UKCEH

Essential science for sustainable cities

Reimagining urban spaces

As cities around the world continue to grow, they are also encountering new and evolving challenges. Urban populations are increasingly experiencing the effects of climate-related events such as heat waves and flooding, along with ongoing concerns like air pollution. These issues highlight important considerations for human health, the environment and the economy.

At the UK Centre for Ecology & Hydrology, we're helping to reimagine urban spaces, making them healthier, more sustainable, and more liveable for all.

Let’s explore a few ways our science could support you.

Creating greener cities

Green and blue spaces - parks, trees, rivers, lakes - are vital to the fabric of city life. They cool our streets during heatwaves, reduce air pollution, and provide much-needed peace and quiet in a world full of noise. More than just pretty landscapes, these spaces have real, measurable benefits for both people and the environment.

City planners are being urged to integrate more of these green and blue spaces into urban designs. In the UK, for example, the Green Infrastructure Framework aims to increase urban green cover to 40% in residential areas.

To help planners achieve these goals, we are creating new tools and models to better understand what the benefits are, make a case for investment in green and blue spaces, and find the best places to create or enhance these in our cities.

City Explorer Toolkit

The City Explorer Toolkit is an interactive web-based tool, which helps planners to understand where best to create urban green and blue spaces to ensure that 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 such as heatwaves, air pollution and flood risk. It also uses population and social data to work out which groups of people will benefit most from a particular option.

The toolkit can be used to:

- Explore population, social and pressure datasets to see where the need is greatest.
- Run models that calculate the benefits of current green and blue space.
- View maps of 'potential' for users to plan the best locations for new green and blue space.
- Visualise and download summary information.

The toolkit can help design better outcomes for young people in cities. Read more.

Research shows nature in cities is vital for improved health and climate resilience. Read more.

We have toolkits running for Portsmouth in the UK, and Aarhus in Denmark, and have applied the models in cities across the globe, helping planners make informed decisions that promote a more sustainable future. If your city is interested in using the City Explorer Toolkit, please get in touch.

We could do even more...

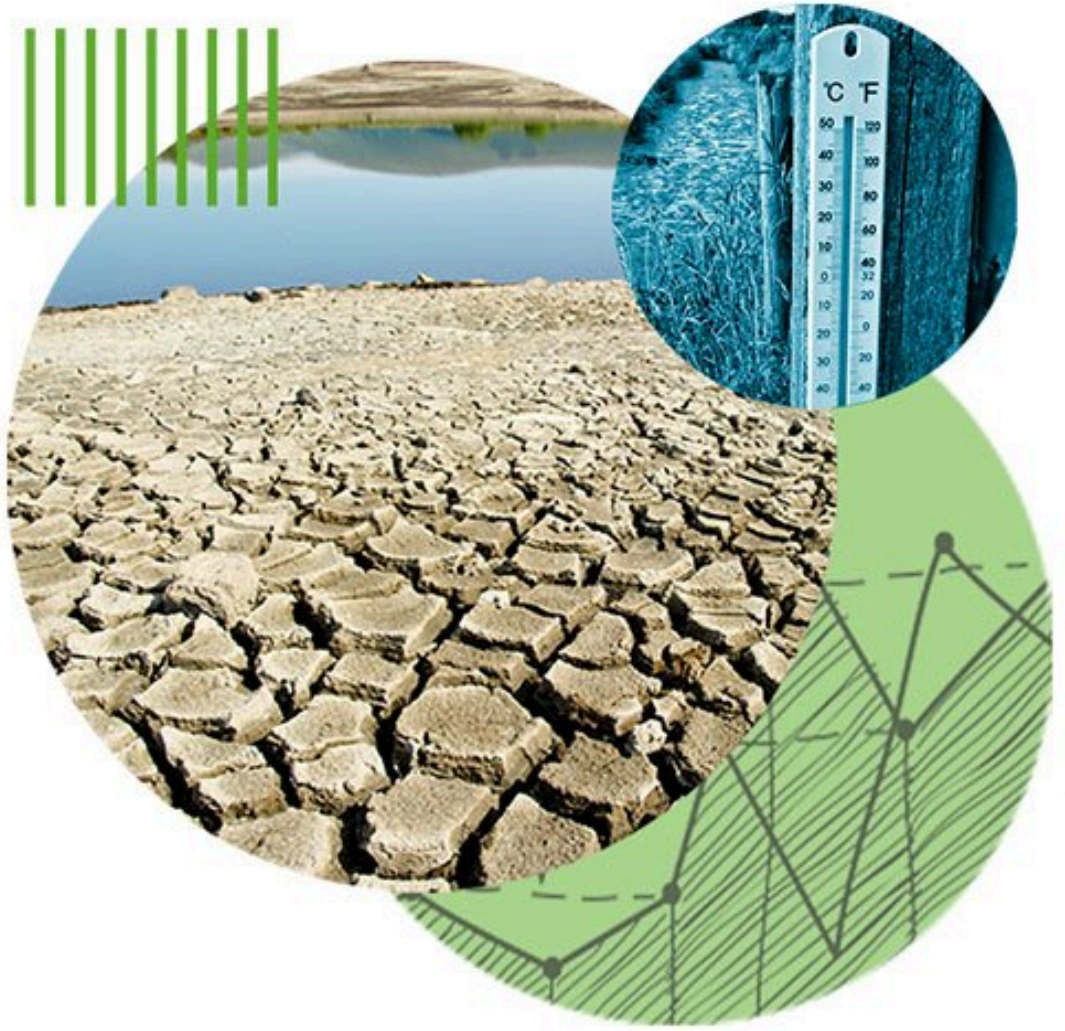
Our scientists are working on a carbon stocks model that could be integrated into the Toolkit to further support cities in achieving their net zero goals. With additional funding, this new feature could be released sooner. To find out more or support our initiative, please contact us.

UKCEH

Measuring urban cooling

Heat-related deaths in the UK are projected to more than double by the 2050s due to climate change. Extreme outdoor temperatures can also dramatically reduce worker productivity, with associated economic losses in the billions.

Green and blue features in cities such as parks, lakes, ponds and rivers can reduce temperatures and provide shade, reducing these effects. Our models enable planners and others to quantify the cooling benefit of these features, using a range of city-wide and street level approaches.

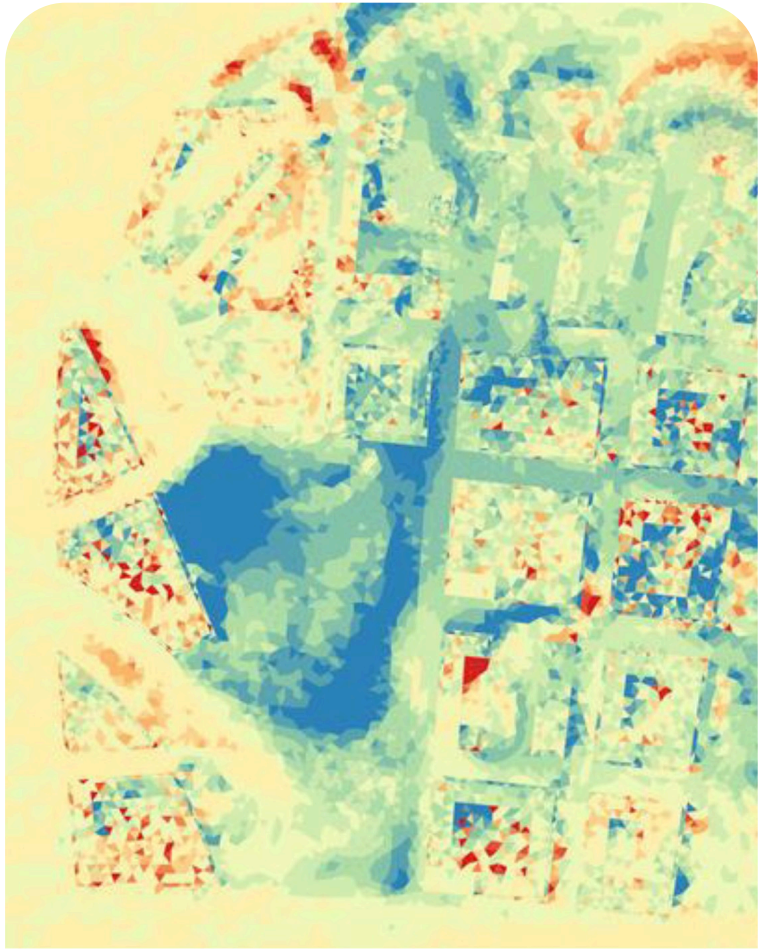


Modelling cooling benefits from urban greenspace

We use modelling tools to estimate the amount of cooling provided by urban trees, grass and water, and its economic value. We have approaches that can be applied at city-scale, and can also calculate more local benefits from parks, gardens and water bodies.

CASE STUDY:
Fine scale modelling of cooling potential in Prague

Our scientists worked with the consultancy Ecoten to model the local benefits (air temperature, thermal comfort) at a city-block scale using Computation Fluid Dynamics modelling, looking at Prague in Czechia. This shows that local-scale cooling effects are important but can be influenced by air flows.



The screenshot shows cooler air temperatures (blue colours) due to wooded park located centre, lower-left of image

Natural capital accounting for urban cooling

Assessing our ecosystem services and natural capital allows us to capture the importance of nature's assets and the benefits that flow from them. This gives the natural environment a place in decision-making and allows more sustainable management choices for the future. UKCEH develops natural capital and ecosystem services modelling tools which allow us to calculate the impacts of urban cooling by vegetation.

We developed the methodology that underpins the Office for National Statistics (ONS) urban accounts for cooling by vegetation. This estimates the reduction in hot-day temperatures for 11 UK City Regions, due to cooling by urban greenspace. This was worth £243m in avoided productivity losses for 2017.

Click here for ONS urban accounts for 2019

Predicting, preventing and mitigating floods

Urban areas are expanding, and so is the flood risk they face through a combination of increased impervious cover and removal of natural soil drainage and local water storage.

Our research to understand these effects and the role of nature-based solutions is essential for future proofing development – particularly with the threat of increased storm rainfall under climate change.

We have the expertise and tools to help to predict, prevent and mitigate floods in an urban environment, with work in the UK, Europe and globally.

Natural flood management

UKCEH's expertise in monitoring and modelling hydrological processes is being applied to natural flood management to understand the effectiveness of both existing and planned interventions in urban areas. We are able to help you to apply this knowledge to assess and optimise the potential impact of interventions.

CASE STUDY: **Nature-based solutions for flood mitigation in the UK**

Our scientists have carried out detailed and long-term monitoring of urban rainfall, river flows and water quality to understand how towns and cities are responding to urban development and storm rainfall. Working in areas such as Bracknell and Swindon with local stakeholders and water companies, we have provided data on urban impacts, to help identify how to apply nature-based solutions for flood mitigation.

Flood estimation

Our flood estimation expertise, the result of many years of hydrological monitoring, modelling and analysis, has been a primary focus of UKCEH and its predecessor organisations for more than 40 years. In the UK, our latest statistical rainfall model (FEH13) has been formally adopted by OFWAT as the standard method for assessing the severity of rainfall events.

TOOL: ANaRM model

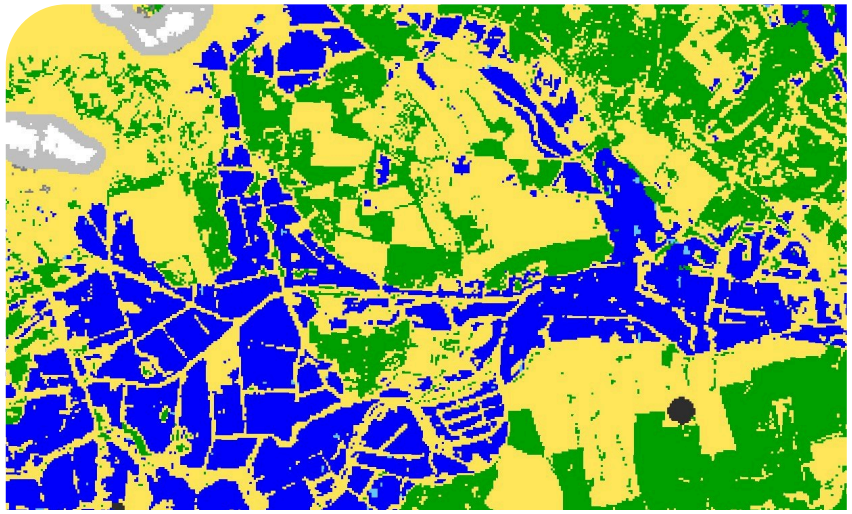
UKCEH scientists have developed an ecosystem service model to measure the effects of nature-based solutions (NBS) on flood hydrology, based on the widely used Rational Method and modified to represent flow accumulation along a hydrological network and flood attenuation through water bodies. The validated 'Adapted Nature-based-solutions Rational Method' (ANaRM) model provides realistic flood peak flow estimates at a high spatial resolution across and within urban catchments.

We used ANaRM in the city of Birmingham, UK, to simulate the hydrological effects of land use change from impervious to greenspace, and installation of SuDS and ponds. The method can be used to inform urban planning as well as to estimate the impact of NBS already in place in urban environments. The model has also been applied in Aarhus in Denmark, and in Paris. The ANaRM model is written in the R programming language and available from .

Flood forecasting

UKCEH state-of-the-art hydrological models and tools are used for real-time flood modelling and forecasting from hours to seasons ahead, at national and local scales. We work collaboratively with stakeholders to create new services and solutions such as real-time flood risk and impact forecasts.

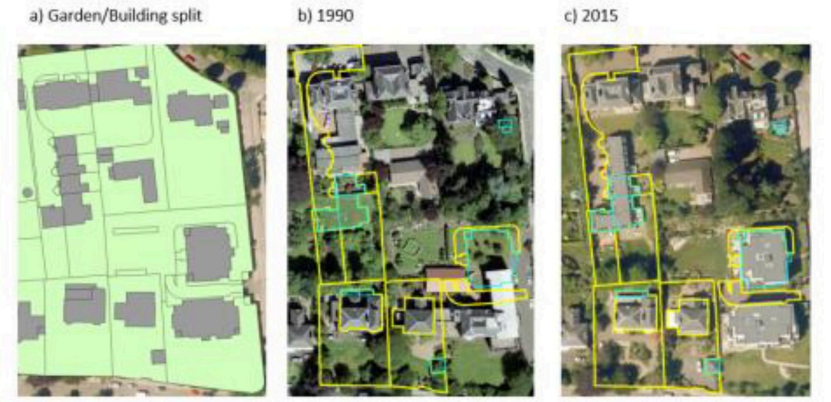
The Flood Forecasting Centre (England and Wales) and Scottish Flood Forecasting Service use our models to inform the Flood Guidance Statements they provide to the emergency response community. Our models support the flood warnings sent to the public and businesses by the Environment Agency (EA), Natural Resources Wales (NRW) and Scottish Environment Protection Agency (SEPA).



CASE STUDY:
Urban creep in Edinburgh

Urban creep describes the conversion of gardens and other vegetated areas (which help to soak up rain) into built-up surfaces which are impervious. It is an important risk factor for surface water flooding.

We developed a method to map urban creep and applied it to aerial photography for Edinburgh for 1990, 2005 and 2015. This allowed the first city-wide estimates of urban creep to be produced for Scotland, supporting better understanding of the surface water flood risk. We found that in Edinburgh, an area the size of nine football pitches is being lost to urban creep each year, putting extra pressure on drainage. This supports the need for future flood management planning.



Calculating loss of urban greenspace in Edinburgh

International urban datasets

UKCEH has generated a wide diversity of urban datasets that support flood risk assessment and future flood mitigation planning – both in the UK and internationally. Working collaboratively with partners to collect long-term and high-resolution data enables important data that underpins urban models and tools used by industry and stakeholders.

These include:

- High-resolution urban hydrology data from Thames catchments used to develop UK models.
- Urban hydro-meteorological observation data from Burkina Faso co-developed with regional partners.
- Detailed land cover mapping of Malaysia used to assess flood risk across scales.
- Application of models to assess the NBS contribution to reducing flood risk in Denmark, France and Croatia.

Reducing air pollution

Air pollution presents a major risk to human and environmental health, resulting in biodiversity loss and health complications including respiratory and heart problems.

As urban environments have many sources of pollution, such as road transport, city dwellers' health is more at risk. The UK government has set a legal target to reduce the exposure of people to PM2.5 by 22% in 2028, compared with 2018 levels, and by 35% in 2040. This sets a new challenge for local authorities.

We generate long-term, high-frequency monitoring data of atmospheric composition, identify emission sources, and we model potential solutions. This delivers vital data needed to develop effective clean air policies and to monitor progress.

Modelling air pollution removal by vegetation

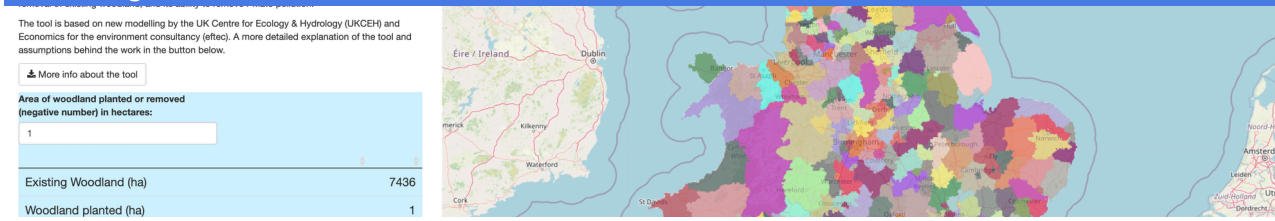
Trees as well as other vegetation inside and outside cities can remove pollution from the air. Our scientists use a combination of high-power computing and simpler model-based tools to calculate the amount of pollution that is removed by trees, as well as changes in pollutants like PM2.5 that people are exposed to on a daily basis. By combining this with health data, we can estimate an economic value for the health benefits that come from lower exposure to air pollution.

TOOLKIT:
Pollution removal by vegetation

All vegetation types can remove pollution from the air, but trees are better at removing particulate matter, and this has health benefits to society which can be valued. The quantity of pollution removed and the associated health benefit vary around the country mainly due to the amount of tree cover, levels of pollution and population density.

This UK-focused tool allows users to explore the change in economic value resulting from new tree planting, or removal of existing trees within any local authority, based on its ability to remove PM2.5 pollution. Users can select a particular local authority area and can see relevant data on the total area, the area of woodland, and the human population, as well as the quantity of pollution removed, and that the long-term asset value of that service.

The pollution removal tool was developed by UKCEH with the environment economics consultancy eftec. Its latest improved version will be released in summer 2025. Join our mailing list to be informed!



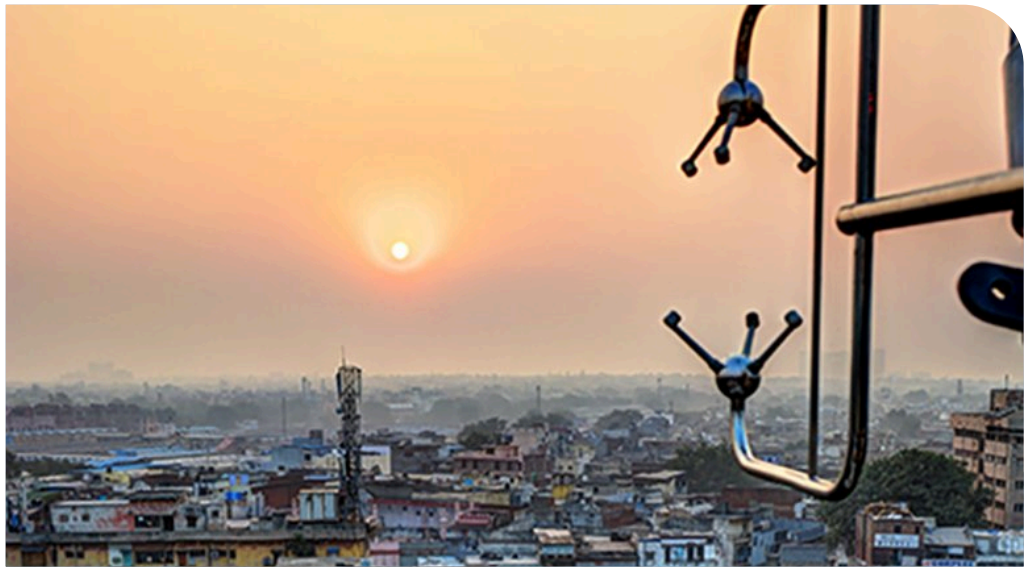
Screenshot of pollution removal tool

Accounting for the health benefits of air pollution removal

Knowing the economic value of nature's benefits can make the contribution of nature to livelihoods and economies visible, enabling smarter decisions that account for nature in our economic systems.

UKCEH scientists can help governments, local governments and businesses to calculate how air pollution removal by our trees and other natural habitats supports their economies. We developed the Natural Capital Account methodology used by UK Office for National Statistics (ONS) to report on health benefits of air pollution removal by habitats in the UK.

Read the 2024 UK natural capital accounts.



Monitoring atmospheric pollutants

UKCEH monitoring activities cover atmospheric pollutants, including ammonia (NH3). As most ammonia emissions originate from agriculture, their tracking has historically focused on rural areas, but agricultural ammonia also contributes to higher concentrations of fine particulate matter (PM2.5) in cities. Other ammonia sources in towns and cities include road traffic and waste accumulation. Exposure to PM2.5 carries substantial health risks.

UK National Ammonia Monitoring Network

UKCEH manages the UK National Ammonia Monitoring Network, currently comprising 115 sites across the UK. We have operated the Network on behalf of Defra since 1996, which makes it one of the longest time series in the world. We are adding more urban monitoring sites to improve our understanding of urban ammonia sources and their impact on the chemical composition of urban aerosols in order to improve emission inventories.

CASE STUDY:
Integrated Research Observation System for Clean Air (OSCA)

UKCEH was a partner of the Integrated Research Observation System for Clean Air (OSCA) project which ran from 2019 to 2023 as part of the UK Clean Air Programme. The project gathered new data to provide a definitive assessment of the current state of UK urban air quality, and of trends in air pollutants. The research aims to inform policy makers' and local authorities' decisions to enable the development and optimisation of emission abatement measures for the protection of human and environmental health.

About the UK Centre for Ecology & Hydrology

The UK Centre for Ecology & Hydrology (UKCEH) is an independent, not for-profit research centre carrying out excellent environmental science with impact. We are home to over 600 scientists who specialise in investigating, monitoring and modelling environmental change, and our science has helped to make better decisions for nature and people for over 50 years.

https://www.ceh.ac.uk