

Royal Botanic Gardens
Kew

Scientific Priorities

2021–2030

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The world we live in is **changing rapidly**. The devastating and intertwined impacts of biodiversity loss and climate change are already being felt, and we need to **act now**, before it is too late. We at the Royal Botanic Gardens, Kew have an **ambitious plan** to help **stop biodiversity loss** and **discover sustainable nature-based solutions** to some of our biggest global challenges.

Responding to a changing world

Life on Earth is in peril. Never before have so many challenges manifested themselves so clearly and intensively. Every year, millions of hectares of forest are lost; fire devastates huge swathes of natural habitats; floods and hurricanes hit our cities; heat and drought decimate our harvests; people struggle to feed their children and combat disease; and species suffer a silent death, never to return. These challenges are a direct or indirect result of unsustainable human activities, causing the depletion of natural resources and the widespread loss of biodiversity, our life-support system.

Achieving sustainable human development across the globe therefore requires **transformative societal change**, which will only materialise through scientific innovations, public engagement and knowledge transfer. Within this global context, drawing on our unique assets and potential, we at the Royal Botanic Gardens, Kew (RBG Kew) are determined to **shift our scientific focus** to help societies around the world tackle the environmental crisis.

The physical and natural worlds and their products and processes are intricately linked, such that damaging one part impacts upon another. Much of this damage is being done by us, humankind, and **biodiversity loss** is both a consequence of this damage and the cause of further impacts on human health and well-being.

Land clearance for urbanisation and agriculture drives extinction directly, through rapid habitat loss, and removes the capacity of the land to capture carbon dioxide. This accelerates **climate change**, leading to extreme weather conditions and further loss of wildlife, people's homes and livelihoods.

In the more immediate term, the loss of vegetation means the reduction or loss of the many **ecosystem services** we rely on: the provision of natural products such as water, food, medicine, fuel and other materials; processes such as flood prevention and nutrient cycling; and cultural benefits such as recreation. The clearance of vegetation can also increase our contact with wildlife that may be carrying harmful pathogens, as shown by the recent wave of viruses (including SARS-CoV-2) that have had severe effects on humans and livestock.

A reduction in the diversity of the natural world also has direct impacts on our **food security**. The erosion of natural diversity that has arisen from crop breeding has left many varieties vulnerable to pests, diseases and changing environmental conditions. The genetic diversity still to be found in wild species and underutilised crops is critical to providing resilience against these threats and to solving the problems arising from nutritional depletion of crops.

Indeed, biodiversity holds the answers to many of the challenges we face, and our exploration of the natural world is far from complete. The useful properties of the world's plants and fungi are **largely untapped** – fungi in particular – and hold the potential to **bring benefits to all parts of our lives**.

RBG Kew's contribution

For more than 260 years, RBG Kew's scientific work has focused on exploring nature, finding and describing species of plants and fungi, investigating their uses, and sharing their wonders and beauty with people. But **the world has changed**. The plants and fungi we depend upon, either directly or indirectly, are now disappearing faster than ever before. We would have to go back 66 million years to find a similar wave of extinctions – then caused by a meteorite, but today a result of human activities.

Scientists have long recognised that humanity is operating beyond the 'Planetary Boundaries' of sustainability and this message is now clearer than ever. The *2020 Global Risks Report* produced by the World Economic Forum highlighted that **the top five major risks to the world are all environmental**, and the RBG Kew-led *State of the World's Plants and Fungi 2020* report estimated that **40 per cent of all plant species** are currently threatened with extinction.

Despite these stark messages, **there is hope**. It is within our collective power to remedy the loss and decline of biodiversity before it is too late, but **we must act now**. RBG Kew, in partnership across disciplines and sectors, has an outstanding opportunity to **push the frontiers of fungal and plant science** and make substantial contributions to the biggest challenges facing humanity, through a new mission and renewed focus.

This document provides an outline of the scientific ambitions of RBG Kew, in collaboration with partners across the world, for the next ten years. We reveal our new scientific mission and set out five priority areas to help us achieve transformative change and maximum positive impact. This overview of our aims will be followed by a much more detailed **Science Strategy** in the latter half of 2021, which will set specific actions and targets for the period up to March 2026. The Science Strategy will be underpinned internally by detailed operational plans for resourcing, including infrastructural development to enable delivery.

Our mission

To understand and protect plants and fungi for the well-being of people and the future of all life on Earth

In partnership with our global network of collaborators, our scientific actions will help to **understand, protect and restore biodiversity** at taxonomic, genetic, functional and ecosystem levels, and at all spatial scales. Our expertise will contribute fungal and plant knowledge to partnerships aimed at safeguarding all biodiversity, and our exploration of the useful properties of plants and fungi will provide significant benefits to society. Protecting biodiversity will contribute substantially to one of the critical UN Sustainable Development Goals – **Life on Land** (SDG 15) – and will also directly support several other goals, contributing to **sustainable livelihoods** (SDGs 1, 8, 11), **food security** (SDG 2), sourcing new **medicinal plants** (SDG 3), **protecting watersheds** (SDG 6), exploring alternative **energy sources** (SDG 7) and increasing resilience under **climate change** (SDG 13). Our biodiversity research will also support other crucial areas, such as building the **research capacity** of countries (SDG 9) and developing **international partnerships** (SDG 17). Within the United Kingdom and its overseas territories, our work will help the government to achieve its 25-Year Environment Plan, as well as supporting the environmental commitments of the devolved governments.

RBG Kew's Scientific Priorities

1

**Ecosystem
Stewardship**

2

**Unlocking
Properties**

3

**Digital
Revolution**

4

**Accelerated
Taxonomy**

5

**Enhanced
Partnerships**

Our strategy

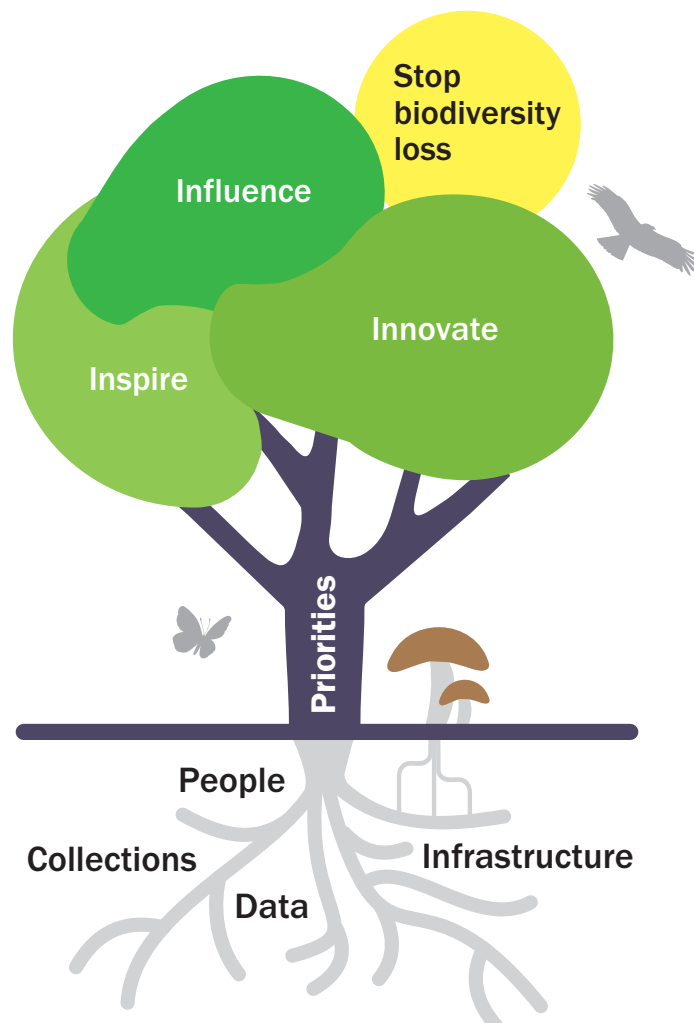
To **achieve the aims of our new scientific mission**, we will build and share robust scientific evidence, greatly accelerate the identification and naming of fungi and plants, mobilise our collections, expand our training portfolio, enhance the influence of biodiversity considerations in discourse across sectors, and maximise positive impact through working with communities, governments, companies, land managers and other practitioners.

We will capitalise on, and further develop, our most fundamental assets – our **collections, infrastructure, people and data** – to pursue **five key Scientific Priorities**. We will deliver each Priority through three modes of action. Here, we outline our ten-year vision and how we will **innovate** (research and explore), **inspire** (motivate, train and educate) and **influence** (engage externally). The strategy is conceptualised in the figure below and its components, which are explained on the following pages.

Underpinning all five Priorities, our **living and preserved collections** will be further developed through collaborations to increase geographic and taxonomic coverage of reference material and data. Our collections are essential for supporting the hypothesis-driven research of the Scientific Priorities,

and our collecting activities will focus on enhancing the coverage and depth of our collections to achieve our goals. Our horticultural and scientific programmes will be coordinated both for scientific endeavour and *ex situ* conservation of key species. **Curation** of the collections will be maintained at the highest standard to ensure the scientific robustness of our **biodiversity data**. Our **infrastructure** will be enhanced and developed so that we have state-of-the-art physical and digital environments to support our critical work.

People are our fundamental resource. Drawing upon activities and expertise across the five Scientific Priorities, we will raise our ambition to **train the next generation of fungal and plant scientists and horticulturists** through in-person and virtual training. We will continue to strive for a culture of scientific excellence at the heart of what we do, attracting and retaining new talent through competitive recruitment, evaluating performance through annual reviews of our scientists, and developing the skills of our staff, students and associates through the process, in particular through our Future Leader Fellowship (FLF) programme. This work will build critical capacity to help **discover and implement sustainable nature-based solutions** to the challenges we face today.



Our Scientific Priorities

Priority 1: Ecosystem Stewardship

Ecosystem stewardship combines the *in situ* (on-site, in-country) protection of biodiversity with its sustainable use. Good ecosystem stewardship generates knowledge and practices that sustain, promote and restore natural and cultural capital. RBG Kew's unique contribution in this area includes the collection and analysis of plant and fungal diversity data (from genes and species through to whole ecosystems), enhanced by insights into evolutionary processes, ecological interactions (including pollination systems and mycorrhizal fungi), diverse and sustainable agriculture and agroforestry, ecological restoration and ecosystem health and productivity.

Ten-year vision:

We will **innovate** by developing a novel pipeline for rapid quantification and assessment of biodiversity, identification of priority areas for conservation and restoration, and implementation of sustainable nature-based solutions to global challenges. To achieve this, we will integrate fieldwork, curation and collections-based research, and use and generate multiple data sources, including genomic, trait, ethnobotanical and spatial data, employing a combination of scientific expertise, artificial intelligence and predictive modelling techniques. Innovative research into plant and fungal adaptation will help us to understand and mitigate biotic and abiotic threats. We will develop new participatory approaches with local communities and in-country partners to enhance livelihoods and ecosystem services by working across managed and less managed landscapes, including agro-ecological systems, clearly linking biodiversity to human benefits through sustainable nature-based solutions.

Our results will inform actions undertaken by our partners in the priority countries for RBG Kew's scientific work. We will also extend research into understanding the causes of biodiversity loss and use these new insights to inform efforts to stop this trend.

We will collaborate with and help train partner scientists in the evaluation of habitats and species and **inspire** citizen scientists, land managers, conservationists, development organisations and the academic community to understand, sustainably use, protect and promote the recovery of native species and the ecosystems in which they occur. To achieve this, we will build on existing partnerships, and develop new ones with relevant organisations, for data gathering, processing and implementation, and we will build a network of citizen scientists to broaden our engagement with communities in the UK and across the world. We will also use our network and public engagement opportunities in the gardens and online to inspire a diverse public to value, sustainably use and strive to protect biodiversity.

We will **influence** discussions with governments to inform and facilitate policies that encourage responsible access and equitable use of biodiversity, and with companies to increase investment in the protection and restoration of the world's most valuable and vulnerable ecosystems, moving beyond simple species counts to integrate other metrics of biodiversity and their contributions to human well-being, including economic value and health benefits. To achieve this, we will promote our science to these sectors through our external affairs and science policy teams and our collaborative partners overseas. We will also conduct research on trade with threatened species and continue our role as the designated UK Scientific Authority for Flora for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as well as our long-standing membership of the International Union for Conservation of Nature (IUCN) Red List Partnership.

Priority 2: Unlocking Properties

Plants and fungi hold the key to addressing many of the challenges facing the natural world. But there is still much we do not know about the properties that have enabled them to survive in the environment. Understanding these traits, how they have evolved and how they function, will enable us to better conserve these species, both within and outside their natural range or habitat, and to identify species and molecules we can use sustainably and equitably for the benefit of humankind. RBG Kew's collections, particularly the Seed Collection at the Millennium Seed Bank and the Living Collections at Kew Gardens and Wakehurst, provide a priceless reserve we can mine to drive this process of discovery, taking into account access and benefit agreements associated with the Nagoya Protocol, related legislation and best practice. The exploration of biodiversity offers a wealth of opportunities for improving human health and well-being, and may provide new solutions for sustainable development.

Ten-year vision:

We will **innovate** in the use of new technologies and methods to explore the properties of plants and fungi, and their potential applications, as well as researching the underlying evolutionary forces driving change and resilience in genomes, species and ecosystems. To achieve this, we will draw on our unique collections in addition to newly collected material. We will seek funding for a new cryosphere facility and a conservation and research nursery, to promote the genomic and experimental exploration of useful traits. Notable applications of this research include increasing the success of ecological restoration and species re-introduction programmes, and developing a broader range of species to improve nutrition and provide nature-based solutions to critical socio-environmental challenges. In particular, we will explore traits that can be used in agriculture, both through introduction into major crop species and through the development of minor crops that may be better suited to a changing environment than species presently grown more widely. We will also explore the molecular basis of useful traits, combining genomics and chemistry, and identify new biomolecules with potential to enhance human health, livelihoods and well-being. Innovative plant health research will reveal the genetic basis of resistance to major pests and pathogens in economically and ecologically important species.

We will **inspire** governments, companies and our visitors to think about the benefits of exploring and harnessing the power of biodiversity to deliver solutions to the world's needs, and to appreciate the value of protecting it for the benefit of future generations. To achieve this, we will showcase economically important plants in our gardens, give our visitors the chance to experience unfamiliar plant-based products at our Science Festival, and educate our on-site, online, professional and commercial audiences about the ecosystem services provided by plants and fungi and the potential for them to be used in new ways for health and well-being.

We will **influence** the development of international policy (for example, through the Convention on Biological Diversity – CBD) to ensure that the benefits of this work are equitably shared across the globe. To achieve this, we will contribute to development and implementation of the CBD and its associated protocols, advising the UK government and contributing to discussion among scientists, communities and policymakers to maximise access to and use of physical and digital materials.

Priority 3: Digital Revolution

RBG Kew holds a globally unique, substantial and growing collection of fungal and plant data and databases that store information on specimens, names, taxonomy, images, traits, distributions, phylogenies, phenology, germination and conservation. Yet our collections still hold vast quantities of uncaptured data from physical specimens, their labels and their DNA. The large-scale digitisation of specimens and integration of systems will release this information, helped by innovative new online tools for data retrieval, analysis and visualisation. This digital revolution will facilitate more efficient curation and management, while increasing the global value and use of the collections by scientists and the wider public. Digitisation and digital innovation will allow virtual repatriation of specimen images and data to countries of origin, while unleashing new opportunities for large-scale data mining and analysis for scientific discovery and innovation.

Ten-year vision:

We will **innovate** by producing, synthesising and distributing fungal and plant data, to unlock the vast resource of information held within our collections and advance global research on the causes of biodiversity loss and factors conferring resilience. This will help us to protect the natural world and find sustainable nature-based solutions to the challenges facing humankind. To achieve this, we will put the digitisation of our collections at the heart of our science, aggregate our digital assets and integrate our data with the most up-to-date plant and fungal trees and networks of life.

We will **inspire** millions of people to learn more about the wonders and benefits of the natural world through interaction with our digital resources. To achieve this, we will make our research, data and publications open, communicate fungal and plant knowledge on diverse online platforms, and integrate citizen science and machine learning methods into the collection, translation and analysis of specimen data.

We will **influence** and be influenced by other scientific institutions, leading by example in the dissemination of biodiversity data in globally agreed formats. We will encourage the sharing of data sets for mutual benefit and coordination of efforts, working towards common digital outputs. To achieve this, we will build on and contribute to multilateral partnerships for data synthesis in fungal and plant diversity knowledge.

Priority 4: Accelerated Taxonomy

Taxonomy is the science of naming, identifying and classifying living organisms. It is the bedrock for the scientific study of life: any research involving living organisms needs a taxonomic point of reference and it is therefore hugely important to the global scientific community, yet in need of increased resources and focus. Taxonomy has been the backbone of RBG Kew's scientific research throughout our history, and our collections and taxonomic experts are essential to the processes of discovering, describing and conserving biodiversity. Drawing on increased data availability and new tools and technologies, including phylogenomics and machine learning, we will push the frontiers of taxonomic research to accelerate the characterisation and identification of species in near real-time and develop methods for speeding up the discovery of hidden diversity in natural history collections. Our focus will be on taxonomic groups and regions where progress is most needed, and our outputs will include monographs, online tools and other resources tailored to the specific needs of our stakeholders.

Ten-year vision:

We will **innovate** in the identification, naming and classification of fungi and plants, accelerating the description of the world's biodiversity. To achieve this, we will lead a paradigm shift in taxonomy to embrace machine learning, trait research (including genomic, chemical, morphological and ecological) and citizen science, guided by our expertise and collections in key families, our knowledge of conservation threats, and a consideration of socio-economic benefits.

We will train a new generation of students and professionals and **inspire** them to dedicate their careers to biodiversity studies in the context of a changing world, focusing on a solutions-oriented approach. To achieve this, we will deliver modern taxonomic training focused on transferable skills, integrative techniques and expertise in the fields of highest value to employers.

We will **influence** funding bodies, governments, companies and research organisations around the world to prioritise the inventory, description and monitoring of biodiversity. To achieve this, we will generate, and showcase the critical importance of, evidence-based analysis across science and society.

Priority 5: Enhanced Partnerships

RBG Kew's scientists work with collaborators in over 400 institutions from more than 100 countries across the globe – a network that we have built through our worldwide portfolio of scientific and training activity. Structured partnerships, focusing on impactful goals, are essential to the continued success of our collecting, research and conservation activities. As we move forward with our mission, cross-disciplinary partnerships, especially with academic and commercial institutes that focus on the uses of biodiversity, will be essential to increasing the understanding, appreciation and protection of biodiversity and its useful properties. Priority 5 will weave through all of the other four Priorities, because enhancing scientific and educational partnerships within the UK and across the world will be essential to maximising real-world impact.

Ten-year vision:

We will **innovate** across science and society to protect, sustainably use and conserve biodiversity and to find solutions to urgent global challenges. To achieve this, we will enrich our impactful partnerships, especially those in the Millennium Seed Bank Partnership (MSBP); form collaborations with professionals in disciplines such as environmental economics and the broader social sciences, arts and humanities, medical and food sciences, and climatology; and consolidate plans for enhancing our scientific facilities. We will focus the MSBP on hypothesis-driven research, to better support species conservation and habitat restoration,

We will **inspire** scientists, governments, commercial entities and non-governmental organisations to join forces in new, transdisciplinary, impactful programmes in applied and fundamental science. This will be implemented through key themes of current and future relevance, including decolonising science, drug discovery and improving food security. We will create a flexible and dynamic scientific platform to allow us to seize emerging opportunities of the highest quality and impact in line with our mission. We will also act to inspire public interest in and support for this mission, because we are all part of the solution as we strive to achieve a more sustainable future. Building on our scientific strengths and the evolving needs of society, we will join forces with universities to deliver cutting-edge training for the next generation of experts, through MSc and PhD programmes, and a combination of online, on-site and off-site courses. We will train scientists in the use of new and improved plant and fungal conservation techniques and **inspire** companies and individuals to support conservation.

We will **influence** politicians, policymakers and industry to invest in biodiversity research and infrastructure. To achieve this, we will help evaluate, improve and measure the biodiversity, climate and livelihood benefits of nature-based solutions, convene public debates, be vocal in the media, strengthen our links with influential groups and expand our commercial and innovation activities. We will increase the MSBP's global influence in seed-banking, promoting best practice and common goals and supporting the conservation of threatened species and restoration initiatives worldwide.

Delivering our Scientific Priorities

The five Scientific Priorities will be delivered through three new departments: Research, Partnerships, and Science Operations. The Research department will deliver Priorities 1 to 4, while the Partnerships department will focus on Priority 5. The Science Operations department will be focused on the infrastructure, collections and services necessary to achieve the goals of the Scientific Priorities, and partner strategies such as the *Science Collections Strategy 2018–2028*. Key components of the Science Operations department are Science Collections, Library Resources, Science Services and Laboratories, and Kew Madagascar Conservation Centre Operations – the latter supporting our team based in Madagascar, where RBG Kew has a long-term base fighting biodiversity loss in a critically threatened, megadiverse environment.

The alignment of our departmental structure to the Scientific Priorities is the optimal way to maximise delivery of our mission through scientific innovation, excellence and real-world impact. Staff will be contributing their expertise across departments and Priorities, ensuring that the knowledge and experience embedded in Kew Science is used to its full potential.

In partnership with our global network of collaborators, our scientific actions will help to understand, protect and restore biodiversity at taxonomic, genetic, functional and ecosystem levels, and at all spatial scales.