

Living Collections Strategy

2019

Scoliopus bigelovii



Foreword

The Royal Botanic Gardens, Kew has an extraordinary wealth of living plant collections across our two sites, Kew Gardens and Wakehurst. One of our key objectives as an organisation is that our collections should be curated to excellent standards and widely used for the benefit of humankind. In support of this fundamental objective, through development of this Living Collections Strategy, we are providing a blueprint for stronger alignment and integration of Kew's horticulture, science and conservation into the future.

The Living Collections have their origins in the eighteenth century but have been continually developing and growing since that time. Significant expansion occurred during the mid to late 1800s (with the extension of British influence globally and the increase in reliable transport by sea) and continued into the 1900s. In recent years, a greater emphasis has been placed on the acquisition of plants of high conservation value, where the skills and knowledge of Kew's staff have been critically important in unlocking the secrets vital for the plants' survival.

Held within the collections are plants of high conservation value (some extinct in the wild), representatives of floras from different habitats across the world, extensive taxonomically themed collections of families or genera, plants that are useful to humankind, and plants that contribute to the distinctive landscape characteristics of our two sites.

In this strategy, we have sought to bring together not only the information about each individual collection, but also the context and detail of the diverse growing environments, development of each collection, significant species, and areas of policy and protocol such as the application of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, the Convention on Biological Diversity and biosecurity procedures.

The metrics within the document provide quantified answers to often-asked questions, such as 'How many plants do we grow?' and 'Which families and genera are best represented?'. We know, for example, that we currently have over 27,000 species, subspecies and varieties in the collection, representing 319 plant families (over 70% of the families now recognised in botanical science) and including 872 IUCN Red List threatened plant taxa. The 68,490 accessions (specimen lines) have been sourced from across the world, reflecting Kew's active global research programmes and partnerships. This is an incredibly rich and unparalleled resource, which, in addition to constituting the living components of two spectacular landscapes and gardens, can underpin important scientific research.

This strategy addresses some key questions about the Living Collections, their future direction and their utilisation



for future research in line with Kew's Science Strategy and Science Collections Strategy. We also set out our aims to more fully utilise the Living Collections to support Kew's mission through education and training, more effective interpretation for our wider community of visitors, and improved integration of horticultural and scientific activities. These aims will help us contribute to and support a scientifically, horticulturally and ecologically literate society.

Our Living Collections are at the heart of Kew's purpose and identity as a botanic garden. We look forward to achieving the aims of this strategy, thereby ensuring that across both our sites we deliver the positive benefits of this rich living legacy.

Richard Barley

Director of Horticulture, Learning & Operations

Executive summary

The Royal Botanic Gardens, Kew is a global resource for plant and fungal knowledge and holds some of the largest and most diverse collections of living and preserved specimens in the world. Our extensive collections of living plants – the foundation of the botanic gardens at the 330-acre site at Kew in West London and 535-acre estate at Wakehurst in West Sussex – are together known as Kew's Living Collections. They are utilised by our scientists and horticulturists for cutting-edge research and conservation in collaboration with our partners worldwide, and they form the basis for innovative interpretation and a vast programme of training and education.

Our vision for the collections is for them to be taxonomically, geographically and genetically diverse, aligned with Kew's scientific priorities and displayed and interpreted in innovative ways to communicate the wonder of plants to diverse audiences. We set out five overarching strategic aims to fulfil this vision:

1. To develop and maintain diverse living plant collections in support of current and future scientific and horticultural research programmes.
2. To support plant conservation programmes through *ex situ* propagation and cultivation of threatened taxa and by providing sources of genetic material for future conservation programmes.
3. To further enhance the important living heritage and contemporary aspects of the landscapes at Kew and Wakehurst.
4. To expand visitors' understanding of the diverse world of plants through the provision of engaging and authoritative interpretative information linked to the living plant collections, including compelling stories about Kew's global and local activities and impact.
5. To maintain habitat diversity and quality within *in situ* conservation areas at both Kew and Wakehurst.

A key aim of this strategy is to achieve stronger alignment between the Living Collections and both Kew's *Science Strategy (2015–2020)* and *Science Collections Strategy (2018–2028)*, with the intent of achieving a higher level of utilisation of the collections for contemporary science. In addition, the contribution of the Living Collections towards *ex situ* and *in situ* conservation programmes will be a focus.

The strategy seeks to address four key questions:

- What collections do we currently have?
- What are the priorities for current collections and new accessions?
- How do we manage and develop our collections?
- How do we increase the value of our collections to support Kew's mission and strategic objectives?

In addition to providing strategic direction and priorities for the future development and use of the Living Collections, this document brings together detailed information about each living collection, including its origins, development, growing conditions, key taxa, and summary metrics. Our unique, extensive and diverse collections include hardy temperate taxa that grow outdoors at both sites and taxa from many different climates around the world requiring specialised environmental conditions, usually provided in glasshouses. We describe the growing environments of each of the major glasshouse facilities (nurseries and public conservatories) and also the outdoor growing environments of the Kew and Wakehurst sites. This detailed information is currently not accessible in any other single location.

We set out the value of the Living Collections for supporting scientific research, specifically aligning this to the aims and research questions of the *Science Strategy*, and we specify geographic, taxonomic, conservation and landscape priorities for current accessions and future collections. The development and management of the collections is then addressed, looking at plans, policies and procedures relating to plant record management, accessions, plant health and biosecurity, and compliance with international conventions for transfer of genetic material.

Next, we address how we increase the value of the collections to support Kew's mission and strategic objectives, through effective interpretation, education and training, and through better integration of horticulture, science and conservation. The key principle of understanding that horticulture (and the management of the Living Collections) is an applied science and therefore part of Kew's science continuum is explained.

The final section provides an outline of what will be achieved by successful implementation of this strategy and includes a list of metrics by which to measure success.

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Introduction



Kew's extensive collections contain plants from tropical, temperate, arid, boreal and alpine environments.

The Royal Botanic Gardens, Kew is a global resource for plant and fungal knowledge and holds some of the largest and most diverse collections of living and preserved specimens in the world.

Our extensive collections of living plants – the foundation of the botanic gardens at the 330-acre UNESCO World Heritage Site in West London (Kew Gardens) and 535-acre estate in West Sussex (Wakehurst) – are together known as Kew's Living Collections. A living collection is a group of plants grown for a defined purpose, including for reference, research, conservation, education or ornamental display. Kew's Living Collections are utilised by our scientists and horticulturists for cutting-edge research and conservation, and they form the basis for innovative interpretation and a vast programme of training and education.

Alongside the 8.5 million specimens of the Science Collections and the extensive holdings of the Library, Art and Archives Collections (see Table 1), the Living Collections lie at the heart of Kew. Containing more than 68,000 accessions[^] of over 27,000 taxa*, including nearly 19,000 species, they span the landscapes, glasshouses and nurseries at the

two sites and contain plants from tropical, temperate, arid, boreal and alpine environments. They are the most diverse collections of any botanic garden in the world, with other large gardens containing around 20–21,000 taxa.

The aims of this document are to describe these diverse, extensive and unique collections of living plants and the environments in which they are grown at each of the two sites, Kew Gardens and Wakehurst; to specify strategic aims and priorities for the current collections and new accessions; to set out how to best manage and develop the collections; and to define how we can increase the value of the collections to support Kew's mission and strategic objectives.

[^] An accession refers to one or more living plant specimens derived from the same collection.

* Taxa, singular taxon. A taxon refers to a unit of classification, such as species or subspecies. In this case, 'taxa' encompasses all levels of classification down to subspecies, varieties and cultivars.

Box 1: The role of living plant collections

A key feature of botanic gardens is that the living plant collections contain accurately identified, documented and labelled collections of plants for one or more of the purposes of conservation, reference, research, interpretation, education and pleasure. This distinguishes them from other public gardens and parks and highlights their role as a valuable scientific and cultural resource. Ensuring our collections are well curated underpins their value for Kew's scientific research programme and also supports our organisation's key strategic objective, that our collections should be curated to excellent standards and widely used for the benefit of humankind (Figure 1).

To fulfil this role effectively, cultivated specimens within Kew's Living Collections are supported by detailed information regarding the collector, location and source of the plant, together with any specific conditions under which they were collected. All collections at Kew and Wakehurst comply with the requirements of the Convention on Biological Diversity and its various protocols and regulations and all other relevant national and international laws and regulations. Where possible, new accessions are derived from wild-collected sources and have a full complement of supporting data.

This set of attributes makes the collections a valuable resource for scientific research, plant conservation, education, training and innovative interpretation. They support cutting-edge research at Kew and beyond, providing a source of accurately named living reference material and samples for a wide range of studies, from genomics to pollination biology. The aesthetic role of the Living Collections is also critically important, particularly for those collections that make up the outdoor

living landscape. Development of collections and individual plants that contribute in a positive way to the overall visual quality and which augment the historical context or 'spirit of place' of each landscape is essential.



Table 1: An overview of Kew's other major collections

The Science Collections and the Library, Art and Archives Collections sit alongside the Living Collections at the heart of Kew's work and mission. This strategy links closely to the *Science Collections Strategy*, which along with this document will inform the forthcoming Library, Art and Archives Strategy.

Collection	Approximate size*	Description
Science Collections		
Herbarium	7,000,000	Preserved dried vascular plant specimens ¹
Spirit Collection	76,000	Specimens of plants, plant parts and fungi preserved in spirit
Fungarium	1,250,000	Preserved dried fungi, lichens and fungal analogues such as oomycetes and myxomycetes
Economic Botany Collection	100,000	A broad range of samples ² documenting the use of plants by people, including 42,000 wood collections
Seed Collection	86,000	Living seed collections ³ held in the Millennium Seed Bank (MSB)
DNA and Tissue Bank	58,000	48,000 samples of plant genomic DNA stored at -80°C, and 10,000 silica-dried tissue samples at room temperature
Microscope Slide Collection	150,000	Microscope slides documenting plant and fungal anatomy
In Vitro Collection	6,000	Living plants and fungi cultured on agar
Library, Art and Archives Collections		
Library	300,000	Printed books, journals and pamphlets covering the worlds of plant and fungal science and horticultural history
Art	200,000	Prints and drawings assembled over the last 200 years and ranging in date from the eighteenth century to the present day; additional works on paper, portraits, photographs, and three-dimensional objects
Archives	7,000,000 sheets of paper in 4,600 collections	Unpublished material comprising correspondence, field notebooks and photograph albums, records of plants received at Kew and sent out from Kew, and maps and plans tracing the development of the gardens

* The exact size of the larger collections and the precise number of species contained within them is unknown; the sizes given for these therefore represent an estimate based on our knowledge of the collection and those specimens that have been digitised.

¹ A specimen = material collected from a single plant or fungal species at a given location and a given time.

² A sample = tissue or DNA collected/extracted from a single plant at a given time.

³ A collection = a group of related specimens. In the case of seed collections these represent seeds gathered from the same individual or same population at the same time.

Samples from Kew's Economic Botany Collection



Figure 1: Kew's corporate strategy objectives, with the collections at the centre



Historical legacy

Kew's living plant collections have their origins at the West London site in the mid-to-late eighteenth century. At this time, Frederick, Prince of Wales started to gather a collection of trees and shrubs in the landscape; his widow, Princess Augusta, then expanded the collection under the guidance of John Stuart, 3rd Earl of Bute. The diversity and value of the collection was significantly raised through the work of plant collectors commissioned by Sir Joseph Banks during his tenure as 'unofficial' first director of Kew between 1773 and his death in 1820. Many species new to British horticulture were introduced during this period, and a further period of growth in collections occurred during the directorships of both Sir William Hooker and his son Sir Joseph Hooker in the nineteenth century. There are significant historical collections at Kew – the Cycad Collection stretches back to the time of Sir Joseph Banks and William Aiton (Kew's first Curator) in the eighteenth century, and the Orchid Collection is the oldest and largest of its kind.

Further additions continued through the last century and up to the present day, with the increase of diversity greatest in collections under glass in the Tropical and Alpine nurseries and in the display glasshouses. In 2003, the Kew site was inscribed onto the UNESCO World Heritage List, acknowledging the international value of the site's botanical collections and unique living landscape. Recently, the focus and priority for accession of new plants has generally been to ensure that a plant is conserved *ex situ*, that a gap in the collection within a genus or family is filled, or that a taxon that is the subject of research is grown for observation and documentation.

At Wakehurst, the exotic plant collection started in earnest in the mid-nineteenth century and grew rapidly under the sponsorship of Gerald Loder, 1st Baron Wakehurst. A scion of the family who created the famous garden of High Beeches

in West Sussex, Gerald Loder enthusiastically sponsored early twentieth-century plant hunting trips to China, Nepal, Tibet, Tasmania and Chile, amassing 3,000 taxa at Wakehurst by 1907. Loder built his reputation as a great plantsman through his garden at Wakehurst and this was reflected in his presidency of the Royal Horticultural Society between 1929 and 1931.

Successive Wakehurst owners added layers of exotic plant material. Lady Downshire initiated the planting of *Sequoiadendron giganteum* in the 1870s, but it was her successor, RHS president Gerald Loder, who made Wakehurst a nationally significant plant collection. Wakehurst's exceptional growing conditions (mild climate, varied topography and fertile, acidic sandy loam soil) nurtured successive introductions from China, Chile and Tasmania, bringing the site to Kew's attention as it sought a location for its new temperate plant collection in the 1960s.

For both Kew and Wakehurst, the severe storms of 1987 and 1990 were pivotal moments. Over 700 trees were lost at Kew, primarily mature broad-leaved deciduous trees from the areas developed under William Hooker. Losses in 1987 included the 200-year-old turkey oak (*Quercus cerris*) near the Palm House Pond and a walnut (*Juglans regia*) planted by the Queen in 1959 near Kew Palace. Many botanical rarities including *Ehretia acuminata* (= *E. thrysiflora*) and *Ulmus villosa* were also lost. The devastation at Wakehurst was orders of magnitude higher, with 10,000 trees felled, followed by three years of restoration. Yet, out of the devastation came an extraordinary development: *Temperate Woodlands of the World*. This themed planting contains over 100 acres of wild-collected trees, arranged phytogeographically and planted to evoke the wild landscapes of Chile, Tasmania, the USA, Japan and South Korea from which they were collected.

Encephalartos ferox



Dendrobium speciosum





Sequoiadendron giganteum

Our vision

Taxonomically, geographically and genetically diverse collections, aligned with Kew's scientific priorities and displayed and interpreted in innovative ways to communicate the wonder of plants to diverse audiences

A strategy for our Living Collections

Throughout Kew's history, the collections have reflected the changing interests of its directors, its scientists, horticulturists and the government, and no unifying set of priorities has guided the development of the collection of living plants. The physical layout of the collections at Kew has benefited from two Master Plans (by Wilkinson Eyre in 2002, and Gross Max in 2010); each provides analysis of the structure of the landscape, its buildings and capital opportunities and they have been recently reviewed and analysed as part of the horticultural planning process within Kew. However, the scope of these plans did not include detailed planning for the living plant collections. Similarly, Wakehurst's design and planting philosophy is directed by the Designed Landscape Plan (2016), but this does not set out priorities for future collections. Building on the past and preparing for the future, the aim of this *Living Collections Strategy* is therefore to provide direction for the management and future development of the collections at Kew and Wakehurst, while also allowing flexibility to accommodate and reflect changes in scientific, social and cultural attitudes towards botanic gardens.

To take the historical legacy along with the current vibrancy and scientific value of the collections into the future, this strategy sets out a framework for the development of the Living Collections over the coming decades. The strategy outlines the themes and criteria that will be used for defining, assessing and developing the Living Collections and closely aligns with Kew's *Science Strategy (2015–2020)* and *Science Collections Strategy (2018–2028)*. It provides a consistent and systematic approach for developing the existing collections and selecting and establishing new ones. As the Living Collections form a central component of Kew's World Heritage designation, their conservation and management are central to the continued conservation and management of Kew as a World Heritage Site. The *Living Collections Strategy* will therefore inform and shape relevant policies within the Kew World Heritage Site Management Plan.

5 overarching aims for the Living Collections:

1. To develop and maintain diverse living plant collections in support of current and future **scientific and horticultural research** programmes.
2. To support plant **conservation programmes** through *ex situ* propagation and cultivation of **threatened taxa** and by providing sources of genetic material for future conservation programmes.
3. To further **enhance** the important living heritage and contemporary aspects of the landscapes at Kew and Wakehurst.
4. To **expand visitors' understanding** of the diverse world of plants through the provision of engaging and authoritative interpretative information linked to the living plant collections, including compelling stories about Kew's global and local activities and impact.
5. To **maintain habitat diversity and quality** within *in situ* conservation areas at both Kew and Wakehurst.

Aligning with Kew's Science Strategy

Under the 1983 National Heritage Act, Kew has a responsibility to care for its collections and to use them for scientific investigation and as a resource for reference, education and enjoyment. At Kew and Wakehurst, our suite of collections provides unique opportunities for horticultural and scientific activities to support and inform each other. Kew has an extensive scientific research programme, guided by the scientific vision and priorities set out in our *Science Strategy*, and many research projects involve synergies between science and horticulture. The long continuity of some of the collections has allowed specimens from the Living Collections to be incorporated into the Science Collections and used for research over many years (see Box 2). The connections between science and horticulture also feed into education and the display and interpretation of living plants at Kew and Wakehurst.

The use of the Living Collections more widely in Kew's scientific research has historically been sporadic, and to some degree unplanned. However, the publication of Kew's *Science Collections Strategy* presented an opportunity to develop more tangible links between the Living Collections and the Science Collections. The aim is to provide a more complete set of reference plants to underpin taxonomic and systematic research and other priorities as outlined in the *Science Strategy*.

The three key strategic aims of the *Science Strategy*:

1. To document and conduct research into global plant and fungal diversity and its uses for humanity.
2. To curate and provide data-rich evidence from Kew's unrivalled collections as a global asset for scientific research.
3. To disseminate our scientific knowledge of plants and fungi, maximising its impact in science, education, conservation policy and management.

The Living Collections are a valuable resource for achieving these aims, providing living material for taxonomic descriptions and physiological, chemical and genomic investigations and allowing Kew's scientific research to be disseminated to a wide and varied audience through inspiring and informative interpretation accompanying the displays in the gardens and glasshouses.

As well as supporting general research across Kew, the Living Collections are a significant source of specimens for the Science Collections, and for the outputs set out in the *Science Strategy*. Significant alignment with the *Science Strategy* is already underway in this regard. For example, 132 species (as at April 2019) have been newly sampled for the Plant and Fungal Trees of Life (PAFTOL) project, which aims to map out the evolutionary relationships between plant families and genera. This project has also been able to make use of a large number of the 8,000 samples of DNA that have been incorporated into the DNA Bank using samples collected from the Living Collections at Kew and Wakehurst over the last 25 years – these represent 304 families, over 2,000 genera and over 2,000 species, with Orchidaceae and Asparagaceae particularly well represented.

Wakehurst's nursery undertakes a substantial propagation programme for Kew Science, including supporting Banking the World's Seeds, through the verification and regeneration programme of the Millennium Seed Bank (MSB). The nursery also generates seed for the UK Native Seed Hub and propagates material for projects such as Crop Wild Relatives and for natural capital research, including seeking a 'sweet' form of Ethiopian white lupin (*Lupinus albus*).

To develop these initiatives further and fully exploit the synergies between horticulture and science at both the Kew and Wakehurst sites, a better understanding of the plant resources already available within the Living Collections will be developed, together with prioritised diversification and expansion of the collections to support scientific research into the future, as outlined later in this document.

8,000

samples of DNA have been incorporated into the DNA Bank using samples collected from the Living Collections at Kew and Wakehurst over the last 25 years.

*Aloe africana**Aloe dawei**Aloe speciosa**Aloe rupestris*

Box 2: Scientific use of the Arid Collection

The Arid Collection at Kew is an important resource for scientific research, with many specimens having been used in published research spanning more than 50 years. Accessions from the collection are represented in Kew's Science Collections as DNA samples, tissue in silica gel and herbarium specimens, contributing to baseline taxonomic studies and research that aims to identify how plants can be used to address twenty-first-century challenges facing humanity. The adaptations of desert plants to high temperatures, drought and temperature fluctuations are of interest, for example, with respect to food security and managing environments where a changing climate will affect how people live.

Among the Arid Collection, living plants of the genus *Aloe* have contributed most to scientific research at Kew. Kew holds a substantial collection of around 600

accessions representing approximately 150 species of *Aloe*, an iconic leaf-succulent group that includes the economically important species *Aloe vera*. The oldest *Aloe* accession is *Aloe pendens* from 1907 and the collection also contains several type specimens (the specimens on which the names and descriptions of species are based). The collection is particularly rich in species from East Africa, and 70% of accessions are of wild origin.

Historically, scientists at Kew have used the plants in this collection to support the description of new species and for long-running studies of the genetic and chemical diversity of *Aloe* as laboratory techniques have advanced. The collection is currently the focus of investigations into the tree of life for *Aloe* and studies of the evolution and properties of the water-storing tissue in the leaves. The *Aloe* Collection will remain a key priority over the coming decades.

Ex situ and in situ conservation

The collections have an important role to play in conservation and this role will remain vitally important in the future. Some of Kew's living plant collections are of significant value as the most complete collections of a particular group in the world (e.g. the Juno iris collection – *Iris* subg. *Scorpiris*). Rare and threatened species are also a significant part of the collections, including 13 taxa that are regarded as being extinct in the wild. In total, around 872 taxa in the Living Collections are categorised as threatened on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (334 Vulnerable, 334 Endangered, 191 Critically Endangered and 13 Extinct in the Wild). Additional taxa that are known to be rare but have not yet been formally assessed are also part of the collections. Planting at scale allows us to bank genetic diversity within our collections, exemplified by our mass planting of coastal *Araucaria araucana* at Wakehurst.

Accessions of conservation importance have usually been targeted and collected in the wild, as part of an ongoing conservation programme, but some plants are sourced through adventitious collections or donations,

and some material arrives at Kew as a result of seizures and confiscation by the UK Border Agency.

Many plants within the Living Collections have been involved in controlled pollination processes in recent years to provide seed for the MSB, the largest and most diverse wild plant seed bank in the world and part of Kew's Science Collections (see Box 3). Maintaining the diversity of taxa through their seed is important for mitigating the risk of loss of species through extinction, as is ensuring that there is genetic diversity within the sampled collection. The Living Collections also support restoration and reintroduction programmes, with expert horticultural protocols developed for the propagation of threatened species (see Box 4).

The natural environment at Wakehurst is of national conservation importance and *in situ* conservation is therefore also an important component of the management of the site. Wakehurst's *in situ* conservation priorities are guided by its Site of Special Scientific Interest status, supported by frameworks such as national Biodiversity Action Plans and partners like the High Weald Area of Outstanding Natural Beauty.

872

taxa in the Living Collections
are threatened with extinction.

Box 3: The Living Collections as a source of seed

The Seed Collection from Living Collections project at Kew started in 2006 as an inter-departmental effort to bank seeds from the Living Collections and to contribute to Kew's scientific target to secure seeds of 25% of the world's flora through the Millennium Seed Bank Partnership (MSBP) by 2020. Since then, the project has developed gradually into banking the many wild-collected, threatened and historical specimens found in the Living Collections, to preserve these important plants for future use. These activities will continue, enhancing Kew's Science Collections and reinforcing the value of the Living Collections for ex situ conservation.

Total number of accessions collected: 1,738

IUCN Red-Listed accessions collected: 477

Wild-sourced accessions collected: 1,224

The image shows seed collection from *Chassalia boryana* for storage in the MSB. This species is endemic to Mauritius and known only from a single population – there are less than ten plants left in the wild.





Iris nusairiensis
(Critically Endangered)

Box 4: Ex situ conservation and restoration

An example of an integrated approach leading to a successful ex situ conservation outcome is that of the St Helena ebony, *Trochetiopsis eburneum*. This shrub is endemic to St Helena and was thought to have been extinct since the mid-nineteenth century. However, in 1980, it was rediscovered – two plants were found clinging to a cliff edge on the eastern side of Blue Point Ridge (Ebony Point). Cuttings from both plants were taken in 1980; new cutting material was taken again from both plants in 2013. Material was brought to the Tropical Nursery, propagated and grown on to flowering size. Seed collection following controlled pollination enabled the genetic diversity of the species to be increased; seeds were then stored in Kew's MSB and also repatriated to St Helena to bolster population size and diversity. There are currently seven accessions of *T. eburneum* at Kew. It is also now widely cultivated on St Helena, where it has been reintroduced to semi-natural situations such as the drylands area of the Millennium Forest and Ebony Plain. Initiatives such as this, which combine horticultural and scientific expertise to achieve conservation success, will form an essential part of the increased integration of science and horticulture set out in this strategy.



Trochetiopsis eburneum

To ensure our vision and strategic aims for the Living Collections are achieved, we collate our current knowledge of the collections and set our framework for the future by considering four questions:

- What collections do we currently have?
- What are the priorities for current collections and new accessions?
- How do we manage and develop our collections?
- How do we increase the value of our collections to support Kew's mission and strategic objectives?

Adiantum raddianum



Hippeastrum psittacinum





Tropical Nursery, Kew

What collections do we currently have?



Encephalartos woodii

The landscapes, glasshouses and nurseries at Kew and Wakehurst house the largest, most diverse collections of living plants in the world.

They contain plant species from 319 plant families from across the globe and comprise 68,490 accessions, representing 27,267 taxa and 18,834 species. China and the USA are particularly well represented in the collections, followed by Japan, Turkey, South Africa and Australia (see Figure 2). 872 taxa in the collections are categorised as threatened with extinction on the IUCN Red List of Threatened Plant Species, and there are 3,148 accessions of these taxa, representing 5% of the collections. Some taxa are grown at both sites, but duplication is minimal, and each location has a unique assemblage of species shaped by the landscape, climate, soil, glasshouses and history of the site (see Figure 3 for an overview). Overall, over 87% of the accessions are identified to species level, making them a truly significant horticultural and scientific resource.



87% of accessions are identified to species level

39% of accessions are of wild origin

3% of taxa are threatened with extinction

5% of accessions are taxa that are threatened with extinction

13 taxa are classified as Extinct in the Wild by the IUCN



Figure 2: Geographical origins of the Living Collections

Countries or regions are shaded according to the number of accessions originating there. Significant numbers of accessions have come from China, the USA, Japan, Turkey, South Africa and Australia.

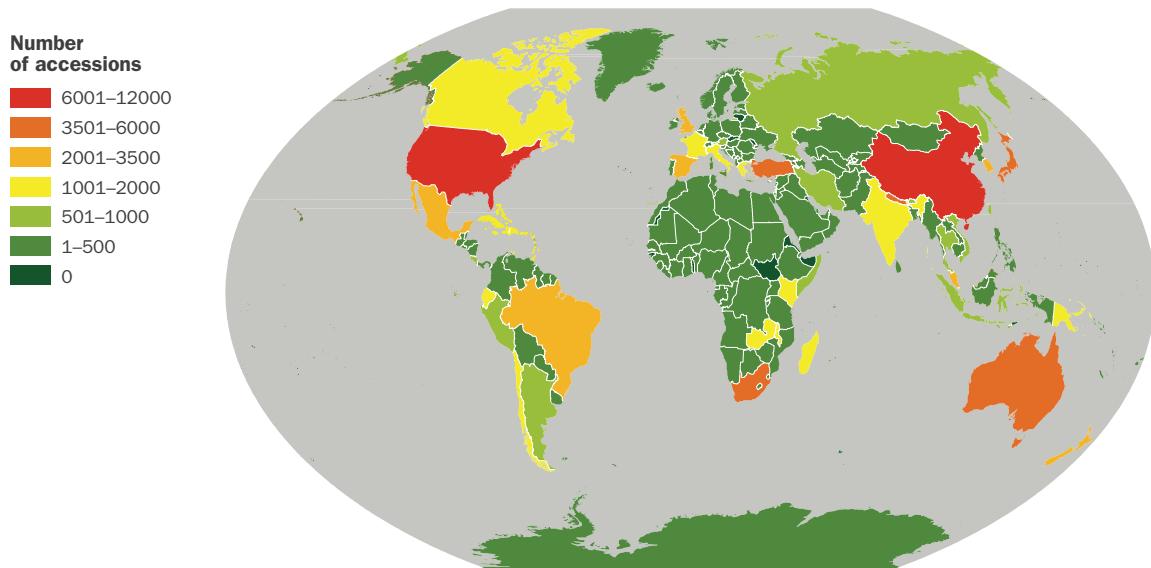
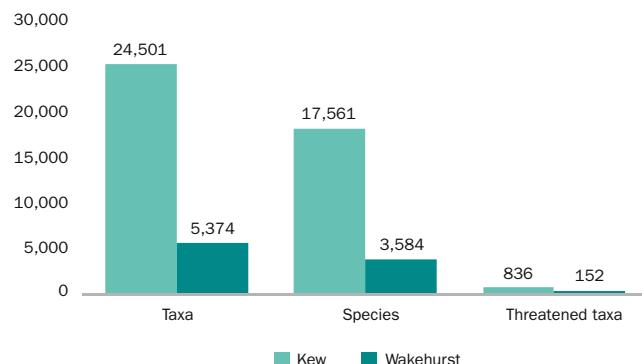
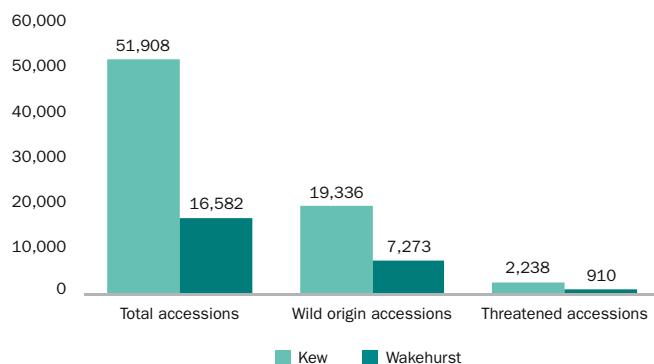
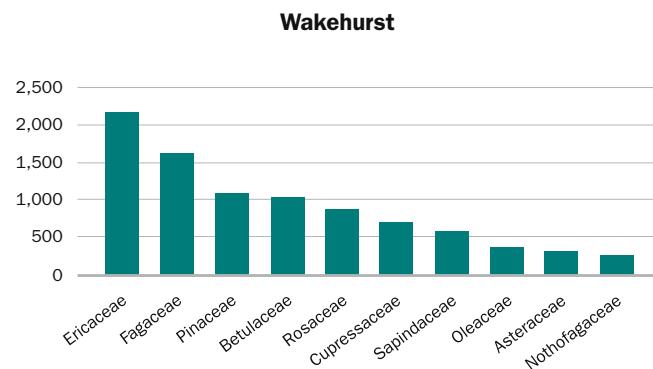
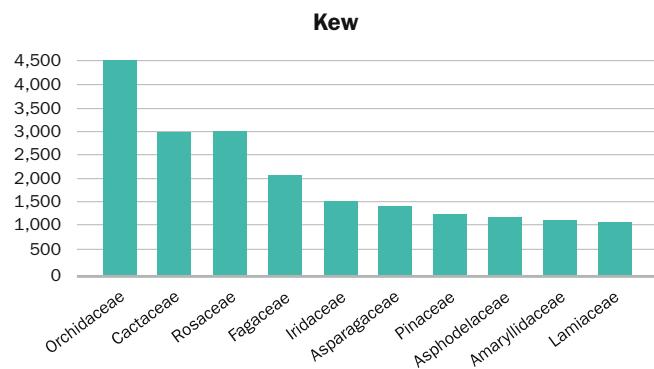
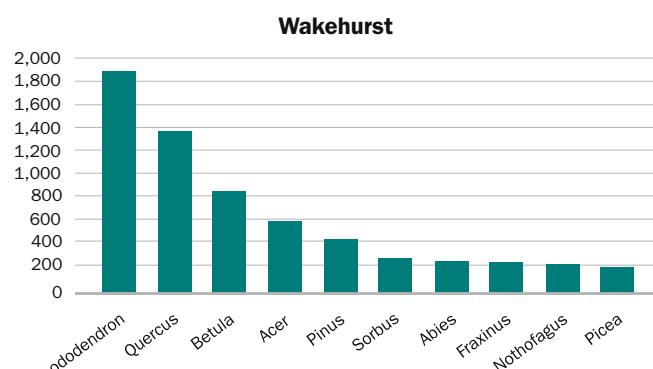
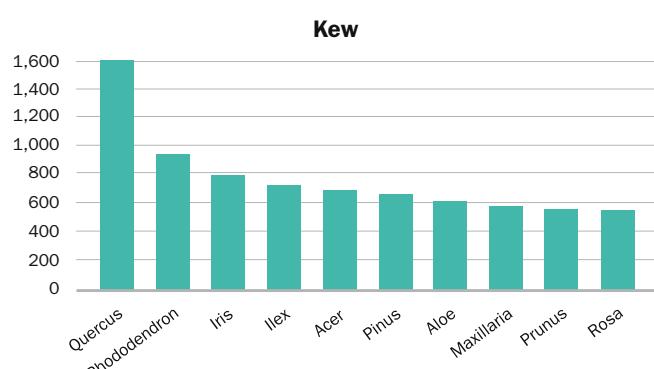


Figure 3: Overview of the collections at Kew and Wakehurst**Overview of accessions and taxa****Top ten families represented in the collections, by number of accessions****Top ten genera represented in the collections, by number of accessions**



Sharing information on dry forest species in the Menabe Antimena Protected Area, western Madagascar

Working in partnership

Kew's living plant collections across both the Kew and Wakehurst sites are the product of over 250 years of working cooperatively with partner institutions, collectors and collaborators around the world. Developing existing partnerships and building new partnerships and cooperative relationships with governments, organisations and other external stakeholders, together with Kew's own scientists and horticulturists, will ensure that the diversity and quality of the living plant collections continues to be enhanced. We will explore ways by which Kew's wealth of living plants can be further accessed for research or conservation activities by partners within the UK and internationally, to maximise the benefits from the accumulated collections and their expert curation. Kew is recognised nationally and globally for the development of effective access and benefit-sharing procedures, which underpin our collection partnerships

worldwide, particularly through arrangements with over 100 countries currently listed as Kew Science partners. We will continue to comply with the Convention on Biological Diversity (CBD), the Nagoya Protocol, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and national laws of partner countries on access to genetic resources and benefit sharing. Where possible and practical, we will support reintroduction of threatened species to their original habitats in partnership with in-country stakeholders. We will also continue to work in partnership with the UK government's border and plant health agencies to provide resources and facilities as needed for biosecurity research, border seizures and plant quarantine.



The living plant collections at Kew Gardens, a UNESCO World Heritage Site, contain over 17,500 species, including 836 taxa that are threatened with extinction.

Amorphophallus titanum

The collections at Kew

The majority of the public site at Kew is planted as a temperate arboretum, with trees planted in family groups that are broadly consistent with Bentham and Hooker's nineteenth-century classification of plant families. There is strong representation of taxa from the temperate northern hemisphere, particularly eastern Asia, North America and temperate regions of the southern hemisphere, such as South America, Australasia and southern Africa. The collections and natural woodland create a living landscape containing around 14,000 individual temperate zone trees. Other key features include a rock garden, woodland garden, grass garden, plant family beds, an extensive rose garden, aquatic displays, large-scale herbaceous borders and a natural zone at the southern end of the site containing mature woodland and wetland habitats.

The glasshouse and conservatory collections add greatly to the diversity of temperate collections (those not able to withstand local winter cold) and also include extensive tropical collections, bulbs and alpines, arid and succulent taxa, aquatic plants, and orchids from around the globe. Some of these collections have their foundations in the eighteenth- and early nineteenth-century collecting, commissioned and guided by Sir Joseph Banks. Plants from tropical, temperate, arid and alpine environments are displayed in our iconic conservatories: the Palm House, Temperate House, Waterlily House, Princess of Wales Conservatory, and Davies Alpine House. In addition, many species are grown and curated out of public view in the 'back-of-house' nurseries: the Tropical Nursery, Arboretum Nursery, Jodrell Glass and Melon Yard (encompassing the

Alpine Nursery). Many of these collections have very specific growing needs, which can be provided through closely managed climate controls and environmental conditions. A state-of-the-art Quarantine Unit is also located within the Tropical Nursery site, allowing inbound plant material to be safely and hygienically isolated, grown and monitored to reduce the risk of pest or pathogen introductions. Key genera and families of significance across the collections at Kew include *Aloe*, *Acanthaceae*, *Arecaceae*, *Bromeliaceae*, *Cactaceae*, *Fraxinus*, *Iris* subg. *Scorpiris* (*Juno* irises), *Nothofagus*, *Orchidaceae*, *Piperaceae* and *Quercus*.

Since the Victoria era, in addition to scientifically valuable living collections, Kew has provided horticultural displays for purely decorative purposes and to recreate natural habitats. Examples include seasonal displays in the Palm House parterre, roundabouts and other display beds. Decorative plantings such as this, which are developed and maintained purely for aesthetic reasons, complement the more botanically interesting living plant collections across the site. Some of the collections are also, by their nature, primarily grouped under an ornamental display theme, or perhaps as a demonstration of the diversity within our rich horticultural heritage.

Alongside being a UNESCO World Heritage Site, the Kew site is also a Grade I Registered Historic Park and Garden, Conservation Area and protected Metropolitan Open Land. Together these designations recognise Kew's significant heritage value, providing local, national and international protection for the landscape, trees and listed buildings within.

Fritillaria acmopetala



Mellissia begoniifolia





Alpine and Rock Garden Collection

Description: A collection of plants from the alpine and rocky regions of the world, which generally occur in hilly and mountainous regions below the lower limit of permanent snow

Location: Alpine Nursery, Alpine House and Rock Garden

Accessions: 6,312 **Taxa:** 3,439 **Wild-sourced:** 70%

Geographic strengths: Mediterranean and Central Asia

Taxonomic strengths: Bulbous monocots of the families Liliaceae (particularly *Tulipa* and *Fritillaria*), Iridaceae (*Iris*, *Crocus* and *Gladiolus*) and Amaryllidaceae (*Narcissus*, *Allium*, *Galanthus* and *Acis*); Plant Heritage National Collections for Juno iris (*Iris* subg. *Scorpiris*) and *Tulipa*

Notable specimens: Rarely cultivated species and forms of *Iris* subg. *Scorpiris* and *Tulipa*; large hardy and half-hardy bromeliads, including *Fascicularia*, *Ochagavia* and *Puya*; many rare species of *Galanthus*; the threatened British natives *Cypripedium calceolus*, *Karpatiosorbus bristoliensis* (= *Sorbus bristoliensis*; Endangered) and *Cotoneaster cambricus* (Critically Endangered); and several other Critically Endangered taxa, including *Galanthus trojanus*, *Centaurea akamantis* and *Iris boissieri*



Aquatic Collection

Description: A collection of waterlilies, lotuses and other aquatic and marginal plants

Location: Tropical Nursery and Princess of Wales Conservatory

Taxa: 91 **Accessions:** 441, incl. 280 *Nymphaea* **Wild-sourced:** 35%

Geographic strengths: Australia, South America and Asia

Taxonomic strengths: Nymphaeaceae (all genera; also all sub-genera for *Nymphaea*) and Nelumbonaceae

Notable specimens: 'Kew-made' *Nymphaea* hybrids that are only displayed at Kew (e.g. *Nymphaea* 'Kew's Stowaway Blues' and 'Kew's Kabuki'); *N. thermarum*, a species known only from one hot spring habitat in Rwanda but now extinct in the wild; and *N. kimberleyensis*, likely to be the largest-flowered waterlily in the world, with blooms up to 40 cm in diameter



Arboretum

Description: A collection of temperate woody plants comprising 100 ha of botanical plantings and 30 ha of seminatural woodland

Location: Southern two-thirds of the Kew site, encompassing the lake environs, Bamboo Garden and Rhododendron Dell, Berberis Dell, Pagoda, Pinetum and surroundings of the Temperate House. Also includes the original 1759 botanic garden at the north end of Kew

Tree taxa: 2,153 **Accessions:** 10,917 **Wild-sourced:** 26%

Shrub taxa: 3,526 **Accessions:** 8,254 **Wild-sourced:** 39%

Geographic strengths: Temperate Far East (especially Central and Western China), South Korea, Japan, Taiwan, Europe (including the Mediterranean), North America, Vietnam and the Caucasus

Taxonomic strengths: Betulaceae, Caprifoliaceae, Celastraceae, Cupressaceae, Fagaceae, Magnoliaceae, Oleaceae, Pinaceae, woody Poaceae (bamboos), Rosaceae and Sapindaceae

Notable specimens: *Fraxinus americana* (Central and Eastern USA), *Juniperus bermudiana* (Bermuda) and *Paulownia kawakamii* (Taiwan) – all Critically Endangered



Arid Collection

Description: A collection of plants adapted to arid environments
Location: Tropical Nursery, Princess of Wales Conservatory and Temperate House
Taxa: 2,000 Accessions: 5,000 Wild-sourced: 30%
Geographic strengths: Africa, Madagascar and the Americas
Taxonomic strengths: Aizoaceae, Asphodeloideae (Aloe, Gasteria, Haworthia, Bulbine), Cactaceae (including epiphytic Cactaceae and Melocactus), succulent Euphorbiaceae, succulent and herbaceous Pelargonium species, Crassulaceae (Adromischus, Tylecodon, Sedum, Echeveria, Cotyledon and Crassula), Asparagaceae (Agave), succulent/caudiciform Apocynaceae and succulent Vitaceae
Notable specimens: Sansevieria kirkii var. pulchra dating back to 1903; Cylindrophyllum hallii, saved from extinction and propagated at Kew; the Critically Endangered Aloe suzannae and Aloe helenae from Madagascar; Dioscorea strydomiana, a Critically Endangered medicinal plant and the world's most threatened yam; and Aloيدendron barberae, given to Her Majesty Queen Elizabeth The Queen Mother during the Royal Tour in the Union of South Africa in 1947



Aroid Collection

Description: A collection of species of Araceae, a widespread tropical family also found in north temperate regions
Location: Tropical Nursery, Palm House and Princess of Wales Conservatory
Taxa: 525 Accessions: 1,003 Wild-sourced: 50%
Geographic strengths: Africa and Asia
Taxonomic strengths: National Collection of Amorphophallus; also Philodendron, Anthurium, Raphidophora, Scindapsus and Alocasia
Notable specimens: Titan arum, Amorphophallus titanum, and other fascinating specimens from the genus, including A. bulbifer, A. variabilis, A. paeoniifolius, A. konjac and A. ankarana; Philodendron adamantinum, endemic to the Espinhaço Range in Minas Gerais, Brazil; and Anthurium superbum (Vulnerable to extinction)



Bonsai Collection

Description: A collection of deciduous and coniferous temperate woody trees and shrubs cultivated using the techniques of the Bonsai Japanese art form to produce miniature specimens
Location: Bonsai House and Walled Garden
Taxa: 19 Accessions: 84 Wild-sourced: 12%
Geographic strengths: China and Japan
Taxonomic strengths: Juniper, Acer and Prunus
Notable specimens: A bonsai Acer palmatum that is approximately 100 years old; two Juniperus chinensis specimens that are thought to be the earliest bonsai imported into the UK (1935); and a specimen of Juniperus rigida representing the 'sharimiki' or driftwood style, which is thought to be 200 years old



Bromeliad Collection

Description: A collection of species of Bromeliaceae from humid tropical rainforests and arid regions

Location: Tropical Nursery, Princess of Wales Conservatory, Palm House and Rock Garden (hardy specimens only)

Taxa: 656 **Accessions:** 974 **Wild-sourced:** >50%

Geographic strengths: Neotropics, particularly the Atlantic Forest (Mata Atlântica) in Brazil

Taxonomic strengths: *Aechmea*, *Neoregelia*, *Pitcairnia* and *Tillandsia*

Notable specimens: *Alcantarea imperialis*, a rupicolous bromeliad endemic to inselbergs in eastern Brazil; *Neoregelia cruenta*, an ecologically important species of sandy coastal plain vegetation; *Goudaea ospinae* var. *gruberi*, endemic to Colombia and a recently described genus; and *Canistrum montanum* and *Nidularium fulgens*, endemic to the Mata Atlântica and not common in cultivation



Carnivorous Plant Collection

Description: A collection of plants that display carnivory, including five of the largest carnivorous genera

Location: Tropical Nursery and Princess of Wales Conservatory

Taxa: 175 **Accessions:** 572 **Wild-sourced:** 24%

Geographic strengths: South-East Asia; Australasia and North and Central America

Taxonomic strengths: *Nepenthes*, *Drosera*, *Pinguicula*, *Sarracenia* and *Utricularia*

Notable specimens: *Nepenthes robortleyi*, a new species from the Philippines described from the Living Collections and under threat of extinction in the wild; the King sundew, *Drosera regia*, known from only two locations in the Bainskloof Range in South Africa; and *Nepenthes rajah*, a species first described by Kew Director Sir Joseph Hooker and restricted in the wild to Borneo's Mount Kinabalu – reputed to produce the largest pitchers of all *Nepenthes* species



Cycad Collection

Description: A collection of 83 cycad species from two of the three extant cycad families: Cycadaceae and Zamiaceae

Location: Palm House, Temperate House and Jodrell Glass

Taxa: 81 **Accessions:** 197 **Wild-sourced:** 23%

Geographic strengths: South Africa and Mexico

Taxonomic strengths: *Ceratozamia*, *Dioon*, *Encephalartos*, *Macrozamia* and *Zamia*

Notable specimens: A number of Critically Endangered species: *Ceratozamia kuesteriana*, *C. miquelianiana*, *Microcycas calocoma*, *Encephalartos sclavoi* and *E. cerinus*; *E. woodii*, which is now classified as Extinct in the Wild; and a specimen of *E. altensteinii*, believed to be the oldest pot plant in the world; Kew holds 27% of the world's cycad species



Nepenthes bicalcarata



Thelypteris reticulata



Fern Collection

Description: A collection of tropical and temperate ferns and lycopods

Location: Tropical Nursery, Palm House, Princess of Wales Conservatory and Temperate House

Taxa: 297 **Accessions:** 432 **Wild-sourced:** 40%

Geographic strengths: South-East Asia

Taxonomic strengths: *Selaginella* and *Polypodiaceae*

Notable specimens: *Angiopteris*, which have the largest known fronds of any fern; filmy ferns (*Hymenophyllum* spp.), whose leaves are generally only one cell thick; *Pteris adscensionis* (part of the *P. dentata* complex), one of only seven remaining endemic plant species on Ascension Island; and *Selaginella willdenowii*, an iridescent species



Grass Collection

Description: A collection of annual and tropical grasses and cereals

Location: Grass Garden

Taxa: 382 (290 species) **Accessions:** 391 **Wild-sourced:** 31%

Geographic strengths: Europe, Africa, South and North America

Taxonomic strengths: *Festuca*, *Stipa*, *Bromus* and *Panicum*

Notable specimens: 22 taxa that are under threat, including *Bromus interruptus*, extinct in the UK until reintroduction in 2004, and the Critically Endangered *Puccinellia distans*



Island Flora Collection

Description: A collection of species from island floras of key interest to Kew

Location: Tropical Nursery, Princess of Wales Conservatory and Temperate House

Taxa: 447 **Accessions:** 790 **Wild-sourced:** 78%

Geographic strengths: UK Overseas Territories, Madagascar, the Canary Islands and the Mascarenes; some accessions from Hawaii, Socotra, Lord Howe Island and the Caribbean

Taxonomic strengths: Wide taxonomic coverage of the islands but Fabaceae particularly well represented

Notable specimens: Many threatened island species rated Critically Endangered by the IUCN, including: *Alsinidendron trinerve* and *Hibiscadelphus distans* from Hawaii; *Sonchus brassicifolius* (= *Dendoseris litoralis*) from Juan Fernández Island; *Cylindrocline commersonii* and *Hibiscus fragilis* from Mauritius; *Melissa begoniifolia* and *Pelargonium cotyledonis* from St Helena; *Salvia caymanensis* from the Cayman Islands; and *Rondeletia buxifolia*, known from one location of around 12 km² on the island of Montserrat



Bulbophyllum fletcherianum



Mediterranean Garden Collection

Description: A collection of plants from the Mediterranean Basin biodiversity hotspot

Location: Mediterranean Garden, Rock Garden and Duke's Garden

Taxa: 339 **Accessions:** 863 **Wild-sourced:** 64%

Geographic strengths: southern Spain

Taxonomic strengths: Cistaceae, Fabaceae (Leguminosae-Papilionoideae), Asteraceae and Lamiaceae

Notable specimens: *Narcissus viridiflorus*, which is threatened by coastal development, and *Gadoria falukei*, a newly discovered species in its own new genus, found in only one location in the Gador mountain range, Almeria, Spain



Orchid Collection

Description: A collection of tropical, subtropical and temperate Orchidaceae encompassing terrestrial, epiphytic and lithophytic species

Location: Tropical Nursery, Princess of Wales Conservatory, Palm House and Temperate House. Hardy species in the Rock Garden and wildflower areas

Taxa: 2,500 **Accessions:** 4,500 **Wild-sourced:** 27%

Geographic strengths: Malaysia, Indonesia, China, Africa, Madagascar and Cambodia

Taxonomic strengths: National scientific collection of *Maxillaria*; generic collections of *Paphiopedilum*, *Bulbophyllum* and *Oncidium*

Notable specimens: *Dendrobium forbesii* (New Guinea); the Critically Endangered *Epidendrum montserratense* (endemic to Montserrat, Caribbean); the Critically Endangered *Paphiopedilum druryi* (endemic to South India and only found as small colonies in the Agastyamala Hills); and *Phaius tankervilleae* (linked to eighteenth-century collections and the first tropical terrestrial orchids brought to flowering at Kew); 600 accessions are on the IUCN Red List of Threatened Species



Palm Collection

Description: A collection of tropical, subtropical and temperate Arecaceae

Location: Palm House, Temperate House, Princess of Wales Conservatory and Jodrell Glass

Taxa: 274 **Accessions:** 482 **Wild-sourced:** 31%

Geographic strengths: Madagascar, South-East Asia and South America

Taxonomic strengths: *Arenga*, *Chamaedorea*, *Dypsis*, *Livistona*, *Phoenix*, *Pritchardia*, *Ptychosperma*, *Sabal*

Notable specimens: *Dictyosperma album*, *Roystonea regia* and many Critically Endangered species, including *Carpoxylon macrosperrnum*, *Chamaedorea plumosa*, *Coccothrinax borhidiana*, *Masoala madagascariensis*, *Pritchardia kaalae*, *Ravenea moorei*, *Tahina spectabilis*, *Pelagodoxa henryana*, *Dypsis carlsmithii* and *Hyophorbe verschaffeltii*



Temperate Herbaceous Collection

Description: A collection of temperate, hardy, non-woody plants with some sub-shrubs

Location: Systematic Garden (Evolution Garden) and adjacent wall borders, Peony Garden, Woodland Garden, Queen's Garden and Grass Garden. Small numbers in the Great Broad Walk Borders, Duke's Garden and Secluded Garden

Taxa: 2,000 **Accessions:** 5,269 **Wild-sourced:** 39%

Geographic strengths: North America, Asia, particularly China, Japan and South Korea, and Europe

Taxonomic strengths: Iridaceae, Poaceae, Lamiaceae (especially *Salvia*), *Paeonia*, *Epimedium*, *Trillium* and *Hosta*

Notable specimens: *Salvia miltiorrhiza*, a Chinese medicinal plant under investigation for possible alleviation of dementia symptoms, *Bromus interruptus*, extinct in the UK until reintroduction in 2004; *Cardiocrinum giganteum*, the largest of all the flowering lilies; and the globally Endangered *Saruma henryi*, *Kirengeshoma palmata* and *Cypripedium formosanum*



Tender Temperate Collection

Description: A collection of frost-sensitive temperate plant taxa, ranging from small herbaceous plants to woody trees and climbers

Location: Tropical Nursery and Temperate House

Taxa: 1,557 **Accessions:** 1,801 **Wild-sourced:** 41%

Geographic strengths: South Africa and South America, particularly the Andes

Taxonomic strengths: Proteaceae (including *Alloxyylon*, *Banksia*, *Banksia*, *Grevillea*, *Hakea*, *Leucadendron*, *Mimetes*, *Protea* and *Stenocarpus*); Ericaceae (including *Agapetes*, *Macleania*, *Erica* and *Rhododendron*); and climbing plants including *Clematis*, *Hardenbergia*, *Hoya*, *Jasminum*, *Kennedia*, *Mutisia* and *Solanum* with a major focus on *Passiflora*

Notable specimens: Specimens of the rare *Banksia brownii*, *Erica verticillata* and *Passiflora cremastantha*; and the largest ex situ collections of arboreal passionflowers (subgen. *Astrophea*) worldwide



Tropical Herbaceous Collection

Description: A collection of herbaceous species from the main tropical plant families of the world

Location: Tropical Nursery, Princess of Wales Conservatory, Palm House, Waterlily House

Taxa: 918 **Accessions:** 2,582 **Wild-sourced:** 29%

Geographic strengths: Tropical East Africa and South America

Taxonomic strengths: Acanthaceae, Gesneriaceae, Marantaceae and Zingiberaceae as well as miscellaneous herbaceous plants in Commelinaceae, Poaceae and Amaryllidaceae. Key genera include *Begonia*, *Saintpaulia*, *Peperomia*, *Impatiens* and *Dorstenia*

Notable specimens: *Issochoma variegata*, a Tanzanian species currently only known in cultivation at Kew; *Heteradelphia paulojaegeria* from Guinea, rated Endangered by the IUCN and not seen in the wild for decades; and *Saintpaulia* – all specimens are of wild origin and all are threatened, making this a valuable ex situ conservation resource



Tropical Woody and Climbers Collection

Description: A collection of woody plants and climbers from every tropical region in the world

Location: Tropical Nursery, Princess of Wales Conservatory, Palm House and Temperate House

Taxa: 1,600 **Accessions:** 2,409 **Wild-sourced:** 42%

Geographic strengths: Mascarenes (100 endemic species represented, most of which are Critically Endangered or Extinct in the Wild)

Taxonomic strengths: Woody collections include Annonaceae, Bignoniaceae, Dracaena, Fabaceae, Lecythidaceae, Malvaceae, Moraceae, Piperaceae, Rubiaceae, Rhizophoraceae and many more. Some of the key climbing genera are *Passiflora*, *Dioscorea* and *Aristolochia*

Notable specimens: *Ramosmania rodriguesii* (café marron), endemic to the island of Rodrigues in the Indian Ocean and brought back from the brink of extinction at Kew; and *Brownea × crawfordii*, a beautiful tropical ornamental tree accession that has been cultivated at Kew since the eighteenth century



Passiflora quadrangularis

The living plant collections at Wakehurst, contain over 3,500 species, including 152 taxa that are threatened with extinction.



The collections at Wakehurst

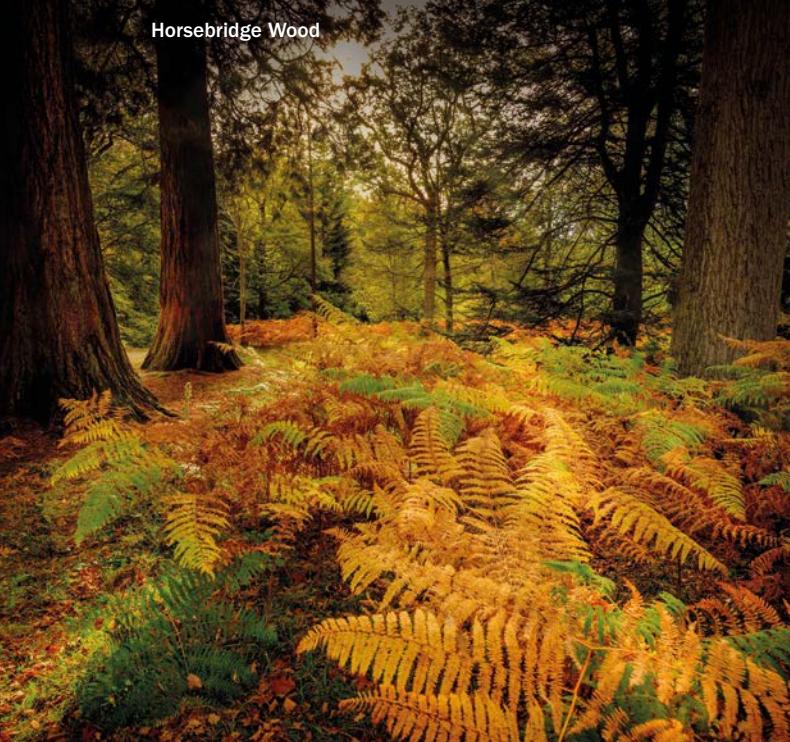
Wakehurst was founded as Kew's 'new' temperate plant collection in the 1960s and the landscape contains around 40,000 individual temperate zone trees. Its large-scale, naturalistic plantings dominate the landscape and accentuate the natural geology and are evocative, immersive and redolent of the wild landscape and plant communities from which the material originates. They are planted phytogeographically to 'woodland' rather than 'arboretum' design principles, in accordance with Armen Takhtajan's Floristic Regions of the World.

Wakehurst's exotic plant collection represents significant temperate woody taxa from the southern hemisphere (Chile, Argentina, South Africa, Australia, New Zealand), the Mediterranean, temperate Asia (the Himalaya, southern China, central Asia and the Caucasus) and temperate North America. Key genera and families of significance include *Rhododendron*, *Magnolia*, *Nothofagus*, *Betula*, *Eucryphia*, *Acer*, *Skimmia*, *Abies*, *Pinus*, *Sorbus*, *Stewartia*, Myrtaceae, Ericaceae and hardy southern hemisphere conifers including *Athrotaxis*, *Podocarpus*, *Pilgerodendron* and *Araucaria*. Composed mainly of wild origin accessions, they are planted in character areas that connect to form a Temperate Woodlands of the World walk. Landscapes such as the Asian Heath Garden and Southern Hemisphere Garden also feature notable accessions that include dramatic specimens of *Osmanthus yunnanensis*, *Pittosporum dallii* and *Sorbus caloneura*.

Wakehurst's collections are also important conservation resources, aligned to the work of Kew's Conservation Science department. A small but significant group of taxa from the MSB's global conservation partnerships are held within the main Wakehurst Nursery and Millennium Seed Bank Greenhouse.

Wakehurst is a definitive High Wealden landscape (an Area of Outstanding Natural Beauty), characterised by sandstone outcrops, deciduous woodland and varied topography. It has been shaped by glaciers and early industry and is one of the most intact medieval landscapes in Europe. The wild habitats nurture a flora of European significance, and the designed landscape holds a UK conservation collection featuring important species such as the Plymouth pear (*Pyrus cordata*). Wakehurst and Chiddingly Woods has been designated a Site of Special Scientific Interest, while the designed landscape of Wakehurst is a Grade II* Registered Historic Park and Garden.

Horsebridge Wood



Magnolia campbellii





Coates Wood Collection

Description: A collection of southern hemisphere trees

Location: Coates Wood, a woodland plateau on the eastern boundary overlooking Bloomers Valley

Taxa: 115 **Accessions:** 833 **Wild-sourced:** 67%

Geographic strengths: South America and Australasia, particularly Chile, Argentina and Tasmania

Taxonomic strengths: *Araucaria*, *Prumnopitys*, *Pilgerodendron*, *Astrocedrus*, *Eucalyptus*, *Wollemia*, *Eucryphia*, *Athrotaxis*, *Nothofagus* and *Podocarpus*; over 60 species in Coates Wood are on the IUCN Red List and some have been stored in the MSB

Notable specimens: Over 70 wild-sourced *Araucaria araucana* specimens collected from their last coastal distribution in Chile; *Eucalyptus morrisbyi*, a rare and Endangered tree endemic to south-eastern Tasmania; and 30 *Wollemia nobilis* specimens planted in a grove



Horsebridge Wood Collection

Description: A collection of North American trees

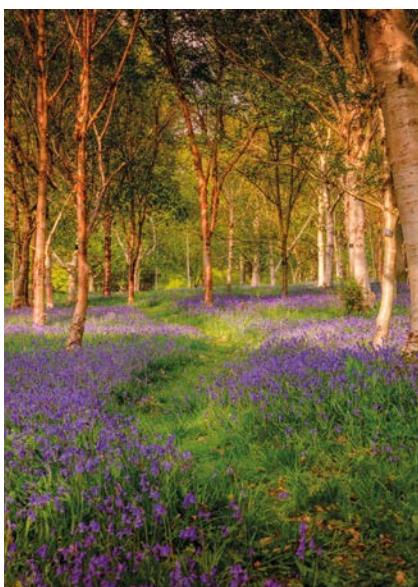
Location: Horsebridge Wood, dominated by a sandstone ridge east of the boundary

Taxa: 235 **Accessions:** 1,306 **Wild-sourced:** 67%

Geographic strengths: Six North American floristic provinces are represented: Appalachian, Vancouverian, Rocky Mountain, Californian, Atlantic and Gulf Coastal Plain, and Canadian

Taxonomic strengths: *Quercus*, *Abies*, *Acer*, *Calocedrus*, *Pinus*, *Sequoia*, *Pseudotsuga*, *Sequoiadendron*, *Picea* and *Carya*, including 135 threatened species; and new wild-collected *Abies fraseri* plantings – this species is threatened and decreasing in the wild

Notable specimens: *Sequoiadendron giganteum*, *Sequoia sempervirens*, *Pseudotsuga menziesii*, *Picea breweriana* and *Abies bracteata*



National Betula Collection

Description: The national collection of *Betula* (birch)

Location: Bethlehem Wood (native oak and ash), adjacent to Coates Wood

Taxa: 103 **Accessions:** 825 **Wild-sourced:** 56%

Geographic strengths: USA, China, Japan, South Korea and Nepal

Notable specimens: The collection has over 40 IUCN threatened taxa, including the Critically Endangered *Betula chichibuensis* (young seedlings of this species are currently being grown at Wakehurst Nursery); the Endangered *B. megrelica*; and *B. pubescens* var. *litwinowii* and *B. tianschanica*, both of which are listed as data deficient



National *Nothofagus* Collection

Description: The national collection of *Nothofagus* (Southern beeches)

Location: Coates Wood, a woodland plateau on the eastern boundary overlooking Bloomers Valley

Taxa: 19 **Accessions:** 258 **Wild-sourced:** 95%

Geographic strengths: Chile, Australia, Argentina and New Zealand

Notable specimens: 16 threatened *Nothofagus* species; significant new plantings of Australian and Chilean species, including the Endangered *N. alessandrii*; and some impressive mature specimens of *N. alpina*, *N. dombeyi*, *N. obliqua* and *N. fusca*



Rhododendron Collection

Description: A varied collection of *Rhododendron* taxa

Location: Westwood Valley, Asian Heath Garden and Water Gardens

Taxa: 546 **Accessions:** 1,885 **Wild-sourced:** 33%

Geographic strengths: China, Bhutan, Japan, Taiwan and Nepal

Notable specimens: Over 100 threatened taxa, many of which are also uncommon in cultivation, including *Rhododendron fauriei*, *R. × diphrocalyx*, *R. dimitrum*, *R. forrestii*, *R. fragariiflorum*, *R. glaucophyllum* subsp. *glaucophyllum*, *R. huidongense*, *R. kongboense*, *R. mimes*, *R. sanguineum* var. *cloioiphorum*, *R. taiwanalpinum*, *R. temenium* var. *gilvum* 'Cruachan' and *R. zaleicum* var. *flaviflorum*; the Kew and Wakehurst *Rhododendron* collections are globally significant and Wakehurst is now part of the Global Conservation Consortium for *Rhododendron*



Westwood Valley Collection

Description: A collection of Asiatic woodland plants

Location: Westwood Valley, a ghyll woodland ravine creating a central spine connecting the upper gardens to the more informal landscape

Taxa: 825 **Accessions:** 2,899 **Wild-sourced:** 53%

Geographic strengths: China, India, Nepal, Japan, Taiwan, South Korea

Taxonomic strengths: *Rhododendron* (with over 1,800 accessions) and significant collections of *Acer*, *Betula*, *Magnolia*, *Tilia*, *Prunus*, *Ilex*, *Deutzia*, *Viburnum*, *Pinus*, *Pieris* and *Weigela*

Notable specimens: Over 150 Red List species, including species in the genera *Rhododendron*, *Betula*, *Tsuga*, *Taiwania*, *Thuja* and *Taxus*; the collection also includes some large specimens of *Pseudotsuga menziesii*, *Quercus* and *Fagus*



Neoregelia concentrica

The growing environments



Palm House

Description: The Palm House is one of Kew's most iconic buildings and is Grade I listed due to its historic and architectural significance. It has a large central atrium approximately 20 m high, with a 9-m-high walkway that is reached by two spiral staircases. There are also two wings attached to the central atrium, which are all connected and open. Nearby sits the Campanile, which is Grade II listed and served as the chimney to the Palm House boilers. The environment is tropical and varies throughout the zones, as the south end receives more sunlight.

Designed by: Decimus Burton

Constructed: Between 1844 and 1848 by Richard Turner

Area: 2,174 m²

Humidity: 70–100%

Temperature: 20°C+

Plants: Mixed tropical ornamental plants with major collections of palms and cycads, many economically and ethnobotanically important plants and many of conservation value.



Waterlily House

Description: A Grade II listed square tropical glasshouse with a central circular pond, originally constructed to house the giant waterlily *Victoria amazonica*. At the time of its construction, it had the widest unsupported span of any glasshouse, achieved through the use of trusses strengthened with iron hoops.

Designed by: Decimus Burton

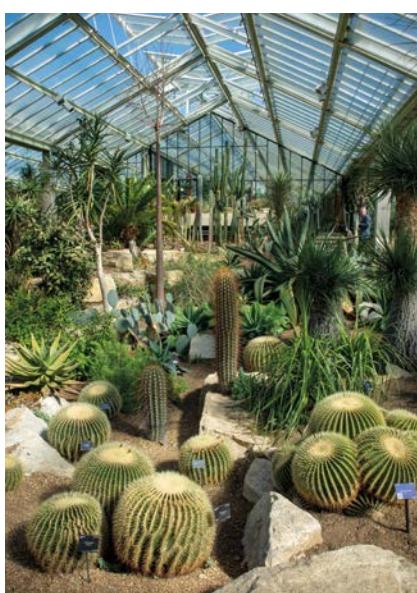
Constructed: 1852 by Richard Turner

Area: 225 m²

Humidity: 75–100%

Daytime temperature: 20°C+ (pond 28°C)

Plants: Mixed tropical ornamentals and aquatic plants, including waterlilies (particularly *Victoria* spp.), ferns, papyrus and hanging gourds (Cucurbitaceae).



Princess of Wales Conservatory

Description: The Princess of Wales Conservatory is the most complex glasshouse at Kew. It is a low-profile glasshouse designed to showcase different environments, associations and plant adaptations. It was named after Augusta, Princess of Wales (the mother of George III), and opened in 1987 by Diana, Princess of Wales. There are ten computer-controlled climate zones covering arid, temperate, seasonally dry and tropical environments, and aquatic displays within two large tanks.

Designed by: Gordon Wilson

Constructed: 1987 by French Kier

Area: 4,500 m²

Humidity: Ranging from 65–75% in the arid zone to 75–100% in some tropical zones.

Temperature: Ranging from 5–10°C in the cool temperate zone to 20–26°C in the rainforest zone.

Plants: Mixed plants from wet and dry tropical, temperate and arid climates. Orchidaceae, Cactaceae, carnivorous plants and ferns are particularly well represented, along with key tropical families such as Araceae, Bromeliaceae, Marantaceae, Begoniaceae, Acanthaceae, Heliconiaceae and Gesneriaceae.



Davies Alpine House

Description: An open-sided glasshouse with a convex curved ridge, designed to display elements of the Alpine Collection to visitors. Standing at 10 m tall with a north-south orientation, it was designed to maximise light transmission and air flow in summer and be frost-free in winter. Shading is provided when necessary by two sail-like shading wings that service each face.

Designed by: Wilkinson Eyre

Constructed: 2005 by Tuchschen Constructra AG

Area: 96 m²

Humidity: Ambient

Temperature: Minimum 1°C

Plants: Alongside a permanent display of larger alpine specimens, potted show-plants are brought from the Alpine Nursery weekly, including bulbous monocots, particularly Liliaceae, Amaryllidaceae and Iridaceae, cushions and mat-forming species within genera such as *Dionysia*, *Draba*, *Androsace* and *Saxifraga*, Araceae, *Sempervivum*, and a selection of other genera from the montane regions of the world.



Temperate House

Description: A Grade I listed glasshouse comprising a main central rectangle joined by two octagons to two further rectangles (north and south blocks). Made of cast and wrought iron, steel, wood and glass, it has undergone two major restorations, the first in the late 1970s and the second from 2012 to 2018. A new interpretation style and presentation was developed for the latest restoration and this provides visitors with insights into Kew's scientific activities, in addition to building environmental literacy.

Designed by: Decimus Burton

Constructed: 1859–1899 by William Cubitt and Co. and Jabez James of Lambeth (structural engineer)

Area: 4,880 m²

Humidity: Ambient

Temperature: 8–26°C

Plants: 1,300 temperate plants from Australasia, Africa, the Americas, Asia and island floras, including many threatened species and several taxa that are now extinct in the wild.



Davies Exploration House

Description: A Grade II listed aluminium glasshouse originally built to house a collection of Australian plants (Australian House) and subsequently set out to depict the stages of plant evolution (Evolution House). Currently, it displays plants from south-west Western Australia and is named the Davies Exploration House.

Designed by: S. L. Rothwell (Ministry of Works Architect)

Constructed: 1952 by Crittall Manufacturing Co.

Area: 770 m²

Humidity: Ambient

Temperature: 12–26°C

Plants: Mixed temperate shrubs and herbaceous plants from south-west Western Australia.



Tropical Nursery

Description: An extensive nursery built to provide plants for the three public display houses and for conservation and scientific research. There are 21 individually controlled climatic environments, containing the most diverse collections of plants at Kew. The complex also includes a propagation glasshouse built for the Temperate House restoration project and to produce plants for seasonal display. In addition, there is an old quarantine house used for propagation of plants from the Palm House (to guard against the spread of chilli thrip, *Scirtothrips dorsalis* to other collections).

Area: 6,500 m²

Humidity: From ambient to 60–80%

Temperature: Tailored to each of the 21 climatic environments but ranging from 5–10°C for temperate carnivorous plants, to 10–24°C in the general temperate growing and propagation zones, to 14–28°C across the tropical zones. There are also six large aquatic tanks for cultivation of waterlilies, heated to desired temperatures ranging from 24°C to 30°C.

Plants: 10,200 taxa divided into four units across the 21 zones: cacti and succulents; moist tropics; orchids; temperate.



Alpine Nursery

Description: A complex of frames (rain covers with open sides or removable roofs/lights) and modified Venlo-style houses dedicated to growing the Alpine Collection, producing display material for the Alpine House and the Rock Garden and housing IUCN Red-Listed alpine taxa. It is one of the largest facilities for growing alpines in a botanic garden setting in the world.

Area: 893 m²

Humidity: Ambient

Temperature: Ambient for external structures. Minimums of 1–6°C for glasshouses.

Plants: A selection of plants from the alpine and mountainous regions of the world, with Liliaceae, Amaryllidaceae and Iridaceae well represented.



Arboretum Nursery

Description: A glasshouse and field facility for the propagation of the hardy woody plant collections, and also the hardy herbaceous collections for the Arboretum and Gardens. It contains six environmentally controlled zones within the main glasshouse complex (one of which can house larger trees to give some winter protection), two polytunnels and a potting shed. A key feature is the public access route, to provide visitors with a look behind the scenes at the facility and its activities. The climatic zones provide the varied temperature and humidity levels needed for germinating seeds, rooting cuttings, growing on pricked out seedlings and hardening off transplants before they are grown on in the field.

Area: 957 m²

Humidity: 50–75%

Temperature: Minimum day and night temperatures range from 3 to 12°C.

Plants: A range of hardy woody and hardy herbaceous plants for the Arboretum and Gardens.



Decorative Nursery

Description: A complex of two glasshouses, a polytunnel and two standing out grounds for producing plants for displays across the outdoor environment at Kew. The main house is a Cambridge design and is divided to create two environments, one for growing plants on and the other for seed germination, propagation and growing plants that require higher temperatures. The second glasshouse is a warmer house for tropical, taller-growing plants and the polytunnel is used to overwinter hardy plants that need some winter protection. The two standing out grounds are used for hardening off plants before planting out into beds or containers.

Area: 675 m²

Humidity: Ambient

Temperature: The two zones in the main house are at 11–14°C and 13–18°C and the second house is at 20°C.

Plants: A range of herbaceous plants for displays across the Gardens.



Jodrell Glass

Description: Jodrell Glass is a multi-span glasshouse range that provides a resource for science support, research and conservation activities. It comprises five zones ranging from temperate (ambient conditions/frost-free) through to lowland tropical conditions.

Area: 1,000 m²

Humidity: Ambient or can be increased manually

Temperature: One zone at 12°C, two at 21°C and two at 25°C.

Plants: A high proportion of the plant material propagated and cultivated in Jodrell Glass is of wild origin and of conservation concern. Plants are also often produced for the display houses and outdoor summer displays. Major plant groups routinely managed include tropical, temperate and aquatic palms, cycads, *Dioscorea* (yam) species, woody Mexican and Madagascan legumes, *Welwitschia* and members of the Lamiaceae.



Plant Reception and Quarantine Unit

Description: A state-of-the-art, purpose-built, government-licensed facility used for the containment, inspection and management of live plant material, the growth of endangered species and taxa prohibited under plant health legislation, and the study of plant-pathogen interactions. The Unit provides containment facilities equivalent to containment category 2/3 and is vital in enabling Kew to safely add wild-collected plant material from fieldwork to the Living Collections.

Area: 900 m²

Humidity: Ambient to 85% as required

Temperature: 16–50°C in high containment bays, -2–40°C in growth chambers, 4–60°C in cooled incubators and ambient in the temperate store.

Plants: A wide range of plant species, largely obtained through fieldwork overseas, controlled or prohibited under plant health legislation; high-risk plants and propagules; material on behalf of plant health and border control agencies; incoming material intended for incorporation into the Living Collections or for research (e.g. plants, wood, fungi).



Wakehurst Nursery

Description: A complex of six greenhouse zones, polytunnels, shade structures, standing out space and cold frames. This area houses the Plant Propagation and Conservation Unit, which grows plants of national and international significance. Around 50% of its production is dedicated to Kew's scientific research and 50% to the botanical, conservation and display collections at Wakehurst. The nursery unit produces plants for scientific verifications, research, display and regeneration of seed internationally but also for the UK Seed Hub native wildflower project.

Area: 6,000 m²

Humidity: Ambient to tropical

Temperature: Ambient for external structures and 1–20°C for glasshouses.

Plants: Temperate plant species, including conifers, broadleaved trees, shrubs and herbaceous plants. Also palms, succulents and UK wildflowers for the MSB.



Millennium Seed Bank Greenhouse

Description: A complex of four greenhouse zones, including a potting shed area, dedicated to Kew's scientific research. This encompasses producing plants for scientific verifications, research, display and regeneration. The area is also part of the Plant Propagation and Conservation Unit, which grows plants of national and international significance.

Area: 600 m²

Humidity: Ambient to tropical

Temperature: Greenhouse temperatures range from 6 to 20°C.

Plants: Temperate plant species: conifers, broadleaved trees, shrubs and herbaceous plants. Also palms, succulents and UK wildflowers for the MSB.



The Great Broad Walk Borders at Kew



Boardwalks at Wakehurst



Bethlehem Wood at Wakehurst

Outdoor environments

Outdoor environments at Kew

The landscape at Kew combines elements of significant historical planting with more contemporary aesthetic and decorative themes, and horticulturally and scientifically important wild-sourced accessions. Features include the Rock Garden, Arboretum, Rose Garden, Order Beds (being redeveloped in 2019 as the Agius Evolution Garden) and adjacent wall borders, Peony Garden, Woodland Garden, Rhododendron Dell, Queen's Garden and Grass Garden. Features that are primarily decorative include the Great Broad Walk Borders, Duke's Garden and Secluded Garden. The soil profile is formed from the floodplain of the River Thames and the substrate therefore has a riverbed composition of sandy/silty soil, lacking in organic matter and water retention. As a result, the display beds require organic matter to be worked into the soil on an annual basis and regular watering is required during dry periods. The location on a floodplain also means that the Gardens are predominantly flat, with varied topography being provided through site excavation (such as the Rhododendron Dell), landscape construction (such as the Rock Garden and Japanese Gateway) and other local modifications.

The Rock Garden provides perhaps the most varied of habitats in the outdoor sections of the Gardens. It is constructed from Hoathly sandstone and is used for displaying hardy and half-hardy living collections from seven mountainous and rocky regions of the world. It includes several water features, allowing carnivorous, bog and marginal plants to be cultivated. The three-dimensional structures and use of water allow for microclimates to be created throughout the garden, allowing successful cultivation of plants not considered hardy.

At the southern end of the Kew site is an extensive area of semi-natural woodland, managed as a habitat to maintain biodiversity.

The annual average rainfall at Kew is 622.5 mm (24.5 in), with 113 days of rain per year*. The growing environment equates to Zone 9 under the United States Department of Agriculture (USDA) Hardiness Zone system.

* Data from metoffice.gov.uk for the period 1981–2010

Kew



Yearly average temperature



Yearly total sunshine hours



Yearly total rainfall

Outdoor environments at Wakehurst

The living plant collections at Wakehurst are inextricably linked with the landscape. Exotic plants are woven into native woodland, dramatic valleys and plateaus are accentuated by new plantings, and the native flora is sustained by the extraordinary sandrock geology. Wakehurst's Elizabethan mansion sits at the heart of this landscape, commanding a series of domestically-scaled gardens with ornamental species. The wider designed landscape is dominated by exotic, wild-collected woody plantings. Features of the landscape include native and exotic woodlands, the Southern Hemisphere Garden, Winter Garden, species-rich native grassland of Bloomers Valley, and Westwood Lake at the bottom of the estate.

Wakehurst and Chiddingly Woods contain extensive exposures of sandrock, a nationally rare habitat, which are of biological and geological importance. This site has the richest sandrock community in the country, supporting a unique flora. The wooded ghylls have been formed by streams cutting through formations of Wadhurst clay and Lower Tunbridge Wells sands, leaving exposed outcrops of sandstone in the valleys. The warm, moist microclimate allows plants that are more typically restricted to the west of the country to flourish. The sandrocks support rich communities of ferns, bryophytes and lichens. These are a remnant of a Western 'Atlantic' plant community once far more widespread in distribution.

The annual average rainfall for Wakehurst is 818.8 mm (32.2 in), with 124 days of rain per year*. The growing conditions equate to Zone 8/9 under the United States Department of Agriculture (USDA) Hardiness Zone system.

* Data from metoffice.gov.uk for the period 1981–2010

Wakehurst



Yearly average temperature



Yearly total sunshine hours



Yearly total rainfall

What are the priorities for current collections and future accessions?



The Orchid Collection at Kew is the oldest and most comprehensive collection of live orchids in the world.

Cattleya trianae

Kew's living plant collections already represent a significantly diverse and valuable resource. We will aim to increase the geographical, taxonomic and genetic diversity of the current collections and maintain a staggered age profile, with all plants in good health and accurate and detailed supporting data for all accessions.

Our top priorities will be the development of the collections to provide greater value for Kew's scientific research and strategic outputs, and increased representation of rare and threatened taxa, particularly IUCN Red-Listed taxa.

Continuing to add to the general diversity of the Living Collections remains a priority, where this is practically achievable. This is possible where either the controlled climate conditions within Kew's nurseries or conservatories are a good match for the optimum growing conditions, or the taxon is well suited to the outdoor climatic and edaphic conditions. In some cases, removal or substitution of common taxa for rarer or more unusual taxa may be an option.

In considering future priorities, it is necessary to be aware of the differences between the nature of nursery-based (or conservatory-based) containerised or in-ground stock and plants growing in the broader landscape. Clearly there is more scope for change in containerised collections, rather than those growing in the ground, particularly when considering long-lived woody stock that may also be performing roles in overall landscape quality or as elements of heritage significance. Change in the landscape is necessarily a slower process.

In publicly accessible locations at both Kew and Wakehurst, there will continue to be a focus on taxa that can be used to tell 'plant stories' for visitors, to enable better understanding of plant biology, life cycles, classification and evolutionary relationships, and environmental issues.

Pachystachys lutea



Begonia platanifolia



Supporting Kew's scientific research

Diversification of the Living Collections to increase their value for Kew's scientific research programmes is one of our key aims, and this will greatly enhance the integration of horticulture and science and provide reciprocal benefits.

The Living Collections have the potential to provide material for many different lines of scientific investigation, including taxonomy, genomics, reproductive biology and more (see Figure 4), and the expansion of the current collections will be undertaken in line with this aim, where space and resources allow. Kew's Science Strategy sets out four key questions to provide a framework for scientific research activities, and the Living Collections are a valuable resource for addressing each of these questions:

1. What plants and fungi occur on Earth and how is this diversity distributed?

Documenting plant diversity is one of the key activities at Kew, and our expert taxonomists are engaged in naming and describing up to 250 new species every year. However, the identification and naming of specimens often requires flowers or fruits to be present, which is often not the case. If living specimens or seeds are brought back from expeditions, our horticultural experts can incorporate them into the Living Collections and nurture them through to flowering or producing fruit, so that identifications can be made. This is particularly valuable for research on orchids, where large numbers of specimens are cultivated just to produce flowers for identification purposes. Specimens that are cultivated for this purpose may turn out to be new to science (see Box 5), and the living plants then become invaluable for preparing the formal description of the new taxon and for interpretation opportunities. In developing the links between horticulture and science, we will continue to cultivate and propagate unidentified material from priority families and regions, supporting the discovery and documentation of the world's plant diversity.

2. What drivers and processes underpin global plant and fungal diversity?

Gaining scientific understanding of the evolutionary relationships across the tree of life, and the drivers and processes that result in adaptation and diversity, is fundamental research that often requires living specimens.

Our aim is to build up the Living Collections to align more closely with the taxonomic and geographic priorities set out in the Science Strategy and to make them available for the study of natural variation among organisms. Samples of living material can be taken from selected specimens to be used for fundamental research on the classification and evolution of plants (including samples for phylogenetics, genomics, transcriptomics and metabolomics) and investigating the evolution of characteristics such as flower and pollen morphology, genome size, seed and dormancy characteristics,

and specific morphological adaptations to arid environments. In this way, the Living Collections can greatly facilitate understanding of the patterns in plant evolution and diversity.

3. What plant and fungal diversity is under threat and what needs to be conserved to provide resilience to global change?

We cannot conserve what we don't understand, and Kew's collections and taxonomic experts are essential to the processes of discovering, describing and therefore conserving biodiversity. The Conservation Science department helps to document and conserve threatened species and to highlight priority species and areas, providing vital information for conservation planners and policymakers.

There are active research programmes across the globe, particularly in the UK Overseas Territories and Madagascar, and an extensive global seed collecting programme contributing to the Banking the World's Seeds strategic output. There is also a strong focus on UK threatened and priority species. We will continue to support *ex situ* conservation projects in priority areas and to propagate material of threatened plants where needed for identification, as a source of seed, or for restoration programmes. Several successful restoration programmes have resulted in the repatriation of material grown at Kew to native locations, in some cases averting the extinction of endemic island species. We will continue to build up new accessions of threatened island plants and to propagate them, where doing so will achieve a positive conservation outcome. We will also continue to collect seed from key collections to deposit in the Seed Collection at the MSB and enhance the diversity of *ex situ* collections.

4. Which plants and fungi contribute to important ecosystem services, sustainable livelihoods and natural capital, and how do we manage them?

Through collaboration with the Science Directorate, we will seek to use the Living Collections to undertake research into how the collections as a whole, and the plant species they contain, contribute in a positive or negative manner to ecosystem services that underpin societal benefits; these include provision of clean air, carbon capture and sequestration, food, energy, human health and wellbeing, and resilience to pests and diseases. We will prioritise accessions of taxa important to food security, especially non-mainstream crops and edible wild plants and species associated with pollinators that play key roles in ecosystem function, crop pollination and bee health. We will also seek to ensure that we hold species that contribute to human health and wellbeing and those that can help ameliorate the effects of global climate change, such as those adapted to conserve water. We will make material from these plants available for comparative investigation, for example for phylogenetic and chemical analysis.

Figure 4: The diverse uses of the Living Collections for scientific research

Kew's Living Collections provide living plant material for many fields of scientific study. Alongside the traditional but rapidly evolving fields of taxonomy and conservation, living plants can provide samples for the many emerging 'omics' fields of study – e.g. genomics (the study of the structure, function, mapping and evolution of genomes), transcriptomics (the study of the products of gene expression within cells – RNA molecules) and metabolomics (the large-scale study of metabolites – small molecules produced by plants for growth, development and specific functions such as defence or attracting pollinators).



Box 5: Accelerating species discovery

In 2014, specimens of an unidentified plant in the family Gesneriaceae were brought to Kew and Edinburgh from a temperate evergreen rainforest in Northern Vietnam. The specimens were collected on a joint expedition between Kew, the Royal Botanic Garden Edinburgh (Logan Botanic Garden), Longwood Gardens, the University of British Columbia and the Institute of Ecology and Biological Resources, Hanoi. Plants grown on from seed collections made on the expedition flowered at Kew and Edinburgh in 2016 and were confirmed to be a species new to science in the genus *Oreocharis*. The formal description of the plants was made using this flowering material and herbarium specimens collected in the field, and the new name was formally published as *Oreocharis tribracteata* in 2018. This would not have been possible without the combined efforts of taxonomists and horticulturists. We aim to continue such activities to accelerate the documentation of the world's plant diversity.

Oreocharis tribracteata



Geographical priorities

Kew's Science Collections Strategy identifies four main target regions for increased collecting activity: Africa, South-East Asia, Central and South America, and the UK, including the UK Overseas Territories. These are based on areas of expertise and target areas that require further botanical and mycological exploration to fill knowledge gaps or gaps in the collections. Combining scientific and horticultural expeditions in these regions will bring benefits to both the Science and Living Collections, aligning interests across the organisation.

It will also strengthen our overseas partnerships and bring a more holistic approach to our work, both at Kew and internationally. We will also focus on the UK native flora to make use of our natural spaces and the inherent suitability of both sites for growing these species.

Africa

Priorities for development of the African collections include further collections from threatened habitats in Madagascar, from temperate southern Africa (including new material of the genus *Aloe* and other succulent and cacti genera from sensitive or threatened habitats) and also new collections

from the floristically rich southern tropical or subtropical zones, including Angola and Mozambique.

Central and South America

The focus for new collections from this zone will include herbaceous Andean alpine taxa (for possible inclusion in the Rock Garden or Davies Alpine House) and specific additions to collections of Orchidaceae and Asteraceae. Cool temperate deciduous and evergreen trees and other woody plants from the southern zone (Chile, Argentina) will also continue to be a priority for outdoor planting. A southern hemisphere conifer collection will be developed for Wakehurst.

South-East Asia

Possible new areas for collection development for Kew include higher altitude taxa, additional Orchidaceae (including newly described taxa) and potentially threatened island floras. The island of New Guinea is currently a focus of scientific research leading to the production of the first *Flora of New Guinea*. This is therefore a potential focus for new

Aloiaampelos ciliaris
(South Africa)



Bulbophyllum nasica
(New Guinea)



collections, particularly given the floristically rich and diverse habitats, which range from mangroves and rainforest to alpine grasslands.

Within the Wakehurst collections, the priority countries for new collections from the wider Asian region build on the strengths of the existing regional collections while exploring the rich floras of other under-collected central and east Asian zones. They include China, Nepal, Tibet, South Korea, Taiwan, Vietnam, Japan, Kyrgyzstan, Azerbaijan, Armenia, Georgia and Turkey.

UK Overseas Territories

Further additions of IUCN Red-Listed taxa, or those known to be under threat and for possible future listing, will be made from the UK Overseas Territories, in particular: the Caribbean islands; St Helena and Ascension Island in the Atlantic Ocean; Tristan da Cunha, South Georgia, South Sandwich and the Falkland Islands in the South Atlantic; and the Pitcairn Islands in the South Pacific. Priority will be given to herbaceous or smaller shrub material, due to space restrictions for tree stock.

British native species

The collection of British natives will be expanded, both in the Natural Areas of the Arboretum and within the nurseries and Rock Garden. At Wakehurst, the *in situ* conservation areas will continue to be managed and developed in line with Natural England frameworks. The UK High Wealden flora will remain a priority.

Phytogeographic priorities at Wakehurst

In addition, at Wakehurst there will be continuing geographical emphasis on the southern hemisphere collections: from New Zealand, Australia (with a focus on Tasmania), Chile and Argentina. This will include development of a temperate southern hemisphere conifer national collection. North America (Canada, USA) and Mexico will also remain as priorities, as will European regions including Spain, Italy, the Carpathian Mountains, and alpine zones.

British Virgin Islands



Taxonomic priorities

Kew's Science Collections Strategy identifies seven target plant families for global research: Arecaceae, Asteraceae, Fabaceae, Myrtaceae, Orchidaceae, Poaceae and Rubiaceae.

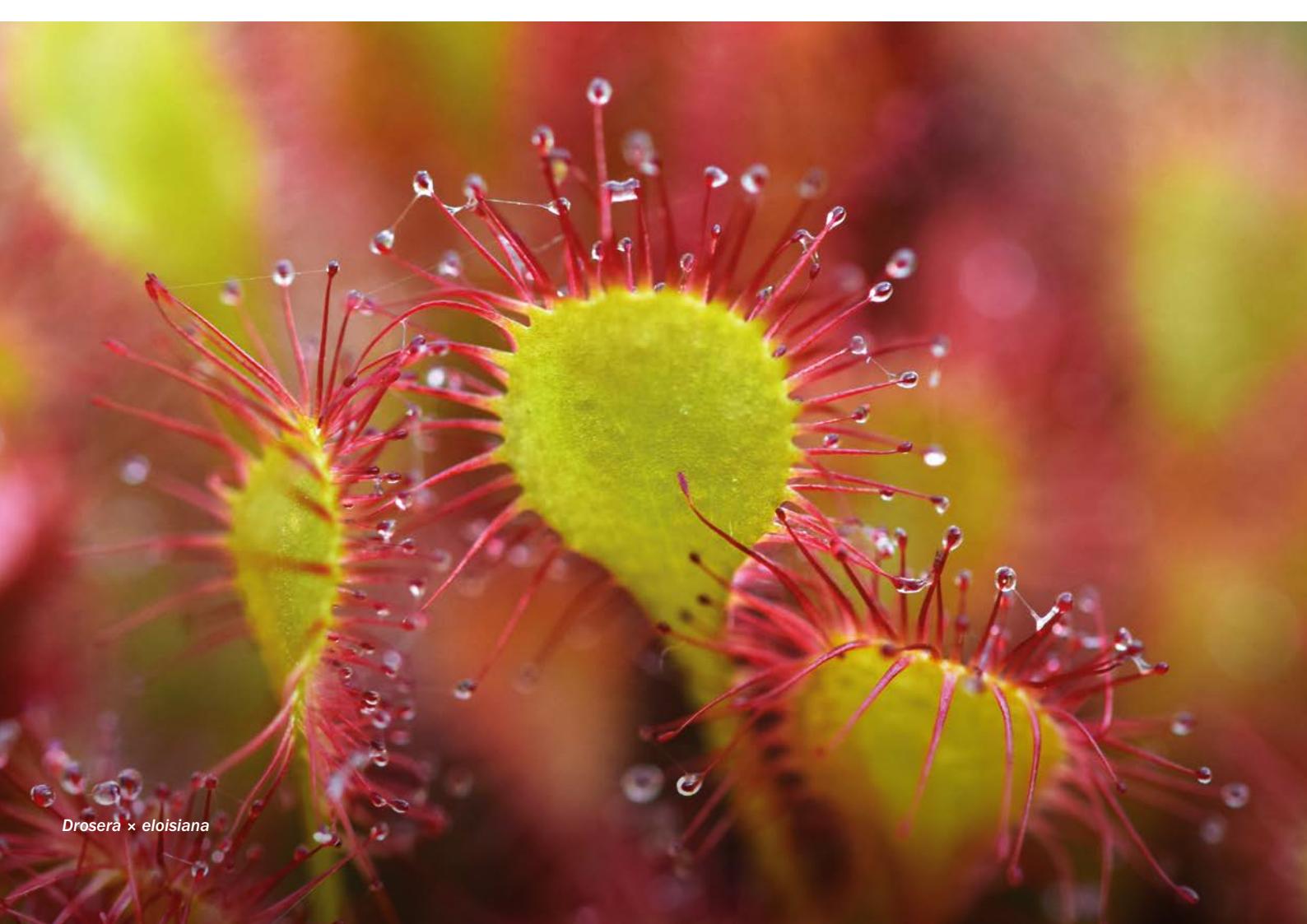
Work on these families builds on the large numbers of scientific specimens in Kew's Science Collections and decades of research at Kew into their taxonomy, traits and evolution, in some cases heavily utilising the Living Collections. To align priorities for the Living Collections with Kew's scientific priorities, we will target genera and species of particular research interest. We already hold dedicated orchid, palm and grass collections, and our collections will be enhanced where possible with specimens from the other target families.

Priorities for new accessions will also include the development of the following family and genus-level collections: *Nepenthes*, Pandanaceae, Bromeliaceae, Primulaceae, *Galanthus*, Araceae, Iridaceae, Lamiaceae, and temperate carnivorous plants (*Drosera*, *Drosophyllum*, *Sarracenia*, *Heliamphora*, *Utricularia*, *Pinguicula* and *Cephalotus*). We will also maintain and develop our diverse and extensive collections of the genera *Iris*, *Tulipa* and *Fritillaria* within the Alpine Collection.

In addition, particular families and genera will be targeted to enhance collections that support broad research themes, such as investigations into genome size. As specified in the *Science Collections Strategy*, the families that exhibit large variations in genome size and are therefore targets for further research include Liliaceae, Melanthiaceae, Santalaceae and Asparagaceae. Living plant collections are essential for such research, as the measurement of genome size requires fresh plant material from which to extract and analyse the cell nuclei. To preserve some of the scientific value of wild-collected accessions of priority groups in case of specimen death, herbarium voucher specimens will be taken, and they will be made available for DNA and pollen sampling and subsequent incorporation into the Science Collections.

Within the Arboretum, there will be a continuing focus on collections of Juglandaceae, Podocarpaceae, Sapindaceae, Fagaceae, Oleaceae, Pinaceae, Araucariaceae, Fabaceae, and the genus *Sorbus* (of British origin).

At Wakehurst, the National *Betula* Collection will be reviewed and enhanced, and the *Rhododendron* Collection will be included in Botanic Gardens Conservation International's global survey of *ex situ Rhododendron* collections.



Conservation priorities

Currently, 5% of the Living Collection accessions and 3% of taxa are categorised as threatened by extinction on the IUCN Red List of Threatened Plant Species. If taxa that are categorised as Near Threatened and Data Deficient are included, these figures rise to 7% of accessions and 5% of taxa. Due to the wider value of these specimens, the collections will be further enhanced with an increased representation of IUCN Red-Listed threatened taxa, or generally rare and threatened taxa that have not yet been assessed or that are locally rare, or both. Populations that are rare in some regions but common across their range, or those at the edges of their range, may hold unique genetic diversity that could be valuable in future breeding programmes. While it is recognised that *ex situ* conservation on its own will not address the long-term conservation of rare taxa, it does mean that living material for future multiplication and possibly generation of seed is available to aid repatriation or new wild planting programmes. Wakehurst's *in situ* priority species will also be conserved within favourable habitats, which will continue to be managed to maintain the habitat integrity and persistence of the priority species.

While many of the taxa within the collections are significant from a conservation perspective, and IUCN Red-Listed taxa are the most obviously identifiable in this regard, there will be further development of collections to augment conservation programmes for specific taxa and to complement the conservation priorities set out in the *Science Collections Strategy*. For example, island floras (which generally have a high level of endemism and are prone to disturbance and species loss), *Brugmansia*, east-Asian conifers, selected Araucariaceae, Orchidaceae, Cycadaceae, *Aloe* and Mediterranean taxa. Priority will also be given to improving collections of UK and UK Overseas Territories taxa under threat of extinction. We will aim for a 5% increase per year for the next ten years in IUCN Red-Listed taxa held in the Living Collections.

We will also continue to grow scientific collections that require flowering and fruiting to allow identification. In some cases, such specimens prove to be species new to science and of high conservation priority due to their restricted distribution. Production of fruit and seed may also provide valuable additions to the Seed Collection at the MSB, contributing to *ex situ* conservation and to the Banking the World's Seeds strategic output.

Selected habitats within Kew, such as the two sites of acid meadow and the Natural Areas, are regarded as being of high conservation value for the Greater London Area, and will continue to be managed to conserve the integrity of the sites and the species assemblages present.

At Wakehurst, the *in situ* British native species conservation programmes will continue in line with Natural England frameworks. New temperate planted landscapes will be developed in collaboration with Kew Science's Conservation department.

Tropical Important Plant Areas

Kew scientists are targeting areas of rich plant and fungal diversity under threat as part of the Tropical Important Plant Areas (TIPAs) programme. This programme aims to identify concentrations of threatened species in the tropics, designating these areas as TIPAs and enabling national authorities to prioritise their protection. Focal areas currently include Guinea-Conakry, Mozambique, Cameroon, Indonesian New Guinea, Bolivia and the British Virgin Islands. Horticultural activities will support this programme where there is an alignment of objectives and scope to propagate and grow live material for future study or display.

Brugmansia × rubella



Chimanimani Mountains
in Mozambique



Landscape priorities

In addition to their scientific or conservation value, the role of the Living Collections as key aesthetic components of the living landscapes of both Kew and Wakehurst cannot be underestimated. The quality of the landscapes can be further augmented through the judicious selection and careful design of the displays of living plants.

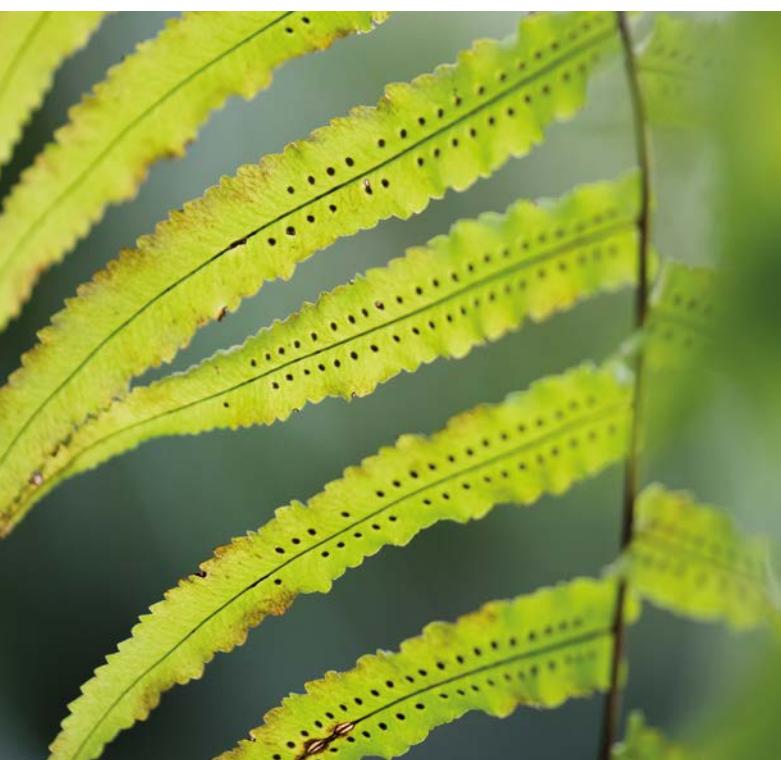
Various planted landscape features of the Kew and Wakehurst sites contain living plant collections that will be developed and enhanced further into the future. Examples of priority landscapes at Kew include the Rose Garden, the Azalea Garden, the Mediterranean Landscape, the Japanese Garden, the Salvia Border, the Rhododendron Dell, the Woodland Garden, the Rock Garden, and the water features (the Aquatic Garden, the Palm House Pond and the Lake). New features such as the Agius Evolution Garden, the Children's Garden and Chinese Landscape are all priorities for completion in 2019.

Kew's living landscape is also a central component of its World Heritage designation, representing a palimpsest of successive layers of landscape interventions by celebrated designers, horticulturists and scientists, gradually shaping the Gardens over centuries of cultural and scientific evolution. It is important that the tree framework that provides the essential structure for the landscape's key vistas and views is appropriately and sensitively choreographed over the long term, to ensure that these

significant aspects of the living landscape are maintained and enhanced. Strategies such as managing canopies to avoid view closure and planting new avenue trees in pairs have been underway for a number of years. Further strategic strengthening of boundary plantings and screening within the site will also be required in the long term, to offset the threat of ever-taller external building developments becoming visible within the landscape.

At Wakehurst, a series of designed non-woody wild landscapes featuring analogues of steppes, meadows and grasslands will be developed in accessible locations. An approach for enhancing understoreys of North American and southern hemisphere woodlands will be developed, and Horsebridge Wood, our North American woodland, will be renovated. Kew's conservation partnership with Kyrgyzstan will use seed collected for the MSB to create a colourful Silk Road Garden representing the Eurasian grasslands. The landscape will also be enhanced with the wild relatives of crops and a new Ancestral Orchard will be created, connecting visitors to the origins of modern crops.

Landscape development at each site will aim to connect to historical, scientific and conservation themes, to bring the landscape to life and reflect Kew's activities across the globe. The priority will be to showcase our Living Collections and our scientific work and combine effective interpretation with skilful horticultural displays.



Representativeness

In fulfilling the priorities for new accessions, the collections will inherently become more diverse. However, we will also strive to increase the representativeness of the collections so that the full diversity of plants, their habitats and lifeforms are represented in the collections. We will aim for taxonomic, genetic, morphological and functional diversity.

We will build the collections to strive to represent:

- all orders and families of flowering plants
- all climatic zones and a wide range of associated plant adaptations
- examples of key scientific concepts, such as evolutionary convergence and divergence
- the major groups of Crop Wild Relatives (wild species closely related to domesticated crops)



King William's Temple,
Mediterranean Garden, Kew

How do we manage and develop our collections?



Africa and Mediterranean section of the Rock Garden

To ensure the Living Collections develop in close alignment with the aims set out in this strategy, and that their future use for research, conservation programmes, public education and enjoyment and other purposes is optimised, it is important to introduce a more defined process for collection management and development.

It is essential that this is underpinned by an accurate, up-to-date and robust database that is explicitly linked to the scientific databases, to allow the connections between the Living Collections and Science Collections to be used to their maximum potential for horticultural and scientific research and conservation.

The Living Collections will be managed in a systematic way, utilising the combined expert skills and knowledge of staff. Each individual collection will have a nominated ‘owner’, as the person who will take responsibility for the curation and development of the collection into the future. A Collection Management Plan will be prepared for each collection and maintained by the curator of the collection.

This plan will include an outline of the collection objectives and an overview of the horticultural procedures required to ensure the health and vigour of material in the collection. Collection Management Plans will be evaluated and reviewed every three to four years, or sooner if necessary, to ensure that they remain relevant and useful.

An Annual Action Plan, strategically aligned with the Living Collections Strategy, will accompany each Collection Management Plan. This will detail short-term objectives and tasks to be undertaken by the curator of the collection in a period from April to March. Annual Action Plans will be reviewed and updated each year and will form part of the curator’s annual performance plan.

Strategies for managing and developing the collections:

- Maintain the highest level of horticultural care and curation of the Living Collections and their associated data.
- Develop an improved record management system, with potential for integration with Kew’s scientific collection database, location and mapping functionality and public accessibility.
- Develop individual plans to guide the development of each living plant collection.
- Ensure existing growing facilities are well maintained and build new facilities to meet the future requirements of the collections.
- Ensure the collections are protected from disease and contamination by maintaining strict biosecurity procedures.
- Ensure continued compliance with all applicable national and international laws and conventions on plant collection and movement.

Data and records management

The diversity of the living plant collections across the two sites and the long timespan over which they have been built up has meant that there is not a completely accurate digital record of all accessions, their origins and their associated data. Baseline data and database functionality are essential to the management and utilisation of the Living Collections. We therefore aim to complete an audit of the Living Collections by 2023 and to ensure that there is a working interface between the Living Collections database and the Science Collections databases, allowing the full potential of the collections and the links between them to be utilised.

As an immediate priority, a significant investment is required for the Living Collections Database, to update and improve the functionality and compatibility with Kew's other records systems and public accessibility. To further improve digital access to, and management of, our collections, we aim to improve the data quality and integration of our collection databases and other relevant data sources. This will provide efficiencies in updating plant nomenclature and cataloguing the collections, will ensure easier tracking of movements between collections and will support increased digital access to collection data. This will also enable us to provide better public access to information about the Living Collections, and we will develop a linked mapping function for both Kew and Wakehurst showing the location

of different species or particular specimens. We will aim for excellence in data standards and record management.

We also aim to maintain a high quality of curation, including verification of identifications and labelling. The risks when a collection is not closely curated are that plant health deteriorates, plants hybridise without controlled pollination, and labelling accuracy declines as nomenclatural changes are not reflected in the plant records. In collaboration with Kew's taxonomic experts in the Science Directorate, we will increase the percentage of plants in the current collections identified to species level and will aim for this minimum level of accuracy for all new accessions.

To ensure that the woody collections in the Arboretum are correctly identified, a new Horticultural Taxonomist post was created in 2016 to verify identifications. Since the post was created, the genera *Quercus*, *Aesculus*, *Fraxinus* and *Salix* have been fully verified and re-labelled. All these genera are being used for research into pests and diseases and we can now reliably send fully verified samples. Future verification work includes the genera of *Carpinus*, *Ostrya*, *Torreya* and the family Juglandaceae. We will also prioritise increasing the accuracy of *Rhododendron* identification and labelling. At Wakehurst, a comprehensive verification and taxonomic revision programme will be undertaken.

Box 6: Uses of the Plant Reception and Quarantine Unit

There are many situations where living plant material is required to be grown or inspected in a contained environment, and the Plant Reception and Quarantine Unit at Kew is therefore used by teams across the organisation and also by government agencies. Its functions are:

- to act as a single point of entry for incoming live plant material (including cuttings, seeds and *in vitro* cultures), timber samples and non-pathogenic fungi
- to enable safe inspection and management of incoming live biological material
- to enable the containment, cultivation and propagation of imported plant material
- to enable isolation, screening and preparation of plants for export (especially to vulnerable habitats e.g. island ecosystems)
- to act as a Confiscation Assessment and Rescue Centre for material controlled under international conventions and plant health legislation
- to permit safe study of plant-pathogen interactions, including licensed work on the ash dieback fungus (*Hymenoscyphus fraxineus*)



Examples of the use of the facility to support Kew's scientific research and collections include: cultivating wild-origin *Nicotiana* species to enable studies on speciation; growing seed of taxa normally prohibited entry to the UK to produce voucher specimens for taxonomic verification; investigation of bumble bee feeding behaviour; facilitating import of wood samples for the Xylarium (a collection of authenticated wood specimens); studying the life cycle of oak processionary moth (OPM, *Thaumetopoea processionea*) and testing potential organic controls; and propagating and cultivating rare, threatened or unidentified taxa, some of which may be new to science.

The Unit also acts as a Confiscation Assessment and Holding Centre for the inspection, investigation and safe management of controlled plant material for government agencies such as the Animal and Plant Health Agency and the UK Border Force. This service is therefore essential to improving UK biosecurity and strengthening compliance with CITES, the CBD and other international laws and conventions.

Plant health and biosecurity

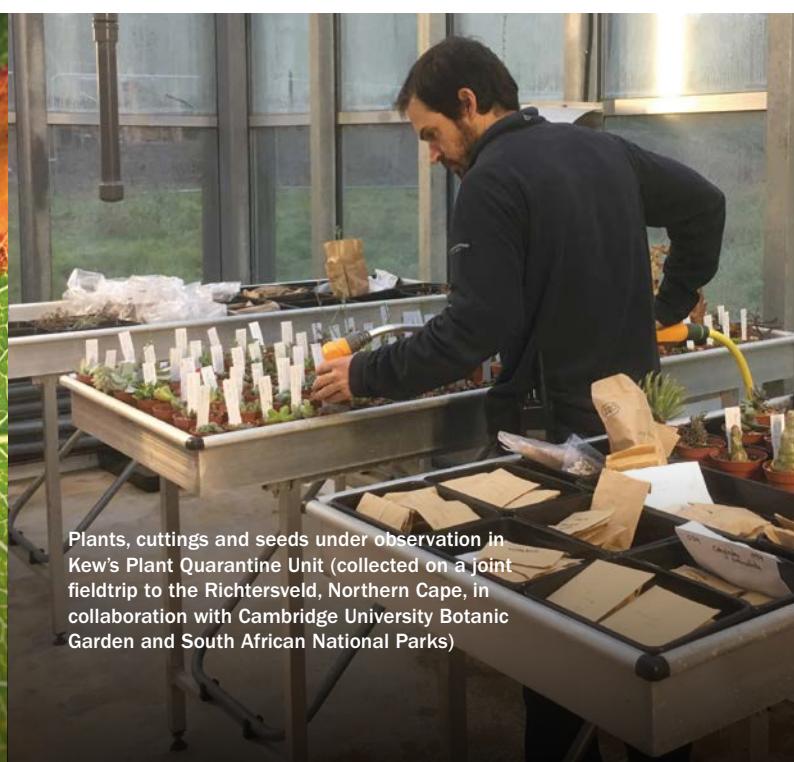
Biosecurity is the application of knowledge, preventative techniques and equipment to reduce the risk of inadvertent or deliberate release of potential biological hazards into the environment, including organisms that may have a detrimental effect on plant health. Plant health and biosecurity at Kew is the responsibility of a dedicated team who operate the licensed Plant Reception and Quarantine Unit and provide biosafety advice, services and support to horticulturists and scientists across Kew and Wakehurst, to government agencies, and to other external organisations (see Box 6). Activities include developing and providing training that significantly improves compliance with UK and international plant health and quarantine legislation, thereby significantly reducing biosecurity risks. In terms of plant health, pathogens such as *Hymenoscyphus fraxineus*, which causes ash dieback, could significantly damage the collections and dramatically change the landscape, at Wakehurst in particular. It is therefore vital that the appropriate measures are taken to prevent such outbreaks or to monitor and deal with them efficiently if they do occur – we are continually developing protocols to manage such situations.

Kew has an overarching biosecurity policy that covers both sites; there are detailed protocols relating to the policy for the Kew site, and these are currently being developed for the Wakehurst site. There are procedures in place to manage the import, movement, use and sharing of biological materials by staff, students and associates – whether plants, DNA, herbarium specimens or artefacts. Key to this approach is having reliable data, assessing the risks associated with movement of material before it arrives on site and operating single points of entry for each site. This is particularly important when dealing with invasive species, whether

this is the plants themselves or plant pests or diseases. Procedures with implications for biosecurity are, and will continue to be, periodically reviewed for compliance – for example field collection, plant sourcing, de-accessioning and sharing of material. The risks associated with these activities are also identified, assessed and managed.

Communication, teaching and training are a vital part of compliance work, so that relevant evidence- and experience-based information can be disseminated to varied audiences that include politicians and policymakers, professional horticulturists, researchers, students and the public. All new staff and students commencing work at Kew are given a tour of the Quarantine Unit as part of their induction, and this helps underline the importance of biosecurity and legal compliance for the organisation, both in professional and personal lives.

As part of our education programme, we will continue to develop and refine a training module in ‘Biosecurity, Plant Health and the Law’ that is delivered as part of Kew’s Diploma in Horticulture. The module provides students with a unique overview of relevant themes through applied examples. Students also undertake assessments with practical themes and outcomes, for example identifying documentation required for import, export or exchange of plant material, communicating the range of plants controlled under CITES which are of horticultural interest, and highlighting best hygiene practices and the appropriate management of different types of plant waste at the Kew site. The module is supplemented by sessions to improve practical skills and the understanding of the impact, management and control of invasive species, pests and pathogens.



Compliance with international conventions

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement that commits countries to protecting wild populations of fauna and flora from over-exploitation for trade in wild-sourced species. Kew is the UK CITES Scientific Authority for Flora, and as such formally advises the Animal and Plant Health Agency on CITES plant import and export permits and helps to ensure wild species are legally collected in a sustainable way. Countries in the tropics have the largest number of CITES-listed species, and as these regions are a focus for scientific and horticultural collections, we take steps to ensure that all staff are legally compliant with national and international legislation through provision of training, policies and procedures. We also ensure all plant material is legally accessioned, used and supplied. CITES and horticulture teams at Kew facilitate the identification of seized materials and provide advice to the various wildlife crime agencies. Together with the Department for Environment, Food and

Rural Affairs (Defra), and the EU and CITES working groups, we provide a well-coordinated and multi-faceted approach to tackling the illegal trade in plant species from the wild.

Most countries have now developed national legislation governing how plant material can be collected and exported, and under what terms. In accordance with the Convention on Biological Diversity and its Nagoya Protocol, benefits from the use of genetic resources need to be shared fairly and equitably with countries of origin. Kew takes these obligations very seriously and has developed policies and procedures to ensure that all plant material has been collected legally and that it can be housed at Kew, with accompanying records detailing the terms and conditions under which it can be utilised. Kew also uses Access and Benefit Sharing Agreements and Memoranda of Collaboration to ensure clarity of obligations and to set out the terms under which material and data are exchanged, used and provided to support our vital conservation partnerships.

Kew ensures that all wild species are legally and ethically collected in a sustainable way.



Illegal rosewood stockpile

New facilities

A range of growing structures can be found across the two sites of Kew and Wakehurst, generally classed as conservatories, glasshouses, greenhouses or polytunnels. The purpose of these structures is to provide modified and controllable environments, as required to propagate and grow a wide diversity of plant types and individual taxa from around the world. Generally, the controllable elements relate to temperature, humidity, air movement and light level. Irrigation is provided either automatically or by hand.

Not surprisingly for such a long-established organisation, the condition and quality of our growing facilities is quite varied. The recent restoration of the Temperate House (Grade 1 listed) has brought it back from a state of perilous decay, and the Palm House (Grade 1 listed) and Waterlily House, while not having the same degree of structural or fabric issues, are also in need of attention in the coming years. While the more recently constructed public display houses – the Princess of Wales Conservatory (1987) and the Davies Alpine House (2006) – are in far better order, they nevertheless also require a more significant and regular maintenance programme than has perhaps been allocated in the past, to avoid difficult and expensive restorations.

All the facilities within the nursery sites at Kew and Wakehurst will be subject to an improved level of inspection and planned maintenance to ensure they remain fully functional and so that the living plants are not put at risk from failures of heating, cooling and irrigation supply.

In terms of future requirements for new facilities on the Kew site, we foresee the need for a decent glasshouse, to facilitate holding stock from the Palm House if and when major restoration works are required. The preferred location is on the site currently occupied by the ‘old quarantine’ glasshouse, which is no longer used for that purpose. The Palm House plants cannot be mingled with other nursery plants because of the need to maintain biosecurity protections, as the Palm House has a notifiable pest (the chilli thrip, *Scirtothrips dorsalis*).

The bedding glasshouse at the Alpine Nursery may require replacement, extension or significant refurbishment within the next five to ten years. This is to allow it to continue to operate effectively for the growing and supply of ornamental or decorative bedding crops for the whole site.

Wakehurst undertakes a complex and extensive nursery operation in 40-year-old glasshouses, with inevitable challenges around ergonomics and efficiency. A new nursery complex, fit for purpose and calibrated around Kew Science’s long-term growing requirements, would deliver substantial strategic and operational gains for Wakehurst.

Wakehurst’s development plan (2018) positions a new research nursery and science hub as a key strategic development – strengthening connections between science and horticulture and opening up the opportunity for public access to Wakehurst’s historic walled garden. This new hub will enable us to continue to deliver vital significant conservation and strategic science work and develop this internationally.



Policies and procedures

Plant acquisition criteria

The following criteria detail the acceptable quality of plant acquisitions in priority order:

- plants collected in the wild with full provenance details
- plants obtained from another botanic garden or accredited collector, either as progeny of plants collected in the wild, or grown without danger of hybridisation
- plants of known origin from an accredited source

Plants in the following categories will not be acquired:

- specimens that contravene international policy on plant collecting and trading, specifically CITES (unless received as confiscated materials with appropriate government permissions and authority)
- prohibited imports
- declared noxious weeds (unless for specific research projects related to the particular taxon)

Plants in the following categories will not be acquired except for specifically approved purposes of research or display:

- likely or known environmental or agricultural weeds
- plants known to have a high risk of facilitating the transmission of serious pests to commercial crops and natural landscapes
- likely sources of introgression problems (genetic contamination)

Siting of new accessions

New plant collections will be selected in accordance with the collection themes and criteria set out in this strategy. For practical reasons, plants should be selected for their suitability for the growing conditions of either the Kew or Wakehurst site. While some experimentation to establish a taxon's tolerance of the limits of cold or heat may have value, introduction of accessions from geographic origins with analogous climatic conditions to the southern UK will be the general approach. We acknowledge that climate change may present a challenge for some taxa within the outdoor living collections at Kew. The generally accepted view (supported by climatic data and projected trends) is that the climate of south-east England may become hotter (increase in annual mean temperature) and drier (lower annual rainfall) over the coming decades. Drought events may also become more frequent, together with more severe storms. Decisions around planting of long-lived taxa within the landscape will include consideration of the suitability of each taxon for the likely future growing conditions.

For outdoor locations, plant selection and siting will be based on the suitability of available microclimate and edaphic conditions to support plant health against projected climatic conditions, rather than seeking to attempt to

adjust the local growing conditions significantly to suit the collections or plant. A collection can be displayed at one site, be distributed across the whole garden, or a combination of these, whereby the major part of the collection is at one location with other plantings being distributed across the site or across other botanic gardens where prevailing conditions are more suitable.

New accessions that are introduced to the nursery collections will be allocated to the appropriate zone for their particular growing requirements (temperature, humidity, light and ventilation). As space in the nurseries can be a limiting factor, generally only three healthy individuals of any accession will be grown on after initial propagation. Exceptions to this guideline may exist where the plants are very rare and the Kew collection may constitute a significant population, or where multiple individuals are needed for scientific sampling. Where possible, capturing genetic variation within taxa will be the aim.

New collections to be held under glass in public display houses will augment and complement the existing suite of collections, while also supporting the strategic aims for the Living Collections; those plants held only in nurseries or under glass away from public access will generally have a strong research or conservation aim.



Emmenopterys henryi

Succession planning

Where an individual plant is known to be coming to the end of its healthy life, a decision needs to be made in relation to the propagation or replacement of that taxon. The aim will be to retain the diversity, longevity and resilience of the Living Collections, rather than losing or simplifying the collections through attrition. In the case of trees senescent within the landscape, a similar planning process will be undertaken and, where possible, a young accession of the same species will be planted. In some situations, the senescent tree may be of historical, cultural or landscape design significance, in which case it may be kept *in situ* while young stock is planted and also grown on site.

Tree Risk Assessment Management System (TRAMS)

For any public site with an abundance of trees, a repeatable, auditable system of assessing the risk of harm caused by falling trees or boughs is essential. At Kew and Wakehurst, we employ a Tree Risk Assessment Management System (TRAMS). Every individual planted tree in the Arboretum and gardens at Kew and Wakehurst is given a unique accession number, recorded on the Living Collections database at the time of planting. These are uploaded to the TRAMS database every six months with any new accessions. The TRAMS database records all inspections and mitigation works carried out on each individual tree. All trees have risk assessments carried out on them by our own fully trained and qualified arborists to ensure that both sites remain safe places for our staff and visitors to enjoy.

Kew's tree planting and establishment practices, and general arboricultural care of mature trees, are recognised widely as demonstrating 'best practice' and have been adopted by other gardens and arboreta within the UK and worldwide.

Sustainability

Kew will only be able to achieve the positive global impact to which it aspires if it is a sustainable and dynamic organisation. We hold ISO 14001 certification for both the Kew and Wakehurst sites (Kew was the first World Heritage Site to gain ISO 14001), which provides a valuable framework for planning, monitoring and reporting on all aspects of environmental sustainability within the organisation. Under the terms of ISO 14001, the environmental management systems of both sites are subject to a detailed external audit on an annual basis. With direct relevance to the living plant collections, all aspects of water and waste management and energy are monitored, reported and audited and this will continue.

Distribution or removal policy

When available, surplus plants from within the living plant collections at Kew and Wakehurst will be distributed to other public botanic gardens or kindred institutions for the improvement of their collections, under the terms of formal material supply agreements. Consistent with the CBD, the terms of these agreements generally preclude commercialisation of the plant material. The supply of the plant material must remain consistent with the terms under which it was originally acquired by Kew or Wakehurst. Any commercialisation to which Kew agrees will be subject to a separate written agreement setting out fair and equitable sharing of benefits with the country of origin of the material.

Plants will be removed from collections when they are deemed to no longer be of value to the collection. This may be, for example because they have been replaced by material of known provenance or wild origin; are one of many multiples in excess of the ideal representative total of three individuals per taxon or genetic entity; have become diseased or have died; pose an unacceptable risk to public or staff safety; or are identified as not being part of a valid living collection and have no conservation or plant heritage value.



Pinus pinea at Kew

Box 7: Modelling ecosystem services at Wakehurst

The integration of the collections into the natural environment at Wakehurst has resulted in a landscape of great value. In recognition of this valuable natural capital, one of Wakehurst's strategic goals is to become a centre of excellence for natural capital mapping and modeling of ecosystem services – demonstrating the value of our land management and fostering impactful research. We seek to explore the value of the natural environment at Wakehurst and the benefit to society, while developing research methodologies valuable to the UK government and our regional partners.

Underpinned by the UAV (unmanned aerial vehicle) mapping undertaken by Kew Science's Biodiversity Informatics and Spatial Analysis department, a research programme at Wakehurst will model carbon sequestration, pollinator services, hydrology and recreation services. Our programme will combine LiDAR and stereo camera footage with multiple modelling approaches and ecological datasets to demonstrate the landscape's value to the wider catchment and local population. Drawing upon Kew's core principle of collections-based research, Wakehurst's exotic and native large-scale plantings will be used to model ecosystem services such as flood mitigation, carbon uptake and pollution mitigation.



How do we increase the value of our collections to support Kew's mission?



Annual orchid festival displays in the Princess of Wales Conservatory provide an opportunity for cultural interpretation.

The mission of the Royal Botanic Gardens, Kew is to be the global resource for plant and fungal knowledge, building an understanding of the world's plants and fungi upon which all our lives depend.

The central strategic objective for the organisation is that our collections are curated to excellent standards and are widely used for the benefit of humankind. Surrounding this, we aim to be valued as the pre-eminent provider of public education on plant and fungal science, conservation and horticulture; to be the world's leading botanic gardens, where our large and diverse audiences develop their understanding of why plants and fungi matter; to be a sustainable and dynamic organisation, making positive global impacts in partnership with others; and for our science to make a demonstrable contribution to solving critical challenges facing humanity today.

Three important pathways to achieving these objectives through Kew's Living Collections are:

- interpretation
- education and training
- integrating horticulture, science and conservation

Interpretation for public understanding

Effective interpretation is simply communication that assists visitors in the discovery and appreciation of their environment. It is a skilful mix of orientation, information, inspiration, customer service, entertainment and education, providing a window for the visitor and illuminating meaning in a landscape or collection.

At its best, interpretation facilitates discovery, wonder, curiosity and enjoyment. By providing a sense of place and establishing meaningful and rewarding experiences, interpretation brings our relationship with a site to life.

Interpretation is commonly delivered via a variety of elements:

- Experiences – customer service, exhibition explainers, guided tours, performance and events
- Structures – wayside shelters, visitor centres and activity carts
- Associated objects – artworks, discovery tables, installations, artefacts and interactive displays
- Other media – directional signage, information boards and wayside markers
- Publications – maps, factsheets, brochures, etc.

Strategies for interpretation of the Living Collections:

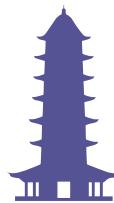
- Interpret all Kew's publicly accessible living plant collections, as guided by our Interpretation Master Plan.
- Provide visitors with an understanding of the scientific, historical and cultural value and use of the Living Collections.
- Use innovative, engaging and effective interpretation of the Living Collections to build a scientifically, horticulturally and ecologically literate community.

Figure 5: Themes for interpretation**Kew Science**

Stories about the role of science at Kew; scientific stories about plants and fungi

**Kew Horticulture**

Stories about horticulture, gardening and plants

**Heritage Kew**

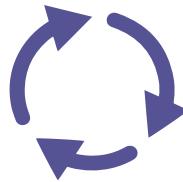
Stories about the historic legacy of Kew's cultural stories about plants

**Wild Kew**

Stories about the natural history of the landscapes at Kew and Wakehurst

**Sensory Kew**

Stories that highlight the sensory nature of the visitor experience

**Sustainability at Kew**

Stories that highlight sustainable practice at Kew

Why do we provide interpretation?

Effective interpretation can play a key role in the management of sites of natural and cultural heritage. It is an important communication tool that can minimise the impact on natural and cultural resources and facilities and educate visitors about Kew's mission, aspirations and objectives. We will use the rich diversity of our gardens and collections to provide knowledge, inspiration and understanding of why plants and fungi matter to everyone.

There is evidence that good interpretation will engage, involve, educate, challenge and entertain visitors. It provides a sense of place and meaning and brings the garden and collections to life. Effective interpretation (delivered via skilled guides, visitor centres, displays, signs or other media) is seen as one of the key aspects of satisfying visitor needs and expectations. Interpretative planning informs the quality of the communication and services that will be provided to visitors.

Kew's approach to the interpretation of Living Collections

Interpretation at Kew will engage our visitors by bringing stories contained within the Living Collections to life – stimulating intellectual and emotional connections with our scientific, horticultural and cultural assets. Within the collections at Kew and Wakehurst is a vast treasure trove of stories. An important thread that runs through them all is the passion of the people who work at both sites – their passion is the bridge to engaging our visitors.

Through interpretation, we aim to inspire curiosity and wonder in the rich diversity of our gardens and collections, drawing our audiences into a lifelong journey of discovery and love of plants and fungi. Our goal is to promote an understanding of why plants matter and to make sense of our valuable science and conservation work. In achieving this goal, we will contribute to the creation of a scientifically, horticulturally and ecologically literate community. We will seek to engage diverse audiences and ensure that our interpretation is as accessible as possible. Both the planning and delivery of interpretation will be governed by dedicated Interpretation Master Plans for each site.

We aim to create interpretation that supports and augments the positive experiences that are available at both the Kew and Wakehurst sites, without distracting from them.

- We strive to inspire wonder among diverse audiences.
- We will encourage our audiences to participate.
- We want to connect emotionally with people and highlight the human relevance of the collections.
- We will embed our core messages throughout the entire visitor experience.
- All interpretation is temporary and should evolve with the collections and our scientific work.



Araucaria araucana at Wakehurst

Box 8: Science in the Wakehurst landscape

Box 8: Science in the Wakehurst landscape

New Wakehurst landscapes are developed in partnership with Kew Science, incorporating taxa of conservation or ethnobotanical significance collected through our international partnerships. The project teams developing new landscapes are always multidisciplinary, including science, horticulture, learning, marketing and programming staff. Current areas of collaboration include the Caucasus Fruit and Nut Conservation Project, the basis for a new Wakehurst Ancestral Orchard, the North American Landscape and the Kyrgyzstan Conservation Programme. Collaboration between science and horticulture allows research outcomes to be embedded in the design for new landscapes. The North American Landscape will drive research into pollinator services, soil microflora and seed traits.

Translating wild plant communities into designed landscapes using seed of wild origin defines Wakehurst as a distinctive botanic garden and forms a tangible connection between the MSB's globally significant conservation work and Wakehurst's visitors. A vista full of beautiful plants can inspire new connections to plant conservation.

The storytelling boards in the newly refurbished Temperate House are a good example of the kind of approach and direction that Kew wants to take to static interpretation of collections in the future. They tell stories about rare and threatened plants from the temperate world and illuminate the science and horticulture stories that sit behind the conservation of these plants.

The interpretation is designed to appeal to a range of our visitors and uses a variety of techniques to make engaging with the content as easy as possible. Stories are told in the 'first person', using quotes from our experts as well as engaging portrait photos to communicate the passion that our experts feel for their work and the plants they are trying to rescue.

Big bold images are also used alongside text. Reproductions of artwork from Kew's vast collections, photographs of herbarium specimens or seeds from the MSB are used to demonstrate the wealth of Kew's collections. Where scientific or horticultural terms are used, they are explained in full. Maps are used to illustrate the natural range of plants, with a feature to indicate a plant's threatened status as designated by the IUCN.

The Temperate House interpretation was created by a cross-disciplinary team utilising the very best of Kew's knowledge and skills. This collaborative approach will continue, to ensure the highest standards of interpretation across both sites.



Education and training

Kew's Living Collections provide a rich resource for education and training. We provide educational opportunities ranging from formal qualifications to talks and courses for horticultural amateurs and enthusiasts. Living plants are the most effective teaching materials, illustrating themes and concepts and allowing students to gain essential practical skills. Our education and training programmes and resources are delivered through the School of Horticulture, the schools and visitor learning programmes, the MSc in Plant and Fungal Taxonomy, Diversity and Conservation, in-house training courses and web-based resources.

School of Horticulture

Kew's School of Horticulture provides world-class vocational training in botanical horticulture, and the Living Collections are fundamental to the training given to our students and apprentices. Courses include the globally recognised Kew Diploma in Horticulture, along with apprenticeships, modular certificates and specialist certificates in subjects such as arboriculture and propagation. All our courses link academic knowledge with hands-on practical skills. The Living Collections underpin both these aspects. From a practical perspective, students and apprentices work with the living plants in the Gardens, and in the display glasshouses and propagation facilities (see Box 10).

When working in the Gardens, students and apprentices learn about collections management, along with the day-to-day maintenance involved in keeping the collections alive and in a healthy condition. The Living Collections are also used in the delivery of plant science classes, such as plant systematics.

Kew attracts applicants to the School of Horticulture's training programmes from around the world, many attracted by the prospect of working and learning in a botanic garden with the largest and most diverse living plant collections in the world.

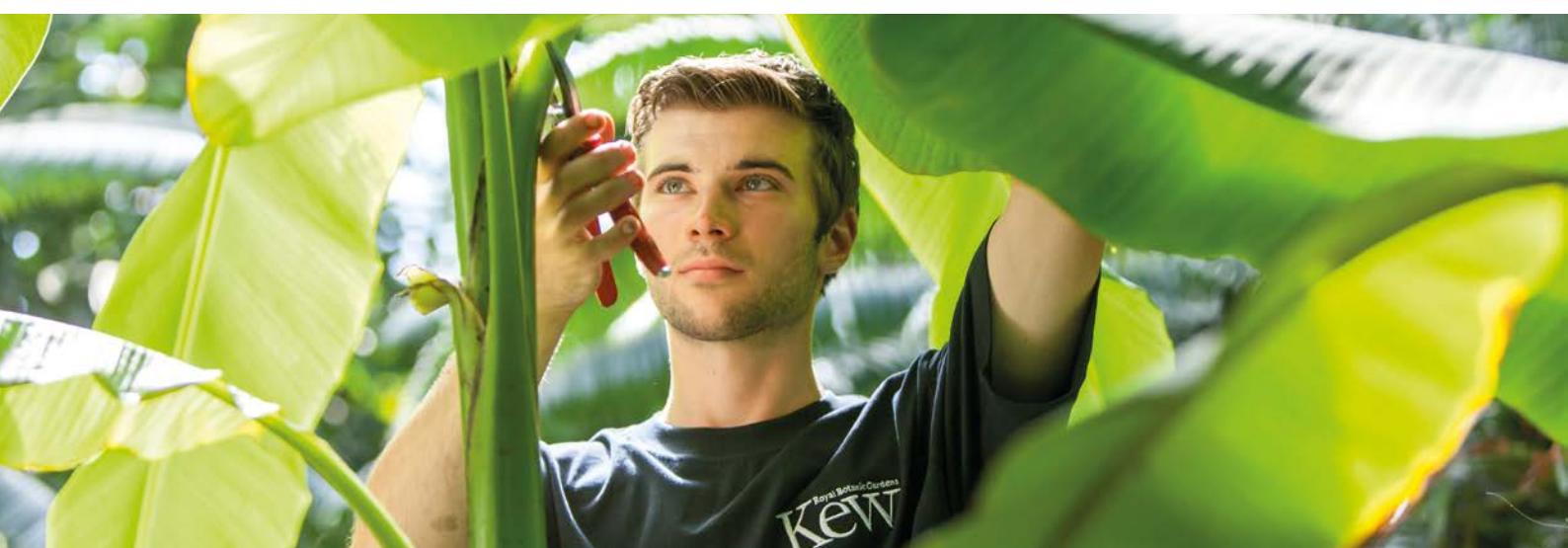
Schools programme

Kew's highly rated schools programme welcomes over 100,000 pupils to Kew Gardens and Wakehurst every year.

More than half participate in a session with a Kew teacher and enjoy the unique experience of learning outside the classroom and engaging with plants from all over the world. All learning is based on the Living Collections and all areas of the gardens are used for teaching. Schools can choose from 50 modules at Kew Gardens and Wakehurst, ranging from 'Tremendous Trees' (Early Years) and 'Plant Explorers' (Key Stage 1), through to 'Rainforests: People and Plants' (Key Stage 2), 'Ex Situ Conservation', and 'Ecosystems and Climate Change' (Key Stage 5). Each module is aligned with the English National Curriculum and Kew Science and Horticulture. Particular locations within the gardens enhance the teaching experience: the Princess of Wales Conservatory, with its ten different climate zones, for example, is ideal for teaching evolution and adaptation, while the black poplar field gene bank at Wakehurst's nursery is used to illustrate how cloning contributes to species recovery. Living plant material is also used in sessions to teach topics such as pollination, pathogens and gene banking.

Visitor learning programme

At the heart of the visitor learning programme is the mission to help all our audiences learn more about Kew's living plant collections, scientific work and history. One of the most visible ways in which we achieve this is through the volunteer-led guided tours programme, which offers tours to the visiting public free of charge on 364 days of the year. Over the past three years, these tours have introduced over 40,000 visitors to the Living Collections through thematic tours. Topics have included 'Introduction to the Gardens' (covering seasonal collection highlights and a history of Kew), 'Tremendous Trees' (exploring Kew's extensive Arboretum), 'Medicinal Plants', and many more. A new range of visitor learning programmes has also invigorated visitor engagement (see Box 11) and we will continue our commitment to bringing the Living Collections to life for a diverse audience of all ages.



Strategies for using the Living Collections for education and training:

- Maintain excellence in specialist horticultural training through the use of diverse collections spanning a range of growing environments.
- Harness the diversity of the Living Collections to illustrate the fundamental themes of plant science and the key characteristics of the major orders and families of plants.
- Provide a rich, diverse array of well-curated specimens for use in school and postgraduate education, training and research.
- Build knowledge, skills, attitudes and values, highlighting career pathways for the next generation of horticulturists, botanists and mycologists.



Box 10: Training student horticulturists in bromeliad cultivation

Bromeliads have been cultivated at Kew since the eighteenth century, when growing pineapple (*Ananas comosus*) in hothouses was popular among the wealthy. Today, more than 600 species of bromeliads are grown under controlled environmental conditions in the Tropical Nursery. Most of these are well-documented plants sourced from the wild and they come from a huge range of habitats – from the canopies of humid forests, to sandy coastal plains, to high altitude grasslands on rocky soils and isolated inselbergs. This diversity of ecological conditions is matched by diversity in life forms, and bromeliad cultivation therefore requires a specialist set of skills.

Students on Kew's Horticulture Diploma engage in a variety of exercises using the Bromeliad Collection. Training covers propagation and cultivation techniques, management of pests and diseases, and how to vary environmental conditions to suit different species, including rupicolous bromeliads that grow on bare rock outcrops and epiphytes that grow high up in the canopy of humid forests. Fundamental topics related to *ex situ* conservation are also taught using the extensive accessions, many of which are from the highly biodiverse and threatened Atlantic Forest biome. Conservation techniques include controlled pollination and seed collection for storage in the MSB and the development of cultivation protocols for threatened species. Such protocols have been used in the reintroduction of plants to locations where they have become rare or even extinct.

Box 11: Using The Living Collections for visitor learning

2017 saw the launch of a range of new visitor learning programmes at Kew supported by the Heritage Lottery fund, targeting audiences from London boroughs with high levels of diversity and those from deprived areas. They include the Kew Babies programme, aimed at under-fives and their parents/carers, which engaged over 3,000 children and adults in its first year through sessions such as 'Little Explorers'. Each of these sessions is themed around a story linked to the Living Collections (e.g. pollination, which plants produce dyes, which trees lose their leaves and why), and children are supported and encouraged to observe and question, taking their first steps towards enquiry-based learning.

We also launched the award-winning Youth Explainer Programme, which trained 27 young people (aged 14–17) to become expert public engagement volunteers in the Temperate House at Kew. In this year-long programme, young people went behind the scenes to learn about Kew's collections and scientific work. Inspired by the plants of the Temperate House, the Youth Explainers worked together to design unique engagement games to help visitors learn about the threats faced by temperate plants around the world and uncover the fascinating stories that can be found throughout the Gardens.

Kew is committed to programmes such as these – bringing the Living Collections to life and engaging a wide and diverse range of visitors with the science and wonder of plants.



Box 12: Using the Living Collections for postgraduate education

Saxifraga is a genus of approximately 440 herbaceous species occurring throughout the northern hemisphere in a variety of habitats, from lowlands to mountain tops. The genus is represented in the Living Collections at Kew by 66 species and subspecies (including seed in storage) and 58 cultivars. This valuable collection is an important resource for research, and during 2017 it allowed a student on the Kew MSc course to address important questions relating to how plants adapt to new habitats.

In this project, *Saxifraga* was used as a model group to look at adaptation to the harsh environments of high mountains. With few exceptions, plants rely on their leaves for photosynthesis: having well-functioning leaves is vital for growth and survival. Not all leaves work well in all environments, and the characteristics of leaves are therefore highly variable across plants. Changes in these characteristics are thought to help colonisation and adaptation to new environments, and the MSc project aimed to test this. *Saxifraga* provided an ideal model genus, and the extensive collection of living *Saxifraga* plants in the Alpine Nursery and specimens in Kew's Herbarium provided a wealth of material from which to take leaf measurements. Well-curated, diverse living collections such as this are ideal for addressing scientific hypotheses and can provide an important resource for the expanding postgraduate research programme at Kew.

MSc in Plant and Fungal Taxonomy, Diversity and Conservation

Kew's MSc programme, which began in 2015 and is delivered in partnership with Queen Mary University of London, teaches vital plant and fungal identification skills in the context of evolutionary biology and conservation theory and practice. Using living plant material alongside Kew's Science Collections is essential to the success of this vibrant course. Samples from the Living Collections are used in practical sessions, and the gardens and glasshouses are used for interpreted tours led by the horticulture staff and course lecturers. The collections are also available for sampling as part of the six-month research projects that make up 50% of the course (see Box 12). To support the expanding postgraduate training opportunities at Kew, our ambition is to increase the use of the living plant collections at both Kew and Wakehurst to illustrate the fundamental themes of plant science, reinforce the key characteristics of the major orders and families of plants, and provide a source of well-curated, diverse collections for use in practical classes and research projects.



Sarracenia x mitchelliana

Supporting international conventions

Kew is internationally recognised for the development of effective access and benefit-sharing procedures and as the UK Scientific Authority for Flora for CITES. We will continue to comply with the CBD, Nagoya Protocol, CITES and national laws of partner countries on access to genetic resources and benefit sharing, as these underpin our science, horticulture and our partnerships worldwide. Compliance requires the delivery of training, and the Living Collections are an invaluable part of this process, both for educating staff at Kew and other partner organisations and for training people involved in the enforcement of international conventions (see Box 13).

Digital dissemination

Kew's digital resources have an important role to play in connecting the public with our collections and educating them about the importance of plants and fungi to human lives. We will continue to utilise Kew's extensive media and social media

Box 13: Using the Living Collections in CITES training

The Living Collections at Kew and Wakehurst contain many species regulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Some specimens are of historic origin (pre-convention), many are recent acquisitions, and some are from seizures of illegally imported material and given to Kew by the Crown to look after and use for conservation and education purposes.

The CITES team at Kew host an annual training course attended by enforcement officers, where a representative range of CITES-regulated plants from the Living Collections are used to teach basic plant skills. Being able to distinguish an *Aloe* leaf from an *Agave*, or a cycad from a tree fern, may come easily to many of the experts at Kew, but to the frontline enforcement officers for CITES (UK Border Force and the police) it is no easy task. The Living Collections provide a rich array of living material for this course and also for internal CITES training courses to ensure our own compliance. Specimens include orchids, succulents such as *Aloe*, *Euphorbia* and cacti; carnivorous plants such as *Dionaea*, *Sarracenia* and *Nepenthes*; tree fern and cycad specimens; and even tissue culture examples. The Living Collections also provide plants as and when required for in-house and outside exhibitions and conferences, such as the Illegal Wildlife Trade Conference in October 2018.



channels to promote access to, awareness of, and engagement with, the collections – for example, highlighting their use in the *ex situ* conservation of threatened species and scientific research. In addition, we will also continue to engage the public in the stories behind our collections, highlighting specimens and collections of historic or scientific importance and using the stories and images to convey fascinating facts about the plant kingdom and Kew's Living Collections. We will also engage a global audience through the latest online opportunities, sharing our passion for plants and fungi in our 'virtual garden'.

Public access

Our aim is to make the gardens and glasshouses as accessible to the public as possible so that all parts of society can enjoy the benefits of our diverse collections and the accompanying information and interpretation.

We will also increase access to the 'back-of-house' collections. Access to the collections held within the non-public nurseries is provided on certain dates each year (as 'open days') and also by specific arrangement, accompanied by Kew or Wakehurst staff. Visiting groups or individuals are frequently given guided tours of the living plant collections held in the nurseries and are provided with insights into some of the rarest or most fascinating species.

The newly developed Arboretum Nursery includes an area for regular visitor access, to allow them to see behind the scenes. Visitors will be able to observe the processes of woody plant propagation and growing and also the infrastructure required to operate a modern sophisticated nursery facility. Static and digital interpretation will be included, to assist understanding of the specialised nursery activities.

Increased access to 'back-of-house' collections will provide visitors with insights into some of our rarest and most fascinating species.



Corytoplectus capitatus

Integrating horticulture, science and conservation

Kew's collections of living plants present a special opportunity for integrated and collaborative activities in support of Kew's mission to be the global resource for plant and fungal knowledge. Held within the collections is an extraordinary diversity of living material, most with known provenance details. Some of these taxa are rare in cultivation, and indeed 13 are now extinct in the wild. Through the periods that these plants have been grown at Kew and Wakehurst, a significant body of knowledge of their growth patterns, cultural requirements, pollination processes, tolerances and other characteristics have become known. Future research and conservation projects could benefit to a far greater extent from this accumulated body of knowledge and from access to the living material itself.

Ensuring that a high percentage of new accessions to the Living Collections are within scientific priority families and genera, or from global locations that have been targeted for continuing research projects, will bring the Living Collections, Science Collections and scientific research closer together. This will allow Kew to develop the highest-quality integrated collections-based science in the world. In addition, some of the more extensive living plant collections may present opportunities for new research proposals, where the scientists can take advantage of the existing resource available at either Kew or Wakehurst. Where additional material is required for scientific research, there may be a possibility to bulk up accessions or enhance the collections with new accessions to provide additional species or genetic diversity.

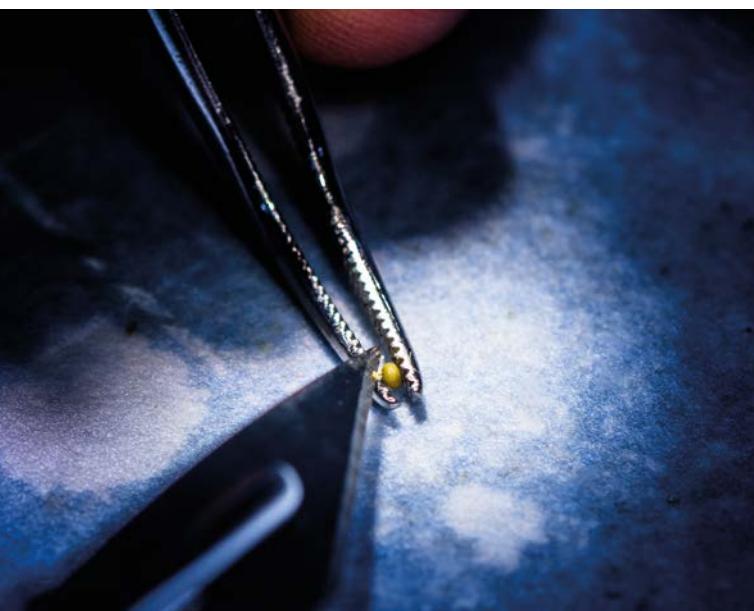
We will explore the potential to increase the representation of threatened species in the Living Collections through targeting plants from areas of scientific interest and key taxonomic groups. Where our scientists are working on the ground to research the biology and restoration of threatened plants, we will aim to provide support through propagating specimens and incorporating them into the collections or making them available for restoration projects with Kew's partners, or both. Threatened species present valuable

opportunities to communicate Kew's horticultural and scientific partnerships and how they have resulted in conservation success stories across the globe. As part of this process, robust cultivation protocols will be developed, detailing the best conditions and methods for each species.

The links to the Seed Collection stored at the MSB (one of the Science Collections and therefore covered under Kew's *Science Collections Strategy*) will be enhanced. Following controlled pollination, seeds from various taxa have been harvested and provided for storage in the MSB over a number of years. Where appropriate (for example for the Temperate House replanting), seed has been accessed from the MSB to grow live material. Occasionally, young seedlings arising from germination trials have been grown on for accession to the Living Collections, to expand the diversity of the collections. Processes such as this highlight the benefits that may be further explored as a result of closer integration of the Living and Science Collections into the future.

As Kew's wild botanic garden, Wakehurst has a specific strategic priority to develop new landscapes using significant wild-sourced taxa from Kew Science's conservation partnerships. This creates evocative, tangible connections between the MSB and Wakehurst visitors: using plants to tell stories and engaging new audiences with Kew's mission.

Underpinning the way that we think about our living plant collections should be the understanding that horticulture is an applied science. We successfully grow plants from around the world because we apply what is known about their physiology, their biological cycles and growth patterns, their natural habitats, pollinators and pathogens. Without expert staff to accumulate and then apply this knowledge, and without purpose-built facilities with controllable climates, we would no longer have the ability to successfully hold and develop these collections and their benefits (current and potential) would be lost.





The Agius Evolution Garden under development,
scheduled for completion in mid-2019

Strategies for integrating horticulture, science and conservation:

- Integrate the Science Collections and Living Collections through targeting new accessions aligned to the geographical and taxonomic priorities as set out in the *Science Collections Strategy*.
- Make collections available for the development of new scientific research proposals and establish horticulture and science working groups to explore synergies and align priorities.
- Coordinate horticultural and scientific programmes to ensure *ex situ* conservation of key species.
- Develop accurate cultivation protocols, particularly for threatened species, and keep records of the biological attributes of taxa within collections.
- Collect seed from selected living specimens for incorporation into the Seed Collection at the MSB and utilise samples from the Seed Collection to enhance the Living Collections.



Taxus baccata

Addressing global challenges

An important part of Kew's scientific vision is the aspiration to bring authoritative expertise to bear on the critical challenges facing humanity today, including loss of biodiversity, climate change, rapidly spreading pests and diseases, human population growth and resulting food insecurity. Through increased scientific and horticultural understanding of plants and fungi, we can help address some of these challenges, contributing to the United Nations Sustainable Development Goals and improving the health of the planet and people's lives. The Living Collections can support this work, through propagating and incorporating plants for research projects on natural capital and livelihoods and helping to monitor plant health.

Kew has a wealth of specimens that can be used to monitor the effects of climate change and the value of living plants in mitigating its effects. Mature tree specimens are particularly valuable for looking at responses to increases in atmospheric CO₂ and for quantifying carbon capture – there are over 450 champion trees across the two sites (those on the Tree Register of the British Isles for being the largest of their kind). The Living Collections are also useful for phenology. Kew has a history of phenological study, and with the existing volunteer community and potential public engagement through citizen science, we can continue to monitor key phenological metrics.

We will grow specific taxa that provide ecosystem services and are the subject of research to seek to enhance their value within a natural capital context. For example, wild relatives of crops that have potential to enhance the diversity and sustainability of food sources. These will include minor, orphan and niche crops and wild edible plants that can contribute to dietary diversity and reverse malnutrition (in the broadest sense), such as minor cereals, tuber crops and legumes/crucifers.

We will monitor plant health within the collections and facilitate research to investigate resilience to pests and pathogens, particularly among temperate trees, to reverse potential losses in the benefits that they provide – ranging from timber to enhanced health and wellbeing. The Plant Reception and Quarantine Unit will play a key role in supporting research on plants and pathogenic fungi and pests. We will also use our collections to hold taxa associated with medicinal use in addressing conditions like dementia, Alzheimer's disease, malaria and diabetes, and containing antimalarial and antifungal compounds.

These species, and the interpretation and digital resources associated with them, will be central to highlighting Kew's role in addressing global challenges and thus our relevance to human lives and livelihoods.

Eleusine coracana



Podophyllum hexandrum



What will success look like?



Success will be represented by the Living Collections continuing to be geographically, taxonomically and genetically diverse, aligned with Kew's scientific priorities and displayed and interpreted in innovative ways to communicate the wonder of plants to diverse audiences.

A full audit of the collections will be completed by 2023.

All new accessions will meet the strategic aims for the Living Collections and focus on priority plants of geographical,

taxonomic, conservation, heritage or landscape significance. Some specific markers of success are given below.

Conservation

- Extensive propagation and cultivation of threatened taxa, providing an important *ex situ* conservation resource and supporting breeding and restoration programmes.
- A 5% increase in IUCN Red-Listed taxa per year for the next ten years.

- Seed routinely collected from key living specimens for storage in the MSB, and samples from the Seed Collection routinely used to enhance the Living Collections.

Curation and research

- High-quality curation of specimens, with accurate and detailed supporting data available for all accessions.
- An increased proportion of specimens identified to species level.
- Genetically diverse collections supporting scientific and horticultural research programmes.
- New accessions aligned with Kew's *Science Collections Strategy* in key geographical areas and taxonomic groups.

- The biological attributes of collections routinely recorded, and their cultivation requirements defined in robust horticultural protocols to support research, conservation and restoration.
- Horticulture and Science Working Group meeting regularly to explore synergies, alignment of priorities and joint research.

Collection management

- Living Collections database fully populated with accurate data, fully functional, integrated with or linked to Science Collections databases, and publicly accessible.
- Staggered age profiles in all major collections and succession planning in place, with all plants in good health.
- Collection Management Plans in place for all major collections.
- Continued compliance with all international conventions on the conservation and legal movement of plants, and support provided to Defra and the Animal and Plant Health Agency to assist in enforcement.

- Robust biosecurity and plant health procedures protecting the collections.
- Acquisition criteria enforced, ensuring procurement of high-quality, data-rich accessions from wild sources and preventing the introduction of prohibited, diseased or pest-infested material, or noxious weeds.
- Plants sited to achieve optimum environmental conditions for growth, taking into account future climate projections where applicable.
- Tree Risk Assessment Management System operating to ensure staff and public safety.
- Excellence in specialist horticultural training, using diverse collections spanning a range of growing environments.

Facilities

- New facilities in place to meet the long-term growing requirements of the collections.
- All nursery facilities undergoing regular inspection with adequate maintenance.
- Environmental and water policies ensuring sustainability across the two sites.

Interpretation, education and communication

- Public displays showcasing thematically linked groups of plants with significant scientific, historical or cultural value.
- Interpretation accompanying all publicly accessible collections, building visitors' understanding about the diversity and value of plants in our collections and contributing to a scientifically, horticulturally and ecologically literate community.
- A rich, diverse array of well-curated specimens used in school and postgraduate education, training and research.
- Kew's extensive media and social media channels promoting access to, awareness of, and engagement with, the Living Collections.

What measures of success will we monitor?

- Diversity of the Living Collections (total number of taxa, percentage of plant families and genera represented)
- Total number of IUCN Red List taxa
- Number of losses of IUCN Red List taxa from the Collections (especially those of Vulnerable, Endangered, Critically Endangered and Extinct in the Wild status)
– nil expected
- Number of accessions linked to Kew's scientific projects
- Number of living plant specimens/taxa cited within scientific papers
- Number of accessions with associated interpretation
- Number of days of public access to non-public collections (such as back-of-house nurseries) and number of people gaining access on these days
- Number of media articles and reports focusing on taxa from the Living Collections or on the Living Collections themselves



Encephalartos altensteinii
in the Palm House

Acknowledgements and further information

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Common abbreviations used in this document

CBD:	Convention on Biological Diversity
CITES:	Convention on International Trade in Endangered Species of Wild Fauna and Flora
ISO:	International Organization for Standardization
IUCN:	International Union for Conservation of Nature
MSB:	Millennium Seed Bank
MSBP:	Millennium Seed Bank Partnership
TRAMS:	Tree Risk Assessment Management System
UNESCO:	United Nations Educational, Scientific and Cultural Organization

Plant family names

Our use of plant family names follows:

Angiosperm Phylogeny Group. (2016). An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV. *Botanical Journal of the Linnean Society* 181(1): 1–20. doi: 10.1111/boj.12385

and

Christenhusz, M. J. M., Fay, M. F. & Chase, M. W. (2017). *Plants of the World: An Illustrated Encyclopedia of Vascular Plants*. Kew Publishing, Royal Botanic Gardens, Kew and The University of Chicago Press.

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A close-up photograph of a large, vibrant green leaf, likely from a tropical plant. The leaf is covered in numerous small, glistening water droplets. A prominent, dark green central vein runs diagonally across the frame, with several smaller veins branching off it. The texture of the leaf's surface is visible through the water droplets.

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