MRV) solutions aren't easily accessible or affordable, particularly for smaller projects with limited funds. UKCEH scientists are therefore researching potential solutions to open up the schemes to new entrants.

As part of the current CivTech Challenge, we're exploring how land-based measurement instruments, such as in-situ sensors, can improve carbon MRV from woodland carbon and peatland restoration sites. The work combines:

- the development of lower-cost alternatives to expensive commercial sensors,
- more efficient sensor deployment to reduce overall MRV costs,
- integration with Earth Observation to scale up observations from point to project scale.

Urban green spaces

At UKCEH, we research woodlands and green spaces, including those in urban areas.

Our scientists use a range of tools and models in collaboration with partners to assess where best to implement these spaces in cities.

Our research has highlighted the many benefits green spaces provide. They store carbon, reduce air pollution, lower noise and temperatures, support biodiversity, enhance people's wellbeing, and more.

Read more in paper >

Spotlight:
City Explorer Toolkit

The interactive, web-based City Explorer Toolkit is designed to understand where best to create urban green and blue spaces like parks and ponds, to ensure that cooling, improved air quality and noise reduction benefits are received by the people who need them most.

The tool uses models and spatial data to calculate the benefits of different green infrastructure and nature-based solutions to tackle challenges in cities. It also uses population and social data to work out which groups of people will benefit most from a particular option.

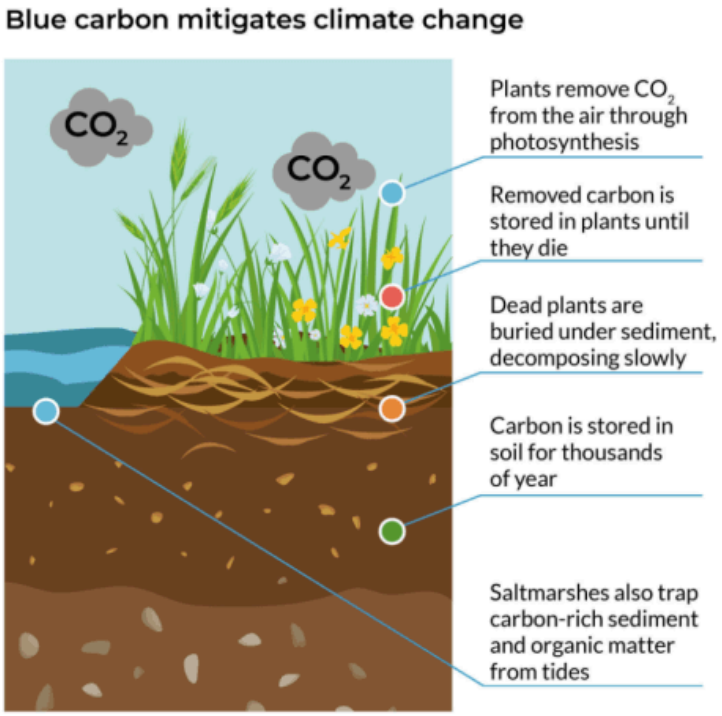
We could do even more...

Our scientists are working on a carbon stocks model that could be integrated into the Toolkit to further support cities in achieving their net zero goals. With additional funding, this new feature could be released sooner. To find out more or support our initiative, please contact us.

Exploring other carbon sinks

Our scientists also research the restoration of coastal habitats in the context of net zero targets and connected benefits to enhance biodiversity and remediate nutrient pollution, amongst others. They have explored the potential for salt marsh restoration, with past findings and current research paving the way for habitat protection, carbon storage and adaptation to climate change.

Saltmarshes collect and store carbon-rich sediment, with plants above-ground photosynthesising and below-ground microbes breaking down organic matter.



UKCEH scientists have been working on The WWF Saltmarsh Research Platform, which will be the first site to measure the full carbon balance of saltmarsh habitat. This will provide key carbon flux data needed for future incorporation into the UK's Net Zero strategy and the UK GHG inventory.

The site will be added to the existing network of GHG flux measurements and will benefit from UKCEH in-house knowledge, experience, and standards previously applied to peatland and agricultural systems.

More about Blue Carbon and Saltmarsh research >

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Scaling up low-carbon and renewable energy

The journey to net zero and beyond requires a significant increase in the production of low-carbon and renewable energy. But how can we ensure that this transition doesn't have unintended consequences? That's part of what our science informs.

Bioenergy
Increasing sustainable biomass production

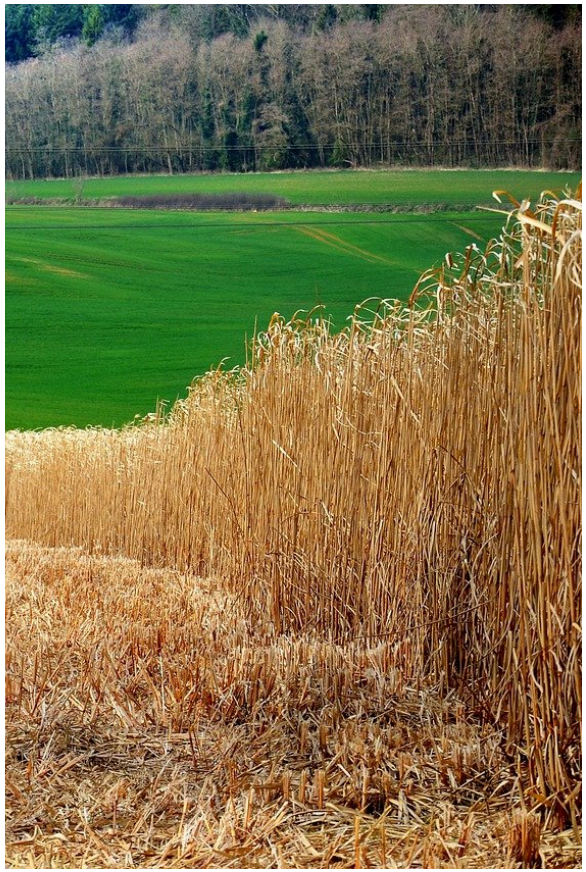
To meet the UK's net zero targets, the Climate Change Committee recommends a major expansion of land dedicated to biomass production in the UK by 2050.

Biomass crops, typically fast-growing herbaceous or woody plants such as willow and miscanthus, can be used for a range of purposes including heat, electricity and bio-based products.

If biomass electricity is combined with carbon capture and storage technology in future then this could deliver negative emissions, reducing atmospheric carbon dioxide. However, there are concerns about the sustainability of biomass production and the amount of land that will be needed to deliver this.

UKCEH leads Biomass Connect, a UK-wide, government-funded programme to showcase best practice and drive innovation in sustainable biomass production. Biomass Connect has created eight biomass demonstration sites across the four nations of the UK which support research, stakeholder engagement, and offer real-world insights into biomass crop management.

This contributes evidence to support agricultural and energy policy, de-risks adoption of biomass crops for land managers and will support the required expansion of the UK's sustainable biomass sector.



Renewable energy production
Understanding its impact on water

UKCEH scientists bring expertise in water quality, ecosystem understanding, the development and implementation of monitoring techniques, and data analysis to assess the potential impacts and unintended consequences of these renewable energy solutions for water quantity and quality, and biodiversity.

Solar energy: Impact of floatovoltaics on reservoir water

UKCEH, in partnership with Lancaster University and the water industry, is studying the effects of floating solar panels, or floatovoltaics, on reservoir ecosystems.

Through in situ monitoring and lab analysis, we're generating evidence to help companies minimise water quality risks while tackling climate change mitigation and achieving net zero targets.

Floating solar panels on Langthwaite Reservoir. Photo: Giles Exley

Geothermal energy: Informing the planning and installation of water source heat pumps

Water source heat pumps (WSHPs) remain underused in the UK despite success abroad.

Building on other countries' approaches, UKCEH scientists have enhanced the data available for GB lakes in the UK Lakes database to estimate the amount of heat energy in lakes and reservoirs and predict potential ecological impacts from alterations in water temperature.

Our research can inform the planning and installation of WSHPs to ensure their effectiveness and low ecological impact.

Green hydrogen production:
The case for more research on its impact on water

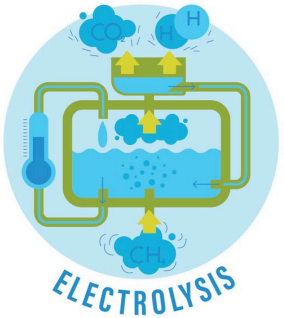
Our scientists have strong expertise in modelling how human activities affect river flow and water quality at various scales, both in the UK and around the world.

We use a range of models to explore changes in the hydrological cycle, including how future developments could impact water availability. We have experience in process representation, model implementation, and scenario development for future artificial influences in the UK.

When it comes to green hydrogen production, UKCEH can:

- **Estimate how much water is available** for hydrogen production at a regional level.
- **Model how hydrogen production could affect river flows** now and in the future at the catchment scale.
- **Analyse those impacts seasonally and annually** using a range of driving data scenarios, such as different climate and land use change, or a set of different hydrological models.

Our expertise also covers modelling water quality, including the effects of pollution from various sources under changing environmental and social conditions.



Renewable energy production
Understanding its impact on biodiversity

As the UK works towards increasing offshore wind capacity to 50 gigawatts by 2030, understanding and managing the impact on biodiversity is essential to achieving net zero in harmony with nature.

Our scientists apply long-term data, monitoring tools using GPS tracking, and advanced modelling to assess how renewable energy infrastructure may affect biodiversity.

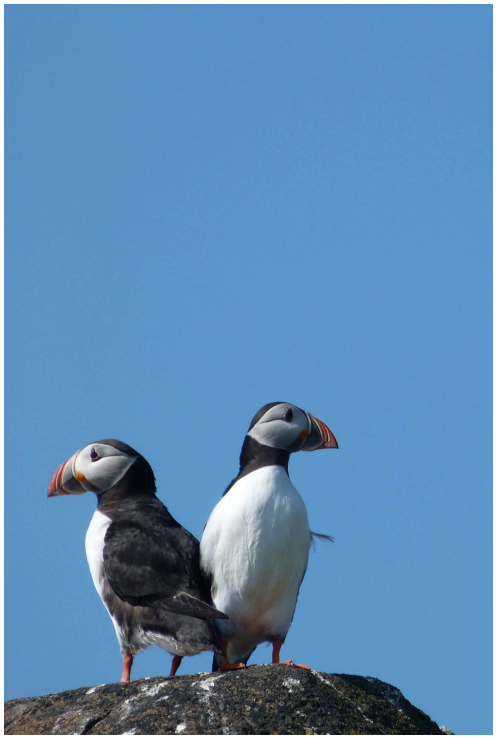
Black-legged kittiwakes.

Offshore wind energy and seabird conservation

The UKCEH-led ECOWINGS project is developing evidence-based tools to support the sustainable growth of offshore wind energy in the UK North Sea.

By studying seabird species like puffins and kittiwakes, the project assesses ecological impacts, tests strategic compensation measures and models solutions that balance renewable energy targets with long-term biodiversity protection.

Our research aims to produce solutions to protect and increase populations.



Atlantic puffins on the Isle of May. Photos: Mark Newell

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Facilitating the adoption of regenerative agriculture

UKCEH researches and shares new farming practices and develops cutting-edge tools to support targets. And our scientists don’t stop there: they go beyond net zero to explore co-benefits for biodiversity and water, soil and air quality.

Researching new farming practices

Agriculture is undoubtedly one of the industries that will require a significant reduction in emissions to deliver the Seventh Carbon Budget.

UKCEH research is well underway to identify land use changes that contribute to carbon sequestration or GHG emission reduction whilst understanding impacts and opportunities for other habitats.

Experiment: Enhanced rock weathering on upland grasslands

UKCEH scientists are trialling an innovative method to mitigate climate change and boost crop yields in mid-Wales. Known as Enhanced Rock Weathering (ERW), this technique involves adding finely ground basalt rock to farmland, a process that has potential to rapidly absorb and lock away carbon dioxide from the atmosphere.

At Pumlumon/Plynlimon in Powys, researchers have applied basalt dust (particles under 2mm) to three hectares of upland grassland annually for three years.

Detailed monitoring of soil GHG emissions of CO2 and CH4; biodiversity of plants, soils and surrounding streams; grassland productivity and soil and stream water chemistry in on-going. Time-lapse cameras even monitor sheep grazing to assess forage changes.

UKCEH has a history of research in the Pumlumon/Plynlimon catchment, and this trial is supported by historic long-term detailed monitoring.

Early signs of change are emerging, but a longer-term study is needed to distinguish rock dust effects from natural variability. A high-resolution dataset of GHG fluxes is now helping researchers model ecosystem responses in detail. To learn more or support the future of this pioneering research, please contact us.

Exploring the potential of biochar

Biochar is a charcoal-like material produced by heating organic matter, such as wood, in a low-oxygen environment in a process called pyrolysis. This process results in a carbon-rich product that can be buried in soil to capture carbon. Beyond carbon capture, biochar can offer additional benefits, including increased crop productivity and reduced soil greenhouse gas emissions.

The UKCEH engages with UKRI, NGOs, government bodies, and the private sector to explore the benefits and trade-offs of biochar use. Our projects include assessing the potential of biochar to mitigate N_2O emissions and other co-benefits in arable cropland, investigating the permanence of biochar in peatlands, and testing its soil health benefits in smallholder farming in Southeast Asia. Additionally, UKCEH is working with the private sector to design robust measurement, reporting, and verification protocols for developing reliable biochar carbon credits.

Agroforestry: Improving the management of hedgerows

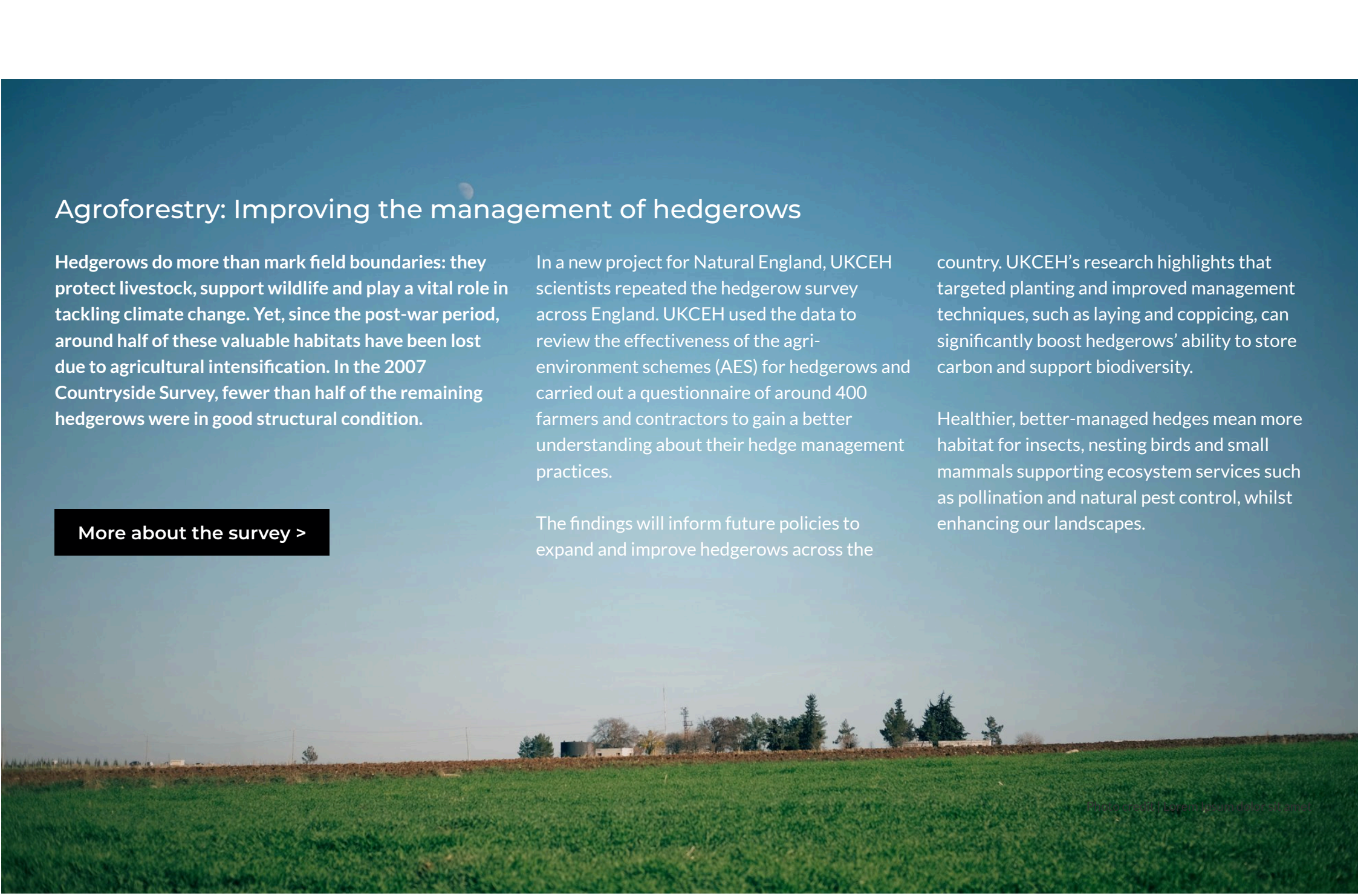
Hedgerows do more than mark field boundaries: they protect livestock, support wildlife and play a vital role in tackling climate change. Yet, since the post-war period, around half of these valuable habitats have been lost due to agricultural intensification. In the 2007 Countryside Survey, fewer than half of the remaining hedgerows were in good structural condition.

More about the survey >

In a new project for Natural England, UKCEH scientists repeated the hedgerow survey across England. UKCEH used the data to review the effectiveness of the agri-environment schemes (AES) for hedgerows and carried out a questionnaire of around 400 farmers and contractors to gain a better understanding about their hedge management practices.

The findings will inform future policies to expand and improve hedgerows across the country. UKCEH's research highlights that targeted planting and improved management techniques, such as laying and coppicing, can significantly boost hedgerows' ability to store carbon and support biodiversity.

Healthier, better-managed hedges mean more habitat for insects, nesting birds and small mammals supporting ecosystem services such as pollination and natural pest control, whilst enhancing our landscapes.



Decision-making support tools

UKCEH scientists work to translate their research into tools that support environmental decision making on the ground, by giving land managers relevant, easy-to-access information on key aspects of their local environment. Examples of these tools include:

Identifying opportunities for ecosystem protection and restoration

UKCEH has created a free, easy-to-use tool designed to help identify areas with potential for environmental improvement within a field, farm or landscape.

E-Planner combines satellite and aerial imagery with national environmental data to evaluate how suitable different locations are for achieving a range of environmental outcomes, including:

- Water resource protection
- Woodland creation
- Seed-rich bird habitat
- Flower-rich pollinator habitats
- Wet grassland restoration

Web-based solutions for habitat monitoring

UKCEH combines scientific expertise and extensive data to assess species populations and explore the links between biodiversity and ecosystem resilience.

A vital step to doing this is to monitor the success of conservation and restoration actions, and we work to support citizen scientists and land managers to collect and explore their own species data.

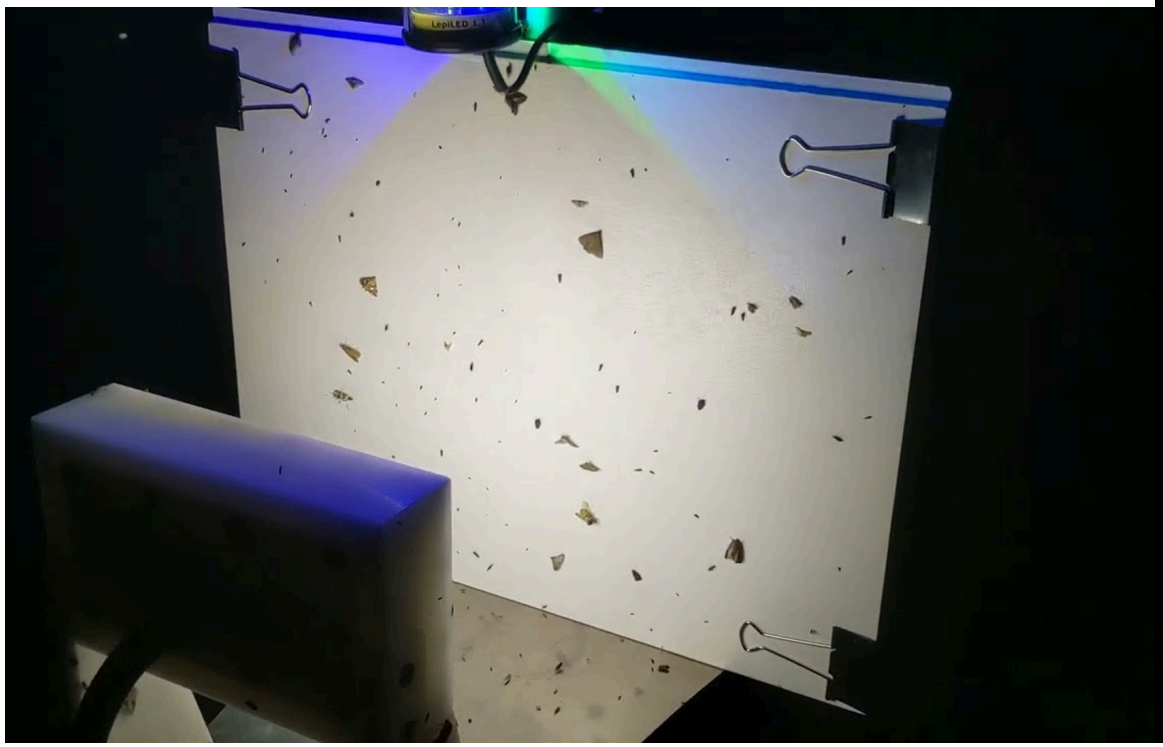
Our E-Surveyor mobile app supports farmers and land managers in assessing the quality of their habitats. With AI-powered plant identification, users can discover which insects and pollinators are linked to specific plants, carry out structured habitat surveys and compare their findings with established checklists.

The app can also be used to:

- Establish natural capital baselines;
- Set and monitor performance against targets.

Advanced technologies for environmental monitoring

UKCEH scientists have developed advanced research equipment which can be used for monitoring and reporting on nature-related metrics. Here are a couple of examples.



Automated Monitoring of Insects (AMI)

Understanding trends in species and their drivers is key to monitoring change in biodiversity, its underlying causes, and how these factors vary across space and time. Effective species monitoring requires robust methods that minimise bias and maximise the quantity and quality of data collected.

Combining robust lighting for attracting insects with high resolution cameras, the UKCEH AMI System offers practical and cost-effective solutions for standardised monitoring.

The AMI System combines computer vision and an autonomous imaging system to capture images of moths in the field, locate them in the image and classify them to species. A second generation device is now undergoing field trials which will significantly reduce costs and increase ease-of-use, likely to be launched in 2026.

More about the AMI >

Air quality sampler systems

UKCEH air sampler systems can be used to monitor atmospheric pollutants including ammonia (NH3), sulphur dioxide (SO2), nitric acid (HNO3) and the chemical components in particulate matter (PM) and fog.

The UKCEH ALPHA® sampler measures ammonia (NH3) concentrations in air. It has been used for over 25 years in the UK Defra National Ammonia Monitoring Network and used globally in research understanding spatial and long term changes in NH3 concentrations allowing the impacts on ecosystems to be understood.

The UKCEH DELTA® system is a low-volume denuder air sampling method for long-term sampling of gas phase NH3, HNO3, HCl, SO2 and particulate matter (NH4+, NO3-, SO42-, Cl-, Na+, Ca2+, Mg2+).

UKCEH has recently developed a Conditional Time Averaged Gradient (CoTAG) product for quantifying pollution deposition fluxes at low time resolution, a conditional fog sampler to separate fog/cloud chemicals and rain chemical deposition and a lab-based green-tech ammonium analyser. We are continually innovating to address environmental measurement needs for both research and policy.

More about the systems >

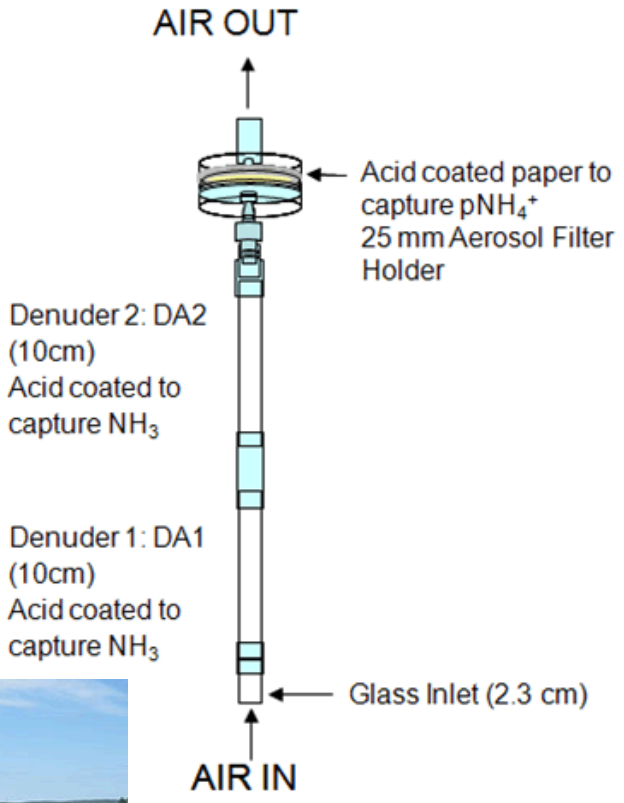


Image above shows example sample train configuration for ammonia/ammonium measurements.

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Unlocking investment in nature

Achieving a green transition calls for a fundamental shift that places climate and nature at the heart of decision-making across society. Across all sectors, efforts are underway to understand environmental impacts and reimagine systems. UKCEH provides impartial scientific evidence and insight to guide this complex transformation, whilst balancing nature and carbon neutrality.

Development of codes for nature markets

Nature markets provide a mechanism to access new funding streams by valuing ecosystem services such as carbon sequestration, water quality improvement, biodiversity enhancement, and flood risk reduction. UKCEH scientists are well positioned to identify opportunities for nature restoration that can deliver these services and inform the development of marketable environmental units.

Our scientists have contributed to and led the development of codes which provide the scientific rigour needed to build trust in nature markets. These codes provide a robust framework for market operations, supporting measuring, selling, buying and monitoring ecosystem services.

Lake sampling in Windermere. Photo: Paul Adams

Leading the development of the UK Saltmarsh Code

UKCEH is leading a cross-sector consortium to develop and launch a UK Saltmarsh Code, similar to the existing Peatland and Woodland Codes. This will support a rigorous and scientifically-based voluntary certification standard for saltmarsh carbon to be marketed and traded by UK companies; and will assure buyers of carbon credits that the benefits being sold are real, quantifiable, additional and permanent.

Ongoing development of the UK Saltmarsh Carbon Code will pave the way for increased funding for saltmarsh restoration which will contribute towards the UK's net zero goals.

More about the Saltmarsh code >

A saltmarsh North East of Caernarfon Airport. Photo: Daniel Hauck

Peatland nitrogen pollution experiment in Edinburgh. Photos: Jo Hanley

Updating and expanding the UK Peatland Code

UKCEH scientists led a major evidence review and developed new methods to update and expand the UK Peatland Code. The Peatland Code, supported by Defra and operated by the IUCN Peatland Programme, is the primary mechanism for private funding and generation of carbon credits for UK peat restoration.

The new method uses data from UKCEH's flux tower network and elsewhere to update estimates of greenhouse gas emissions and removals for different peatland categories. It also extends the Peatland Code to cover lowland fen peats for the first time. The new method enables project developers to estimate emissions reductions that could be achieved by raising water levels, based on data analysis published in Nature in 2021.

UKCEH

The UK Centre for Ecology & Hydrology is a world-leading independent research institute, carrying out excellent environmental science with impact.

Let's talk!

Contact us at partnerships@ceh.ac.uk