Royal Botanic Gardens

Kew

The Landscape Ecology Programme: Nature Unlocked

Impact Report 2021–2022

Contents

Left: Kew scientist Justin Moat using drones to capture above-ground carbon and habitat baselines of Wakehurst.

What is the value of UK biodiversity?

Biodiverse landscapes are more resilient and provide more ecological, environmental, cultural and socio-economic benefits than less biodiverse landscapes.

There are key scientific gaps in valuing biodiversity across UK landscapes. As a result, we risk prioritising overt economic value in land-use decisions. Trade-offs can go unacknowledged, separating issues such as biodiversity and climate change, which should be interconnected.

We need robust scientific evidence on the value of biodiversity at a landscape scale, underpinned by collaborative governance and an understanding of nature's benefits to people. This can influence better land-use decisions and conserve UK biodiversity, with its attendant social and environmental benefits.

Driven by science, our approach exemplifies how we can work with nature to address, mitigate and adapt to social and environmental challenges.

Useful terms:

Biodiversity
The variety and variability of life on Earth, including plants, animals, fungi and other microorganisms, and their genetic diversity.

Natural capital
The stock of renewable and non-renewable resources in nature that combine to provide a flow of benefits to people.

Ecosystem services
The benefits to humans provided by the natural environment and from healthy ecosystems.

Nature-based solutions
An umbrella term for actions that work with and enhance nature to address environmental and societal challenges, for the benefit of both society and nature.

'Biodiversity increases Nature's resilience to shocks, and thereby reduces risks to the ecosystem services on which we rely ... Biodiversity provides ecosystems with spare parts; it enables ecosystems to be resilient, to be able to adapt to changing circumstances and to be productive. Reduce biodiversity, and the health of ecosystems generally suffers'.
The Economics of Biodiversity:
The Dasgupta Review – Abridged Version

Left: Children connecting with nature in the biodiverse wetland habitat at Wakehurst.

Year in review 2021–2022

Quarter	Activities
Q1 (April – June)	• Public launch of the Landscape Ecology Programme (May 2021) • Successful application to HM Treasury Shared Outcomes Fund, in partnership with Natural England, Environment Agency, Defra, Forestry Commission and BEIS • Development of governance structures and strategic vision
Q2 (July – September)	• Launch of five science projects in the landscape, from collecting data on UK native plant use to pollination diversity research • Development of wider research plans across carbon, hydrology, pollination and wellbeing strands • Recruitment of an intern, supported by Sky, to map above-ground carbon stocks at Kew Gardens and Wakehurst
Q3 (October – December)	• Development of wellbeing research in partnership with Royal Holloway • Launch of MSc project on pollinator diversity on roadside verges vs wildflower meadows, supporting planting advice for Ground Control • Official launch of Shared Outcomes Fund research on carbon storage, greenhouse gas flux and biodiversity at Wakehurst • Carbon research featured in the RBG Kew display at COP26 (November 2021). Kew was the only UK institution present in the UN Pavilion, alongside Bloomberg, Facebook and Google
Q4 (January – March)	• Launch of germination trials on 20 UK native seeds to understand impact of climate change on plant uses • Launch of carbon research, including below-ground fungal research, across woodland and grassland habitats at Wakehurst • Development of communications plan for the Landscape Ecology Programme

Aims, research strands and foundations

Aims

The aim of the Landscape Ecology Programme is to research, engage with and share the value of UK biodiversity.

Launched by the Royal Botanic Gardens, Kew, in 2021, the programme is based at Wakehurst, Kew's wild botanic garden in West Sussex, and will run initially until 2024, with a Phase II under development.

We use Wakehurst's landscape as a 'living laboratory' to scientifically measure nature's benefits for people and the environment, and to engage the public with nature and why it matters. We share research to inform policy and practice on how to manage land to solve environmental and social challenges – at Wakehurst and across the UK.

Research strands

The Landscape Ecology Programme has four key research areas, with biodiversity running throughout:

- **Carbon**
- **Pollination**
- **Hydrology**
- **Wellbeing**

Data will be collated into a natural capital baseline of Wakehurst, helping us to understand the value of biodiversity across landscapes and evaluating risks, threats and benefits to people.

Foundations

The programme has four interlinked key measures underpinning its success:

- **High-impact, innovative science**
- **Best practice shared**
- **Connection to nature**
- **Influencing policy**

Collaboration is at the heart of the Landscape Ecology Programme. Bringing together staff from across RBG Kew, our Working Group drives and monitors the overall success of the programme alongside two delivery groups: Science and Communications, and Engagement and Participation. To engage the public with the Landscape Ecology Programme, a public-facing name of 'Nature Unlocked' was launched in early 2022.

Wakehurst's education teams worked with Kew scientists to create Key Stage 2 and Key Stage 3 learning resources on calculating the carbon content of trees; ten horticulturists supported the carbon research by collecting 47 soil samples over two days; and the Arboretum team provided expert advice on tree selection for installing research sensors.

Externally, we have built relationships with over 20 organisations across government, commercial, research, charity and public sectors, from the local to national scale. This includes our key supporters: HM Treasury, Sky Zero, Ground Control, Mount Anvil & Peabody, and People's Postcode Lottery.

'From early conversations about how Wakehurst could be researched, to a thriving multi-partner, multi-disciplinary programme, the Landscape Ecology Programme has grown faster than we ever expected. Founded on collaboration and curiosity, it's exciting to see the research questions Wakehurst is stimulating and the novel approaches being developed.'
Ed Ikin, Director of Wakehurst

Left: Mathilda Digby, a Kew intern, and Hannah O'Sullivan, a PhD student, collecting LiDAR data as part of above-ground carbon research.

Delivery against RBG Kew's core strategies

The Landscape Ecology Programme delivers against RBG Kew's corporate manifesto ('Our manifesto for change 2021–2030') as follows:

RBG Kew corporate priority		Landscape Ecology Programme deliverable
Deliver science-based knowledge and solutions to protect biodiversity and use natural resources sustainably	⟷	Deliver high-quality, innovative science to measure, define and monitor natural capital across Wakehurst and varied UK landscapes
Inspire people to protect the natural world	⟷	Inspire engagement, participation and learning through citizen science and public programmes, enhancing an understanding of and connection to nature
Train the next generation of experts	⟷	Train the next generation through interdisciplinary higher education programmes and internships focused on valuing and protecting UK biodiversity
Extend our reach	⟷	Share replicable protocols and best practice in land management for UK nature-based solutions and biodiversity across varied land uses and stakeholders
Influence national and international opinion and policy	⟷	Inform and influence policy and practice on nature-based solutions across the UK and beyond

The Landscape Ecology Programme is part of the 'Ecosystem Stewardship' priority, set out in Kew's 'Science Strategy 2021 – 2025', while also delivering against other priorities including Trait Diversity and Function, Digital Revolution and Enhanced Partnerships. Contributions to Kew Science include: novel methods for quantifying and assessing UK biodiversity and ecosystem services; genomics and traits research; generation of natural capital metrics and ecosystem assessments; and collation of interdisciplinary research data into models and tools to evaluate nature-based solutions.

Scientific evidence will inform RBG Kew's sustainability strategy by providing carbon and biodiversity baselines and long-term carbon sequestration and land use emissions data. The programme also seeks to provide evidence to government decision makers, delivering strategic impact for Defra, and use a science-led approach to inform business investment in nature.

Left: MSc student Tom France researching the role of invertebrates in providing natural pest management.

The research strands: Actions and achievements 2021–2022

High impact, innovative science

- 11 science projects active or completed
- 6 science projects in the pipeline
- 5 MSc students trained
- 5 research partnerships
- 8 habitats being researched as part of a ‘living laboratory’

Influencing policy

- 1 national policy inclusion
- 6 government partners

Connection to nature

- At least 1,100 members of the public engaged with research
- 4 public engagement days
- 4 TV features
- 5 press features
- 13 social media posts
- 5 blogs

Best practice shared

- 4 corporate partnerships
- 2 land management relationships

Resource

- Total funding FY 21–22 of £1.3m

Left: Kew scientist Gui Castro using GPS to measure sampling locations for above-ground, ground-level and below-ground carbon research.
Right from top to bottom:
The carbon research strand featured on BBC South East.
The launch of the Landscape Ecology Programme featured on Sky's *The Daily Climate Show*.
The launch of the Landscape Ecology Programme featured on Sky News.
The pollination research strand featured on a BBC *Gardeners' World* special episode filmed at Wakehurst.

Climate adaptation and mitigation (Carbon)

The carbon research strand will produce high-resolution, novel research on carbon sequestration, gas flux and biodiversity across Wakehurst's landscape. The methods and results will influence land management at Wakehurst, and data will feed into a landscape modelling tool to 'game' UK landscape change over time and evaluate nature-based solutions. The research will also inform government policy and business practice on nature-based solutions and investing in nature for net zero.

High impact, innovative science

In 2021, we received a £2.3m grant to measure carbon sequestration in Wakehurst's biodiverse habitats. In partnership with Natural England, Department for Environment, Food and Rural Affairs (Defra) and Department for Business, Energy and Industrial Strategy (BEIS), the Environment Agency and the Forestry Commission, RBG Kew is delivering high-resolution carbon research as part of the HM Treasury Shared Outcomes Fund 'Nature-based Solutions for Climate Change at the Landscape Scale' programme (2021–2024).

Kew Science and academic partners have developed a 'vertically integrated' assessment of carbon storage, with above-ground, ground-level gas flux and below-ground carbon research, including the pivotal role of fungal communities in carbon sequestration.

These data, alongside socio-cultural and economic inputs, will be incorporated into a landscape modelling tool developed by the University of Sussex. The modelling tool will be instrumental in extrapolating Wakehurst's research to wider UK land uses, understanding the changing function, value and usefulness of biodiverse landscapes to people.

Natural England and the Environment Agency are selecting five pilot sites, aligning their research methods to RBG Kew's and testing blended finance models for public/private investment. The programme will provide evidence towards policies such as species abundance, net zero and the government's target to raise at least £500 million in private finance for nature recovery every year by 2027.

Influencing policy and best practice shared

Thanks to this success, the Landscape Ecology Programme is attracting further national interest including from the National Farmers Union, the Game & Wildlife Conservation Trust and Defra's Natural Capital Ecosystem Assessment unit (NCEA) and tree team. RBG Kew's display at COP26 featured the Landscape Ecology Programme's carbon research.

RBG Kew continued its partnership with Sky in 2021–22, with Sky investing in the Landscape Ecology Programme's carbon research. Sky Zero sponsored a carbon intern to map above-ground carbon at both Kew Gardens and Wakehurst, and we've advised Sky on a Cairngorms afforestation scheme and a draft nature strategy.

Left: Collecting soil samples as part of high resolution below-ground carbon and fungal research.
Above left: Kew scientist Gary Egan installing greenhouse gas flux sensors in grassland landscapes.
Above right: RBG Kew's COP26 exhibition on nature-based solutions.

Invertebrates in the landscape (Pollination)

The pollination research strand will research the impacts of Wakehurst's biodiverse landscape on pollinator diversity, health and contribution to ecosystem services. Wakehurst is one of several UK sites to inform national-scale natural capital assessment and land management for pollinator diversity. The public will be engaged through citizen science and interpretation in the Wakehurst landscape. In the long term, treatments and interventions at Wakehurst can be used to monitor the function and role of invertebrates in ecosystem services and biodiversity. Research will become part of a fully integrated UK research group on pollinator diversity and inform national strategies.

High impact, innovative science and best practice shared

The last year has delivered three research projects investigating the role of pollinator diversity in providing ecosystem services. These projects have provided opportunities to train the next generation of scientists.

From May to October 2021, a University of Sussex MSc student supported by Ground Control investigated whether roadside verges compensate for lost meadow ecosystem services for pollinators in the High Weald Area of Outstanding Natural Beauty. The results have informed Ground Control's roadside and trackside verge management to enhance biodiversity. Over 90 Ground Control staff participated in a training workshop on habitat restoration for pollinators. From September 2021 to 2022, Mount Anvil & Peabody are supporting an early-career scientist and two summer interns to collect baseline pollinator diversity data across Wakehurst's biodiverse habitats. These data will inform land management for pollinator diversity in urban spaces.

Connection to nature

In 2021, we hosted four citizen science days for 50 RBG Kew new starters and 20 volunteers from RBG Kew corporate members. Data collection feeds into the UK Pollinator Monitoring Scheme's national database, monitoring pollinator trends across the UK. Using iNaturalist, a citizen science app, individuals identified 145 species of pollinators at Wakehurst. These data build on grassland surveys conducted by citizen scientists over more than 30 years at Wakehurst, showing the role of species-rich grasslands in supporting pollination ecosystem services.

Case study: 70 St Mary Axe citizen science day with corporate volunteers

In August 2021, we hosted a pollination engagement day with corporate volunteers from 70 St Mary Axe. Dr Hauke Koch, Research Leader in Pollinator Biological Chemistry, and Jojo Way, Learning Programme Teacher at Wakehurst, led the day. The group went on a bumblebee walk in the morning and carried out surveys in the species-rich Coronation Meadow in the afternoon, including flower-insect timed counts (FIT counts).

At the end of the day, 100 per cent of corporate volunteers agreed or strongly agreed that they were more aware of the biodiversity of insects and plants found in meadows, and 88 per cent agreed or strongly agreed that they gained scientific knowledge and skills. The day enhanced their wellbeing, with the FIT counts described as 'very meditative'.

Left: Kew scientist Hauke Koch and research student investigating pollinator diversity in Bloomers Valley, Wakehurst.

Water and landscape function (Hydrology)

The hydrology research strand will question how different landscapes mitigate against flooding, using Wakehurst's biodiverse and multi-habitat landscape to investigate and model water flow across landscapes, and to examine the role of biodiversity in reducing flood risk and providing landscape resilience. The public will help collect datasets through citizen science, for example pond dipping and investigating water quality. The hydrological research at Wakehurst is connected particularly with carbon research, understanding how gas flux and carbon sequestration is influenced by soil moisture. This holistic landscape-level science will inform UK greenhouse gas emission inventories and land management for nature-based solutions.

High impact, innovative science

Wakehurst's diverse waterscape is a valuable research asset, featuring ornamental cascades, wet woodlands, a lake, a reservoir, brooks and wetlands. Water flows across multiple habitats to Ardingly Reservoir, which feeds the River Ouse, allowing researchers to explore how biodiversity influences hydrological flows and landscape function, including flood and drought scenarios.

Throughout 2021–2022, we strengthened partnerships with institutions like Imperial College London and Royal Holloway to broaden research opportunities at Wakehurst, including further research on greenhouse gas flux, the role of wet woodlands in climate adaptation and mitigation, and hydrological recovery rates of different ecosystems.

Left: Mark Lee, a scientist from Royal Holloway, checking weather sensors in woodland, collecting real-time hydrological and meteorological data across habitats.
Above: Westwood Lake, one of the wetland habitats where researchers will be conducting hydrological research.

Nature connectedness (Wellbeing)

The wellbeing research strand will deliver social research on the relationship between people and landscape, using Wakehurst's biodiverse habitats, a long-standing public programmes team and visitors to design projects on mental and physical wellbeing, access and the diverse values of UK biodiversity. The research will build a body of evidence for the design of landscapes that improve the nature connectedness of communities with their local landscapes across the UK. It will also feed into how we continue to design, build, research and refine our horticultural landscapes at Wakehurst to enhance access and wellbeing.

High impact, innovative science

A collaboration with Royal Holloway generated a pilot project on the psychological and physiological benefits of nature for children and adults. So far, we have successfully recruited 1,180 school children from over 30 local school groups to participate in the research. Over 800 of these children are from high pupil premium backgrounds and many have not visited Wakehurst before, extending our reach. Connecting Wakehurst's landscape and science is an effective tool for increasing engagement with new and existing audiences,supporting our 'living laboratory' principle.

Case study: Researching the wellbeing values of biodiverse landscapes

Supported by the People's Postcode Lottery, the Royal Holloway research project will measure the health and wellbeing benefits of nature for children from 36 local school groups, including surveys and drawing exercises alongside landscape walks and forest bathing.
In addition, 300 adult visitors will gather physiological data using heart-rate variability (HRV) monitoring watches that can be linked to movement through the Wakehurst site. Led by Professor Dawn Watling, the Royal Holloway team will also gather data from 30–40 Wakehurst volunteers, who will complete mental health questionnaires and wear HRV monitors while volunteering for two hours. Using these data, the Royal Holloway team will model how landscape experiences may impact mental and physical health. The results will form a report for local schools and communities, and a peer-reviewed paper, helping to fill vital evidence gaps on the social value of biodiversity across UK landscapes.

Professor Dawn Watling from the Department of Psychology at Royal Holloway said:
'I am really excited to begin this collaboration with Wakehurst. With the biodiverse property at Wakehurst, we have a fantastic opportunity, using a multifaceted approach (from children to older adults, self-reported feelings and objective heart rate variability measurements), to gain an understanding of how different biodiverse landscapes may have unexpected impacts on our wellbeing.'

Connection to nature

Since our launch in 2021, a public awareness campaign has developed in parallel with the research. We noticed that 'Landscape Ecology Programme' formed a barrier to audiences with a non-scientific background. Consequently, 'Nature Unlocked' will be used in the second series of the Channel 5 programme *Kew Gardens: A Year in Bloom*. The Channel 5 team are filming science activities on carbon and nature connectedness, with the new series broadcast in July/August 2022.

Left: School children participating in wellbeing research across Wakehurst habitats.

Creating a natural capital baseline of Wakehurst

Our four research strands will feed into a natural capital baseline for Wakehurst. Natural capital baselines are a fundamental datum point in ecosystem assessment, from which change over time can be measured. The baseline will map Wakehurst's natural assets (e.g. biodiversity) from which risks (e.g. invasive species, climate change) and ecosystem services can be modelled.

High impact, innovative science and best practice shared

In the last year, we launched several projects investigating the role of UK native and non-native landscapes in delivering ecosystem services, risks and adapting to climate change.

From July 2021 to July 2022, a pilot project will research the germination temperature thresholds of over 500 UK native plant species, working closely with RBG Kew's Millennium Seed Bank. The American Prairie at Wakehurst is being used as a research site by MSc students investigating pioneering seed traits of non-native grasslands and pollinator diversity.

These projects bring an ecological approach to land management at Wakehurst, influencing management of our grasslands and the development of a new Silk Road Steppe landscape, which aims to be climate positive and more biodiverse than the existing landscape. We are building relationships with local land managers through Farmer Clusters, understanding how our science can influence land management beyond Wakehurst's borders.

Left: Wakehurst horticulturist Alice Livingston researching the American Prairie grassland.
Above: Understanding floral and pollinator diversity on the American Prairie.

The year ahead 2022–2023

Quarter	Activities
Q1 (April – June)	• Start of the Royal Holloway wellbeing research (May – November 2022) • One-year anniversary of the Landscape Ecology Programme (May 2022) • Launch of pollination summer research internships supported by Mount Anvil & Peabody (June 2022) • Development of hydrology research strand
Q2 (July – September)	• Launch of Channel 5's *Kew Gardens: A Year in Bloom* season 2 featuring carbon and wellbeing research (July 2022) • Launch of a new Participation team to develop a citizen science programme (September 2022) • Recruitment of a Research Lead to deliver the natural capital baseline work • Recruitment of a postdoctoral researcher to deliver pollination research across Wakehurst, supported by Mount Anvil & Peabody • Development of a landscape modelling tool to evaluate nature-based solutions, led by the University of Sussex • Investment in building partnerships with local land managers and farmers, helping to understand how to scale and share research • MSc projects on pollinator diversity and pioneering species start on the American Prairie grassland
Q3 (October – December)	• Launch of joint Royal Holloway / RBG Kew MSc linked to the Landscape Ecology Programme (September 2022) • Results and report for Royal Holloway wellbeing research (November 2022) • Publication of Sky's nature strategy, with expert input from Kew helping them confidently invest in nature for net zero (November 2022) • Design and delivery of the natural capital baseline for Wakehurst • Launch of wider UK pilot sites for carbon research, led by Natural England • Development of governance models and blended finance scheme for nature-based solutions, led by the Environment Agency
Q4 (January – March)	• First season's results on Kew's carbon research produced and integrated into the landscape modelling tool • Start of socio-cultural and economic research across habitats around Wakehurst, led by University of Sussex • First season of wider UK pilot sites carbon research, led by Natural England • Start of PhD research on hydrology and greenhouse gas flux across landscapes, led by Royal Holloway

Acknowledgements

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Tree roots coated by an ectomycorrhizal fungus in a symbiotic relationship.


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