# Living Collections Plan

## Melbourne Gardens 2022–2042

Safeguarding plants for the wellbeing of people and the planet

Royal Botanic Gardens Victoria

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# Acknowledgements

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# Foreword

Living collections are integral to botanic gardens. At Royal Botanic Gardens Victoria, they underpin our scientific research, visitor programs and all our beautiful landscapes and horticultural displays. In 2016 Royal Botanic Gardens Victoria's Landscape Succession Strategy placed the organisation at the global forefront of environmental horticulture and public gardens response to climate change. This work has since been strengthened by the establishment of the Climate Change Alliance of Botanic Gardens, which now has almost 500 members from over 90 countries across the world. This Living Collections Plan supports this work, providing a rigorous framework for the care, development, and stewardship of the Melbourne Gardens valuable plant collections today, and in a changing world.

The production of the Melbourne Gardens' Living Collections Plan has confirmed for us just how important Royal Botanic Gardens Victoria's collections are, and the capacity they have to contribute to national and international plant conservation. The plan is underpinned by an extensive literature review, and research into plant conservation work across the world. It outlines how our collections need to change in response to climate change and emerging community expectations. Notably, we have identified a need for an even stronger focus on accurately identified, wild collected plants, and on increased representation of rare and threatened species.

While the development and care of the living collections is important, their relevance can be greatly expanded by more deeply connecting the public with the collections. Research has shown that one of the most important ways botanic gardens can contribute to plant conservation is through expanding the public's understanding and engagement with this work. It has often been recognised that while the millions of visitors hold the Gardens in great affection, many do not understand the role of the collections, and this Plan provides the opportunity to remedy this and profile the organisations' work.

One of the biggest challenges facing Melbourne Gardens' living collections is climate change. Melbourne's climate is hotter and drier than in 1846 when the Gardens were established, and this change is predicted to continue. This accelerating change puts ever increasing strain on the collections. Some will not be viable into the future. Others require care and transition, especially where they have heritage and ecological value. Underpinning collections management is a desire to increase their climate resilience while maintaining their landscape character and environmental qualities.

All this work would not be possible without the care and expertise of the Gardens' horticulturists and plant scientists. This Plan looks to foster the organisation's corporate knowledge, increase collaboration with other botanic gardens and other plant conservation institutions across Australia and the world and support the work of those who care for the collections.

As we emerge from the impacts of a worldwide pandemic, there has never been a more important time to value and protect Melbourne Gardens and its plant collections. They are at the heart of what the Gardens are and the work we do, safeguarding plants for the wellbeing of people and the planet.

**Professor Tim Entwisle**
Director and Chief Executive
Royal Botanic Gardens Victoria

**Chris Cole**
Executive Director
Melbourne Gardens

# Terminology and Naming

**Access and Benefit Sharing (ABS)**: refers to the way in which genetic resources (plant material) may be accessed, and how the benefits that result from their use are shared between the people or countries using the resources (users) and the people or countries that provide them (providers).

**Accession**: Plant material that is collected at the same time and location from a single species and which is typically propagated and given a unique accession number for identification and tracking purposes.

**BGANZ**: Botanic Gardens Australia and New Zealand Incorporated, a not-for-profit peak industry body formed to build and maintain links with relevant national and international bodies.

**BGCI**: Botanic Gardens Conservation International, an umbrella organisation for botanic gardens and arboreta all over the world with an emphasis on the conservation of plants and plant communities.

**BICON**: Australian Biosecurity Import Conditions. BICON houses the Australian Government's Biosecurity import conditions database for more than 20,000 plants, animals, minerals and biological products.

**BIOCLIM**: A species distribution modelling system created by CSIRO in partnership with the Federal Government's Bureau of Flora and Fauna.

**Board**: Royal Botanic Gardens Board Victoria, the body that has ultimate accountability under *Botanic Gardens Act 1991*.

**CCABG**: Climate Change Alliance of Botanic Gardens, an alliance of botanic organisations taking action to protect and enable adaptation of botanic landscapes in a changing climate.

**CHABG**: The Council of Heads of Australian Botanic Gardens Incorporated, a not-for-profit organisation dedicated to supporting the protection, conservation and enhancement of Australian plants and their ecosystems.

**Convention on Biological Diversity**: An international treaty that seeks to conserve biodiversity, promote sustainable use of its components, and advocate for the fair and equitable sharing of benefits arising from the use of genetic resources.

**DEECA**: Department of Energy, Environment and Climate Action, the State Government Department with responsibility for Royal Botanic Gardens Victoria.

**EVC**: Ecological Vegetation Classes, the standard unit for classifying vegetative types in Victoria.

**Footprint Percentage**: Percentage of plants which meet the collection criteria for collections with a defined landscape area (e.g., 62% of plants within the Southern Africa area are from Southern Africa).

**GIS**: Geographic Information Systems, a system that creates, manages, analyses and maps all types of data.

**GSPC**: Global Strategy for Plant Conservation. A program of the UN's Convention on Biological Diversity founded in 1999. The GSPC seeks to slow the pace of plant extinction around the world through a strategy of 5 objectives.

**HortFlora**: A guide to the cultivated plants of south-eastern Australia.

**IABG**: International Association of Botanic Gardens, an umbrella organisation for botanic gardens and arboreta all over the world, representing all aspects of their business.

**ID3**: A component of RBGV plant identification ranking system and indicates botanical verification is completed by a plant scientist. **ID2** status generally means that plants have been partially verified but uncertainty persists, or identification is not yet fully possible. **ID1** status indicates that plants have not been verified.

**Living Collection**: A categorised group of living plants curated for a defined purpose.

**Melbourne Gardens**: South Yarra land under management of Royal Botanic Gardens Victoria. Includes the National Herbarium of Victoria, Original Botanic Gardens, The Ian Potter Foundation Children's Garden, and the Melbourne Observatory site. Also referred to as 'the Gardens' or simply 'Royal Botanic Gardens'.

**Metacollection**: An individual plant or defined group of plants grown for agreed conservation outcomes across multiple organisations and locations to maximise genetic diversity and reduce risk of loss.

**MTA**: Material Transfer Agreement, a contract that governs the transfer of tangible research materials between two organisations.

**National Herbarium of Victoria**: The building on the corner of Birdwood Avenue and Dallas Brooks Drive, home to the State Botanical Collection in 2020.

**Provenance**: The location from which a plant is sourced, and which is known and documented.

**Royal Botanic Gardens Victoria or RBGV**: The whole organisation including the sites at Melbourne and Cranbourne, the National Herbarium of Victoria and the State Botanical Collection.

**SDM**: Species Distribution Modelling, using environmental data to predict the distribution of a species across geographic space and time.

**State Botanical Collection**: The scientific collection of preserved plants, algae and fungi under the stewardship and management of Royal Botanic Gardens Victoria and held within the National Herbarium of Victoria, including the specimen collection, library, archives and botanical art collections.

**Taxa**: Plural for taxon. A taxonomic group of any rank, such as family, genus, or species. In this document, 'taxa' often means the total of distinct plants at the lowest taxonomic rank—this can include varieties and cultivars.

**Traditional Owners**: Refers to the Woi Wurrung and Bunurong language groups. The Traditional Owner Registered Aboriginal Parties for the Melbourne site are the Wurundjeri Woi Wurrung Cultural Heritage Aboriginal Corporation and Bunurong Land Council Aboriginal Corporation.
It also refers to Traditional Owners across Victoria and other regions of Australia to which our site's work extends.

**Wild Collected / Wild Sourced**: Living plant material that is sourced directly from natural habitats.

**WRAP**: Royal Botanic Gardens Victoria's Weed Risk Assessment Procedure.

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Horticulturist with *Eucalyptus scoparia* on plant collection trip to Bald Rock, NSW

# Executive Summary

Established in 1846, Royal Botanic Gardens Melbourne is recognised as one of the world's most beautiful botanic gardens. Located on the banks of the Yarra River, also known as Birrarung, it is an iconic part of the city's landscape and has been a central element of Melbourne's cultural and social life for generations. One of two botanic gardens managed by Royal Botanic Gardens Victoria (RBGV), it shares its work with the Cranbourne Gardens, a specialist Australian plant garden approximately 60 kilometres to the south–east and set within a large conservation reserve.

Spread across 38 hectares of meticulously landscaped gardens, Melbourne Gardens is home to a collection of over 7,500 plant taxa from 249 families, representing 98% of the world's countries. This rich set of living collections is cared for by expert horticulturists and is an important resource for plant scientists and visitors to better understand and care for the plant life of Victoria, Australia, and the world.

In large part, it is these living collections which make the site a botanic garden and RBGV a world leading scientific institution. Working with the National Herbarium of Victoria's State Botanical Collection, the living collections underpin the organisation's research into plant conservation, climate resilience, water management, urban greening, and restoration. They also play an active part in plant conservation and regeneration programs and engaging and connecting with Gardens' visitors.

For many years Melbourne Gardens living collections have been managed by dedicated horticulturists and guided by a Living Collections Plan with detailed, collections–specific management plans. The time has now come to update this Plan. Royal Botanic Gardens Victoria's pioneering Landscape Succession Strategy 2016–2036 identified the urgent need to transition the Gardens' collections to more climate resilient taxa. This means using plants able to tolerate the hotter and drier conditions predicted under future climate models, and already being experienced by a landscape planted at a time when the climate was cooler.

Changing technology in plant databasing and record keeping opens the way for more proactive management of the collections, and better plant identification and knowledge sharing opportunities. Technology provides the opportunity to share the stories and knowledge embedded in the collections with a wider audience, embracing the public's growing fascination with plants and the outdoors, and increasing awareness of the importance of plant conservation. The time has also come to respond to practical considerations in collections management including addressing soil management issues, more proactive sourcing of wild–collected taxa, and increased recognition and support of the institutional knowledge critical to the responsible management of the collections.

*Themeda triandra* on Princes Lawn

Lastly, the opportunity exists for the living collections to play a more active role in plant conservation programs across the world. The new Plan has been guided by State, National and International conservation policies and protocols including the Global Strategy for Plant Conservation authored by Botanic Gardens Conservation International (BGCI). RBGV is strongly positioned within the world's network of over 1,700 arboreta and botanic gardens, performing the lead role in the recently formed Climate Change Alliance of Botanic Gardens, a network of almost 500 organisations across 90 countries working to protect the world's botanic gardens. Additional plant and seed conservation work is also being undertaken, with RBGV playing an active role in Australia's recovery from the devastating 2019–2020 bushfires. The opportunity now exists to strengthen and expand this work.

The new Living Collections Plan responds to all these challenges. It outlines the direction and management priorities for the care of the collections, supported by other RBGV strategies and plans, and overseen by the long-term strategic direction of the RBG Board. The Plan is driven by clearly identified strategies and targets with the following four objectives:

— Increasing plant diversity and future climate resilience in the landscape

— Supporting plant conservation programs locally and across the globe

— Pursuing excellence in collection curation

— Improving public engagement with the collections and understanding of the vital role plants play in supporting life.

Central to the ambition of the Living Collections Plan is the active care and management of the existing collections, including recommendations for potential expansion, transition to more climate resilient plantings, increasing known provenance and wild-sourced taxa, or, in limited cases, the deaccession and transition of climate susceptible plantings. The Plan makes these recommendations for 23 actively managed collections, as well as providing guidance on the management of the broader living landscape and identifying potential future collections.

This Living Collections Plan aims to do all this and more, providing a solid foundation to protect and develop the living collections and expanding Royal Botanic Gardens Victoria's work around the world.

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View through the New Zealand Collection

# Introduction

The living collections at Melbourne Gardens are incorporated within the framework of a garden which has been skilfully designed in the 19th century picturesque and gardenesque styles. While Melbourne Gardens still retains the overall design introduced by William Guilfoyle (Director, 1873 – 1909), it is the plant collections nestled within this landscape that makes the site a botanic garden.

Melbourne Gardens is home to 46,000 plants of over 7,500 taxa and from 190 countries across the world. This includes many plants which are rare and threatened or even extinct in the wild. Royal Botanic Gardens Victoria has a strong international reputation in the world of botanic gardens, and this has been strengthened in recent years by world-leading research into the care and management of botanic gardens in response to climate change.

While Melbourne Gardens contains many Australian plants, it is seen as a 'Garden of the World', and is complemented by Cranbourne Gardens, which showcases a rich and diverse Australian collection. The Melbourne Gardens plant collection is challenged by a changing climate and increasing stresses on global biodiversity. This Plan highlights the need to grow and protect the living collections, actively caring for and promoting them to share the benefits that plants provide for people and the planet.

## 2.1. What is a Living Collection?

A living collection is a group of plants grown for a defined purpose. Such purposes can include research, interpretation, education, conservation, and display. These collections are actively curated, with the taxa displayed adding to the completeness and usefulness of the collection as a whole. It is these collections which differentiate botanic gardens from public parks, with botanic gardens being valuable scientific repositories of plants, collected and actively curated for scientific and cultural purposes.

Usually, collections are curated within a theme – such as geographical, ecological, taxonomic, conservation, ornamental or cultural – with these themes being complementary to the internationally recognised roles of botanic gardens throughout the world. Central to this idea of curation is the active research, procurement, care, and sometimes removal, of plants within the collections. This requires knowledgeable curators, active record keeping, and collaboration with like-minded institutions. Royal Botanic Gardens Victoria is at the forefront of horticultural research and response to climate change, manifested and informed through active curation of its living collections.

Living collections can be focused in one location or distributed across the entire landscape. A key characteristic of Melbourne Gardens' design is the way its collections are skilfully embedded throughout a cohesively designed picturesque landscape, reconciling the sometimes-competing functions of a multi-purpose public open space and a scientific institution.

Guilfoyle's Volcano collection, an ornamental and cultural collection

Tour of the Gardens' water systems for Design Week 2019

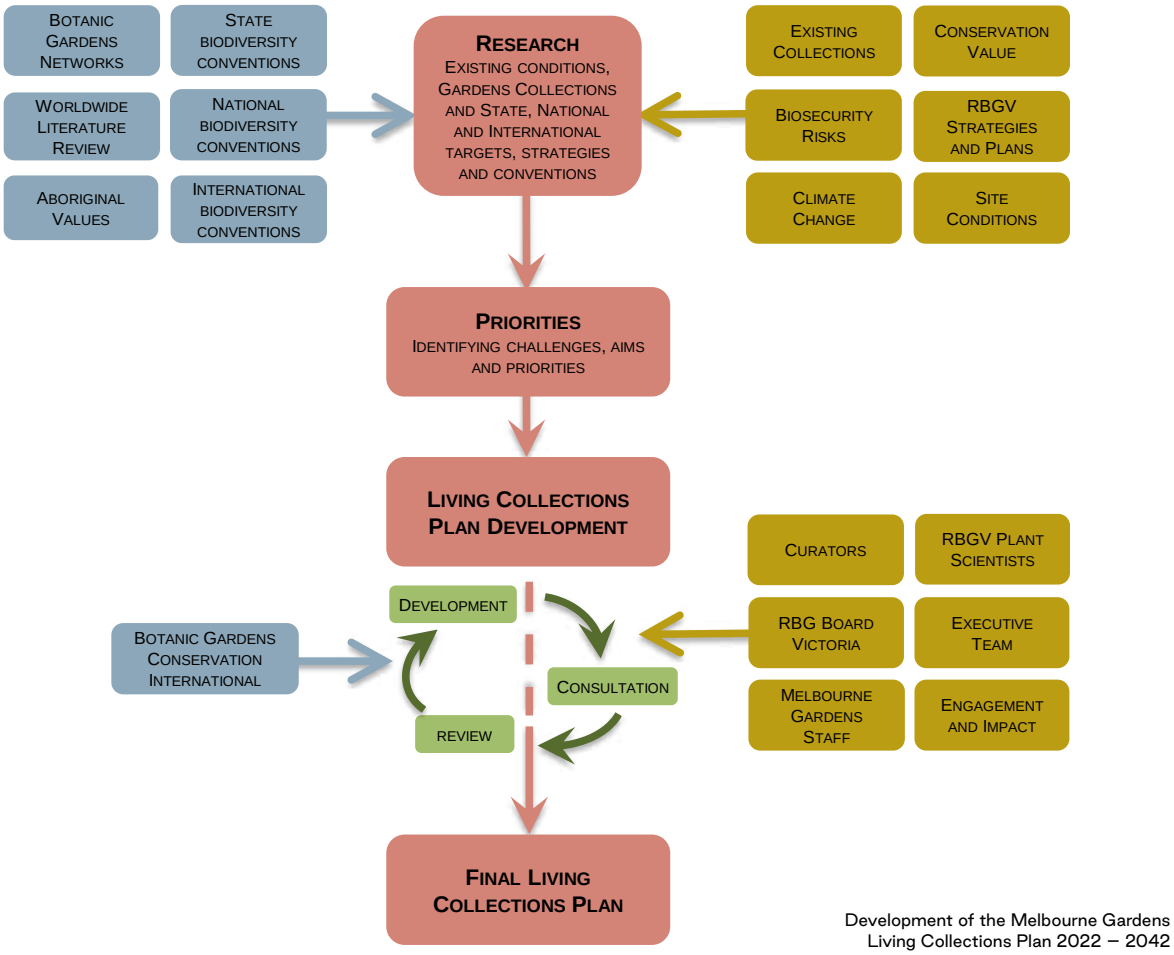
Living collections provide wider scientific and social functions. Active, long-term record keeping makes the collections an invaluable tool for scientific research. By trialling plants in collections, botanic gardens investigate potential plants for the horticultural industry and home gardeners. Perhaps most importantly though, it is through the living collections that botanic gardens undertake some of their most crucial conservation work. It has been estimated that 39% of the world's plants are threatened by extinction . By preserving plants in ex situ populations, living collections help guard against species loss by providing a protected source of known-provenance propagation material for revegetation as well as plant conservation work which is supported by the work of Plant Scientists at the National Herbarium of Victoria.

## 2.2. Purpose and Scope

The *Melbourne Gardens Living Collections Plan 2022 – 2042* for Royal Botanic Gardens Victoria's Melbourne Gardens provides strategic guidance for the long-term care, management, and development of the Gardens' living collections. This Plan has been prepared to guide the development of the collections to support the organisation's vision and mission, as well as state, national, and international targets on protecting plant diversity, and includes support for the metacollection plant conservation work of botanic gardens around the world. The scope of the Plan are the collections held on Royal Botanic Gardens Melbourne site.

Botanical collections and landscapes are constructs of the environment, art, culture, people, and science. Managing these living spaces effectively is complex and occurs over long-time scales, which essentially requires the careful integration of the Living Collections Plan with other organisational plans. The Living Collections Plan is but one document guiding the work of Royal Botanic Gardens Victoria. This document focuses on the care and direction of the plant collections and their role in international plant conservation. It has been informed by, and supports the work of, existing RBGV strategies and plans and should be read in conjunction with other management documents (refer section 3.8). Of particular importance are the *Landscape Succession Strategy Melbourne Gardens 2016–2036*, which guides the organisation's response to mitigating the effects of climate change on the landscape and collections; the *Melbourne Gardens Master Plan 2020–2040*, which addresses the aesthetic and functional design of the landscape; and the *Consolidated Engagement and Impact Strategy 2018–2021*, which speaks to the organisation's ambitions for growth through distinctive and deepened engagement experiences across both sites. Finally, the new *RBGV Corporate Plan 2021–2024* has four pillars and related goal areas to support this Plan that are themed as follows: People, Place, Plants and Planet.

The development of the Living Collections Plan has identified many opportunities for internal collaboration across the organisation. It provides the basis for delivering collection-based science and research supported by effective storytelling, which will increase people's understanding of the vital role plants play in supporting life and health. As in all organisational strategies, the Living Collections Plan also points to opportunities for external collaboration and learning.




Development of the Melbourne Gardens Living Collections Plan 2022 – 2042

## 2.3. Process

The development of the Living Collections Plan followed a scientific and consultative process which was developed to support both the work of the organisation and wider state, national and international plant conservation and biodiversity targets. The methodology for developing the Plan was as follows:

— Research was undertaken into climate change and its impact on the Gardens over many years, especially research by Peter Symes (RBGV), Dr Dave Kendal (University of Melbourne) and RBGV water management expertise. This work underpinned the development of the Plan

— Existing collections were assessed, including researching risks associated with the individual collections such as biosecurity, potential impact of climate change and conservation values

— A review was undertaken of RBGV strategies and plans and existing site conditions including soils, climate, landscape character, organisational structure, and heritage

— State, national, and international plant biodiversity conventions, strategies and targets were reviewed. Specific targets were identified which could be supported by the development of the living collections

— A review was undertaken of professional botanic gardens networks and organisations worldwide with the view to collaboration, and was augmented by a worldwide literature review of botanic gardens living collections policies

— Working with RBGV staff, challenges and aims for the collections were identified and priorities developed

— Feedback was sought and incorporated from the peak industry body: Botanic Gardens Conservation International

— The Draft Living Collections Plan was developed and received internal sign off from a team of RBGV Executives and staff before being presented to RBGV Board, who provided feedback

— The Living Collections Plan was reviewed with the aim of external publication to a wider audience before final approval, graphic design, and publication.

Bush Foods at Melbourne Gardens, including *Syzygium leumanii*

Horticulturist caring for the living collections

## 2.4. Guiding Principles

In developing the Living Collections Plan, Royal Botanic Gardens Victoria seeks to be an innovator in living collections management and support the work of likeminded organisations across the globe in the care for and conservation of plants. To assist with this, the following guiding principles were developed, identifying the underpinning aspects which are most critical to the responsible management of living collections:

**Protection**

**Living collections that are diverse and climate resilient**

The Gardens provide a home to collections which are diverse and resilient. Collections are developed to increase their climate resilience — both now and into the future — protecting the Gardens' character and scientific importance. Increased diversity within the collections is a priority, with a focus on wild sourced and known provenance specimens which support the work of the National Herbarium of Victoria and which have been selected to have the climate resilience needed for a more sustainable and secure landscape.

**Conservation**

**Living collections which support plant conservation programs across the world**

Royal Botanic Gardens Victoria is part of a worldwide network of organisations dedicated to protecting and conserving plant biodiversity. The living collections support this work through global innovation in the management and conservation of plants from across the globe, in research, education, field work and ex situ and meta collections. The global importance of these collections is understood and celebrated throughout the organisation, with development of the collections supporting priority plant conservation programs across the world.

**Stewardship**

**Providing horticultural and scientific excellence in the management of the collections**

The living collections are cared for and curated by horticulturists whose work is supported by investment in best practice professional development. Collections are managed in collaboration with plant scientists, to maximise opportunities for collections research and study, and to build on and share the corporate knowledge they contain. The importance of the horticulturists and curators in this work is understood and celebrated through skills transfer and professional development, as successful collection development is dependent on passionate, skilled horticultural curators.

**Engagement**

**Living collections which educate and inspire visitors in diverse and creative ways**

The living collections are more than just beautiful plants to be photographed, posted, and forgotten. They offer the opportunity to engage and inspire. The collections are used to tell unique and compelling stories, which develop stronger learning and interpretation outcomes with researched, measurable outcomes, all of which leads people to better engage with and protect plants.

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View across Melbourne Gardens and the Ornamental Lake

# Background and Context

Melbourne Gardens is home to over 7,500 taxa from 249 families, including representatives of the flora of 98% of the countries of the world. These plantings are actively curated as a scientific resource and nestled seamlessly into the overall design of the gardens. It is this integration of science and design which makes Melbourne Gardens distinctive from other botanic gardens, with its unified landscape punctuated by living collections differing greatly from the traditional "systems garden" approach to botanic garden design. The following chapter provides the background, current context, and rationale to support the decisions made to develop and protect these valuable collections.

## 3.1. Location and Context

Melbourne Gardens is located within the Domain Parklands, contributing to the network of parks and gardens encircling Melbourne, the capital city of Victoria in Australia. As a city established in the 19th century, the design of Melbourne has a strong focus on the provision of parks and greenspace. The Domain Parklands are one part of a ring of parks and gardens encircling the city, including the Fitzroy, Treasury, Flagstaff and Carlton Gardens adjacent to the city grid; Yarra Park, Richmond; Fawkner Park, South Yarra; Albert Park, South Melbourne and Royal Park, Parkville. In most cases this ring forms an open space boundary between the commercial city centre and the residential inner suburbs.

Melbourne Gardens occupies 38.6 hectares bordering the Yarra River, a little over 2 kilometres from Melbourne's Central Business District. The site is made up of three historical parcels, each with its own character; the Melbourne Observatory, founded in 1863 and transferred to Gardens' management in 1992; the historic Royal Botanic Gardens Melbourne site founded in 1846; and a small parcel of land connecting the two, once part of Kings Domain and now home to The Ian Potter Foundation Children's Garden.

The character and microclimate of Melbourne Gardens derives many of its qualities from the topography of the site. Occupying a hill on the banks of the Yarra River, the site rises from approximately 1.5m above sea level at the Ornamental Lake, a former billabong of the Yarra River, to approximately 35m at its highest point at Guilfoyle's Volcano[i]. A drainage line to the Yarra runs through the centre of the Gardens, providing a natural focus in Fern Gully and the lakes.

The Gardens is a much-loved part of Melbourne's life, and an invaluable scientific resource. The Gardens hold a collection of 7,500 plant taxa from across the globe, while the National Herbarium of Victoria holds the State Botanical Collection, an irreplaceable treasure trove of over 1.5 million preserved plant specimens dating back to the 1600s. The Gardens welcome over 2 million visitors per annum, drawn to the serene landscape, central location and the Gardens' prized living plant collections.

As a state-funded agency, RBGV's Melbourne Gardens respond to the environmental, tourism, education, cultural and climate policies of the Victorian State Government, and as a key highlight of the city align closely to the City of Melbourne's land management guidelines, particularly in relation to the Domain Parklands.

i Australian Height Datum

View across the Gardens taken by the Arboricultural team from the canopy of a *Hesperocyparis macrocarpa*

## 3.2. Melbourne Gardens Living Collections

Melbourne Gardens can be portrayed as a 'Garden of the World', with a 2021 analysis revealing that 190 countries are represented in its collections, equating to 98% of all sovereign nations.[ii] Table 1 demonstrates the breadth and reach of this collection, which includes over 7,500 different taxa of plants.

This diversity means that a 2021 review of over 1,000 botanic gardens across the world ranked Melbourne Gardens as 35th worldwide for taxa diversity, 50th for holdings of threatened taxa and 58th in the world for unique taxa, putting it in the top 5% for these categories worldwide.[iii] While these results are encouraging, there is still opportunity to expand plant diversity and increase curation of threatened species within the collections. It is also beneficial to duplicate unique taxa through sharing material with other botanic gardens, supporting the creation of meta collections and increasing the resilience of ex situ populations.

While all accessioned specimens contribute to the Melbourne Gardens' living collections, there are 23 actively curated and themed collections grouped under five collection themes: Geographical, Ecological, Taxonomic and Evolutionary, Research and Conservation, Ornamental and Cultural. Each collection is overseen by a dedicated horticultural curator who works with the Melbourne Gardens Senior Curator Horticulture to guide the management and direction of the collection. It is the direction of these collections which is the focus of the Living Collections Plan. The Plan provides the mechanisms and support for the regular evaluation which is critical to meeting Melbourne Gardens' plant diversity targets, while supporting associated Royal Botanic Gardens Victoria goals and broader plant conservation objectives.

**Table 1 – Current Holdings of the entire Living Collection (February 2021)**

| | |
|---|---|
| Countries represented | 190 (98%) |
| Families | 249 |
| Genera | 1,716 |
| Taxa | 7,499 |
| Accessions | 23,729 |
| Plants | 46,127 |
| Identified Accessions (ID3) | 38% |
| Taxa of wild–collected provenance | 19% |
| Rare and threatened taxa | 6% |

ii Countries as defined by the United Nations as member states

iii Based on an assessment via Botanic Gardens Conservation International's Plant Search – P Smith (pers. comm. 2019, 21 February)

View through the New Zealand Collection showing the picturesque landscape character

## 3.3. Landscape Character

The layout and character of Melbourne Gardens owes much to the design and stewardship of Director William Guilfoyle (1873–1909), who used the natural beauty of the site to create a garden which epitomises the best of both the picturesque and gardenesque landscape styles. The genius of this design lies in its ability to reconcile the potentially competing functions of a high-level public open space and a scientific institution. By placing the botanical collections within a cohesive and designed setting, Guilfoyle was able to create a unified landscape which met the aesthetic and recreational requirements of a public garden and the scientific obligations of a botanic garden. It is this integration of science and design which makes Melbourne Gardens distinct from other botanic gardens, differing markedly from the traditional "systems garden" approach to botanic garden design and contributing to its international reputation as one of the most beautiful botanic gardens in the world.

Essential to the picturesque design of the Gardens is the series of highly planned views framed by trees and ornamental garden beds, all laid out with a strong sense of balance between the mass and void. The main component of the mass is the plantings which hold the living collections. Within the landscape specimen trees, including palms, are used to provide vertical emphasis and horticultural interest. Placement of these trees is critical, as they are positioned to enhance and frame the important views, not to obscure them.

The natural attributes of the site are further emphasised by the placement and character of the plant collections. Cacti, succulent and arid collections are set among rockeries in the dry, exposed conditions of the higher ground. The sheltered drainage line to the Yarra has become the luxuriant, semi-tropical Fern Gully. The steep hillside near Government House is home to a woodland arboretum, and the dry ridge line of southern boundary holds a collection of Australian forest specimens which shelter the Gardens. These collections adhere to the best principles of planting design, creating an ever-changing display of colour, texture, and botanical richness. Within these landscapes buildings and rock grottos are placed as picturesque focal points which draw your eye through and across the landscape, while always remaining subservient to the plant collections.

Melbourne Gardens also includes two areas with very different landscape characters. The first being the open, flat Melbourne Observatory with its manicured lawns, low-level garden beds and selected trees in a landscape of 19th century scientific buildings. The second is the enclosed, inward looking Ian Potter Foundation Children's Garden; a children's wonderland and the first garden of its type in Australia.

A full description of the landscape and planting character of the Melbourne Gardens is provided in chapter 4.4 of the *Melbourne Gardens Master Plan 2020–2040*, which should be referred to for guidance on the placement and landscape design of living collections.

## 3.4. Storytelling and Learning

Melbourne Gardens' living collections hold immense potential for storytelling and public engagement. Historically, approaches to interpretation at Melbourne Gardens have been ad-hoc and severely constrained by resource challenges. Interpretation was offered primarily through signage, schools' programs, volunteer-led guided tours, and various programs delivered by the Melbourne Friends or Visitor Programs team as budget allowed. Interpretive signage was generally placed within a collection after the completion of the project, in a uniform style consistent with the organisations branding and little to no variation from collection to collection. A whole of organisation Interpretation Strategic Framework is currently in development as part of the new *Corporate Plan 2021–2024*.

Plant labels, the first layer of living collections interpretation and a traditional hallmark of botanic gardens, are relatively prevalent throughout the site using mostly a uniform, brand-led approach. On occasions, expanded plant labels offer short stories about a particular species. In some collections, for example, Lower Yarra River Habitat, there is inclusion of local Aboriginal plant names and usages. Increasingly, knowledge about Aboriginal and First Nations plant use is of particular interest to Melbourne Gardens' audiences.

Children learning about the wonders of the living collections

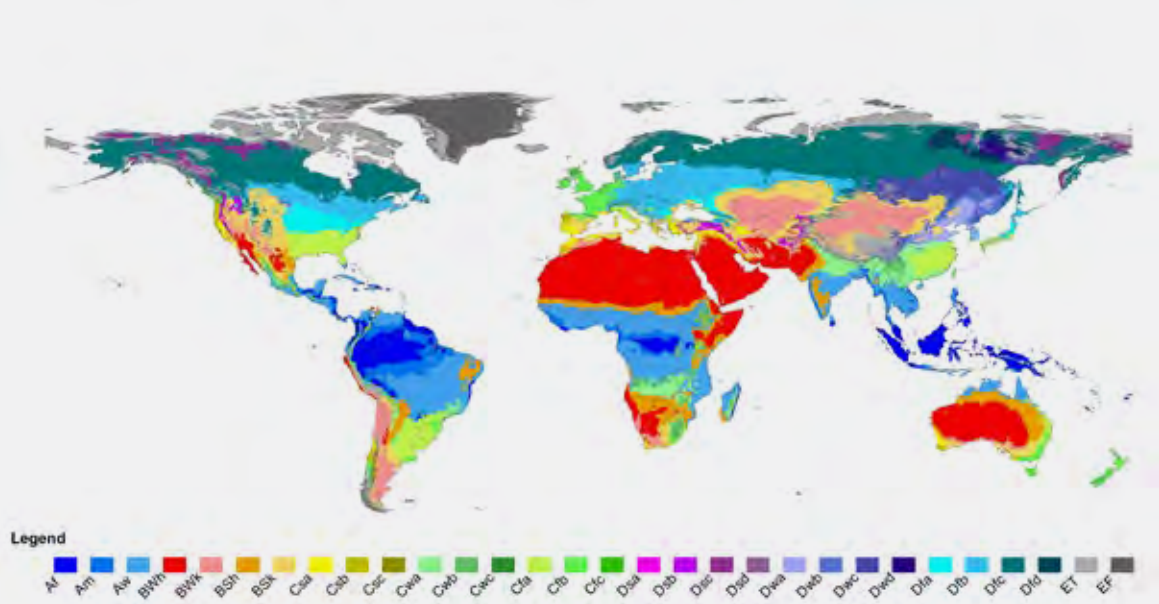
Aboriginal Heritage Walks provide visitors with a deeper knowledge of Aboriginal people's connections to plants

The most recently interpreted collection is the Cacti and Succulent Collection in the Arid Garden, showcasing the Field Collection. The Arid Garden underwent a significant redevelopment in 2020 thanks to a generous donation. This allowed for an increased budget allocation to interpretive design and planning, including elements built into the landscape, tactile sculptures, children's signs, and an audio experience. Custom designed plant labels in the Arid Garden have added another original dimension to plant labels, including a coloured graphic indicating provenance (Field Collections, Blossfeld Expedition, other Arid species). The Arid Garden project won a prize for Interpretation Excellence at the Interpretation Australia 2021 awards, and it provides a case study for possible interpretive approaches in the future, with storylines and approaches that can be expanded, echoed, or developed through other collections (plant labels, signage style, landscape succession, collecting etc.).

Currently, Learning and Participation programs for schools respond best to The Ian Potter Foundation Children's Garden, Herb and Medicinal Garden, Fern Gully, Sensory Garden, Oak Lawn and Australian Forest Walk for interpretation. These are the most accessible living collections for school groups due to their proximity to school group drop off locations. Learning programs also highlight the work of landscape succession and climate resilience through real world and digital content. The pivot to the creation of digital content during the pandemic crisis of 2020–21 has facilitated new and interesting channels for exploration and interpretation of living collections that can be further explored and refined as part of this plan.

With a strong desire to be innovative in storytelling, the cultural and public programming at RBGV has in recent years developed new interpretive tours, talks and experiences to feature, amongst others, the Australian Forest Walk, the Arid Garden, California Collection and Herb and Medicinal Garden, all guided by Gardens' staff. Opportunities to connect with RBGV experts are enormously popular with the public. Artists have been engaged to respond creatively to several collections and tertiary creative arts students from the Victorian College of the Arts have an annual program at the Gardens responding to a particular theme devised by the Gardens. This has included the Australian Rare and Threatened Species Collection and the broader theme of biodiversity. Multiple Aboriginal artists, writers, and performers, as well as an established Māori artist, have collaborated with RBGV curators on cultural storytelling and interpretation projects.

*The Living Collections Plan 2022–2042* can be found on Royal Botanic Gardens Victoria's website, along with the Plant Census Database, and this repository is an important source of plant information for external and internal teams and collaborators.




World Map of Köppen-Geiger climate classification

## 3.5. Climate Resilience

Melbourne has a temperate, warm climate in which winter frosts are rare and with relatively even rainfall across the year. Despite the mild temperatures, the site is subject to extreme heat events during the summer months. There are numerous methods for defining climate across the world, with one of the most widely used being the Köppen-Geiger climate classification. Köppen-Geiger defines climate types based on temperate range, rainfall, and seasonal changes of a region. It does this by grading climate types based on mean, long-term measurement of monthly cycles of temperature and precipitation.[3]

The usefulness of Köppen-Geiger for collections management lies in the fact that the classification was originally developed to link climate classes to vegetation biomes around the world on the basis that *"different regions in a similar class share common vegetation characteristics"*.[4] While the Köppen-Geiger classification is still one of the most widely used systems for mapping world climates,[5] it has some limitations when applied to specific plant selection. This is due to the broad scales applied in the classification which mask local microclimate variation, such as the environmental differences arising in aspect, soil, and altitude.

Melbourne is currently classified as a Cfb climate type: (C) Temperate, (f) without dry season[iv], (b) warm summer (see also Climate Change). Mean monthly precipitation in Melbourne ranges from 40-64 mm[6] so it has no defined 'dry season', although in practice the high evapotranspiration rates and temperatures in summer can result rainfall being significantly less effective. A selected snapshot of the of the most recent 30-year standard climatology (1981-2010) for Melbourne City is shown in Table 2. Of interest in this data is that Melbourne's previous mean wettest month of October has now shifted to December (64 mm of rainfall).

For further information on Melbourne's potential future climate refer to section 6.1.

**Table 2 – Meteorological Snapshot of Melbourne City**

| | |
|---|---|
| Mean Annual Rainfall (mm) | 603 |
| Mean Wettest Quarter | |
| Rainfall (Oct–Dec) mm) | 186 |
| Mean Driest Quarter Rainfall | |
| (Jan–Mar) (mm) | 126 |
| Mean Annual Temperature (°C) | 15.9 |
| Mean Maximum Temperature of Warmest Month (Feb) (°C) | 26.6 |
| Mean Temperature of Warmest Quarter (Jan–Mar) (°C) | 20.6 |
| Mean Minimum Temperature of Coldest Quarter (Jun–Aug) (°C) | 7.6 |
| Mean Temperature of Coldest Quarter (Jun–Aug) (°C) | 11.3 |

iv Without dry season refers to a basis that all months have relatively even precipitation

Soil prepared for planting in the Sensory Garden

## 3.6. Soils

In 1992, a landscape soil survey identified three main soil types: Deep Sandy Yellow Duplex[v], Loamy Yellow Duplex and Loamy Gradational. The Soil Survey Map for Melbourne Gardens[7] illustrates the distribution of these soil types, which are closely related to parent materials. Underlying the Gardens is sandstone and mudstone laid down from the Silurian era (419–444 million years ago). Sands and clays from the Tertiary period (2–65 million years ago) are more common in the upper parts of the landscape, while Silurian parent material has produced loamy soils at lower elevations.

The report found most of the site to be relatively undisturbed, excepting increased levels of humus in the topsoil as a result of long-term gardening. However, the mapped areas of 'extensive disturbance' are greater than originally shown, as internal soil investigations indicate that these should be extended to include 'the Mounds' between Guilfoyle's Volcano and the Eastern Lawns, the area around Guilfoyle's Volcano, and most of the islands in the lake system. Generally, the topsoils range in texture from sandy loams to sandy, clay loams, which are fertile (to excess) and slightly acidic with mean pH values of approximately 6.5 (in water). The relatively high organic content of the upper topsoil profiles provide good soil structure and high water-holding capacities ranging from 32–38% by volume.

v soil type that has an abrupt change in its texture i.e., from sand to clay

Assessing and updating plant records on site by the Melbourne Gardens team

## 3.7. Record Keeping

Accurate and readily accessible plant records are paramount to the scientific identity of botanic gardens and are crucial for effective management of living collections. Record keeping at Melbourne Gardens has been developed over time, with landscape plant specimens mapped using a Geographic Information System (GIS) on a base plan overlayed with a 10 × 10 metre grid. This information is centrally maintained through the Living Collections Database, which can be accessed by all RBGV horticultural staff. Selected data from the Living Collections Database is also publicly available on the RBGV website via the Living Plant Census, providing a valuable resource for industry and the public. Information in the Database is regularly updated, with arborists and horticulturists undertaking field-based updates such as management records, planting details, noting deaths and removals, and submitting specimens for improved identification status.

## 3.8. Royal Botanic Gardens Victoria Governance and Strategies

### 3.8.1. Organisational Structure

Management of Melbourne Gardens is one division of the Royal Botanic Gardens Victoria, established by the *Royal Botanic Gardens Act 1991* and reports to the Victorian Government Department of Energy, Environment and Climate Action (DEECA). The Gardens is administered by Royal Botanic Gardens Board Victoria (the Board), the statutory authority for the management of organisation under the Act. In carrying out its functions and powers, the Board represents the Crown and is accountable to the Minister for Environment.

The day-to-day management of the organisation is overseen by the Director and Chief Executive and the Executive Team. Management of the organisation is across five divisions: Melbourne Gardens, Cranbourne Gardens, Science, Engagement and Impact, and Corporate Services. Melbourne Gardens is under the direction of the Executive Director Melbourne Gardens who oversees four specialist functional areas: Horticulture, Infrastructure and Facilities, Arboriculture, and Landscape Architecture.

### 3.8.2. Royal Botanic Gardens Act

The Royal Botanic Gardens Act was passed by Parliament in 1991 and amended in 2017 to establish a Board to oversee the care, protection, management, and improvement of the garden, and to establish the Director and Chief Executive's position. The organisation's objectives under the Act are:

- to conserve, protect and improve the botanic gardens and managed land and their collections of living plants
- to conserve and enhance the State Botanical Collection and National Herbarium
- to provide for the use of the State Botanical Collection or plants or plant specimens at the botanic gardens or managed land for scientific or reference purposes, consistent with accepted international practice
- to increase public knowledge and awareness of plants and plant communities
- to provide for the use of the botanic gardens for education, public enjoyment, and tourism
- to provide for the carrying out of and contribution to research into biodiversity and the conservation of biodiversity.

The Perennial Border, an Ornamental and Cultural Collection

Collecting Trip by Horticulturists to Far North Queensland mountain tops

### 3.8.3. Vision, Mission and Values

As the organisation's key strategic statements, the vision, mission and values guided development of the Living Collections Plan.

**Our Vision**: Life is sustained and enriched by plants

**Our Mission**: Safeguarding plants for the wellbeing of people and the planet

**Our Values**: Brave, Remarkable, Open, and Creative

### 3.8.4. Corporate Plan 2021–2024

The new *Royal Botanic Gardens Victoria Corporate Plan 2021–2024* sets out the priorities and performance indicators for the organisation over a specific period. That Corporate Plan includes the following four strategic goal areas:

1. People: Engaged communities
2. Place: Vibrant places
3. Plants: Sharing plant knowledge and discovery
4. Planet: Conservation action

Each goal area is supported by long–term strategies and projects for action and measurement over the three–year life cycle of the Plan.

### 3.8.5. Landscape Succession Strategy

Royal Botanic Gardens Victoria's *Landscape Succession Strategy Melbourne Gardens 2016–2036* (Landscape Succession Strategy) was developed to inform the adaptation and management of the landscape to the challenges of future climate change, dwindling water supplies, aging plant populations and biosecurity. A key goal of the Landscape Succession Strategy is to guide the transition from existing plantings to a composition more suited to the projected climate and environmental conditions of 2090, while retaining the Gardens' heritage character, landscape quality and species diversity for future generations.

The Landscape Succession Strategy sets ambitious but achievable targets, such as maintaining existing plant diversity through a proportionate increase in species more suitable for the projected climate; achieving 100% of irrigation needs from sustainable water sources; and educating the community in adapting to climate change and other landscape development.

A primary role of the Living Collections Plan is to articulate targets of the Landscape Succession Strategy in more detail, particularly those describing botanical value, climate and environmental resilience, and plant diversity. The Landscape Succession Strategy is a primary reference when reviewing living collections or when considering collection development and should be referred to when developing these documents.

Guilfoyle's Volcano – example of combining master planning with collection development

The New Zealand Collection has heritage value as the last project at the Gardens developed by William Guilfoyle

### 3.8.6. Melbourne Gardens Master Plan 2020–2040

From its establishment in 1846 until 1997, the design, layout and development of Melbourne Gardens was overseen by a succession of Directors. However, by the late 1990s it was recognised that a more formal approach to change was required, and a series of Master Plans have since been developed to direct the long–term care and management of the landscape.

The current Master Plan, completed over a four–year period and including over 100 consultation sessions, responds to the latest opportunities and challenges facing the Gardens, including the need for a new National Herbarium of Victoria building, increased recognition of Aboriginal connections to the place, the new Anzac Station, the City of Melbourne's Domain Parklands Master Plan, responding to climate change and a growing recognition of the importance of green space within the expanding city. It also addresses the day–to–day use of the Gardens, including improving comfort for all users, providing guidance on the protection of the picturesque landscape, improving the care of the living collections, and supporting the Gardens' role as an urban green space and wildlife refuge. It does this by aligning with our organisational plans and strategies, including the Living Collections Plan.

The Master Plan provides an agreed upon and comprehensive approach to guide the development of Melbourne Gardens from 2020 to 2040. It is a planning tool that focuses on the landscape of Melbourne Gardens, and guides the major physical changes required to achieve the vision of RBGV. It does not address management issues except where they relate specifically to landscape and infrastructure. The Master Plan provides guidance on the management of the living collections as they sit within the broader, picturesque landscape and as they relate to future projects and use of the site. Of relevance is the guidance it provides in Chapter 4.4 regarding the Landscape Character of the Gardens, and how the living collections sit within the broader picturesque framework. The Master Plan has been developed to support the work of the Landscape Succession Strategy, Living Collections Plan and Tree Plan, and outlines Actions in Chapter 5.4 in relation to these documents. However, it still relies on these other strategies to provide the detailed scientific and horticultural direction needed to care for the Gardens' landscape and to fulfill the organisation's scientific aims.

### 3.8.7. Consolidated Engagement and Impact Strategy 2018–2021

The *Consolidated Engagement and Impact Strategy 2018–2021* sets growth and participation targets for the Gardens in alignment with the Department of Environment, Land, Water and Planning's Biodiversity 2037 Plan, City of Melbourne plans for a resilient city, *Victoria Visitor Economy Strategy Action Plan 2016–2020* and other state policies in Tourism, Health, Education, Aboriginal representation, and Creative Industries. The Strategy describes major actions for the organisation in fulfilling its vision and mission for increased and deepened engagement with individuals, families, international visitors, and local communities.

As related to the Living Collections Plan, the Engagement and Impact Strategy will first focus on creation of the whole–of–organisation Interpretation Framework, with establishment and rollout of key themes that align to the organisation's mission; new supporting infrastructure at both sites, for example, the Nature and Science Precinct project; and collections–specific plant stories as outlined below. Innovative storytelling tools including self–guided tours, new audio–visual, cultural and digital content will be explored as part of new site interpretation for living collections. This will include a post–COVID and diversity lens being placed on collections' storytelling, to facilitate increased numbers of tourists to the Gardens.

### 3.8.8. Conservation Management Plan

The heritage value of Melbourne Gardens is protected and guided through the *Conservation Management Plan: Melbourne Gardens and Melbourne Observatory, Royal Botanic Gardens Victoria*, completed by Context Pty Ltd in 2018. The Conservation Management Plan identifies the heritage significance of the Gardens and provides conservation policies to protect this significance. It also provides a valuable record of the history and heritage fabric of the place.

Of interest to the living collections is the Conservation Management Plan's assessment of the heritage values of the living collections and individual trees. This assessment is based on accepted heritage practice, guided by State and National Legislation and the UNESCO International Council of Monuments and Sites "Burra Charter". These heritage assessments need

Remnant trees such as this ancient *Eucalyptus camaldulensis* are of importance to the Traditional Owners

to be considered in decision making around the collections, especially in relation to the retention or deaccessioning of collections. For example, the New Zealand Collection, while having a high climate risk assessment, is classified as "Significant" as the last collection established by William Guilfoyle and is therefore worthy of the additional resources required to manage and transition the collection.

### 3.8.9. Aboriginal Heritage Values Report

A principal recommendation of the Conservation Management Plan was to undertake further work to understand the tangible and intangible cultural heritage values of the Traditional Owners of the land that is now Melbourne Gardens. This work was recognised as a priority, and was therefore commissioned and completed in 2017 by Context Pty Ltd. The resulting document provides a comprehensive and valuable history of Melbourne Gardens and its associated values to the Traditional Owners.

The nature of the Aboriginal Heritage Values Report is such that it needs to be considered in its entirety and underpins future development work in the Gardens, including the living collections. It also identifies opportunities for RBGV engagement, interpretation, learning and participation programs and strategic management. Of relevance to the development of the living collections are recommendations on the interpretation of the collections, acknowledging that *"Melbourne Gardens represents a range of plants/plant collections of significance to both the international botanical and horticultural fraternity but also to the Traditional Owner groups. There are many shared economic, symbolic and aesthetic values"*[8]. As an outcome of the Aboriginal Heritage Value's document the Master Plan also made a specific recommendation to *"Develop or expand a living collection which explores plants of significance to the Traditional Owners including celebration of the many seasons"*.[9]

### 3.8.10 Tree Plan 2022–2042

The Tree Plan 2022–2042 covers the long–term care and management of the Gardens' tree populations in both Melbourne and Cranbourne, each of which have contrasting challenges such as the maturity and hegemony in the age of the population, heritage and conservation responsibilities, to name but a few. The Tree Plan focuses on the pre–emptive management of risk and provides an evaluation matrix by which to assess a tree and determine the appropriate action. The Tree Plan will work closely with the Living Collections Plan, especially in relation to increasing diversity and climate resilience of the tree holdings. Trees also make up significant components of several living collections, notably Araucariaceae, Eucalypt and Quercus, although there are trees in other collections. As two interdependent strategies these two documents will continue to work together over the next twenty years.

### 3.8.11 Science Strategy

A ten–year Science Strategy for Royal Botanic Gardens Victoria has been approved by the Board and is due to be implemented in 2023. The Science Strategy will provide the framework for a whole of organisation approach in relation to scientific research at RBGV, based on both preserved collections in the National Herbarium of Victoria and living collections at Melbourne and Cranbourne Gardens. Key themes in the Strategy are will be conservation and sustainability, discovering and documenting biodiversity, increasing the visibility and utilisation of scientific assets (especially the collections), and effective communication of science stories.

### 3.8.12 Plans Under Review

Royal Botanic Gardens Victoria have other strategies and plans relevant to the management of the Living Collections, some of which are still in the process of being reviewed at the time of publication.

Cranbourne Gardens are in the process of developing their own Living Collections Plan. As part of the same organisation, there will be strong and ongoing collaboration in regard to collections management across the two sites, and it is expected that there will be a degree of overlap between the documents. Some collections, for example Terrestrial Orchids and Australian Rare and Threatened Species are also managed across both sites.

*Stenocarpus sinuatus*, the Firewheel Tree is from Australia's east coast from the Clarence River to the Atherton Tableland

## 3.9. State and National Context

The Living Collections Plan has been developed to support the work of wider state, national and international plant conservation goals, strategies, and targets. These Strategies are regularly updated, and at the time of publication a number are undergoing review, however the current strategies have informed the development of the Living Collections Plan's goals and priorities and their subsequent versions will provide key guidance in the ongoing management of the living collections, allowing Royal Botanic Gardens Victoria to support wider plant conservation efforts.

### 3.9.1. Victorian Strategies and Legislation

#### Protecting Victoria's Environment: Biodiversity 2037

*Protecting Victoria's Environment: Biodiversity 2037* is the latest plan to guide the protection of Victoria's biodiversity, aiming to stop the decline in native species and encourage Victorians to value and act for nature. This plan was developed to complement Federal biosecurity plans and the United Nations' Convention on Biological Diversity and Sustainable Development Goals (SDGs). Biodiversity 2037 has the following vision and goals:

— Victoria's biodiversity is healthy, valued and actively cared for

— Victorians value nature

— Victoria's natural environment is healthy.

Biodiversity 2037 and its associated Implementation Framework provides considerable profile for Royal Botanic Gardens Victoria, citing it as providing nature–based tourism; delivering opportunities for Victorians to access and engage with the natural environment; empowering Traditional Owners; biodiversity management and planning; applying climate change science; coordinating research and monitoring programs; supporting urban open space planning; weed risk management; and hosting international botanical events.

#### Flora and Fauna Guarantee Act 1988

*The Flora and Fauna Guarantee Act 1988* is the signature Victorian legislation for the conservation of threatened species and communities, and for the management of potential threats. The Act was updated in 2019, with the amendment coming into effect in June 2020. The amendments included consideration of Traditional Owners, climate change, and a nationally consistent approach to the assessment of threatened species, known as the Common Assessment Method. This will assist in guiding the living collections, especially in relation to the conservation of threatened species.

#### Climate Change Act 2017

The *Climate Change Act 2017* was implemented in November 2017 and directs a range of initiatives to drive action on climate change across government and the economy. This includes a carbon neutral target for the State by 2050; development of a *Climate Change Adaptation Plan 2017–2020* (to be reviewed every five years); and the development of adaption action plans for key systems which are either vulnerable to the impact of climate change or essential for Victoria's future climate readiness.

> A study of the tree collections in Melbourne Gardens found that the Garden's trees were sequestering carbon at rates of 4.08–6.72 tonnes of Total Carbon, per hectare per year. This was higher than other urban studies and even apparently high compared to some natural forest systems. (*Webb, 2014*)

The *Climate Change Adaptation Plan 2017–2020* calls for embedding action in core policy areas and sectors. Topics relevant to the living collections include: addressing impacts on the natural environment and biodiversity; preparing for extreme weather events; water management; and supporting resilience in human health and communities.

#### Australia's Strategy for Nature 2019–2030

*Australia's Strategy for Nature 2019–2030* provides a unified framework for conserving biodiversity in all strategies, policies, and legislation across all levels of government, including National, State and Territory and Local Government. Compared to previous, purely protection–based approaches, it aims to integrate adaptation, resilience, and natural resource management in urban, rural, and natural environments.

The Strategy for Nature was prepared by the Biodiversity Working Group, including State and Territory environmental department representatives. This group continues to evaluate and report on

*Sophora toromiro* of Easter Island, extinct in the wild

the implementation of the Strategy and includes membership by the Victorian Department of Energy, Environment and Climate Action, the department in which Royal Botanic Gardens Victoria sits. The national goals of the Strategy are aligned with the United Nation's Sustainable Development Goals and emphasise community engagement, stewardship and understanding nature:

— Goal 1 – Connect all Australians with nature

— Goal 2 – Care for nature in all its diversity

— Goal 3 – Share and build knowledge

Targets of the Living Collections Plan and current collections of Australian flora in Melbourne Gardens readily align with these goals in the Strategy for Nature 2019–2030.

**Environment Protection and Biodiversity Conservation Act 1999**

Coupled with federal biosecurity planning is the legal framework of the *Environment Protection and Biodiversity Conservation Act 1999* to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage sites. Under the auspices of the Environment Protection and Biodiversity Conservation Act, the Department of the Environment and Energy prepares and manages threatened species listings, protection strategies and plans, and facilitates expert consultation.

## 3.10. International Strategies and Conventions

### 3.10.1. United Nations Convention on Biological Diversity

Australia is a signatory to the United Nations *Convention on Biological Diversity* (ratified1993). The Biodiversity Convention was established in response to the recognition that biodiversity is a global asset but is profoundly threatened by human activities. It seeks to conserve biodiversity, promote sustainable use of its components, and advocate for the fair and equitable sharing of benefits arising from the use of genetic resources[10].

A key international agreement and instrument of the Biodiversity Convention is *The Nagoya Protocol on Access and Benefit–sharing* (ratified 2014), which provides legal certainty and transparency on procedures for access and benefit–sharing of genetic materials. Australia has signed the Nagoya Protocol, but is yet to implement it, and at the time of publication some countries are therefore refusing permits for Australian researchers, potentially impacting collections development. Nevertheless, similar obligations also exist under the Biodiversity Convention. Further information on these protocols and their application to the management of the living collections is provided in Appendix 4 Guidelines for Collection and Transfer of Biological Material. The *International Plant Exchange Network* also assists with botanic gardens' compliance with the Biodiversity Convention, promoting best practice and enabling better tracking in the transfer of plant genetic material.

### 3.10.2. Strategic Plan for Biodiversity 2011–2020 and the Post–2020 Biodiversity Framework

A subset of the Biodiversity Convention is the Aichi Biodiversity Targets, five strategic goals to protect and enhance biodiversity, and a key director of two other United Nations conventions: the *Strategic Plan for Biodiversity 2011–2020* and the *Post–2020 Biodiversity Framework*. The first of these was adopted in October 2010, with the premise that biological diversity is the foundation of healthy ecosystems and the provision of ecosystem services essential for human well–being[11].

Currently these plans are under revision, with an update to the Strategic Plan for Biodiversity to include the Post–2020 Biodiversity Framework and revised Aichi Biodiversity Targets. Initially these targets will be aimed at 2030, with a 2050 Vision of "Living in harmony with nature".[12]

*Grevillea willisii*, a plant rare in Victoria and confined to sloping, granite sites near Omeo, grows well at Melbourne Gardens

### 3.10.3. Global Strategy for Plant Conservation

An important outcome of the Biodiversity Convention relevant to living collections management was the development of the *Global Strategy for Plant Conservation* (GSPC). The Strategy sits within the broader context of the Biodiversity Convention's plans and frameworks, as the pressures on plant diversity are interlinked with the general causes of degradation of the living world. Indeed, the overriding philosophy of the GSPC is that the functioning of the planet, human survival, and indeed all life, depends on plants.

The GSPC seeks to prevent the continuing loss of plant diversity and is a landmark document for guiding the conservation work of botanic gardens across the world[13]. The first iteration of the GSPC in 2002 was the first strategy associated with the *Convention on Biological Diversity* that included measurable targets.

The GSPC is currently under review to better align, and sit within, the *Strategic Plan for Biodiversity 2011–2020* and *Post–2020 Biodiversity Framework*. The revised document will still contain clear plant conservation and biodiversity targets.[14] While the specifics of these revised targets are not finalised, it is anticipated that they will be similar to previous principles and intents. Currently the focus for the proposed revision of the GSPC include:

— The provision of quality database information (World Flora Online and IUCN red listings)

— Species conservation and maintenance of genetic diversity

— Ecological restoration

— Sustainable plant use

— Urban greening

— and improving public awareness.

In addition to usual business, botanic gardens are also particularly well positioned to respond to the last two points, providing valuable expertise in the matter of Urban Greening and receiving over 750 million annual visitors worldwide.

As these strategies are under review, it is the aim of Royal Botanic Gardens Victoria to continue to closely align with international biodiversity frameworks and future iterations of the GSPC. These frameworks and strategies should be regularly referenced when reviewing the Living Collections Plan and associated Action Plans. The current targets and objectives for the GSPC which have informed the development of this Plan can be found at Appendix 6 GSPC Objectives and Targets.


United National Sustainable Development Goals, reproduced with permission : /www.un.org/sustainabledevelopment/

### 3.10.4. United Nations Sustainable Development Goals

On 1 January 2016, the United Nations ratified the *Sustainable Development Goals* of the *2030 Agenda for Sustainable Development*. The seventeen Goals aim to end all forms of poverty, while including targets to address climate change and environmental protection, recognising that these are inextricably linked to long term economic prosperity and social development[15].

It is intended that the *Post–2020 Biodiversity Framework* provides clear links to the *Sustainable Development Goals*, and details how implementation of the framework will contribute to achieving these goals.[16] The Sustainable Development Goals have particular relevance to the development and management of Melbourne Gardens' living collections are as follows:

— **SDG 4**: *'Quality education'*: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

— **SDG 11**: *'Sustainable cities and communities'*: Make cities inclusive, safe, resilient and sustainable

— **SDG 13**: *'Climate action'*: Take urgent action to combat climate change and its impacts

— **SDG 15**: *'Life on land'*: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

The detailed targets associated with these *Sustainable Development Goals* can be found at Appendix 5 Selected Sustainable Development Goals and Targets.

### 3.10.5. Convention on International Trade in Endangered Species

The *Convention on International Trade in Endangered Species* (CITES) is a multilateral treaty established in 1975 for the protection of threatened fauna and flora. Its primary aim is to control international trade in specimens of wild animals and plants that may threaten the survival of endangered species (CITES, 2018). Organisations exchanging CITES–listed species need to be specially registered with relevant authorities. Royal Botanic Gardens Victoria is CITES–registered (AU 026), which means it can receive CITES–listed plants subject to relevant permits and regulations. CITES species lists are defined under three appendices for conservation priority and management:

— Appendix I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances

— Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled to avoid utilisation incompatible with their survival

— Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

See also, Appendix 4 Guidelines for Collection and Transfer of Biological Material.

## 3.11. National and International Organisations

### 3.11.1. Botanic Gardens Australia and New Zealand

Botanic Gardens Australia and New Zealand, better known as BGANZ, is the peak industry body for botanic gardens in Australia and New Zealand. It serves to provide advocacy for the aims of botanic gardens and a common forum for information exchange. The collective expertise of this association enables skills development through sharing of best practice, including living collections management. BGANZ acts as a conduit for dialogue with other national organisations such as Parks and Leisure Australia and international bodies including Botanic Gardens Conservation International (BGCI).

BGANZ actively supports professional development of its members by hosting a range of forums from state–based networking events through to the triennial BGANZ congress, which often attracts international speakers and guests.

### 3.11.2. Council of Heads of Australian Botanic Gardens

The Council of Heads of Australian Botanic Gardens (CHABG) is an incorporated association represented by senior executives from Australia's major botanic gardens. Its mandate is focussed on the protection, conservation and enhancement of Australian plants and their ecosystems; the provision of information, education and research about plants and plant communities; and providing a forum to enhance and promote the botanical, horticultural, educational, and environmental work of Australian botanic gardens. This Council provides a national mechanism for organisational leadership in living collections development, and as a member of the Global Partnership for Plant Conservation, contributes to the implementation of the *Global Strategy for Plant Conservation*.

### 3.11.3. International Association of Botanic Gardens

Established in 1954, the International Association of Botanic Gardens (IABG) is a group with a broad remit to promote international cooperation between botanic gardens, arboreta and similar institutes maintaining scientific collections of living plants. Formal relationships of IABG include the International Union of Biological Sciences and other international biological societies and councils. Within its scope, the IABG includes support for the scientific management of botanic gardens, particularly regarding climate change and invasive plants. The IABG also provides worldwide advocacy for botanic gardens and supports the establishment and development of additional botanic gardens.

### 3.11.4. Botanic Gardens Conservation International

Botanic Gardens Conservation International (BGCI) was established in 1987 as an independent UK charity. It has a head office located at Royal Botanic Gardens, Kew as well as offices and representatives in Kenya, China, Russia, Singapore, and USA. With more than 500 member botanic gardens in 99 countries, and in every continent[18], BGCI is a key botanical organisation with the aims of linking the botanic gardens of the world in a plant conservation network. BGCI provides strong advocacy for achieving the targets of the *Global Strategy for Plant Conservation* and is involved in carrying out threat assessments, seed conservation, ecological restoration, plant health and education projects with its members and plant conservation organisations from around the world.

Botanic Gardens Conservation International also provide policy guidance for botanic gardens through instruments such as *The International Agenda for Botanic Gardens*[19]. This International Agenda links the work of botanic gardens directly to international policies and provides a common framework that can be tailored to respective needs and skills.

Melbourne Gardens staff and visiting delegates

### 3.11.5. Climate Change Alliance of Botanic Gardens

In December 2018, the inaugural Botanic Gardens Climate Change Summit was hosted by Royal Botanic Gardens Victoria in Melbourne. This summit resulted in the formation of the *Climate Change Alliance of Botanic Gardens* (CCABG) as an international response by botanical organisations and committed individuals to the unprecedented and borderless impacts of climate change.

The Alliance recognises that the world's arboreta and botanic gardens are custodians of critically needed scientific and horticultural knowledge, and their landscapes are a source of inspiration, learning and a place for positive social change. Current membership of the Alliance is nearing 500 organisations in over 90 countries.

The first major project of the Alliance was to develop a Climate Assessment Tool in partnership with Botanic Gardens Conservation International, University of Tasmania, and Royal Botanic Gardens Victoria, and support from the International Association of Botanic Gardens. The Climate Assessment Tool (CAT) was successfully launched at the Global Botanic Gardens Congress in Melbourne 2022. The CAT provides guidance on the likely suitability of taxa to the predicted future climate scenarios of a selected location. It achieves this by taking datasets of current known occurrences of taxa — such as those observed in the wild, in botanic gardens, and in general cultivation — and compares the current climate of these known occurrences to the predicted climate. The Climate Assessment Tool is freely available to all botanic gardens and hosted on the BGCI website.

4

The Lower Yarra River Habitat collection

# Living Collections

Melbourne Gardens currently hold 23 actively curated plant collections, with several more identified for potential future development. These collections are grouped under themes, indicating the major display, interpretation, and research roles of the collection.

The following chapter describes the Gardens' current and potential future living collections, and provides an overview of their purpose, content, characteristics, and direction, as well as the experience they can create for visitors. More detail for the curation of these living collections is provided in specific management plans.

## 4.1. Collection Themes

### 4.1.1. Theme Overview

Melbourne Gardens' living collections are actively curated to support Royal Botanic Gardens Victoria's work as an international botanic garden. Collections are grouped under five major themes; *Ecological; Geographical; Ornamental and Cultural; Research and Conservation; Taxonomic and Evolutionary,* with each of these being complementary with the internationally recognised role of botanic gardens plant collections worldwide. The following outlines the definition and criteria for each of these themes. Some collections could feasibly fall across several themes, with especially strong links between *Research and Conservation* and *Geographical* collections. However, each of Melbourne Gardens' collections has been placed in one specific theme, indicating the major focus of that collection.

### 4.1.2. Theme 1: Ecological Collections

**Definition**

A collection of plants which typically grow together in an ecological community defined by a particular range of environmental conditions.

**Criteria**

— Plants or remnant vegetation found in a defined ecological community or ecological vegetation classes

— Representatives of a characteristic plant habitat not formally defined that can be readily grown within available microclimatic conditions of Melbourne Gardens.

**Collections**

— Lower Yarra River Habitat.


EXISTING LOCATIONS OF LIVING COLLECTIONS IN THE MELBOURNE GARDENS LANDSCAPE.

Additionally, Araucariaceae are mostly distributed across the gardens as are many specimens from the Australian Rare and Threatened; Cycad; Eucalypt; Palm and Quercus Collections.


Southern China – *Paeonia ostii*


*Banksia* sp. in the Ian Potter Foundation Children's Garden

### 4.1.3. Theme 2: Geographical Collections

**Definition**

A collection of plants based on a defined geographical area.

**Criteria**

— Plants found in a defined geographical region, such as a country, or from a nominated bioregion/biogeographic zone such as a floristic province

— Plants from key vegetation communities of a defined geographical region

— Plants that have cultural significance in a geographical region.

**Collections**

— Australian Forest Walk

— New Zealand

— North American Drylands

— Southern Africa

— Southern China.

### 4.1.4. Theme 3: Ornamental and Cultural Collections

**Definition**

A collection of plants that provide ornamental and cultural themes for community enjoyment, interaction, and education.

**Criteria**

— Hybrids, cultivars, and species used in traditional or contemporary horticultural landscape designs to showcase horticultural display and excellence and support the mission of RBGV

— Plants which have heritage associations with the Gardens and/or demonstrate original design intent

— Plants which are linked to ethnobotany or traditional use and/or used for specific human welfare

— Plants which demonstrate horticultural responses to Melbourne's current and projected climatic conditions.

**Collections**

— 'Climate Ready' Rose Garden

— Fern Gully

— Gardens House

— Grey Garden

— Guilfoyle's Volcano

— Herb And Medicinal Garden

— Perennial Border

— The Ian Potter Foundation Children's Garden.

*Olearia astroloba* in the Australian Rare and Threatened Species collection

Arboricultural work in the *Araucariaceae* collection

### 4.1.5. Theme 4: Research and Conservation Collections

**Definition**

A collection of plants developed in line with recognised conservation plans for ex situ protection of plant biodiversity.

**Criteria**

— Rare or threatened plants identified under Flora and Fauna Guarantee Act 1988 (Vic), National Environment Protection Biodiversity Conservation Act 1999, International Union for Conservation of Nature – Red List of Threatened Species and other recognised listings of threatened species

— Stock of known-provenance rare or threatened plants for either RBGV plant conservation programs or in conjunction with other botanical institutions and reputable organisations.

**Collections**

— Australian Rare and Threatened Species

— Terrestrial Orchids.

### 4.1.6. Theme 5: Taxonomic and Evolutionary Collections

**Definition**

A collection of plants to demonstrate plant classification or evolution.

**Criteria**

— Plants chosen to demonstrate plant classification or evolution

— Plants from a defined taxonomic group

— A selection of taxa within one group that provides reference material for plant identification

— Collections of plants that demonstrate evolutionary adaptations to particular environmental conditions.

**Collections**

— Araucariaceae

— Cacti and Succulent

— Camellia

— Eucalypt

— Cycad

— Palm

— Quercus.

The living collections provide important opportunities to engage the public

## 4.2. Living Collections Visitor Experience

An organisational interpretive framework developed by the Programming and Audience Development team has been approved by the Board. The intent of the interpretive framework is to guide storytelling and engagement themes across the organisation, such that visitors experience coherent, exciting, and elegant storytelling at both Gardens' sites. From this organisational framework, site and collection specific interpretation will be developed.

To support completion of the Living Collections Plan, the Programming and Audience Development team engaged a storytelling and visitor experience specialist to develop a suite of experiential aims for the living collections in consultation with each collections' curator. These illustrative vignettes have been developed for the purposes of this document only and are offered as a starting point for collections–based storytelling. However, the descriptions below are not intended to be static, nor to remain unchanged for the life of the Living Collections Plan. Indeed, they may change through the framework development process and are expected to evolve through additional consultation.

## 4.3. Descriptors

Each living collection is described on the following pages in the same format, starting with the name and theme to which it belongs. Collections, their current condition, and future aims are then described as follows:

**Purpose**
Outlines the overall purpose of the collection, why it is a focus for Royal Botanic Gardens Victoria, and what curation of the collection aims to achieve.

**Description and Overview**
Detailed description of the collection, its history and place in the landscape, and opportunities for its future development.

**Experiential Aims**
A high–level introduction to the experience the collection provides for visitors. The intention of the experiential aims is to guide future interpretation of the collection.

**Collection Targets**
Collections are assigned one of three high level targets: Expand (expand the diversity and/or footprint of the collection), Maintain (maintain the current footprint while increasing the conservation value and climate suitability of the collection), or Transition (transition the collection to a new focus and/or location). Following on from these targets are a series of dot points highlighting the focus for collection development.

Raised Arid Garden displays

**Collection Snapshot**

The Collection Snapshot provides a description of the collection as it exists in 2021. The intention being to provide base line markers to compare the success or otherwise of collections development work. Snapshot data is as follows:

| | |
|---|---|
| **Accessions** | Number of unique accessions (that is plant material that is collected at same time and location from a single species and with its own unique accession number). Indicates the genetic diversity of the collection. |
| **Families** | Number of plant families in the collection. Note: for some Taxonomic and Evolutionary collections this number is inevitably low as by definition the focus is on one family or Genera. |
| **Genera** | Number of Genera in the collection. |
| **Taxa** | Number of Taxa in the collection. |
| **Footprint Percentage** | Only applies to collections with a defined area within the Melbourne Gardens' landscape. This number indicates the percentage of accessions which meet the collection criteria within that area (e.g., 62% of plants within the Southern Africa area are from Southern Africa). No data is provided for Ornamental and Cultural Collections, which by definition have all plants meeting the collection criteria. |
| **Wild source** | Percentage of accessions in the collection that are from propagation material sourced directly from natural habitats (may be seed or vegetative). |
| **Rare and Threatened** | Taxa that are primarily prescribed on State (Flora and Fauna Guarantee Act Threatened List), National (Threatened species under the EPBC Act) and International (IUCN red list) listings for conservation protection, or secondarily are considered vulnerable due to small populations and/or significantly restricted distributions. |
| **Identification Verified (ID3)** | Percentage of accessions in the collection which have had their identification verified by a Plant Scientist. |
| **Heritage Value** | The Heritage Value of the collection as defined by Context Pty Ltd in the *Conservation Management Plan: Melbourne Gardens and Melbourne Observatory, Royal Botanic Gardens Victoria* (2018). |

**Analysis**

Analysis provides explanations for the data in the Collection Snapshot, including any mitigating factors to be aware of and whether the collection is on target or requires improvement.

**Climate Suitability Guide**

Provides details on the mean annual temperate and precipitation of the collections natural range, and an indication of its projected future climate suitability for Melbourne.

**Other collection relationships**

Lists other Melbourne Gardens collections which share taxa or aims with the collection.

## 4.4. Melbourne Gardens Living Collections

# Lower Yarra River Habitat

## Ecological Collection

**Purpose**
To display and preserve plants representing the plant communities of the lower Yarra River for the purposes of plant conservation, cultural interpretation and understanding, habitat creation and use in urban horticulture.

**Description and Overview**
Focused at Long Island and the Bridge Gate wetlands, the **Lower Yarra River Habitat Collection** displays the indigenous flora of Melbourne Gardens and the lower Yarra region, which are part of the traditional lands of the peoples of the Kulin Nation. The indigenous landscape of the Gardens sits around the fertile billabong known as *Tromgin*, where *Birrarung*, or the Yarra River, once ran through the Gardens, along what is now the northern bank of Long Island. In 1900, the river was straightened as part of flood mitigation works, with *Tromgin* fully separated from the river and formed it into what is now the Ornamental Lake. Early directors of the Gardens deliberately retained existing indigenous trees on the site, and many still exist, including River Red Gums (*Eucalyptus camaldulensis*) and patches of Swamp Paperbark (*Melaleuca ericifolia*) around the Ornamental Lake.

Initial enhancement to the Gardens' indigenous vegetation occurred near the Lion's Head Tree (*Eucalyptus camaldulensis*) in the 1990s. In 2002, a project was undertaken to substantially increase the representation of indigenous plantings at Long Island and Baker Island with the aim of supporting plant conservation programs and promoting the re-establishment of indigenous flora in the Lower Yarra River precinct and urban areas of Melbourne. *Melbourne Gardens Master Plan 2020–2040* recommends that the collection be expanded to include plants of significance to the Traditional Owners.

**Experiential Aims**
Walking through the **Lower Yarra River Habitat Collection** is a grounding, learning experience. Traces of the original course of Birrarung / Yarra River — a precious remnant within the City of Melbourne — carry stories for the First Nations people. The Kulin Nation, who co-existed and stewarded native flora and fauna for more than 50,000 years, contribute to this special collection through their storytelling and teaching. All collections interpretation will be developed through consultation with Traditional Owners.

**Collection Targets: Expand**
- Expand landscape footprint to include the Birrarung Gate project and Nature and Science Precinct and, pending a technical review, consider increasing wetland density in the Long Island Backwater to increase water quality
- Instigate a research program to determine actual climate risk to taxa (including broader threat to indigenous flora of the Melbourne region)
- In consultation with the Traditional Owners, include plants of cultural significance to the Kulin Nation
- Increase wild-collected proportions and representation of rare and threatened species through field collecting trips
- Develop staged landscape planting rejuvenation, concentrating on better site selection for plant performance and higher plant diversity
- Review the Ecological Vegetation Classes represented by the collection, with the aim of improving the representation of threatened plants and ecological classes. Especially consider threatened EVCs in the lower Birrarung region.





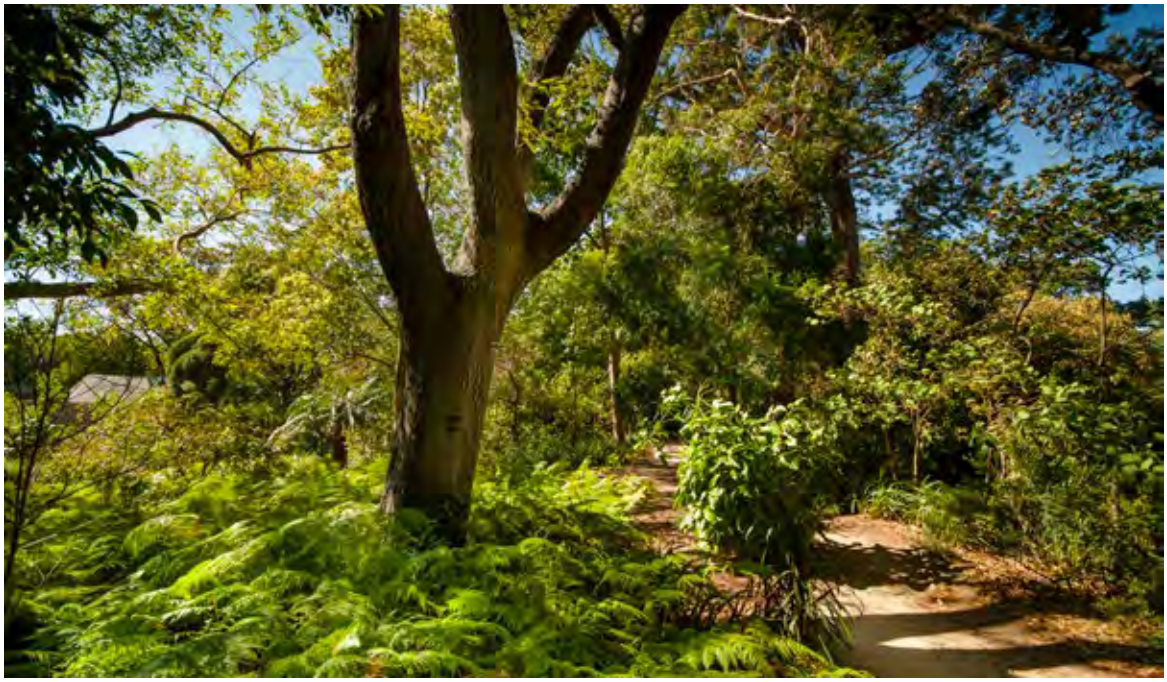



**Other collection relationships:**
No significantly related collections.

| Collection Snapshot | |
|---|---|
| **Accessions** | **482** |
| **Families** | **45** |
| **Genera** | **89** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 95% | **133** |
| **Footprint Percentage** | **95%** |
| **Wild source**<br>The percentage of wild collected material is relatively high for this collection, which is to be expected given easier access to wild plant material, but this should be increased noting the threatened nature of the EVC | **32%** |
| **Rare and Threatened**<br>While the proportion of rare and threatened species in the holdings is quite low, taxa represent habitats that are all considered endangered for the Gippsland Plains Bioregion | **1%** |
| **Identification Verified (ID3)** | **24%** |
| **Heritage Value**<br>The standard of verified identification is too low for this collection of high conservation value and needs to be increased | **Significant** |

| Climate Suitability Guide | | |
|---|---|---|
| | Mean annual temperature of collection's natural range | **14.6°C (pre temperature rise since the 1950s)** |
| | Mean annual precipitation of collection's natural range | **652 mm (pre 1950s)** |
| | The temperature risk ranking by 2070 is moderate to high (red) and the estimated precipitation requirements are low to moderate (current collection is typically not irrigated). Under current understanding of climate risks, this collection is highly vulnerable and requires more detailed investigation. | |

4



# Australian Forest Walk

## Geographical Collection

**Purpose**
To display and conserve plants of Australia's eastern forests, showcasing their biodiversity and providing a place of research, education, collaboration, discovery, and experience.

**Description and Overview**
Located along the Gardens' southern boundary, the **Australian Forest Walk Collection** owes its origins to Director William Guilfoyle, whose previous work in northern NSW inspired in him a love of Australian forest species and lead him to develop the area as a showcase for Australian flora. Under Guilfoyle's directorship, the 'Australian Border' was believed to have started in 1887, with a planting of 400 native trees and shrubs. This drew on the previous work of Ferdinand Mueller, who collected and cataloged over 28,000 Australian plant specimens in his career as a botanist and first Director of Melbourne Gardens.

Of the over 20,000 described vascular plant taxa in Australia, over 80% are endemic to this island continent and many possess special adaptations to aridity and climatic extremes, infertile soils, and fire regimes. As one of the driest continents in the world, and with vast areas of desert, it is perhaps surprising to find swathes of forests (including remnant rainforests) covering 17% of the land area, with their fullest extent in the Great Dividing Range and higher rainfall zones of eastern Australia.

In the 1990s, donor funding supported plant collecting trips to improve the wild–collected provenance rainforest taxa and create the 'Australian Rainforest Walk', however the Millennium Drought coupled with annual rainfall decline and projected climate change made this vegetation composition unsustainable. In 2006, the collection was changed in intent to become the **Australian Forest Walk Collection**.

The collection's current focus is on plant collecting trips on a scale not seen in over two decades to diversify the **Australian Forest Walk Collection** with taxa from areas with a strong match with Melbourne's projected future climate. Collaboration with experts from other botanical organisations such as the Queensland Herbarium and Royal Botanic Gardens and Domain Trust, Sydney have resulted in considerable additions of taxa including dry rainforest species (which are potentially less suited for other ex situ conservation techniques such as seed banking). These strong working relationships and the sharing of information has also led to safeguarding outcomes for threatened species across multiple states.

Today, the **Australian Forest Walk Collection** is one of the largest in the Gardens, extending over half a kilometre along the southern boundary of the Gardens and covering almost one hectare.

**Experiential Aims**
Satisfy the senses with the reassuring and unique sights, sounds, and smells of Australia's eastern forests. Some of these forest giants were planted in the late 1800s, creating a shady canopy beneath which a diverse array of understory species thrives. Just a few meters away, over the fence, lies the hustle and bustle of suburban Melbourne. The Australian Forest Walk Collection proves that even the narrowest natural corridor can be cultivated to invigorate the senses.








**Collection Targets: Expand**

— Expand representation of Australian forest species resilient under Melbourne's climatic conditions, with a focus on increasing diversity of wild-collected taxa from dry rainforest habitats

— Develop metacollections in partnership with other botanical organisations to help conserve selected taxa

— Explore opportunities to expand collection footprint into adjacent areas using selected trees.

**Relationships to Other Collections:**

Australian Rare and Threatened Species, Eucalypt.

| Collection Snapshot | |
|---|---|
| **Accessions** | **1395** |
| **Families** | **101** |
| **Genera** | **286** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) are approximately 98% | **529** |
| **Footprint Percentage** | **76%** |
| **Wild Source**<br>Compared to other collections, there is strong representation of wild-sourced material, rare and threatened taxa and identity-verified plants | **31%** |
| **Rare and Threatened** | **20%** |
| **Identification Verified (ID3)** | **42%** |
| **Heritage Value**<br>While collection is focused on the southern boundary, Australian plants are found across the site. The total holdings across the landscape of Australian flora are significant, including over 1,700 taxa, or 23% of all plants and about 50% of all trees. | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **16.8°C** |
| Estimated mean annual precipitation of collection's natural range | **1,227 mm** |
| Temperature risk ranking by 2070 is low (green), however the estimated precipitation requirements are high | |

4

# New Zealand

## Geographical Collection

**Purpose**
To exhibit a broad range of New Zealand taxa for the purposes of plant conservation and research, cultural and ethnobotanical interpretation, landscape display and to emphasise the distinctive flora of the region.

**Description and Overview**
Located at the southern end of Melbourne Gardens the **New Zealand Collection** created in 1906–1908 was William Guilfoyle's last major landscape development as Director. Numerous collections of New Zealand flora including unusual species occurred early in the history of the Gardens due to the interest of both Mueller and Guilfoyle. Guilfoyle particularly made use of New Zealand species for the characteristic subtropical style of landscaping, and more extensively with ferns in the development of the Fern Gully. In 1967, the Ellis Stones Rockery was added at the western edge of the collection, but with this exception there has been no major redevelopment works since this time, and the collection largely reflects Guilfoyle's original vision.

New Zealand's flora is characterised by high diversity and endemism (82% of taxa are found only in New Zealand). Unusual forms are also common, with many species demonstrating divaricating (displaying diverging internodes resulting in tightly interlaced branching) and heteroblastic forms (abrupt change in shape and function from juvenile to adult). This provides a distinct look and feel for the collection, with strong contrast in foliage shape and form, and a characteristic sub–tropical feel. Of about 2,200 vascular plant species in New Zealand, over 30% are considered at risk. While about half of the land area is still covered by indigenous vegetation, this is more proportionally represented in alpine regions, with the greatest reductions in plant biodiversity found in coastal, lowland, and lower montane zones.

Of all the Gardens' collections, the **New Zealand Collection** is considered one of the most at risk from climate change, with much of the collection being assessed as at 'Extreme Risk' in a projected 2070 climate. However, this provides opportunities to work with plant conservation programs in New Zealand, providing an ex situ assessment of their flora's response to rising temperatures and changing precipitation. Conservation of plant biodiversity cannot be separated from indigenous people and their traditional knowledge. Relationships with Māori representatives are being explored to meet the intents of the Wai 262 claim and international treaties such as the Nagoya Protocol, which makes provision for traditional knowledge associated with genetic resources.

Strong partnerships are currently being established with members of the New Zealand Plant Conservation Network and other NZ botanic gardens to share information and expertise.

**Experiential Aims**
Native to a climate both cooler and wetter than Melbourne's, it is challenging to curate the **New Zealand Collection**. Yet, the plant life of New Zealand is glorious in its beauty and diversity, and plant response within this collection is instructional. There are surprising discoveries to be found because New Zealand's flora evolved in isolation for millions of years creating a species suite that is 80% endemic and has significant botanical quirks. For the Māori, plants are part of their interconnected belief system, many holding value for food, shelter, and medicine.








**Collection Targets: Maintain**

— Substantially improve the proportion of wild collected taxa, preferably through collecting trips to further enhance curation expertise

— Increase climate-resilient plant diversity through provenance-based selections from more suited climate regions and habitats of New Zealand

— Develop research partnerships and programs in collaboration with Māori people and New Zealand botanic gardens to study plant tolerances under climatic change

— Strengthen the connection to Māori cultural uses of plants.

**Other collection relationships:**
Fern Gully (NZ Ferns).

| Collection Snapshot | |
|---|---|
| **Accessions** | **611** |
| **Families** | **48** |
| **Genera** | **72** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) are approximately 83% | **177** |
| **Footprint Percentage** | **74%** |
| **Wild Source**<br>Wild-source, rare and threatened and identity verified plants are all lower than other geographic collections as well as falling short of targets | **4%** |
| **Rare and Threatened** | **6%** |
| **Identification Verified (ID3)** | **18%** |
| **Heritage Value**<br>A high proportion of New Zealand taxa occur within the landscape footprint of the heritage collection, providing this site a distinct landscape character and capacity for interpretation. | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **12.1°C** |
| Estimated mean annual precipitation of collection's natural range | **1,693 mm** |
| Temperature risk ranking by 2070 is extreme (red), and the estimated precipitation requirements are one of the highest in the Gardens. | |

4

# North American Drylands

## Geographical Collection

**Purpose**
To display a range of taxa from the arid regions of North America, highlighting the importance of protecting global biodiversity hotspots, the unique adaptations of this flora for a changing climate and the ethnobotanical uses of plants from the region.

**Description and Overview**
Located on the high land of the Gardens' eastern boundary, the **North American Drylands Collection** is a planned expansion of the existing California Collection. Established in 1992, sections of the California Collection are at high risk from climate change, with many early acquisitions being sourced from cooler regions of the state. This area of the Gardens is well suited to the proposed collection, being on the hotter, drier uplands and already containing a significant number of North American taxa.

Drylands cover over 40% of the world's land area with over two billion people residing in these environments. The drylands of North America[vi], Central America and the Caribbean are estimated to cover about 700 million hectares or about 11% of the world's arid regions. An extensive array of dryland ecosystems occurs in North America, ranging from deserts to forests, and many of these are found within global biodiversity hotspots. Native American people are believed to have dwelt in the southwest of the USA and northwest Mexico for at least c.16,000 years and have developed complex relationships with the natural environment. Their cultural and linguistic diversity mirrors the surrounding geographic and species diversity, and their traditional ecological knowledge and management of local flora varies from community to community and place to place. While some of the region's ecosystems appear wild and rugged, most, if not all, are human–mediated landscapes associated with enormous ethnobotanical wealth: indigenous people relied on plants for cultural ceremonies, wayfinding, clothing and building materials, tools, weapons, toys, food, heating, dyes, and medicine, among other uses.

Through GIS analysis, areas within the drylands of North America were found as having a potential match for selecting plants within temperature and rainfall parameters suitable for Melbourne's projected future climate by 2070. This area covers over half a million square kilometers, including parts of Arizona, southern California, Mexico, and Texas. For the purposes of the collection, the term "Drylands" includes arid and semi–arid climates, which are typically considered to be regions that experience less than 400 mm of mean annual precipitation (pending evaporation). In some warmer arid regions, annual rainfall may be higher, but when combined with higher mean annual temperature, can still result in arid conditions due to the relative increase in evaporative water loss. For collection development, 'aridity' can also be interpreted to include taxa originating from regions with extended dry periods. Currently the collection contains approximately 100 taxa from these geographic regions, forming a strong basis for future expansion.

**Experiential Aims**
Meander the high rocky paths of the **North American Drylands Collection** to discover water–wise plants suitable for Melbourne. Significantly, a great majority hail from the California Floristic Province, one of the world's biodiversity hotspots, so declared for its species diversity and threatened status. Many species here hold great significance for North America's First Nations people and present an opportunity for expanded storytelling.

vi The majority of these drylands are found in North America








**Collection Targets: Expand**

— Build on the California Collection to encompass flora from the wider geographic region

— Increase plant diversity, climate resilience and wild-collected provenance within the expanded landscape footprint as defined by the Master Plan 2020–2040

— Develop strong partnerships with botanical organisations in North America with a focus on developing metacollections of selected flora

— Identify better pathways for sourcing and introducing new taxa, consistent with biosecurity requirements and biodiversity conventions.

**Other collection relationships:**
Guilfoyle's Volcano, Cacti and Succulent.

| **Collection Snapshot**[vii] | |
|---|---|
| **Accessions** | **268** |
| **Families** | **42** |
| **Genera** | **77** |
| **Taxa**<br>There is a relatively high verified identification status compared to other geographic collections, but this is biased to a degree by the need to select North American Dryland taxa with known distribution details to carry out the assessment | **100** |
| **Wild Source**<br>Proportion of wild-source plant material is 10%, below current targets, but should be improved by planned collections in the future. | **25%** |
| **Rare and Threatened**<br>The rare and threatened status meets current targets noting that this will be based mostly on conservation classified taxa within Cactaceae | **10%** |
| **Identification Verified (ID3)** | **55%** |
| **Heritage Value** | **Contributory (California)** |

| **Climate Suitability Guide** | | |
|---|---|---|
| 0° | Estimated mean annual temperature of collection's natural range | **17.1°C** |
| | Estimated mean annual precipitation of collection's natural range | **68 mm** |
| | Temperature risk ranking by 2070 is very low (green) and the estimated precipitation requirements are the lowest in the Gardens | |

vii Metrics based on all North American Drylands holdings in Melbourne Gardens originating from a mean annual precipitation of less than 400 mm, not just those in the existing California Collection.

4

# Southern Africa

## Geographical Collection

**Purpose**
To display and conserve flora from Southern Africa, highlighting the importance of protecting global biodiversity hotspots and describing the climatic, taxonomic, and environmental relationships with Australia.

**Description and Overview**
Centered around the 'Cape Triangle Lawn' in the south–west corner of the Gardens, the **Southern Africa Collection** explores the beauty and diversity of Africa's floral riches. The earliest references to this collection were the planting of several Cape Province taxa by William Guilfoyle in about 1900, establishing an 'African' theme in the Gardens' plantings. The current **Southern Africa Collection** has been actively curated since 1980s. In recent years it has focused on removing weed species and increasing the purity of the collection, relocating non–collection related plants away from the Cape Triangle Lawn to make way for more appropriate plantings.

Some flora from Southern Africa share evolutionary relationships and common adaptations with Australian taxa, such as Proteaceae, due to common origins from the supercontinent Gondwana. South African flora has attracted plant explorers throughout history and provided a wealth of exciting plants for ornamental horticulture. In Australia it has also provided many weed species, due to similarity of environmental conditions. Climatic analysis has indicated an area of over a million square kilometres in Southern and Southern Tropical Africa suitable to select plants for Melbourne's projected future climate, providing a rich potential collecting zone to enhance the collection. This region includes plants from Angola, Botswana, Eswatini, Lesotho, Malawi, Mozambique, Namibia, South Africa, and Zimbabwe.

Southern Africa is one of the global hotspots of biological and ethnic diversity and offers a wide range of potential ethnobotanical interpretation for the collection. As a country example, a spatial assessment suggests South Africa on its own provides about 290,000 square kilometres of potentially suitable area for collecting and selecting plants for a future climate. South Africa is considered one of the most biologically diverse countries in the world due to its species diversity, endemism, and range of ecosystems. While South Africa only occupies 2% of the world's terrestrial surface, it holds 7% of the world's plant species, 14% of which are considered threatened.

**Experiential Aims**
The Southern Africa Collection displays plants from one of the world's biodiversity hotspots. Here you'll find an expanding collection of extraordinary species with wonderful form, texture and colour including bulbs, succulents, cycads, shrubs, and trees. With a climate similar to Melbourne's, many have good horticultural potential.

**Collection Targets: Expand**
— Increase plant diversity, climate resilience and wild–collected provenance and expand the existing footprint within the adjacent landscape area

— Develop strong partnerships with botanical organisations in Southern Africa

— Identify better pathways for sourcing and introducing new taxa, consistent with biosecurity requirements and biodiversity conventions.








**Other collection relationships:**
No significantly related collections, although there are taxa based common relationships with the Cycad Collection, and many Proteaceae in the Australian Forest Walk.

| Collection Snapshot | |
|---|---|
| **Accessions** | **171** |
| **Families** | **35** |
| **Genera** | **75** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 62% | **119** |
| **Footprint Percentage**<br>Footprint Percentage is low and needs to be improved to better display collection and plant characteristics | **62%** |
| **Wild Source**<br>Proportion of wild source plant material is very much below current targets and increasing this should be a key objective for the future | **5%** |
| **Rare and Threatened**<br>The rare and threatened status is slightly below current targets noting that this may also be skewed upwards by the number of Cycads in the collection | **8%** |
| **Identification Verified (ID3)**<br>There is a relatively high verified plant identification status compared to other geographic collections, but this is biased by selecting Southern Africa taxa with known distribution data | **54%** |
| **Heritage Value**<br>While the collection is centred around the triangle lawn, Southern Africa collections are found across the site. For the entire landscape holdings of Southern Africa flora there are approximately 415 taxa with 1896 accessions, but the wild–sourced percentage remains the same. | **Contributory** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **16.8°C** |
| Estimated mean annual precipitation of collection's natural range | **796 mm** |
| Temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are low to moderate | |

4

# Southern China

## Geographical Collection

**Purpose**
To display a diverse collection of flora from Southern China suitable for cultivation in Melbourne's current and future climate, and to explore the cultural and ethnobotanical significance and influence of these plants on modern horticulture, garden design, and everyday life.

**Description and Overview**
Located along Melbourne Gardens' northern boundary, the **Southern China Collection** was originally developed in 1985 to display both rare and common plants from south China. Flora from China is distinguished by a compelling, long history of plant collecting for ornamental horticulture, its diverse cultural and ethnobotanical significance, and its contribution to the impressive influence of Chinese gardens and culture on landscape design. The landscape of Southern China, and origin of the collection, is geographically complex, ranging from the foothills of the Himalayas to tropical sea level.

The original collection was enhanced by several collection trips to Yunnan in the 1990s, with significant funding provided to expand the collection in 1998. Many of these original wild-collected taxa have since been lost, influenced by the Millennium Drought, along with overall annual rainfall decline and increased evaporative stress. However, some specimens still perform well if provided with suitable microclimates. Considerable work has been undertaken by the curator to conserve genetic material by duplicating valuable taxa at the Dandenong Ranges Botanic Garden, with many of these plants thriving in the new location.

China is one of the richest countries in plant biodiversity and a large proportion of the flora is endemic with over 52% (c. over 15,000 endemic species) of seed-bearing plants naturally growing nowhere else on earth. Over 7,000 taxa are endemic to the humid, subtropical, and tropical zones of Central and Southern China alone. Around 11% (3,870) of all assessed Chinese plant species are rare and threatened, with higher proportions of these found in southern parts of China.[21]

Climatic analysis has indicated a geographic envelope of about 36,000 square kilometers of potential suitability for sourcing future plant material in South-Central China. Visitors from China and around the world are drawn to this collection, especially when plants are in flower. The collection is also appreciated by artists, teachers and students and the National Gallery of Victoria has collaborated with Melbourne Gardens to incorporate the **Southern China Collection** into two exhibitions.

**Experiential Aims**
Culturally, the people of China take their plants seriously, value them highly, and name them creatively. The **Southern China Collection** is discovered along a serpentine path — a reference to traditional Chinese garden design. The species selected are carefully considered, including plants with cultural significance (for medicine, fibre, and festivals), plants either common or rare in China, and those one might easily cultivate in a Melbourne Garden. Among them are many beauties with a heavenly perfume, wonderful form and colour. This collection is an exciting bridge to Southern China and is much-admired locally and abroad.








**Collection Targets: Maintain**

— Increase proportion of climate resilient taxa and wild–collected provenance within the existing landscape area

— Develop strong partnerships with botanical organisations in Asia

— Expand representation within Melbourne Gardens and duplication of unique genetic lines of wild–sourced, rare and threatened taxa with other suitable botanic gardens

— Due to cultural interest, review and build on the interpretation and learning potential of the collection.

**Other collection relationships:**

Camellias, 'Climate Ready' Rose Garden and Herb and Medicinal Garden.

| **Collection Snapshot**[viii] | |
|---|---|
| **Accessions** | **364** |
| **Families** | **68** |
| **Genera** | **123** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 83% | **225** |
| **Footprint Percentage**<br>Footprint Percentage is low (i.e., many plants in the collection area are not from Southern China) and needs to be improved to better display collection and plant characteristics | **46%** |
| **Wild Source**<br>Proportion of wild–sourced plant material is below current targets and increasing this should be a key objective for the future. | **23%** |
| **Rare and Threatened**<br>The rare and threatened status is very low compared to current targets | **4%** |
| **Identification Verified (ID3)**<br>Verified plant identification status is good compared to other geographic collections, but this is biased by selecting Southern Chinese taxa with known distribution data | **45%** |
| **Heritage Value** | **Contributory** |

| **Climate Suitability Guide** | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **15.7°C** |
| Estimated mean annual precipitation of collection's natural range | **1,340 mm** |
| Temperature risk ranking by 2070 is low–moderate (yellow) and the estimated precipitation requirements are high, although this collection is fifth in potential water demand | |

viii For the entire landscape holdings of Southern Chinese flora, there are about 377 taxa with 1,197 accessions, wild–sourced is 10%, rare and threatened remains the same, and identity verified is 53%.

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# ‘Climate Ready’ Rose Collection

## Ornamental and Cultural Collection

**Purpose**
To display and interpret roses selected for resilience and ornamental performance under Melbourne’s warming climatic conditions.

**Description and Overview**
Currently located near Gate B, the **‘Climate Ready’ Rose Collection** is a development of the previous Species Rose Collection. There are few references to roses in the history of the Melbourne Gardens, although in 1902 Guilfoyle mentions using 600 types of roses for providing colour across the landscape.

There are approximately 200 species of roses found primarily within temperate to subtropical Northern Hemisphere climates, although modern rose cultivars are believed to be derived principally from just ten species. Of these, *Rosa chinensis* var. *spontanea* and *R. odorata* var. *gigantea* are believed to be the most instrumental in providing the development of the modern rose.

Rose cultivation is ancient, dating back 5,000 years and presumably starting in China, although other civilisations have celebrated roses. They were extensively popular with the Romans, who spread their cultivation into the Middle East. In addition to their ornamental qualities and uses in gardens worldwide, roses have been used for celebrations, medicine, food, perfumery, and political symbology.

The current Species Rose collection originated in 1978, but struggled, presumably due to nematodes, and required relocation to its current location. This problem has risen again, and coupled with the impact of the Millennium Drought, has led some plants in the collection to decline. A 2018 climate risk evaluation found much of the current collection to be at very high risk under projected climate conditions. The original plan to deaccession the collection was revised following extensive public feedback. Instead, the decision was made to reconfigure the collection with a focus on roses that would demonstrate resilience under future warming and drying conditions. There are prospects to select species and cultivars that have warmer climate origins, especially Asian and Middle Eastern species.

**Experiential Aims**
Roses are possibly the most well-known and loved group of plants worldwide, with a rose collection included in many global gardens. In this **‘Climate Ready’ Rose Collection**, you’ll find the usual mix of roses climbing, trailing, heritage, Australian-bred, cultivated, prickly and perfumed. However, our Rose collection is vulnerable to climate change and these plants are being carefully reviewed for their resilience to Melbourne’s changing climate. This is important, for roses go far beyond ‘a dozen red’, being valued for perfume, cooking, cosmetics, medicine, and religious practices.

**Collection Targets: Transition**
— Deaccession the Species Rose Garden Collection and transfer any valuable unique taxa to another botanic garden if possible

— Develop a collection of more climate-suited roses.

**Other collection relationships:**
Southern China, as about 90 species (almost half of known) and 144 varieties of Rosa originate from China.








| Collection Snapshot[viii] | |
|---|---|
| Accessions | 155 |
| Families | 1 |
| Genera | 1 |
| Taxa<br>Snapshot includes all Rosa taxa currently in the Gardens. Taxa with distributions assigned (including Garden Origin plants) is approximately 93% | 126 |
| Wild Source<br>The percentage of wild–source accessions is very low, and the representation of rare and threatened taxa is zero, well below current targets, but not a high priority for an Ornamental and Cultural collection | 3% |
| Rare and Threatened | 0% |
| Identification Verified (ID3)<br>Verified identification of accessions is well below current targets. | 10% |
| Heritage Value | Neutral |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | 9.7°C |
| Estimated mean annual precipitation of collection's natural range | 787 mm |
| The temperature risk ranking by 2070 is extreme (red) and the estimated precipitation requirements are moderate. Coverage of climate risk assessments for this collection is 43% of taxa, mostly due to the large numbers of cultivars. | |

4

# Fern Gully

## Ornamental and Cultural Collection

**Purpose**
To display and interpret fern diversity in a landscape environment that supports visitor wellbeing.

**Description and Overview**
Located within the cool depression flowing through the centre of Melbourne Gardens, **Fern Gully** is derived from a naturally occurring valley and small ephemeral creek that drained the catchment of what is now South Yarra. In his first year, William Guilfoyle commenced substantial work on **Fern Gully**, with rockwork, the planting of trees to provide shade, and sourcing ferns from as far afield as New Zealand. Guilfoyle's vision was for *'a trickling stream winding over the rocky boulder strewn bed of the gully'* to emulate the splendour of a Victorian fern gully, capturing a sense of 19th century 'pteridomania' or 'fern mania'.

In the 1980s, Grey–headed Flying Foxes made an appearance and their colony peaked at about 30,000 individuals, causing substantial damage to the vegetation before their successful relocation in 2004. Following this time, **Fern Gully** was restored, starting with a steel boardwalk to provide equitable access and improve tree health. This project saw the removal of large amounts of running bamboo and other weed species, replacing it with over 2000 new plants, comprised mainly of Victorian ferns. The other major addition to **Fern Gully** was the creation of three Health and Wellbeing Gardens in 2019 to take advantage of the benefits of this magical place for human welfare. A 2014 Monash University PhD project discovered that the Fern Gully could be 4 to 6°C cooler than Melbourne city in summer, with this being backed by additional RBGV research. Today **Fern Gully** is one of the most popular and tranquil places in the Gardens.

**Experiential Aims**
Retreat to the cool and enchanting oasis of **Fern Gully**. Here, forest giants and stately palms form a dense canopy beneath which lush ferns thrive beside a trickling stream. This is a peaceful place of intricate patterns, filtered light, running water, and flitting birds, replete with contemplation nooks. The conversion of an existing gully to this lush Fern Gully was Director Guilfoyle's first project upon appointment in 1873 — and an enduring masterpiece.

**Collection Targets: Maintain**
— Increase diversity and holdings of future climate resilient ferns, with a focus on species from Australasian forests

— Maintain and enhance a landscape environment that enhances community wellbeing

— Explore opportunities to increase palm diversity whilst continuing adequate overstorey protection.

**Other collection relationships:**
This collection shares heritage planting, proximity, and microclimate options with the Palm Collection, and supports ferns from the Australian Forest Walk and New Zealand Collections.








| Collection Snapshot | |
|---|---|
| **Accessions** | **916** |
| **Families** | **81** |
| **Genera** | **160** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is about 83% | **293** |
| **Wild Source**<br>The percentage of wild-source accessions is low and should be higher for this Ornamental and Cultural collection considering the available plant palette | **8%** |
| **Rare and Threatened**<br>The representation of rare and threatened taxa almost meets current targets | **9%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is below current targets | **28%** |
| **Heritage Value**<br>The distribution of plants in Fern Gully is collectively represented by 28 countries. | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **16.0°C** |
| Estimated mean annual precipitation of collection's natural range | **1447 mm** |
| The temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are high. Coverage of climate risk assessments for this collection is 80% of taxa. Climate risk is higher for ferns only, rises to low-moderate (yellow) and precipitation is slightly increased. | |

4

# Gardens House

## Ornamental and Cultural Collection

**Purpose**
To conserve the heritage picturesque and gardenesque landscape and provide a quality horticultural display for visitors.

**Description and Overview**
Located within the grounds of the former Director's Residence, **Gardens House Collection** provides a beautiful backdrop to the heritage building.

In 1854, Gardens House was built as an office and residence for Mueller, with the location likely selected due to its impressive view across the Gardens. The early landscape proximate to Gardens House was dominated by Mueller's Systems Garden, which was located across the present-day Perennial Border into Princes Lawn. On his appointment in 1873 William Guilfoyle commenced the remodeling of the landscape. The first stage was undertaken in this vicinity, with early photographs indicating new garden beds, and groupings of palms, tropical foliage plants and other ornamental specimens. The grounds of the residence were also used to house valuable flowering plants (including camellias) so they could be more easily monitored due to prior thefts.

The last Director to occupy the residence was David Churchill (1971–1986). In 1995–96, Gardens House and the surrounding landscape was renovated, and has since been used for functions and events, primarily to raise revenue for the Gardens. In 2000, vegetation was removed to improve the views to Gardens House from the Perennial Border. The current picturesque and gardenesque grounds evoke a sense of seclusion within the broader Gardens' landscape.

**Experiential Aims**
A garden within a garden is how the **Gardens House Collection** is often described. Encircling the elegant 1854 Gardens House (originally built as the office and residence of the Director), the design is largely Guilfoyle's and includes many traditional features of a 19th century private garden. Sweeping beds and private nooks invite exploration and retreat. These beautiful and intimate private gardens are available for function hire.

**Collection Targets: Maintain**
— Conserve, enhance and interpret the quality of the landscape style of Gardens House according to design intent

— Improve the engagement of clients with plants through quality displays and strong aesthetics

— Increase the proportion of holdings with selected taxa listed in Mueller's and Guilfoyle's reports for historic interpretation.

**Other collection relationships:**
Camellia (131 taxa held in these grounds).







| Collection Snapshot | |
|---|---|
| **Accessions** | **1155** |
| **Families** | **111** |
| **Genera** | **326** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 83% | **737** |
| **Wild Source**<br>The percentage of wild-source accessions is very low and should be higher, even for an Ornamental and Cultural collection | **2%** |
| **Rare and Threatened**<br>The representation of rare and threatened taxa is low but less critical in this collection | **5%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is below current targets | **38%** |
| **Heritage Value**<br>There are 50 countries represented by the distribution of plants in the holdings, one of the highest in the Gardens<br><br>This collection has one of the highest proportions of garden origin plants, at 39% of the holdings<br><br>In comparison with other garden bed-based collections, taxa diversity per area is one of the highest in the Gardens | **Significant** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **15.3°C** |
| Estimated mean annual precipitation of collection's natural range | **1,181 mm** |
| The temperature risk ranking by 2070 is low-moderate (yellow) and the estimated precipitation requirements are moderate to high<br>Coverage of climate risk assessments for this collection is lower than average at 79% of taxa, likely due to a high number of cultivars not being risk assessed. | |

4

# Grey Garden

## Ornamental and Cultural Collection

**Purpose**
To display and interpret the attributes and ornamental qualities of grey and silver foliaged plants for learning and enjoyment, and to inspire their use in horticulture.

**Description and Overview**
The **Grey Garden Collection** is located on the dry mudstone and siltstone escarpment that overlooks the Yarra River, adjacent to Plant Craft Cottage. The site originally overlooked wetlands to the north–east, adjoining the original river course. Following the realignment of the Yarra River in 1900, Guilfoyle converted this area into a large rock garden and constructed the Temple of the Winds. The rockwork includes early example of faux rocks that were innovative for the time. Dryland species such as succulents and some Mediterranean flora were used to embellish the landscape. In 1985, the areas on the northern and southern side of the steps linking the Temple of the Winds to the Southern China Collection were set aside for grey and silver foliage plants that were expected to perform on this rocky, exposed location and provide a themed display. During the 2000s, a series of further landscape developments occurred including extensions down the escarpment, rockwork, and incorporation of the former Canary Islands Bed on the southern side.

Grey, silver, and glaucous plants have adaptations such as hairs, scales, spines, and waxes to cope with water loss, high levels of solar radiation, and in some cases, even insulate against cold. These plants are typically found in harsh environments such as alpine regions, cliffs, coastal strips, deserts, and salt marshes/pans, and many come from Mediterranean climates.

The **Grey Garden Collection** is on a harsh site with an exposed northern face. Temperature monitoring has shown it to be one of the hottest locations in the Gardens and soils are shallow and rocky. Due to the steep, crumbly slope, the northern side of the **Grey Garden Collection** is challenging to maintain and requires abseiling equipment.

**Experiential Aims**
Grey plants are often overlooked but grey and green complement each other beautifully. In the **Grey Garden Collection** grey plants stand on their own with a surprising variety of textures and forms. Importantly, with such strategies as hairy, waxy, or succulent leaves, grey plants require little water making them perfect for an increasingly hot and dry climate.

**Collection Targets: Maintain**
— Maintain and diversify holdings of climate resilient, grey/silver native and exotic plants for horticultural interest, ornamental display, and landscape design

— Interpret the wide range of grey/silver adaptations across different plant families and lesser–known taxa.

**Other collection relationships:**
No related collections, but some taxa are also found in the Australian and Cacti and Succulent orientated plantings elsewhere.








| Collection Snapshot | |
|---|---|
| **Accessions** | **445** |
| **Families** | **60** |
| **Genera** | **162** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 87% | **307** |
| **Wild Source**<br>The percentage of wild-source accessions is very low, however the representation of rare and threatened taxa almost meets targets | **9%** |
| **Rare and Threatened** | **9%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is lower than targets | **30%** |
| **Heritage Value**<br>There are 34 countries represented by the distribution of plants in the holdings—the third highest for collections in the Gardens<br><br>Taxa diversity per area is very high and ranked as second highest in the Gardens. | **Contributory** |

| Climate Suitability Guide | | |
|---|---|---|
| | Estimated mean annual temperature of collection's natural range | **16.1°C** |
| | Estimated mean annual precipitation of collection's natural range | **661 mm** |
| | The temperature risk ranking by 2070 is low-moderate (green-yellow) and the estimated precipitation requirements are low. Coverage of climate risk assessments for this collection is 80%. | |

4

# Guilfoyle's Volcano

## Ornamental and Cultural Collection

**Purpose**
To display and interpret a range of flora suited to growing in Melbourne's current and future climate and to encourage community interest in the use of arid flora through stimulating landscapes.

**Description and Overview**
Located on the Gardens highest point, adjacent to Anderson Street, **Guilfoyle's Volcano** is one of Melbourne Gardens' most striking landscape features. It is built around William Guilfoyle's 1876 bluestone–lined 'turkey nest' reservoir, which was intended to resolve water supply problems that had vexed management of the Gardens from its very beginnings. The reservoir was used to irrigate the gardens with water pumped from the Yarra River until the 1883 removal of natural cascades allowed estuarine water upstream and within a few years the water was too saline for irrigation.

The reservoir was originally landscaped to resemble the cone of a volcano, with rockwork simulating lava flows, possibly inspired by Guilfoyle's experience observing an active volcano in Vanuatu in 1868. Lawn areas through the present–day 'Mounds' were shaped to symbolise lava flows and bold, ornate plantings including cacti and succulents were used on the higher ridges with rockwork extending into the surrounding areas.

By the mid–20th century, the area had fallen into neglect, and it was not until 2010 that the landscape and the reservoir were revitalised as stage one of the Working Wetlands project. 'Guilfoyle's Volcano' was reborn with a landscape design that honours the original intent of a reservoir that now performs an integral role in lake water recirculation and treatment through floating treatment wetlands. The project objectives also included providing learning about water conservation and climate change through plant selection and signage.

There is a strong focus on planting design throughout the entire garden and plant colour, form and texture are used to create maximum design impact. While cacti and succulents dominate the plant palette, other species from drier and warmer climates are also displayed. Planting around the cone relies on the repeat planting of succulent specimens that help create a rhythm and reinforce the circular shape. Repeat specimens include *Echinocactus grusonii, Aloe castanea, Crassula falcata, Cleistocactus winteri and Agave parryi,* and it is an important facet of the design that these key plants remain.

**Experiential Aims**
Much of Melbourne is built on a 50–million–year–old lava flow. In 1876, an inspired Guilfoyle constructed a reservoir within a volcano–shaped hill at the highest point of the Gardens to gravity feed water into the Gardens. The 'volcano' is still used for water storage today but is now part of a sophisticated garden–wide reticulation and treatment system. Masses of succulents mimic the flow of lava while striking accent plants are reminiscent of a desert landscape. **Guilfoyle's Volcano** is possibly the Gardens' most intriguing site.

**Collection Targets: Maintain**
— Continue to display a range of inspiring flora suited to growing in Melbourne's current and future climate

— Reinforce landscape linkages to the Arid Garden, North American Drylands Collection and other drylands developments as outlined in the Master Plan.








**Other collection relationships:**
Strong linkages to the North American Drylands, Cacti and Succulent.

| Collection Snapshot | |
|---|---|
| Accessions | 192 |
| Families | 31 |
| Genera | 69 |
| Taxa<br>Taxa with distributions assigned (including Garden Origin plants) is 94% | 176 |
| Wild Source<br>The percentage of wild-source accessions is well below targets, considering the potential of this collection | 7% |
| Rare and Threatened<br>The representation of rare and threatened taxa is higher than current targets. Verified identification of accessions is significantly higher than current targets | 12% |
| Identification Verified (ID3) | 58% |
| Heritage Value | Contributory |

| Climate Suitability Guide | | |
|---|---|---|
| | Estimated mean annual temperature of collection's natural range | 17.4°C |
| | Estimated mean annual precipitation of collection's natural range | 708 mm |
| | The temperature risk ranking by 2070 is very low (green) and the estimated precipitation requirements are low. Coverage of climate risk assessments for this collection is 84%. | |

4

# Herb and Medicinal Garden

## Ornamental and Cultural Collection

**Purpose**
To display and interpret fragrant, culinary, medicinal, dye, insect–repelling and fibre plants from a diverse range of countries and cultures.

**Description and Overview**
The **Herb and Medicinal Garden**, located just off the Oak Lawn, can trace its antecedents back to the earliest botanic gardens. The origins of modern botanic gardens have their foundation in the curation of medicinal herbs for study and drug production, usually in association with medical institutes, such as those created in Pisa (1544), Padua (1545) and Oxford (1621). This continues to today with a 1998 BGCI study identifying medicinal plant collections in 480 botanic gardens around the world.

At Melbourne, the first Director, Baron Ferdinand Von Mueller, had obtained a pharmaceutical qualification in his younger years, and this may have promoted his interest to include herbs and other economic plants in the Experiment and System Gardens he created. In 1880, Guilfoyle responded to requests for medicinal plants from pharmacists and hospitals by establishing a medicinal garden in the vicinity of Oak Lawn, which by 1887 had extended to eight beds containing 318 species. In 1986, the current Herb and Medicinal Garden was opened, supported by the Herb Society of Victoria and the Friends of the Gardens.

The **Herb and Medicinal Garden** precinct is distinctive as large medicinal trees are associated with the collection. It is a popular location for visitors and learning activities and identified for rejuvenation and expansion in the Master Plan, with an extended focus beyond the current emphasis on western and culinary herbs. Many wild plants are used for traditional culinary and medicinal purposes by millions of people around the world, and it is estimated that there are 70,000 medicinal plant species alone, with many threatened by habitat loss and over–harvesting. There is a clear role for the Gardens to expand learning beyond the enjoyment of these plants to safeguarding them for ecosystem function and people's health and livelihoods.

**Experiential Aims**
Since ancient times, in every culture, herbs have played a fundamental role in our daily lives. From tiny, short–lived annuals to grand, century–old trees, the Garden's historic **Herb and Medicinal Garden** includes a medley of plants from around the world. Their uses — medicinal, culinary, aromatic, and spiritual — are as diverse as their form and origin. Delight your senses in this garden of sensory delights — inhale deeply and touch gently. For peak fragrance, visit late spring to early autumn.

**Collection Targets: Develop / Expand**
— Increase plant diversity (including wild crop origins), climate resilience and wild–collected provenance

— Improve landscape footprint area in accordance with Master Plan to allow for better visitor circulation and plant display

— Provide effective interpretation and learning that captures the ethnobotanical importance of plants to diverse human communities and cultures throughout the world.

**Other collection relationships:**
The Ian Potter Foundation Children's Garden (Kitchen Garden).








| Collection Snapshot[ix] | |
|---|---|
| **Accessions** | **648** |
| **Families** | **86** |
| **Genera** | **213** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is 87%<br><br>There are 48 countries represented by the distribution of plants in the holdings—the second highest proportion for collections in the gardens<br><br>Taxa diversity per area is also the highest out of all the collections | **435** |
| **Wild Source**<br>The percentage of wild-source accessions is very low, and the representation of rare and threatened taxa is very low. The need for better conservation of medicinal plants indicates there is scope to improve these metrics | **3%** |
| **Rare and Threatened** | **2%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is slightly higher than current targets | **51%** |
| **Heritage Value** | **Contributory** |
| **Climate Suitability Guide** | |
| Estimated mean annual temperature of collection's natural range | **13.5°C** |
| Estimated mean annual precipitation of collection's natural range | **952 mm** |
| The temperature risk ranking by 2070 is moderate (orange) and the estimated precipitation requirements is moderate. Coverage of climate risk assessments for this collection is 83%. | |

ix The maps and database for the Herb and Medicinal Garden precinct have not been audited for some time, which may affect the quality of this data.

4

# Perennial Border

## Ornamental and Cultural Collection

**Purpose**
To provide a vibrant horticultural display and ornamental foreground for Gardens House using combinations of flowers, colour, texture and form from a diverse range of plants suited to Melbourne's climate.

**Description and Overview:**
Providing a dramatic foreground to Gardens House, the **Perennial Border** uses a diverse range of plants to create a colourful, ever–changing display. The use of herbaceous or perennial borders probably dates to derivations of English cottage gardens in the early 19th century. This type of display was widely popularised in the late 1800s by people such as Gertrude Jekyll, who applied colour theory with large informal drifts of perennial plants to develop a herbaceous border.

Guilfoyle used herbaceous plants and annuals to highlight concentrated bursts of colour across the landscape, but generally preferred displays to be provided by more woody plantings. Some of the perennial species used for colour at the time included agapanthus, cannas, and bulbs such as gladioli and watsonias.

In the 1980s, perennial borders and cottage gardens experienced somewhat of a renaissance in Melbourne, and in 1986 a perennial border was established on the current site. This border was designed in the Jekyll style and provided an excellent display but proved to be very high maintenance. The border was redesigned in 1994 to reduce maintenance and provide a more contemporary display but it lacked structure and impact. In 1998, the current border was designed to accommodate hotter conditions and provide a quality display over a longer period. A simple, half–moon shaped path was laid, and a mix of herbaceous plants, succulents, grasses and bold foliage perennials and shrubs were incorporated in large drifts.

**Experiential Aims**
A classic well known garden style, the **Perennial Border** is a vibrant mix of evergreens, succulents, perennials, and grasses, including both sun and shade lovers. Visit through the seasons for inspiration on planting design and note how balance has been achieved through the repetition of colour and form to great effect. Spread a picnic on the lawn and immerse yourself in a visual gala of flora beauty.

**Collection Targets: Maintain**
— Continue to provide an engaging horticultural display through climate resilient and highly ornamental plant selection

— Experiment with new species and curation techniques to optimise seasonal performance

— Include new wild–collected taxa with ornamental attributes

— Regularly review plant palette and plant combinations to maintain a dynamic and interesting border.

**Other collection relationships:**
No related collections.








| Collection Snapshot | |
|---|---|
| **Accessions** | **115** |
| **Families** | **31** |
| **Genera** | **56** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is 93% | **69** |
| **Wild Source**<br>The percentage of wild-source accessions is zero, and the representation of rare and threatened taxa is below targets. These metrics are less essential for an Ornamental and Cultural collection, but improving these could be explored with plants with suitable ornamental qualities | **0%** |
| **Rare and Threatened** | **7%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is on target | **50%** |
| **Heritage Value**<br>There are 13 countries represented by the distribution of plants in the holdings. | **Contributory** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **14.4°C** |
| Estimated mean annual precipitation of collection's natural range | **1050 mm** |
| The temperature risk ranking by 2070 is low-moderate (yellow) and the estimated precipitation requirements is moderate. Coverage of climate risk assessments for this collection is 74% | |

4

# The Ian Potter Foundation Children's Garden

## Ornamental and Cultural Collection

**Purpose**
To provide a diverse, planted environment that enhances family and children's connection to plants and nature for learning, personal development, and wellbeing.

**Description and Overview:**
Located between the Melbourne Gardens and Melbourne Observatory, **The Ian Potter Foundation Children's Garden** welcomes over 230,000 visitors each year. The planted landscape has been designed to provide mystery and intrigue, specifically to enhance the connection children and their carers have with plants, in learning, play and wellbeing.

Studies have found that children with access to green space and unstructured environments have greater capacity for healthy physical and psychosocial development. This can lead to improved cognition and school grades, and better social behaviors. In 1997, the Royal Botanic Gardens Melbourne Master Plan considered development of an 'Education Lawn' as part of the Observatory Gate Precinct, this idea was expanded to become a Children's Garden. In 1999, planning took place to develop a space that included education, but primarily a space that engages children with the natural world and places an emphasis on plants for their sensory experience.

An in-house design team was established and research undertaken, which included technical tours by staff to the USA to examine the approaches taken by other leading botanic gardens. The Ian Potter Foundation provided $1.7 million in funding for the development of a new children-focused landscape. In 2003-2004, The Ian Potter Foundation Children's Garden was constructed. Attention was given to selecting plants suitable for high wear and tear, and to design landscape soils that would cope with compaction pressures. There are nine main planting themes in the Garden including a Bamboo Forest, a Blossom Lawn (including water play), a Gorge, Kitchen Garden, Meeting Place (with water play), Plant Tunnels, a Rainforest Ruin, and the Wetland, all scaled to meet a child's view of the world.

The Children's Garden has exceeded all expectations, with high visitation reaching to 230,000 visits per annum. To help manage the demand and celebrate 10 years of operation, an extension of approximately 500m2 adjacent to Observatory House was completed in 2014. This innovative project set the standard for nature-based play in Australia and New Zealand and has inspired the construction of similar spaces across both countries.

**Experiential Aims**
Carefully designed for children, **The Ian Potter Foundation Children's Garden** is where a little bit of magic happens. Here, the landscaping is best appreciated from a child's perspective and comprises a wonderful array of different plant spaces designed to help connect children to the plant world, including a bamboo forest, wetlands, rocky gorge, running water and huggable trees. It also includes an education space and a kitchen garden to demonstrate the source of some of our common edible foods.

**Collection Targets: Maintain**
— Continue to provide a landscape environment and displays that connect children to the plant world

— Increase the climate resilience of the holdings, and where possible increase wild-collected, provenance, and rare and threatened taxa








— Inspire and inform the development of other landscapes for children and families both internally and as external outreach

— Continue to provide the living platform for development of innovative interpretation and learning.

**Other collection relationships:**
Herb and Medicinal Garden via the Kitchen Garden.

| Collection Snapshot | |
|---|---|
| **Accessions** | **498** |
| **Families** | **97** |
| **Genera** | **226** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is relatively low at 70% | **351** |
| **Wild Source**<br>The percentage of wild-source accessions is lower than targets | **5%** |
| **Rare and Threatened**<br>The representation of rare and threatened taxa is higher than current targets | **12%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is lower than desired targets | **35%** |
| **Heritage Value**<br>There are 33 countries represented by the distribution of plants in the holdings. | **Neutral** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **15.6°C** |
| Estimated mean annual precipitation of collection's natural range | **1,128 mm** |
| The temperature risk ranking by 2070 is low-moderate (green-yellow) and the estimated precipitation requirements is moderate. Coverage of climate risk assessments for this collection is 88%. | |

4

# Australian Rare and Threatened Species

## Research and Conservation Collection

**Purpose**
To conserve, display and interpret Australian rare and threatened species in collaboration with partner organisations for the purpose of conservation and education.

**Description and Overview**
Currently focused around island beds on Central Lawn, with additional specimens in suitable microclimates across the Gardens, the **Australian Rare and Threatened Species Collection** supports plant conservation work around Australia. The original collection was established to conserve Victoria taxa in the mid–2000s, creating a clear display area on Central Lawn for the previously isolated ex situ populations scattered across the Gardens. Following a 2018 climate risk review, the collection was expanded to include a broad range of Australian rare and threatened taxa and build this collection across the landscape in appropriate areas.

Collections of Australian species from further afield are in early phases of development, but there has been good progress through strong working relationships with Royal Botanic Gardens and Domain Trust in Sydney. Analysis has highlighted approximately 3,400 threatened Australian plant taxa, with approximately 700 of these suitable for Melbourne's predicted future climate. This highlights a key role for Melbourne Gardens in conserving Australia's threatened flora. The current intention is to continue to explore collections of species from warmer climates, especially those less suited for seed–banking such as some dry rainforest taxa.

**Experiential Aims**
From an Australian research perspective, the **Australian Rare and Threatened Species Collection** is the Garden's most important living collection. Here, rare and threatened species are grown for botanical study and preservation of their genetic material. The Gardens work closely with other botanic gardens, institutions, and government departments to safeguard priority species that are compromised by climate change and habitat loss.

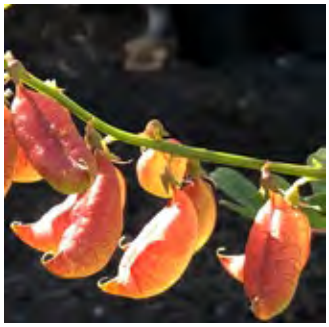
**Collection Targets: Develop**
— Increase threatened plant diversity, climate resilience and wild collected provenance

— Strengthen collaborative relationships with other botanical organisations for collecting, exchange and protection of threatened taxa

— Identify and develop additional focal areas of rare and threatened species in the Gardens for display and learning

— Attain stronger ex situ conservation outcomes through development of identified metacollections.

**Other collection relationships:**
Australian Forest Walk, Eucalypt, Terrestrial Orchids.








| Collection Snapshot[x] | |
|---|---|
| **Accessions** | **2083** |
| **Families** | **92** |
| **Genera** | **247** |
| **Taxa**<br>Taxa with distributions assigned is 100% | **564** |
| **Footprint Percentage** | **100%** |
| **Wild Source**<br>The wild–source percentage of accessions is significantly lower than what might be expected. This could be due to deficiencies in plant records or repropagation of wild source plant material from landscape specimens, which can diminish wild rankings over time | **24%** |
| **Rare and Threatened** | **100%** |
| **Identification Verified (ID3)**<br>For such a high value collection, the identification status is below target and should be significantly improved. | **38%** |
| **Heritage Value** | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **15.6°C** |
| Estimated mean annual precipitation of collection's natural range | **1029 mm** |
| The temperature risk ranking by 2070 is moderate (orange) and the estimated precipitation requirements are moderate.<br><br>Coverage of climate risk assessments for this collection is 92% of taxa. While there is a moderate climate risk, there are prospects to improve this rating by the introduction of warmer climate Australia taxa in line with ex situ conservation and metacollection development. | |

x This assessment includes taxa on Australian state lists, but which may not be threatened in all jurisdictions

4

# Terrestrial Orchids

## Research and Conservation Collection

**Purpose**
Provide a representative collection for conservation, research, and interpretation of Victorian Terrestrial Orchids in order to promote their protection.

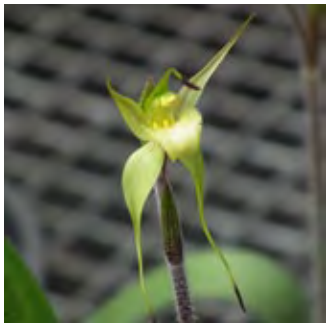
**Description and Overview**
Located within Melbourne Gardens' Nursery, the **Terrestrial Orchids Collection** was first established in 1979 as a response to threats to native orchid survival from human activities. Many terrestrial orchids rely on symbiotic partnerships with mycorrhizal fungi for germination and adequate growth, and many also require specific pollinators for reproduction. These relationships can easily be disrupted by changes to environmental conditions and land use. Unfortunately, on a global scale, approximately 25% of orchid extinctions occur in Australia.

In 1990, improvements to growing environments in the nursery were achieved with a new growth house and in 2015, the establishment of a collection at Cranbourne Gardens significantly expanded the ex situ conservation of these plants. At Melbourne Gardens, the collection provides an essential function for supporting research programs, contributing to genetic studies, and providing conservation outcomes such as 'renting out' plants for pollinator baiting, hand pollination and seed collection. Experimental work has also begun with the cultivation of European terrestrial orchids in conjunction with plant scientists, which will expand knowledge on cultivation techniques. The Melbourne Collection can also provide some duplication and risk mitigation opportunities for material primarily housed at Cranbourne Gardens.

This **Terrestrial Orchids Collection** at both sites has led to outstanding collaboration with other botanic gardens, institutions, orchid societies, and government departments to maximise protection of Victoria's approximately 30 genera and 300 species of terrestrial orchids. Moreover, there is substantial public interest in these distinctive plants, so engaging people with the importance of plant conservation. In relatively recent years, successful trial plantings of selected species within the Australian Forest Walk and Long Island have readily caught visitor attention.

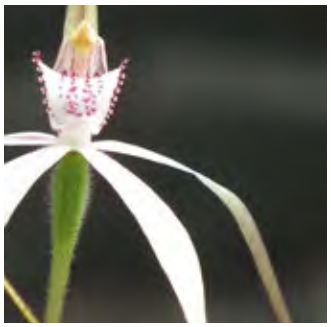
**Experiential Aims**
The Gardens' **Terrestrial Orchids Collection** is a critical conservation project to help safeguard Victoria's threatened terrestrial orchid species. Propagating this delicate and intriguing group of plants in the Garden's nursery is akin to microsurgery. With urban development threatening our wild orchid populations, their health is a good barometer for how we value our natural habitats.

**Collection Targets: Maintain**
- Maintain, develop and futureproof the nursery collection for supporting conservation programs and public engagement
- Develop the opportunities to further display terrestrial orchids in the Australian collections and other locations to engage visitors
- In pursuing these targets, treat the Terrestrial Orchids Collection across both sites as a 'distributed collection' (meta), with particular species and projects housed at the most appropriate location but with duplication of critical material where possible.










**Other collection relationships:**
Australian Rare and Threatened Species, Cranbourne Gardens Terrestrial Orchid Collection, Lower Yarra River Habitat.

| Collection Snapshot | |
|---|---|
| **Accessions** | **90** |
| **Families** | **1** |
| **Genera** | **9** |
| **Taxa**<br>Taxa with distributions assigned is 91% | **39** |
| **Footprint Percentage** | **100%** |
| **Wild Source**<br>The wild–source percentage of accessions is lower than what might be expected. This could be due to deficiencies in plant records or repropagation of plant material from collection holdings, which can diminish wild rankings over time | **48%** |
| **Rare and Threatened** | **64%** |
| **Identification Verified (ID3)**<br>Identification status is higher than the overall collections target but should exceed this for such an important collection. | **56%** |
| **Heritage Value** | **Significant** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **12.6°C** |
| Estimated mean annual precipitation of collection's natural range | **716 mm** |
| The temperature risk ranking by 2070 is high (red) and the estimated precipitation requirements are low to moderate. Coverage of climate risk assessments for this collection is 100% of taxa.<br><br>This collection is based in climate–controlled plant houses | |

4

# Araucariaceae

## Taxonomic and Evolutionary Collection

**Purpose**
To display a diverse selection of Araucariceae suitable for Melbourne's climate for the purposes of plant conservation and landscape aesthetics, and for interpretation of the unique biogeography and botanical features of this plant family.

**Description and Overview**
Scattered across Melbourne Gardens, the **Araucariaceae Collection** includes representatives of 70% of the world's Araucariaceae taxa. Araucariaceae is one of the most primitive conifer families and the fossil record suggests that this family was originally widely distributed across both southern and northern hemispheres. Today, Araucariaceae is comprised of three genera: *Agathis, Araucaria* and *Wollemia*, containing around 41 taxa, mostly distributed in tropical and subtropical rainforests of Australia, Malesia, Melanesia (including New Guinea), New Zealand, New Caledonia, and South America.

*Wollemia nobilis* captured the world's imagination as a 'living fossil' when discovered in 1994 as a relic population in the Blue Mountains of New South Wales. Araucaria species are dominant in New Caledonia, with 14 of the 20 species occurring there, and often on ultramafic (serpentine) soils that are infertile and high in some metals. Many Araucariaceae are rare and threatened in the wild or are approaching this status due to habitat loss.

In Melbourne Gardens, *Araucaria cunninghamii* and A. heterophylla were among the first exotic plantings for the emerging botanical collection, being planted in 1851 by John Dallachy near The Terrace. With the regularity in size, shape and placement of their leaves and an ordered symmetry to their branch structure, members of Araucariaceae stand out in the modern landscape. In addition to its conservation and taxonomic significance, this collection has high landscape value in the Gardens, providing structural silhouettes on the eastern and western skylines, and with many magnificent individuals throughout the landscape. Several of the species have performed well in the current conditions considering the significantly warmer climate and higher precipitation of their natural habitats.

**Experiential Aims:**
The *Araucariaceae Collection* of conifers is spread across the Gardens. These stately sentinels give structure to the Garden design, their grand presence reassuring, their scent familiar. To stand beneath them and notice their orderly network of branches, or focus on their neat whorls of compact leaves, is to feel safe and secure.

**Collection Targets: Expand**
— Increase plant diversity and wild collected provenance as much as possible under climatic conditions and constraints on access to new material

— Develop a tree propagation and replacement schedule in line with landscape succession plans

— Identify and implement contemporary learning technology and techniques to provide better public information on this distributed group

— Explore the development of a focal landscape area that is more environmentally suited to support and display (smaller) representative taxa of the family for interpretation and learning.

**Other collection relationships:**
No related collections.








| Collection Snapshot | |
|---|---|
| **Accessions** | **146** |
| **Families** | **1** |
| **Genera** | **3** |
| **Taxa**<br>Taxa with distributions assigned is 97% | **29** |
| **Wild Source**<br>The percentage of wild-source accessions is lower than current targets | **16%** |
| **Rare and Threatened**<br>There are at least 14 vulnerable and threatened taxa, or 50% of the holdings (which is a high proportion), with others facing near threatened status | **50%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is higher than desired targets<br><br>The standard of verified identification is higher than current targets. | **62%** |
| **Heritage Value** | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **19.8°C** |
| Estimated mean annual precipitation of collection's natural range | **1,677 mm** |
| The temperature risk ranking by 2070 is low (green) with some taxa under the current climate ranked at the coldest extent of their potential temperature range, and the estimated precipitation requirements are one of the highest in the Gardens. | |

4

# Cacti and Succulent

## Taxonomic and Evolutionary Collection

**Purpose**
To display and interpret the unique evolutionary adaptations, ornamental qualities, and broad diversity of succulent and similar adaptation–related plants.

**Description and Overview**
Cacti and succulents are found across Melbourne Gardens, with higher density pockets around Temple of the Winds and City Gate, within Guilfoyle's Volcano and at the Arid Garden. Cacti and succulents have been an intrinsic part of Melbourne Gardens since its early development, with specimens of this readily seen in early photographs as part of William Guilfoyle's plantings across the site, valued for their tolerance to dry conditions, ornamental form and structure.

Plants which have evolved to withstand considerable stress in the environment often take on forms and habits which, to the eye accustomed to the morphology of a temperate climate, are unusual, unorthodox, and startling to behold. This is particularly true of arid species, where water scarcity renders it the most precious resource. Cacti have largely forgone traditional photosynthetic leaves and become wonderful architectural structures with unexpected geometry. Other taxa have instead repurposed their leaves. No longer the flat sheets by which a leaf is commonly defined, they have become plump storage organs which take on an extraordinary range of forms, shapes and colours.

Definitions of succulence are typically known for leaf succulents (e.g., *Crassula species*) and stem succulents (mostly Cacti) but can also include other stem–storage plants such as caudiciforms (e.g., *Cyphostemma juttae*) and pachycauls (e.g., *Brachychition rupestris*). The **Cacti and Succulent Collection** can broadly include other plant groups such as Bromeliaceae with Crassulacean Acid Metabolism (CAM) photosynthesis, and there are even Orchidaceae taxa that might be defined as succulents. In the 1990s the collection was enhanced through collecting trips to southwestern USA and staff exchanges with Huntington Botanic Gardens. In 2020, the construction of a revitalised Arid Garden enabled the display and interpretation of the significant donation of unique plants from Robert Fields.

**Experiential Aims**
Discover the genius of arid living in the colourful **Cacti and Succulent Collection**. The masterfully designed Arid Garden perfectly displays these strong, prickly, and curious plants. Robert Field has donated most of the plants in this collection — his is an extraordinary story of a lifetime's devotion. Stand among the tall or delight in the small as you marvel at patterns, shapes, textures, and vibrant flowers. The creative storytelling will leave you in no doubt as to nature's clever design and adaptation.

**Collection Targets: Expand**
— Expansion of the existing landscape area to include the Arid and Drylands Precinct

— Increase plant diversity and wild collected provenance as much as possible, noting CITES constraints on access to new material

— Explore increasing the diversity of a sub–group of Australian succulents.

**Other collection relationships:**
North American Drylands, Guilfoyle's Volcano.








| Collection Snapshot | |
|---|---|
| **Accessions** | **752** |
| **Families** | **16** |
| **Genera** | **73** |
| **Taxa**<br>Taxa with distributions assigned (including 52 Garden Origin plants) is approximately 80% | **323** |
| **Footprint Percentage** | **63%** |
| **Wild Source**<br>The percentage of wild-source accessions is lower than current targets | **8%** |
| **Rare and Threatened**<br>The percentage of rare and threatened taxa is slightly under target, and this is mostly comprised of rare Cactaceae in the collection rather than other succulents | **9%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is lower than desired targets and this is recognised as a difficult group. | **31%** |
| **Heritage Value** | **Significant** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **17.1°C** |
| Estimated mean annual precipitation of collection's natural range | **706 mm** |
| The temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are one of the lowest in the Gardens. Coverage of climate risk assessments for this collection is only 63% of taxa. | |

4


# Camellia

## Taxonomic and Evolutionary Collection

**Purpose**
To conserve heritage cultivars, and display and interpret the cultural uses, horticultural history, and ornamental qualities of Camellias.

**Description and Overview**
Located in the centre of the Gardens, north of Oak Lawn, the **Camellia Collection** is one of the oldest, continually managed collections in the Gardens. Camellias have been cultivated in China and Japan for hundreds of years for cultural, ornamental, economic and medicinal reasons. Strong colonial interest in acquiring tea from *Camellia sinensis* also resulted in the introductions of many species and cultivars to Europe, mostly from China and Japan during the late 1700s. Currently, it is estimated that there are between 250 and 300 camellia taxa, with more being discovered every year, and over 20,000 accepted cultivar names.

Five camellias were noted growing in Melbourne Gardens in 1851, but only two were mentioned by Mueller. In his Annual Report of 1875, William Guilfoyle lists 85 camellias planted between 1873 and 1875, with more in following years. Remarkably, about 75 of these Guilfoyle plantings still exist today and the current Camellia Bed first appeared on a Gardens' map in 1883.

Alexander Jessep (Director 1941–1957) was a noted authority on camellias, and a founder and first President of The Australian and New Zealand Research Society. The Society devoted itself to sorting out camellia nomenclature, which had become very confused worldwide. Jessep planted the species extensively through the Gardens and his detailed lists and maps are still of great use today.

Dr. Bob Withers also had a major influence on camellias in the Gardens, donating around 170 plants in 1998–99, and in 2004 the Gardens acquired his collection of nearly 300 camellias. His reputation and enthusiasm led to the recognition of the collection by the International Camellia Society.

In addition to the Camellia Bed, other concentrated plantings of camellias can be found at Gardens House, the Southern Chinese Collection, Lake View Shelter Bed, Western Border Bed, Zelkova Bed, and Directors' Tunnel beds amongst other areas.

**Experiential Aims**
Winter visitors to the Gardens should head to the **Camellia Collection** to find flowering in abundance. It's difficult to decide whether a camellia's grandiose flowers are more beautiful on the plant, or when they drop and carpet the ground. Originating in Southeast Asia, camellias were first valued for their oil or brewed for tea. In Australia, cultivars have been grown since the early days of settlement and are highly valued for both their flowers and glossy foliage.

**Collection Targets: Maintain**
— Maintain collection footprint but diversify holdings with additional climate suited species

— Seek to increase proportion of wild-source and rare and threatened plants.

**Other collection relationships:**
Southern China, Gardens House (high proportion of Camellia cultivars).








| Collection Snapshot | |
|---|---|
| **Accessions** | **890** |
| **Families** | **1** |
| **Genera** | **1** |
| **Taxa**<br>Taxa with distributions assigned (including 431 Garden Origin plants) is approximately 96% | **513** |
| **Wild Source**<br>The percentage of wild–source and rare and threatened species are one of the lowest in the Gardens and well below current targets | **0.4%** |
| **Rare and Threatened** | **1%** |
| **Identification Verified (ID3)**<br>Verified identification for this collection is one of the highest amongst all the collections and well above current targets. | **72%** |
| **Heritage Value** | **Outstanding** |

| Climate Suitability Guide | | |
|---|---|---|
| | Estimated mean annual temperature of collection's natural range | 15.1°C |
| | Estimated mean annual precipitation of collection's natural range | 1,512 mm |
| | The temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are high. Coverage of climate risk assessments for this collection is 82% of taxa. | |

4

# Cycad

## Taxonomic and Evolutionary Collection

**Purpose**
To conserve threatened species, and display and interpret the unique adaptations, diversity, and evolutionary history of cycads.

**Description and Overview**
Scattered throughout the Gardens, with a concentration in the Cycad Bed on Eastern Lawn, the **Cycad Collection** represents a highly threatened plant group which receives worldwide botanical attention. Cycads are one of the most ancient of plant lineages, with fossils dating back to the Permian epoch. By the Mesozoic era they had achieved a worldwide presence, and in fact were so dominant in the landscape that the Jurassic epoch is also dubbed the 'Age of Cycads'.

From this epic dynasty, the cycads are now only found in tropical and subtropical regions. They are classified into three families, Cycadaceae, Zamiaceae and Stangeriaceae — in which are 11 genera, and some 339 species. Modern though current species may be, they nevertheless retain the basic morphology of their prehistoric ancestors. With assorted armatures and the sheer size of both cones and seeds, cycads conjure the ghosts of long-lost megafauna who fed upon them. One of the earliest references to cycads in the Gardens were the many plants raised from seed and overseen by William Guilfoyle in 1873. Plantings of cycads were also noted within and proximate to the current Palm Lawn. However, by 1881, this group was relocated to an unknown location.

About 70% of cycad species are considered to be at high risk of extinction , the driving factors of which are habitat loss due to climate change or clearing, and mass harvesting of wild specimens to feed a black market for collectors around the world. This threat is further compounded by the fact that cycads are 'exceptional species', meaning that their seeds cannot be preserved in traditional seed banks. Ex situ collections are thus vital for cycad conservation.

Most taxa within the Gardens are contained within Zamiaceae (66 taxa), followed by Cycadaceae (11 taxa), and Stangeriaceae (2 taxa). As a highly future-climate suited collection and with a high proportion of threatened species, there is scope to expand the holdings for safeguarding threatened plants through metacollection development.

**Experiential Aims**
A little bit palm-like and a little bit fern-like, cycads have changed little since grazed upon by dinosaurs. While the **Cycad Collection** is focused on the Eastern Lawn, individuals occur throughout the Gardens — their distinctive form an important aesthetic. Found from desert to rainforest, they occur in many countries throughout the world. Ancient heritage, slow-growers, long-livers, often with a specific pollinator — quite simply, a fascinating group of plants.

**Collection Targets: Expand**
— Increase plant diversity and wild-collected provenance as possible, and improve collection documentation on phenology and sexes of these dioecious plants

— Explore how to better engage audiences with the features of cycads in the existing Cycad Bed, such as providing a pathway or lookout for an immersive experience

— Investigate suitable microclimates and soil profiles for successful incorporation of the collection across the broader landscape.








**Other collection relationships:**
No specifically related collection, but cycads are also found in Southern Africa, China, and into Mexico.

| Collection Snapshot | |
|---|---|
| Accessions | 169 |
| Families | 3 |
| Genera | 8 |
| Taxa<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 81% | 79 |
| Wild Source<br>The percentage of wild–source accessions is slightly below target | 30% |
| Rare and Threatened<br>The proportion of rare and threatened taxa is very high and well above target | 43% |
| Identification Verified (ID3)<br>Verified identification of accessions is lower than current targets. | 25% |
| Heritage Value | Significant |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | 19.5°C |
| Estimated mean annual precipitation of collection's natural range | 1046 mm |
| The temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are moderate to high. The proportion of climate risk assessments for this collection is 80% of taxa.<br><br>Like palms and oaks, cycads are not suited to current seed banking techniques and need to be curated as living specimens to conserve unique genotypes. Better climatic environments could be available now or in the future at Melbourne Gardens to safeguard these specimens through networked metacollections. | |

4

# Eucalypt

## Taxonomic and Evolutionary Collection

**Purpose**
To display, interpret and research the unique adaptations, diversity, and history of eucalypts, including *Eucalyptus, Corymbia* and *Angophora* taxa.

**Description and Overview**
Scattered across the landscape, with a focus around Eucalypt Lawn in the Gardens' south–east corner, eucalypts are the quintessential Australian tree and part of the indigenous flora of the site. Ancient eucalypts have been found as 52–million–year–old fossils from Patagonia, South America. Today, the group of plants known as eucalypts are often perceived as the epitome of the Australian vegetated landscape with almost 900 species. The term 'Eucalypt' includes three closely related genera: *Angophora, Corymbia* and *Eucalyptus*. Nearly all eucalypts are endemic to Australia, except for four species from Timor and *Eucalyptus deglupta* (Rainbow Gum), which extends into Papua New Guinea, Indonesia, and the Philippines.

In the Gardens, the remnant Lions head Tree (*Eucalyptus camaldulensis*) is one of the oldest in the Gardens, with a possible age of up to 400 years. Mueller was keenly interested in eucalypts, collecting over 600 specimens of 130 taxa across Australia and describing around 90 new species. The origin of the actual **Eucalypt Collection** may be in 1875, when the Eucalypt Lawn was dedicated as an area for planting of these species, but there were probably other plantings already established, as well as the deliberately retained indigenous specimens.

Despite the commonality of their name, eucalypts are highly diverse with an amazing array of bark types, inflorescences and fruits, and plant forms ranging across the archetypical, single–trunked tree to multi–trunked 'mallees' with branches arising from a central lignotuber and 'marlocks' which are single trunked but shrubby in appearance.

Eucalypts may be one of Australia's most successful 'exports', as this widely travelled plant group is grown for ornamental purposes, timber and oil in plantations right around the world. This global spread has come with some detrimental effects such as invasiveness and increased fire risk. Due to their climatic distribution eucalypts provide many choices for future gardens and landscapes, including a wide variety of smaller, highly ornamental taxa for home gardens.

**Experiential Aims**
The eucalypts, a group that for many evoke the essence of Australia, have become ubiquitous around the world. As well as exploiting the many products of these trees, communities are now turning to eucalypts to help adapt their landscapes to a changing climate. The **Eucalypt Collection**, comprising the genera *Corymbia, Angophora* and *Eucalyptus*, presents a selection of the extraordinary genetic diversity still present in Australia. You'll find them on the Eucalypt Lawn and throughout the Gardens.

**Collection Targets: Maintain**
— Increase plant diversity, climate resilience and wild–collected provenance

— Display, interpret and research key characteristics and biogeography of *Angophora, Corymbia* and *Eucalyptus*.

**Other collection relationships:**
Australian Forest Walk, Australian Rare and Threatened Species.








| Collection Snapshot | |
|---|---|
| **Accessions** | **246** |
| **Families** | **1** |
| **Genera** | **3** |
| **Taxa**<br>Taxa with distributions assigned is approximately 95% | **101** |
| **Wild Source**<br>The percentage of wild–source accessions is lower than current targets | **15%** |
| **Rare and Threatened**<br>Representation of rare and threatened taxa at 25% is high – likely due to cross over with the Australian Rare or Threatened Collection | **25%** |
| **Identification Verified (ID3)**<br>Verified identification at 46% of accessions is almost on target. | **46%** |
| **Heritage Value** | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **15.2°C** |
| Estimated mean annual precipitation of collection's natural range | **842 mm** |
| The mean temperature risk ranking by 2070 for current holdings is low–moderate (yellow). While the climatic values may suggest some vulnerability, eucalypts grow over a wide breadth of climatic envelopes and present many choices for representing the collection. About half of the current taxa are ranked in the green to yellow level of risk. The estimated precipitation requirements are moderate. Coverage of climate risk assessments for this collection is 90% of taxa. | |

4

# Palm

## Taxonomic and Evolutionary Collection

**Purpose**
To display and interpret the adaptations, diversity, and unique features of Palms (Arecaceae family).

**Description and Overview**
Scattered throughout the Gardens, with a concentration near Fern Gully on Palm Lawn, the **Palm Collection** represents one of the world's most widely recognised plants. Globally, the distribution of palms covers all tropical and sub–tropical regions, and extends into Mediterranean, temperate and semi–arid environments, including across mainland Australia.

Although the structure of a palm is simple and repetitious, there is still extraordinary morphological variation. Leaf form alone is incredibly diverse, but trunks also vary from single, to multi–trunked, or even branching in the case of the *Hyphaene* genus. Being monocots, palms do not produce true wood. All growth in these plants is primary, from the apical meristem, and therefore past a certain point stems do not widen with age. Palms have been used in myriad ways by various human cultures throughout history, and many communities are still reliant upon them today.

In Melbourne, a fascination with palms led to the construction of a 'spacious and elegant palm house' by Mueller around 1859. Mueller's Palm House drew attention when the maturing specimens broke through the roof, and it appears that many of these specimens were distributed into the landscape by William Guilfoyle. Guilfoyle was particularly interested in palms for their foliage diversity, graceful flowering, and tropical origins, and in 1873, raised thousands of seedlings. In 1880, a Palmetum (possibly the Palm Lawn) was established at the upper end of Fern Gully.

Today, palms are found across the landscape, with a focal site still located in the Palm Lawn. As a legacy of Guilfoyle's interest, palms are a significant part of the landscape character of Melbourne Gardens. From a future temperature rise perspective, there is scope to diversify the collection. There are also known gaps in ex situ collections of generally tropical species in botanic gardens worldwide. Within this context, adding to palm diversity in the Gardens bears consideration.

Like cycads and oaks, palms are 'exceptional species' not suited for seed banking and the Gardens can play a role in conserving unique genotypes at threat from changing climatic conditions through collaborative development of metacollections.

**Experiential Aims**
Roaming amongst the **Palm Collection** every visitor will feel a sense of nostalgia, evoking either home or holiday, for palms exist on every continent except Antarctica. Guilfoyle is responsible for planting many of the older palms, using their form and shape to give a distinct character to the Garden. Many new species have also been introduced. Quite the attention seekers, palms take out honours with largest leaf, as the largest monocotyledon, and a wide distribution. Their cultural significance for food, fibre, and building cannot be understated.

**Collection Targets: Develop**
— Increase taxa diversity and wild–collected provenance through partnerships with other botanical institutions and collecting trips

— Consider expansion of a central collection area to include the current Grass Garden area








— Identify suitable microclimates (such as Lake and Fern Gully creek margins) to better incorporate species with specific microclimate requirements

— Develop interpretation resources to highlight the traditional and current ethnobotanical uses of palms and also risks to natural populations (Asia, Central America, Australia).

**Other collection relationships:**

No related collections, but palms are dominant in Fern Gully and this area could be used to increase diversity for the **Palm Collection** while supporting the growing environments for ferns.

| **Collection Snapshot** | |
|---|---|
| **Accessions** | **734** |
| **Families** | **1** |
| **Genera** | **28** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 85% | **66** |
| **Wild Source**<br>The percentage of wild-source accessions is very low, and well below targets | **1%** |
| **Rare and Threatened**<br>The representation of rare and threatened taxa is higher than current targets | **21%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is below current targets. | **39%** |
| **Heritage Value** | **Outstanding** |
| **Climate Suitability Guide** | |
| Estimated mean annual temperature of collection's natural range | **20.6°C** |
| Estimated mean annual precipitation of collection's natural range | **1380 mm** |
| The temperature risk ranking by 2070 is low (green) and the estimated precipitation requirements are high. Coverage of climate risk assessments for this collection is 88% of taxa. | |

4

# Quercus

**Purpose**
To conserve, display and interpret the diversity, unique features, and ethnobotanical attributes of the genus *Quercus*.

**Description and Overview**
Centered around the iconic Oak Lawn, the **Quercus Collection** is also displayed around the landscape. Worldwide there are over 430 species of oaks,[xi] primarily across the Northern Hemisphere, but with incursions into the Southern Hemisphere in South–East Asia. Oaks are found as the dominant element in a diverse array of habitats, from temperate deciduous and evergreen forests to subtropical and tropical savannas, cloud forests, tropical montane forests and tropical jungles, and the Mediterranean vegetation in both the Old and New World. While most oaks are large trees growing 20–30 metres tall, the genus also includes many small and large shrubs.

One of the earliest references to *Quercus* species in the Gardens was during Mueller's time; around thirty were planted by 1862 in an area somewhere south of Gardens House, possibly Oak Lawn. Other mentions include during Guilfoyle's significant tree transplanting program in his first year as Director in 1873.

Oaks have fascinated people for generations and have deep cultural associations. Being common, dominant, and long–lived, oaks have a long and well–documented presence in the cultures and histories of the Northern Hemisphere. Known for their majesty, supply of food (acorns) and timber, many historically significant events are noted as having taken place beneath oak trees.

Oaks are often considered as keystone species in many ecosystems and are found in many habitat types across Asia (mostly China), Europe, North Africa, and North America. Of serious concern, about 30% of the known *Quercus* species are threatened with extinction due to (in order of most severe) land clearing for agriculture, forest logging, residential and commercial development, climate change, and pests and diseases – amongst other stresses. Acorns are also exceptional seeds which cannot be stored in traditional seed banks, increasing the importance of ex situ populations.

**Experiential Aims**
To rest in the dappled shade of a grand old oak is a wondrous thing. The **Quercus Collection** is a highly valued character of the Gardens. Revered for thousands of years in their countries of origin, oaks symbolise strength, endurance, and wisdom. On a practical level, oaks have contributed a great many products for shelter, transport, food, medicine, and industry. They are the keystone species in many ecosystems, supporting a plethora of birds, mammals, and insects. While grown throughout the Gardens, most of the older, larger oaks are on Oak Lawn.

**Collection Targets: Maintain**
— Increase plant diversity, climate resilience and wild–collected provenance

— Develop stronger ex situ conservation outcomes through partnerships and metacollection development, particularly through the Global Oak Conservation Consortium.

**Other collection relationships**
The distribution of Quercus species provides links to Southern China and the North American Drylands.

xi Cyclobalanopsis has been treated as a subgenus of Quercus and is included in the Quercus Collection. There are about 150 species, mostly in tropical–subtropical Asia.








| Collection Snapshot | |
|---|---|
| **Accessions** | **116** |
| **Families** | **1** |
| **Genera** | **2** |
| **Taxa**<br>Taxa with distributions assigned (including Garden Origin plants) is approximately 89% | **73** |
| **Wild Source**<br>The percentage of wild–source accessions is below current targets | **11%** |
| **Rare and Threatened**<br>The representation of rare and threatened taxa is slightly lower that current targets | **8%** |
| **Identification Verified (ID3)**<br>Verified identification of accessions is above current targets. | **59%** |
| **Heritage Value** | **Outstanding** |

| Climate Suitability Guide | |
|---|---|
| Estimated mean annual temperature of collection's natural range | **13.9°C** |
| Estimated mean annual precipitation of collection's natural range | **935 mm** |
| The temperature risk ranking by 2070 is moderate (orange) and the estimated precipitation requirements are moderate. Coverage of climate risk assessments for this collection is 84% of taxa. While there is a moderate climate risk, there are prospects to improve this rating by the introduction of warmer climate taxa particularly for ex situ conservation<br><br>Quercus spp. are considered as 'exceptional species' not suited for seed banking and need to be grown in living collections. Some threatened *Quercus* spp. may already be vulnerable to changing climatic conditions in their natural habitat and or current ex situ collections and Melbourne Gardens could provide a better growing environment now, or in the future, to safeguard these plants. | |


*Colletia paradoxa*, native to Argentina


*Taxodium mucronatum* native to Mexico

## 4.5. Proposed New Collections

In addition to the above collections, a number of potential new collections have been identified. These collections could assist Royal Botanic Gardens Victoria's international conservation efforts and increase the climate resilience of the holdings. While five potential new collections are highlighted below, others may be also be identified in the future and it is anticipated that new landscape projects may generate additional Ornamental and Cultural Collections, including the proposed Nature and Science Precinct.

### Argentina / South America

**Geographical Collection**

**Strategic Direction**
Investigate as potential new collection or collections.

**Rationale**
There are 1070 accessions and 376 taxa in the current holdings of South American flora, which potentially provides the basis for a significant geographic collection. From a future temperature perspective, the climate suitability of these holdings compares well to other geographically themed collections in the Gardens.

There are 84 Argentinian taxa in the Melbourne Gardens holdings, and in Argentina a large area of potential high climate suitability has been identified (second largest potential collecting area after Australia).

### Mexico

**Geographical Collection**

**Strategic Direction**
Investigate as potential new collection.

**Rationale**
There are 774 accessions and 265 taxa from Mexico in the current holdings, which potentially provides the basis for a significant geographic collection. From future temperature and precipitation perspectives, the climate suitability of these holdings is excellent. For future accessions from Mexico, a large area of potential high climate suitability has also been identified.


*Nepenthes lowii x veitchii*


*Ficus dammaropsis*

## Tropical Flora

**Geographical / Ornamental and Cultural Collection**

**Strategic Direction**
Investigate as potential new collection.

**Rationale**
There are known gaps in worldwide conservation of tropical flora, with relatively low proportions of these plants held in botanic gardens. There is potential to increase the landscape holdings as there are already around 150 taxa growing in the Gardens that can be readily identified from tropical climates. Further, there are approximately 500 taxa originating from climates warmer than a mean annual temperature of 19°C. A proposed Lakeside Conservatory could also provide opportunities to showcase tropical plants and support their conservation.

## Herbarium Systems Garden

**Ornamental and Cultural Collection**

**Strategic Direction**
Investigate as potential new collection in conjunction with the Nature and Science Precinct project.

**Rationale**
The proposed Nature and Science Precinct will provide a new gateway to the Gardens and be the main entrance for many of the Gardens' visitors. There is potential to develop a contemporary take on a Systems Garden as part of this project, providing a tangible, plant–focused interpretation of the work of the National Herbarium of Victoria.

## Ficus

**Taxonomic and Evolutionary Collection**

**Strategic Direction**
Investigate as potential new collection.

**Rationale**
There are 33 *Ficus* taxa currently grown in the Melbourne Gardens and analysis has revealed that the genus has a high suitability for Melbourne's projected future climate. With over 800 species of Ficus, they are one of the largest flowering genera in terms of taxa and are of significant cultural and economic interest. With their large, green leaves and iconic forms, Ficus species form a signature part of the Melbourne Gardens landscape character.

## Salvia

**Taxonomic and Evolutionary Collection**

**Strategic Direction**
Investigate as potential new collection.

**Rationale**
Over 102 *Salvia* taxa are already cultivated in the Gardens, many of which are climate suited and currently perform well. Salvias are well represented in existing geographic collections such as Southern China, Southern Africa, and the North American Drylands. The Herb and Medicinal Garden also contains salvias, and these have high interpretation value.

5

Melbourne Gardens Horticulturist on a collecting trip in far north Queensland

# Collection Priorities

The following Collection Priorities will direct the management of the Melbourne Garden's living collections over the next 20 years. These are grouped under four high level strategies, followed by more detailed targets and associated actions. These priorities are based on analysis of the existing living collections and have been developed to align with state, national and international priorities regarding plant conservation, engagement, and sustainability.

Strategies 1 and 2 contain the greatest challenges and opportunities and are expected to provide the botanical drivers of plant conservation, diversity and protection that inform the other Strategies. Strategy 3 looks to reimagine learning and public engagement, while Strategy 4 underpins all collections works, and addresses the foundational investment in professional development, capacity building and continuous improvement. More comprehensive information relating to these directions for the living collections can be found in the relevant sections throughout this document.

| Action | Timing (Years) | | |
|---|---|---|---|
| | Short 0–5 | Medium 6–10 | Long 11–20 |
| **Strategy 1: Establish living collections with increased plant diversity and future climate resilience** | | | |
| **Target:** By 2041, evaluate and develop collections that are more climate–ready and well matched to their respective criteria and themes than the 2020 baseline. | | | |
| Evaluate and develop new climate–suited collections and increase representation of resilient taxa compared to 2020 baseline. | | continuing | |
| Achieve an average annual increase of 120 climate–suited taxa to overall holdings, comprising at least 75% wild sourced taxa. | | continuing | |
| Comply with international agreements, biosecurity regulations, internal weed risk assessment evaluations and relevant documentation for all applicable plant introductions. | | continuing | |
| Develop reports in the Living Collections Database to produce an annual score card that generates collection metrics readily compared to international benchmarks for: total taxa, new introductions, wild–collected, rare and threatened, climate suitability and identification status, etc. | | continuing | |
| Audit all collection records to maintain greater than 90% accuracy between living specimens, the Living Collections Database and GIS maps. | | continuing | |
| Evaluate and review of all Collection Management and Action Plans (minimum of five per annum). | | continuing | |
| Audit and update the Australian, Exotic, and Rare & Threatened tags in the Living Collections Database. | | Annually | |
| Investigate the potential to develop or expand climate–matched biogeographic collections, focusing on potential regions within Australia, Argentina, Mexico, Southern Africa, and the USA. | | | |
| Review and prepare policies and procedures on Access and Benefit Sharing, including improving the efficient traceability of supplied and received material. | | | |
| Investigate RBGV membership of the appropriate plant exchange networks or comparable mechanisms for sharing genetic material. | | | |
| Develop agreed criteria to support decisions for deaccessioning low value taxa, including the removal of non–accessed plants in collections. | | | |
| Increase accessions with Identification 3 (ID3) status from 39% to 50% (approximately 270 additional per annum).[xii] | | | |
| Plant diversity is equal to or greater than 8,000 distinct taxa with at least 35% wild provenance–sourced plants. | | | |
| Increase tropical plant biodiversity within the overall collections, including threatened taxa. | | | |
| Improve documentation and representation within the collections of non–vascular cryptogams such as mosses, hornworts, liverworts, and lichens, including better storytelling of their role within the plant kingdom. | | | |
| Aim to phylogenetically characterise all species of known provenance within the living collections to increase phylogenetic diversity for long–term research. | | | |

xii Or rationale is documented for exclusions (e.g., lack of maturity, non–flowering, difficult species, poor literature, etc)

Horticulturists protect ex situ collections by propagating and replanting short lived species

| Action | Timing (Years) | | |
|---|---|---|---|
| | Short 0–5 | Medium 6–10 | Long 11–20 |
| **Strategy 2: Support and implement local and world plant conservation priority programs with a particular focus on the Global Strategy for Plant Conservation (GSPC)** | | | |
| **Target:** Increase collaboration between Melbourne Gardens and Science divisions, and botanical institutions worldwide for improving plant biodiversity; support local and global targets for plant conservation programs of threatened species. | | | |
| Integrate ex situ plant conservation with relevant Plant Science programs to improve collaboration between in situ and ex situ plant conservation targets. | | continuing | |
| Enhance the State Botanical Collection through an increase of known provenance specimens in the living collections which represent voucher herbarium specimens, while supporting a comprehensive online flora. | | continuing | |
| Support the maintenance of ex situ specimens of all known Victorian species of terrestrial orchids along with their mycorrhizae. | | continuing | |
| Protect ex situ gene pools for collections specimens of wild–sourced provenance and rare and threatened taxa by working closely with local government and other botanical organisations. | | continuing | |
| Conserve rare and threatened species not suitable for Melbourne's climate through seed banking/preservation techniques and/or are transferred to other botanic gardens and agreed partners. | | continuing | |
| Improve messaging of plant conservation through learning programs and collections interpretation. | | continuing | |
| Increase the diversity of rare and threatened species to at least 10% of taxa holdings (with the aim of 15% of holdings). | | | |

Wild collected native cuttings in propagation

The Working Wetlands treats the stormwater harvested and collected in the Gardens, and benefits from regular maintenance

| Action | Timing (Years) | | |
|---|---|---|---|
| | Short 0–5 | Medium 6–10 | Long 11–20 |
| **Strategy 3: Improve public understanding of the living collections and the vital role plants play in supporting life** | | | |
| **Target:** Demonstrate that effective learning, interpretation, storytelling and programming leads to an increase in public awareness of conservation action and a more nature–focused Victorian community. | | | |
| Evaluate the impact of learning programs, programming and interpretation activities connected to the living collections. | continuing | | |
| Support interpretation and storytelling about the living collections and trial new methods to communicate plant–based information. | continuing | | |
| Share results of adaptive management, research, subject matter expertise and trials. | continuing | | |
| Deliver at least three public or professional presentations per annum. | continuing | | |
| In line with an Interpretation Framework and social marketing approaches, provide compelling stories about the collections via traditional and emerging media. | | | |
| Develop detailed learning and interpretation themes for Collection Management Plans. | | | |
| Consider development of temporary (or discretionary) collections/ displays to provide information on current interests or engaging plant stories. | | | |
| **Note:** As the delivery of interpretation projects and learning programs sits with the Engagement and Impact Division, this section is to be read in conjunction with relevant Engagement and Impact strategies and plans. | | | |

| Action | Timing (Years) | | |
|---|---|---|---|
| | Short 0–5 | Medium 6–10 | Long 11–20 |
| **Strategy 4: Pursue excellence in horticultural and landscape management for living collection curation** | | | |
| **Target:** Horticultural excellence through continuous improvement in living collection curation and pioneering curatorial practices, research, and monitoring. | | | |
| Facilitate Curators' professional development through scholarships (aim of one per annum) and other methods to increase subject matter expertise and better inform collection's decision making. | | continuing | |
| Support Curator participation in field collection trips and local, national and international forums where they correspond with collections priorities. | | continuing | |
| Target staff presentations and articles for various media (aim of three per annum). | | continuing | |
| Foster relationships with tertiary institutions focussed on collections management (aim of at least one post–graduate research project per annum). | | continuing | |
| Undertake continuous improvement research, such as landscape water management and collections relevant climate adaptation (aim of at least one active research project per annum). | | continuing | |
| Incorporate soil analysis and testing within living collections management (all collections tested within a rolling five–year program). | | continuing | |
| Invest in an annual plant nutrition program to remediate the significant nutrient deficiencies of the landscape. | | continuing | |
| Continuously improve collection records through current and emerging technology. | | continuing | |
| Develop staff resourcing plans and career successional pathways with a focus on living collections curation. | | | |
| In consultation with curation staff, document curation standards that correspond with collection priorities and available resources. | | | |
| Develop processes for introducing, growing and establishing new taxa. | | | |
| Develop a Landscape Soil Health Strategy. | | | |
| Develop a curation module within the Living Plant Collections Database to record heat and climatic impacts on taxa, and capture specialist knowledge on plant performance, tolerances, and management techniques. | | | |
| Document best practice and scientifically based methodologies for improved vegetation management to attain healthy, diverse, mixed–age communities. | | | |

6

The Oak Lawn in spectacular autumn display

# Considerations for Collection Development

Melbourne Gardens Living Collections Plan is intended to guide the development of the living collections, to support national and international plant conservation programs, and to provide for the ongoing management and care of the Gardens and its scientific collection of plants. This care inevitably brings challenges, especially when dealing with a changing climate, a heritage garden, and the complexities in complying with plant acquisition and quarantine protocols. The following chapter outlines the challenges faced by the collections and the issues which will need to be considered in their management and development.

## 6.1. Climate Change

Climate change arguably presents the greatest challenge for the management and health of the living landscape of Melbourne Gardens. Under current climate scenarios, Melbourne's climate is predicted to become hotter and drier, with an increased probability of extreme weather events including heat waves and flooding.

Three reports have been used to guide Royal Botanic Gardens Victoria's assessment of climate risk. The first, *'Assessment of the climate change risk to the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria'*[23] primarily assesses the risk from rising temperatures, with *'Projections for selected Australian cities, CSIRO and Bureau of Meteorology, Australia'*[24] and *'Greater Melbourne Climate Projections 2019'*[25] including additional parameters and climate zone shifts. The first report assesses risks to a 2070 baseline and incorporates an estimate for urban heat increase, whilst the other reports provide projections to 2090.

The 2017 Kendal and Farrar report predicts a potential increase in the mean annual temperature for Melbourne City from 15.9°C (1986–2005 mean) to 19.3°C by 2070. This could place significant strain on the collections, as over 6,000 taxa in Melbourne Gardens have been modelled as originating from mean annual temperature conditions of less than 15.1°C – excluding 745 taxa in glasshouse cultivation. Melbourne's historic mean annual temperature from 1856 to 1950 was 14.7°C. However, the mean annual temperature in the last thirty years has been about 16.2°C


Climate Assessment of Melbourne Gardens undertaken in 2017 by Kendal & Farrer

The potential impact of rising temperatures is alarming. Research has indicated that the correlation for natural and urban plant distributions may be more strongly related to temperature than precipitation.[27] [28] Other research has correlated tree losses with changes in temperature linked to urban heat and global warming.[29] Over the period 1970–2011, Feeley et al. (2020) report on a study that analysed millions of records for thousands of species in plant communities within North, Central and South America and found a trend of increasing heat–tolerant species. A rise in mean temperatures also increases the probability of more extreme heat and associated heatwaves which have caused worldwide forest mortality,[30] [31] especially when combined with droughts.[32] [33] It is projected that Melbourne could have up to about twice as many more days over 35°C (from 8.3 to 16 days under a RCP8.5[xiii] scenario and four times as many days over 40°C (from 1.6 to 6.8 days under RCP 8.5).[34]

Sustainable water management is also challenged by climate change, with predicted future reductions in natural precipitation. Under the 'intermediate' (RCP 4.5) and 'business as usual' (RCP 8.5) climate change scenarios, median values of precipitation for Melbourne are projected to decrease by 8–20% and pan evaporation increase by about 19–34% respectively. The median annual rainfall for the 1986 to 2005 baseline period is about 631 mm. Even under the 'intermediate' scenario, demand for annual irrigation could increase by about 27 per cent (and this might rise to over 50 per cent under a 'business as usual' scenario).

The latest Australian State of the Climate 2020 report also indicates that since the 1990s there has been a rainfall decline in southeast Australia of approximately 12% for April–October,[35] and this could be exacerbated by future climate change, with reductions projected for the cooler seasons of the year. Spring could be subject to the worst scenarios with reductions ranging from 18–30%. These changes to rainfall particularly impact current stormwater harvesting schemes in Melbourne Gardens as the cooler periods are typically when lake systems are initially recharged for the next irrigation season.

xiii RCP 8.5 – stands for a Representative Concentration Pathway from Global Climate Models that represents a 'business as usual' emissions scenario. RCP scenarios were published by the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). Under the sixth IPCC report use Shared Socioeconomic Pathway 3, SSP3.

*Syzygium moorei* – a ramiflorous rare species from a restricted population in northern NSW and suited to Melbourne's current and future temperature regime

Increases in temperature are also likely to impact on the physiology of plants and their effective water usage. For example, it is suggested that global warming will tend to amplify Vapour–Pressure Deficit (evaporative demand) stress on plants,[36] which in turn can increase the risks of carbohydrate starvation and or hydraulic failure.[37] This may occur regardless of soil–water balance, meaning additional irrigation may not be able to rectify these problems. Combined, these stressors may also interact with pest incursions to exacerbate plant decline.[39]

Risks from increases in mean temperature and associated extremes from climate change and urban heat are considered more formidable to manage than precipitation deficits and are anticipated to impact the health of the Gardens' living collections.[40] Research undertaken by Kendal and Farrar (2017) found that under a 'business as usual'[xiv] climate scenario by 2070, approximately 26% of the current taxa in Melbourne Gardens is in the highest risk category from the projected mean annual temperature of 19.3°C.

Current climate change projections also indicate that it is possible by 2030, and much more likely by 2090, that Melbourne's climate with a corresponding increase in mean temperature of its hottest month (February) from 21.3°C to greater than 22°C will subsequently shift from its current Köppen–Geiger climate classification of Cfb(b) 'warm summer' to Cfa(a) 'hot summer' climate type, which is the current classification for Sydney.

## 6.2. Record Keeping

It is accepted that botanic gardens typically contain living collections that are correctly documented and adequately labelled to support public learning and scientific research.[41] The extent and quality of accurate plant identification recorded in the Living Collection Database is the foundation of these records. Currently, only 38% of live accessions have botanically verified identification status (ID3) and this has not improved for several years.[42] Accurate identification is needed for a myriad of purposes to inform the management of living collections, address climate change risks to taxa, note potential invasive species, support research projects, and inform global plant conservation programs. For as American Conservationist Dian Fossey said, "*one of the basic steps in saving a threatened species is to learn about it*". In the meantime, management decisions are based on the assumed identification of taxa in the holdings and the accuracy of these needs to be improved.

Accurate plant identification is obviously linked to identifying the geographic distribution of taxa in the collections. Known distribution helps inform the level of taxa diversity in geographic collections – even if it is only at country or regional levels. About 60% of current taxa in the collection are of known natural distribution. Taxa classified as Garden Origin – that is cultivars – make up another 20% and the remaining 20% of taxa have an unknown distribution. The accuracy of these assignments is complicated by non-verified or partially verified taxa (ID1 to ID2) that have been allocated distribution information and this could be erroneous when identification is verified.

xiv RCP8.5 – Representative Concentration Pathway (produced by the Intergovernmental Panel on Climate Change) now refers to the Shared Socioeconomic Pathway 3, SSP3 and its associated temperature rise.

Botanists use stored voucher specimens in the Herbarium to confirm the identification of plants

Horticulturists on a collection expedition out in the field

Climate risk assessment analyses are currently available for about 75% of collection's taxa, forming another area for improvement to better understand the landscape vulnerability to climate change. Work is underway through the Climate Change Alliance of Botanic Gardens to improve the risk estimation of these assessments, and this will likely be a continuing matter for attention. The risk assessment categories also have similar issues with non-verified taxa as previously discussed.

Regular inventories in the field are required to maintain accuracy of the living collections records. Matching of living specimens with actual database records is an ongoing and vexing challenge. Currently, arborists and horticulturists work with the Gardens Information Officer in the field to check and update Geographic Information Systems (GIS) maps. While significant improvements have been made to check the holdings more frequently, there are garden beds that have not been checked for several years. Solutions include the adoption of current technology to streamline data capture, more timely maintenance of plant record updates (planting sheets and death/removal records), and additional resources to support updates. Developing systems that incorporate handheld devices with real-time connection back to the Living Collection Database would improve recording efficiency. Integration between the Living Collection Database and Geographic Information Systems would assist plant record management and decision making in the field.

## 6.3. Plant Availability

The Landscape Succession Strategy sets out targets to increase plant diversity to 8,400 taxa (currently around 7,500) and a proportionate increase of wild-collected provenance taxa to 35% (currently 18%) by 2036. Sourcing new plants which fit these criteria is complex due to Australia's stringent, yet necessary, quarantine requirements and the need to comply with international treaties on the exchange of genetic material. Options for increasing botanic diversity are described below, and in order of priority and ease of access are as follows:

- Collecting plant propagules directly from habitat (Australian flora)
- Sourcing wild-collected clonal material from other botanic gardens within Australia
- Obtaining new taxa from overseas locations.

Regardless of the collection source, national, state, and local quarantine regulations still need to be reviewed prior to any collection and transfer of plant material across biosecurity control zones.

Australian *Ficus macrophylla* subsp. *macrophylla* a species with potential future climate resilience which also offers high landscape quality

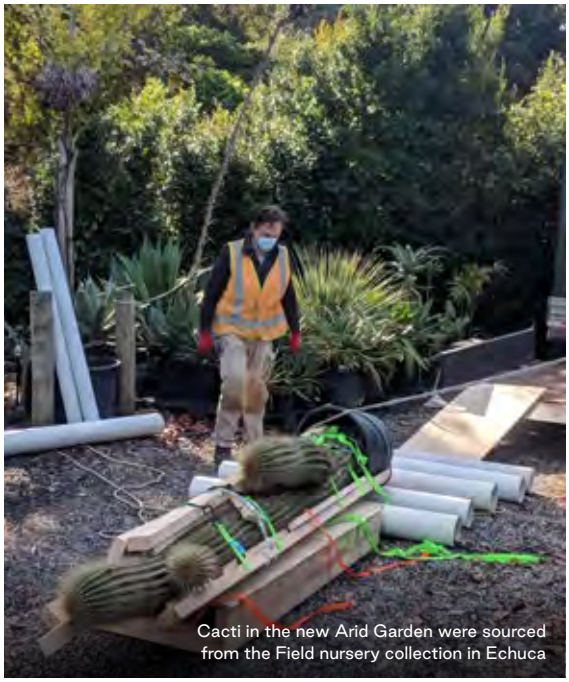
### 6.3.1. Australian flora

Acquiring Australian–sourced plant material is comparatively straight forward compared to accessing international sources. While internal quarantine regulations and plant sharing protocols still need to be followed, there are considerably less barriers and compliance protocols than those which exist for international material. Furthermore, research by Royal Botanic Gardens Victoria's horticultural curatorial team has indicated a strong basis and valuable prospects for improving wild–sourced holdings of Australian native plant diversity.

Many of the landscape's signature Australian trees have already been identified as suited to a future climate including those from Araucariaceae, such as Agathis and Araucaria species, Malvaceae, Brachychiton species, and from Moraceae, the Figs (Ficus). In all, around 48% of the trees in Melbourne Gardens are Australian and contribute significantly to the landscape qualities and botanical values of the Gardens.

Collection of Australian flora requires possession of a collecting permit and/or Prior Informed Consent of the land holder. Within Victoria, RBGV holds a State–wide collection permit that applies to all National Parks and areas managed under the *National Parks Act 1975* and *Crown Land (Reserves) Act 1978* but excludes Reference Areas. As conditions can change, it is recommended that RBGV Science staff be consulted as to current regulations, prior to planning any collection of native flora. Other considerations that must be reviewed include Australian interstate quarantine regulations which govern the transport of plant material across state and regional boundaries.

"Prior Informed Consent" means a collector has received official permission by the national authority of the relevant Country, and any other appropriate stakeholders (such as Traditional Owners), prior to accessing plant material. In best practice this also applies to collection of material from within Australia, where the landholder has been fully informed, in writing, as to the purposes of the material collection, has agreed to this, and has provided prior written permission for the material to be collected.



Cacti in the new Arid Garden were sourced from the Field nursery collection in Echuca

*Quercus engelmannii* acorns obtained through international plant transfer processes

## 6.4. Exotic Flora from within Australia

Regarding exotic plant material, accessing material from other botanic gardens within Australia is generally the easiest proposition, although not without complexity. Most difficult of these challenges to overcome is the lack of exotic flora within Australia which have clear wild provenance details and are climate suitable for the living collections. Put simply, many of the plant species which are most suitable are not currently within Australia. Further, obtaining quality, wild–sourced propagules rely on collecting directly from wild populations, or alternatively, from confirmed first generation, clonal vegetative material of wild–sourced plants now in cultivation. Propagation from seed brings the risks of hybridisation, regardless of whether the seed is sourced from cultivated sources or natural habitat, and higher risks of 'genetic drift' from the original material . The transfer of plant material often requires Material Transfer Agreements to be developed between the supplier and recipient botanic gardens, stipulating the terms and conditions for transferring specimens or samples, including genetic material. Documentation of these agreements is considered best practice. As for native material, compliance with interstate quarantine is also required.

### 6.4.1. International Plant Material

For international sources of plant material, there are additional intricacies such as observance of international treaties, Material Transfer Agreements, more stringent quarantine requirements and additional costs. The Australian Department of Agriculture, Fisheries and Forestry manage international quarantine and provide resources such as the Australian Biosecurity Import Conditions (BICON) Database, allowing an 'importer' to pre–assess the conditions and requirements of a given commodity, including plant material.

The Department of Agriculture Fisheries and Forestry also produce a 'Permitted Species List' for Australia. Plants that are on this list often do not require an import permit, especially if the proposed import is seed for sowing. However, compulsory inspections and, occasionally, fumigation treatments can escalate costs. New taxa that are not specified on the Permitted Species List require prior completion of a 'New Plant Introduction Form' and evaluation by Department of Agriculture, Water and Environment, including a weed risk assessment that can take up to twelve months, after which the species may still be rejected. Asexual propagation material (for micro propagation, cuttings or grafting) has higher risks of transferring pests and diseases than seeds and subsequently incur more regulation and treatment conditions.

Figure *Phytophthora asparagi* damaging highly susceptible *Agave attenuata*

## 6.5. Biosecurity

The threat of pest incursions that result in significant damage to the living collections is currently ranked as a high strategic risk by Royal Botanic Gardens Victoria's Risk Management Framework. This can include all manner of potential sources of disease and infestation which impact plant health including bacteria, fungi and similar organisms, insects, mites, nematodes and phytoplasmas, and viruses. These risks are heightened by the greater movement of people and materials through an increase in globalisation.[44] For example, problems with the spread of *Phytophthora* spp. and other serious diseases in Europe and North America have been linked to the movement of plant materials through associated industries.[45] This risk is only expected to intensify with the projected number of visitors to the Melbourne Gardens, based on pre-pandemic calculations, predicted to increase 67% to 2.5 million people by 2036.[46]

In 1997, an outbreak of what was thought to be Fireblight (*Erwinia amylovora*) in Melbourne Gardens resulted in the removal of host Rosaceae taxa, including wild-collected plants. While the Fireblight scare was a false alarm, other incursions have not been. Since this time, Melbourne Gardens has been the first recorded site at either State or National level for other pest incursions. One of these examples is a devastating disease of Agave species; *Phytophthora asparagi* (syn P. aff. *megasperma*), causing severe damage to many specimens, including wild-collected material, and continuing to be a management concern.[47]

There are numerous pest threats that can disrupt collection development. The most serious risks tend to be presented from polyphagous pests and can be a direct threat to the health of current collections or can complicate plant importation and quarantine measures.[xv] For example, Xylella fastidiosa is an exotic bacterium currently afflicting over 360 plant species across the Americas, Caribbean, India, Iran, Europe, Lebanon, Taiwan, and Turkey, emerging as one of the world's greatest disease threats to plant health. This pest is readily transmitted though cutting materials (but not by seeds), so international access to propagule material for susceptible species is reduced.[48] Other examples of polyphagous exotic pests that could directly threaten Melbourne Gardens' collections include airborne *Phytophthora* species such as *P. ramorum*, Brown Marmorated Stink Bug and Gypsy Moths.

Plant biosecurity at Royal Botanic Gardens Victoria is guided by detailed policy and procedures that can be accessed by all staff. For day-to-day collections management, the Living Collections Database also contains a pest management module, and this can be used by curators to record new incursions, note control programs, and monitor the occurrence of existing pests and diseases. RBGV is also a member of the International Plant Sentinel Network, which operates on the perspective that a network of botanic gardens can act as early warning systems for new pest incursions and share expertise to safeguard plants worldwide. Agriculture Victoria also makes regular use of the diversity of the living collections for passive surveillance of exotic pests that may enter the country, which highlights another important value of the living collections in assisting in the protect the environment and plant-based industries of Victoria and nationwide.

xv Polyphagous refers to diseases which infect a broad range of plants, sometimes across plant families

Staff learning about fungi from a Principal Research Scientist (Mycologist)

## 6.6. Professional Development

Botanical authors champion the role of horticulturists and curators in the field of 'botanical or conservation horticulture' and the importance of supporting professional development in botanic gardens.[49 50] Successful collection development is inextricably linked to the expertise of the horticultural curator managing that specific collection. As such, professional development should be viewed as essential to achieving the objectives of a given collection. Over the last few years, it has been observed that horticultural curators have contributed significantly to the success of international ventures such as the Climate Change Alliance of Botanic Gardens, and have effectively engaged in discussions that included donors, senior executives, and scientists from other organisations. This horticultural capacity to engage at multi-disciplinary and varying seniority levels is a strength to build upon for richer collections development.

Development of subject matter expertise, and ultimately the development of the specific living collection, can be challenged if the number of collections outstrips the number of curators. Multiple collections might be plausibly 'maintained' by one curator, but development could be impaired. Options for addressing this problem include prioritising certain collections, decommissioning unsuitable or poor performing collections, or changing the scope of some existing categories, especially precinct-related collections.

Living Collections Plan succession pathways, and the retention of institutional knowledge are challenges, with current limitations for transferring subject matter and career expertise to the next generation of horticulturists. This issue poses both a reputational and practice risk to the organisation. To better support the implementation of the Plan, workforce and career succession plans need to be developed with a focus on technical support for the living collections.

In recent years staff scholarships and increased funding for staff exchange and overseas ventures have provided valuable avenues for developing respective curator expertise and access to additional plant diversity. It is initiatives such as these, along with attention to continuous improvement, which will need to be fostered within the objectives of the respective Collection Management Plans.


Typical Melbourne Gardens duplex soil profile from the Liriodendron Bed

## 6.7. Soil Management

A healthy landscape soil is the living foundation for the plant collections and their successful performance. Current practices for conserving and protecting site soils could be improved to meet best practice, as the resulting issues, especially compaction, are difficult to remediate. While there are now some promising mechanical/biological techniques available for compaction relief such as the 'scoop and dump' approach advocated by Cornell University,[51] there can be conflicts with these methods through damage to existing tree root systems.

Another problem facing the Gardens is the limited infrastructure or allocated space to manage and stockpile soils that are removed during landscape works. Subsequently, there is usually a need to replace these soil volumes, and it is currently challenging to source soils that meet acceptable quality or Australian Standards such as *4419–2003 Soils for landscaping and garden use* and or compost amendments that meet *AS 4454–2012, Composts, soil conditioners and mulches*. The *Melbourne Gardens Master Plan 2020–2040* proposes options for developing a soil recycling facility. Plans for soil investigation and management of soil health needs to continue to be embedded within the site analysis and concept design of all living collections development and landscape projects.

## 6.8. Plant Nutrition

Long term historic horticultural practices and urban pollution have changed the nutrient availability of Melbourne Gardens' topsoil. For some of the collections the soil chemical properties are still satisfactory, despite the significant imbalances in phosphorous, potassium, manganese, and zinc levels in the soil. These issues impact overall plant health and are now regarded as a strategic matter for living collections management (see Table 3).

High phosphorous and zinc levels are difficult to manage as they cannot be leached or removed effectively unless the soil media is replaced, or 'diluted' through adding other mineral components. Zinc levels in the landscape soil need to be monitored as concentrations may be increased by the Gardens' practice of using recycled urban stormwater. High phosphorous levels are already affecting plant health and have direct implications for the future development of new collections—especially those containing phosphorus sensitive taxa such as South African and Australian flora. To avoid exacerbation of these issues, fertilising practices need to be based on recommendations arising from soil testing.

Nutrient deficiencies can be remedied by fertilising programs, but some of these will need to be extensive and sustained. For example, over 10 tonnes of potassium sulphate are estimated to be needed to address current potassium deficiencies in the landscape.

Lawn specimen of *Jubaea chilensis* showing classic symptoms of potassium deficiency

**Table 3 – Significant plant nutritional issues for holdings in Melbourne Gardens:**

| Issue | Impact |
|---|---|
| Phosphorous (P) (Bray extract) levels frequently above those typically required 20–40 mg/kg.[52]<br><br>Since 2009, over 30 soils tested resulted in mean P levels of 160 mg/kg (excessive). | Reduced growth, toxicities, reduced availability of iron and manganese. Effects Adoxaceae, Arecaceae, Cycadaceae, Ericaceae, Hydrangeaceae, Theaceae and Australian genera from Fabaceae and Proteaceae.[53] |
| Potassium (K) emerging as deficient in wide areas of the landscape (possibly from substantial irrigation leaching). | Reduced growth, less tolerance of drought and pests. Arecaceae and Poaceae (Turf grasses) appear particularly susceptible to K deficiency. |
| Manganese (Mn) deficient in areas of the landscape. | Can be made less available from high phosphorous levels, and in Melbourne Gardens observed to effect on taxa from Arecaceae, Cycadaceae and Rhamnaceae. |
| Zinc (Zn) levels very high from past industrial activity and urban pollution.<br><br>Current mean values of 8g/$m^2$/100 mm depth. | Current values are 10 times what is needed for healthy plant growth. Can impact iron availability.[54] |

6


**LEGEND**

- Areas of extensive disturbance
- Deep loamy yellow duplex
- Shallow loamy yellow duplex
- Deep sandy yellow duplex
- Loamy gradational

Volunteer Meg Bentley working with the collections

## 6.9. Impact of the Global Pandemic

In late 2019 the virus eventually known as COVID–19 emerged. This led to a global pandemic, and amongst other impacts, the closure of both state and international borders, pressure on both public and private funding, and a significant shift in the profile of the Gardens' visitors. This happened across the production of the Living Collections Plan, and its full impact is as yet unknown as society is still moving through the pattern of recovery from the pandemic.

This of course is but one crisis which affects Royal Botanic Gardens Victoria, and people in general. The aim of the Living Collections Plan is to build resilience into the collections, and their work, so that this can continue under a variety of circumstances. Longer term, the living collections have an important role to play in providing people with an opportunity to connect with nature and the natural environment, something that became more valued during Melbourne's many lockdowns.

## 6.10. Public Engagement with the Collections

Like many botanic gardens around the world, Melbourne Gardens has seen a shift in recent years, refocusing its public purpose and potential to drive social change. In particular, the last decade has seen a repositioning of botanic gardens and their collections as uniquely capable of addressing and discussing pressing environmental concerns like climate change and biodiversity loss.[55] This sees botanic gardens playing an active role in reframing the relationship between people and nature, encouraging nature connection, and contributing to behavior change. An example of this approach is now included in policy within Goal 1 of the Victorian government's *Biodiversity 2037 Plan: 'Victorians value nature.'*

Researchers in the social sciences have for some time argued that to communicate environmental issues, it is necessary to appreciate and understand the complex, value–laden relationship people have with concepts like climate change and nature. Also, critical to understand is the diverse motivations people have for coming to places like botanic gardens (which may be primarily for recreation, relaxation, sanctuary), as this may differ to what botanic gardens see as their role as being (conservation, education).[56] Researchers warn that ignoring this can lead to missed opportunities for botanic gardens to connect with their audiences and visitors. These varying motivations are evident in RBGVs visitor segmentation research conducted by Precise Value in 2018. Of six stable visitor segments, a small percentage of RBGV's visitors — 16% – were defined as 'plant lovers', demonstrating an opportunity for engaging visitors more deeply in the stories of plants and conservation.

Engagement and storytelling in the Herb and Medicinal Garden with the collection's curator

There are challenges for all botanic gardens in communicating the mission and purpose of their collections. Unlike zoos and museums, where learning can be a motivator for visitation, research has shown visitors are less motivated by learning opportunities when visiting botanic gardens. For the average visitor entering the Gardens, it may not be immediately apparent what makes a botanic garden different to a park, and the concept of a living collection may also be foreign or abstract, their significance, purpose, and stories not immediately accessible. The dedicated work of botanic gardens horticulture and science teams can also be hidden to visitors. Conservation of rare and/or threatened species is an essential purpose of botanic gardens, but ex situ botanic gardens collections face many practical barriers to being successful conservation tools.[58] This poses a challenge to public engagement teams to effectively communicate the conservation message and connect audiences with this important work.

The term "plant blindness" (aka 'plant awareness disparity') has been described as a condition affecting many in the population, described as being the failure to recognise the importance of plants and the role they play in supporting life.[59] However, there has been an anecdotal but recognisable shift against this, driven by the COVID-19 pandemic. Lockdowns and restricted movement have given rise to a new-found appreciation of neighbourhood green spaces, the value of access to the natural environment and an understanding of how vital plants are to mental and physical wellbeing. The importance of nature for health is well supported by the research, as demonstrated by a literature review commissioned by RBGV and the popularity of RBGVs wellbeing focused programs, such as Forest Therapy. Highlighting the importance of plants (and the diversity of plant life) to the wellbeing of people offers a pathway for revealing to audiences the value of living collections, plants, and nature.

There is also the question of the whole living collection and how the story of Melbourne Gardens as a botanic garden is told. The complex colonial history of collecting institutions like botanic gardens comes with its own reckoning of how collections were originally established. There is an opportunity to share how contemporary botanic gardens collect plant material now, and how this connects to visitors' desire to hear more First Nations plant use stories. At the time of writing, Royal Botanic Gardens Victoria has just completed its Reflect Reconciliation Action Plan, and the opportunities for site interpretation that support the reconciliation process are vast and vital.

A technical review commissioned by Botanic Gardens Conservation International emphasised that most botanic gardens rate visitor engagement based on the number of activities carried out, rather than the impact on the participants.[61] There is also a lack of evidence on the ability of botanic gardens to change people's attitudes towards plants and plant conservation. This provides the opportunity for research and evaluation into varying interpretation and public programming approaches, to understand more deeply how interpretation, learning, arts, or cultural programs may influence attitudes and behaviour change. Accepting that people have varying motivations for coming to botanic gardens, along with their own diverse ways of drawing meaning from experiences, should influence how botanic gardens communicate their stories.

7

*Metrosideros carminea* is endemic to New Zealand

# Management of the Living Collections

The Living Collections Plan sets out bold targets to protect Melbourne Gardens' valuable living collections and enhance their value to the organisation, visitors, and the wider world. Meeting these targets requires careful and considered management, especially where they intersect with the challenges discussed in Chapter 6. The following chapter provides detailed direction for the management of the collections, allowing the organisation to meet the collections' targets and rise to the challenges they face.

## 7.1. Identifying and Responding to Climate Change

### 7.1.1. Collections Development under Climate Change

Collections development within Melbourne Gardens will have a primary focus on assessing and selecting taxa which are more suitable for the projected local climate and site conditions, rather than significantly manipulating the local growing conditions to suit the plant. A focus on climatic suitability also assists in more sustainable practices to maintain plant health. As a result, greater emphasis will be placed on developing collection holdings that contain flora from temperature and rainfall niches that are comparable to Melbourne's future climatic conditions, while still maintaining the style and character of the landscape. Methods to identify and target these niches are provided in greater detail in sections 7.1.2 through 7.2.1, below.

While most of the current living collections contain many taxa that are likely to be suited to the expected future climatic conditions, there are some collections that are expected to be at greater risk, including the New Zealand and Lower Yarra River Habitat Collections.

Collection management responses to climate change will consider:

— Establishment of new, more climatically suitable collections

— Phasing out and removal of unsuitable or unsustainable plant collections

— Modifications in the composition of the existing collections to better respond to climate stresses through more provenance–based selection from appropriate habitats and climates

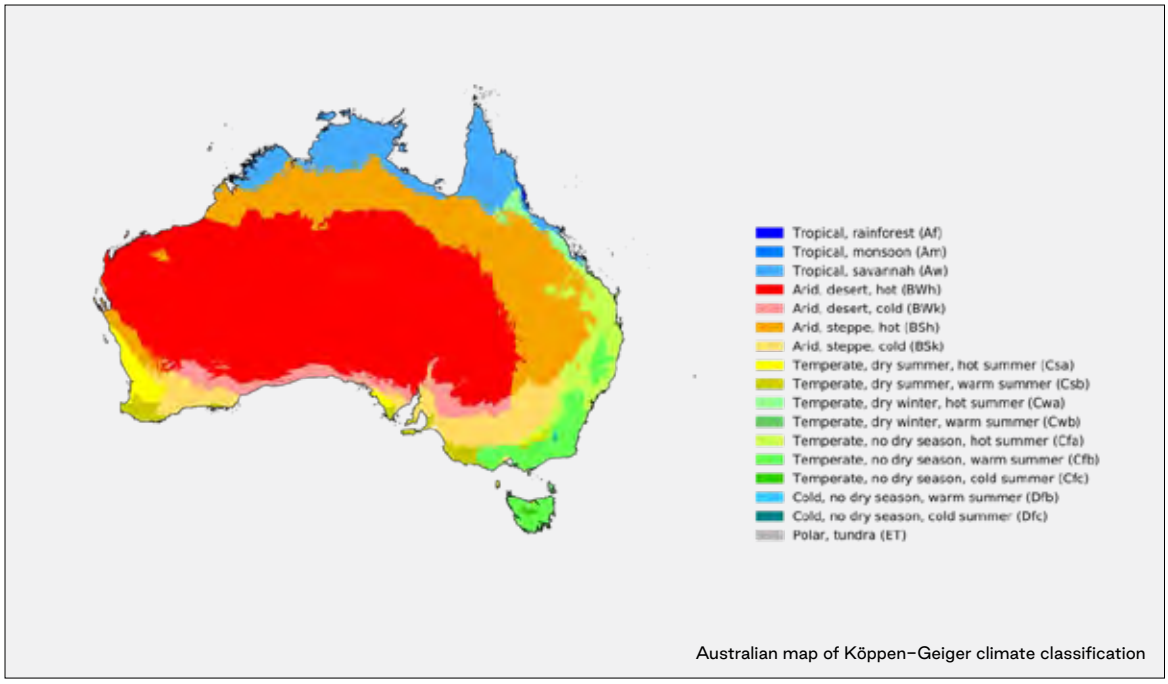
— Transfer of botanically significant and wild–collected plant material to other botanical organisations with more suitable climates

— Increase in research programs to identify actual taxa vulnerability within collections deemed at risk

— Use of at–risk collections as proxy indicators of climate change vulnerability for those managing natural resources and botanic gardens in the plant material's country of origin.

Where data is available, the selection of new taxa would be informed by contemporary science–based methods, such as climate risk assessments to identify new plants that originate from suitable climate–match regions and habitats.

While the risk from climate change may seem challenging, there are conceivably thousands of new taxa potentially suitable for Melbourne's future conditions and the establishment of new collections.




Australian map of Köppen–Geiger climate classification

### 7.1.2. Revised Köppen–Geiger Climate Selections

Prior to the development of the Landscape Succession Strategy in 2016, an internal audit of the Melbourne Gardens living collections was undertaken against the 'business as usual' or RCP 8.5 emission scenario projections for future temperature and precipitation. Based on these projections a new list of more suitable Köppen–Geiger climate zones was identified to inform future geographic locations for plant material.[62] See also, Appendix 8 Selection of potentially suited Köppen–Geiger Climate Classifications. It is these new zones and regions, or their subsequent revisions, which need to inform future development of the living collections, rather than historic climate selections.

To refine the original audit and identify climate match regions a new analysis of world climate regions was undertaken. This was done by conducting a GIS analysis of world regions using climatic spatial layers for a mean annual temperature of 17–21°C and mean annual precipitation of 200–1,100 mm and combing these with Köppen–Geiger Climate layers with identical resolution for the period of 1980 to 2016[63]. This was carried out at a resolution of 30 arc seconds (approximately 1 square km at the equator).

Assumptions of future temperature were based on previous analyses by Kendal and Farrar (2017) and included an additional increase to 21°C Mean Annual Temperature at the upper limit as a precautionary margin if global warming extends beyond projections. For precipitation, a range of 200—1,100 mm was assumed. This was considered to provide a balanced approach between selecting flora more akin to the landscape character of Melbourne Gardens whilst seeking to address water use sustainability.

The precipitation and temperature bands are management guides and need not exclude species selection beyond the range if they can be curated sustainably in Melbourne Gardens' landscape. Currently, the estimated mean annual precipitation of all the current assessed taxa in Melbourne Gardens is 1,064 mm, excluding c. 806 taxa in the nursery glasshouses.

It is assumed that many taxa at the upper end of the range will tolerate lower precipitation amounts in cultivation as they currently do in practice within Melbourne Gardens. This is also supported by research by Kendal et al (2018) on natural populations of trees, which found a broad breadth in precipitation tolerance for certain taxa (636 mm breadth in tolerance between the 2.5th and 97.5th percentiles). This means that for some species at least, their tolerance of differences in precipitation could be around 300 mm either side of a site's mean annual precipitation. In the same study cultivated taxa demonstrated an even wider precipitation niche of 875 mm.

When the temperature and precipitation analysis was combined with Köppen–Geiger classifications and previous audit results, it indicated a number of non–limitative climate types, and associated geographic regions, likely to offer sources of climatically suitable plants for the collections. These are detailed in Table 4 below, in ascending order of size. This offers a total potential collection area of approximately 3.6 million square kilometres, or an area larger than Queensland. The first six categories respectively each cover areas larger than Victoria. See also, Appendix 8 Selection of potentially suited Köppen–Geiger Climate Classifications.

The Gardens' water is managed through a sophisticated irrigation system

**Table 4 – Köppen-Geiger classifications matching a Mean Annual Temperature of 17–21°C and Mean Annual Precipitation of 200–1,100 mm**

| Climate Type | Description | Approximate Potential Collection Area in km2 |
|---|---|---|
| BWh | Arid, desert, hot | 872,252 |
| BSh | Arid, steppe, hot | 806,498 |
| Cwa | Temperate, dry winter, hot summer | 423,663 |
| Cfa | Temperate, no dry season, hot summer | 379,893 |
| BSk | Arid, steppe, cold | 335,066 |
| Csa | Temperate, dry and hot summer | 261,237 |
| BWk | Arid, desert, cold | 221,577 |
| Cwb | Temperate, dry winter, warm summer | 157,092 |
| Aw[xvi] | Tropical, savannah | 132,258 |
| Cfb | Temperate, no dry season, warm summer | 21,318 |
| Csb | Temperate, dry and warm summer | 16,588 |

xvi Relatively small areas of Af (tropical, rainforest) and Am (tropical, monsoon) climate classifications are not included in this table.

### 7.1.3. Water Management

Royal Botanic Gardens Victoria has invested significant resources into successfully reducing Melbourne Gardens' reliance on potable water. Since 1994–95, water use efficiency programs have reduced potable water use from 250 megalitres per annum to 125–135 megalitres per annum. With the introduction of a stormwater harvesting system in 2012, the Gardens is now achieving a 65% reduction in potable sourced water use.

As discussed in Section 6.1, above, sustainable water management is challenged by projected future reductions in natural precipitation. These changes will also impact current stormwater harvesting schemes in Melbourne Gardens, as rainfall is predicted to reduce during the cooler periods, which are typically when lake systems are recharged for the next irrigation season.

Based on data collected since 2012–13 when stormwater harvesting commenced, the Gardens' current combined 'precipitation aggregate' – that is the total irrigation and rainfall amount expressed as mm (depth) – currently averages 1,018 mm per annum, with about 484 mm of this total applied by irrigation and the remaining 534 mm is supplied by rainfall. Average annual total irrigation volumes for the same period (including stormwater) are about 127 megalitres. It should be noted that additional irrigation is applied above what is typically scheduled in some years to 'bank' subsoil moisture in deeper soil layers (see below). However, this may become essential considering the projections for rainfall reduction in cooler seasons.

If the current landscape plantings or irrigated areas are not adapted, then conservative future water demand in line with realised climate change projections could be in the order of 161 ML of irrigation per annum (615 mm over 26.2 irrigated hectares, or an additional 27%). If this total water volume was supplied solely by potable sources, then the equivalent current cost is $540,000 (2019–20 water rates).


LEGEND

Not Irrigated

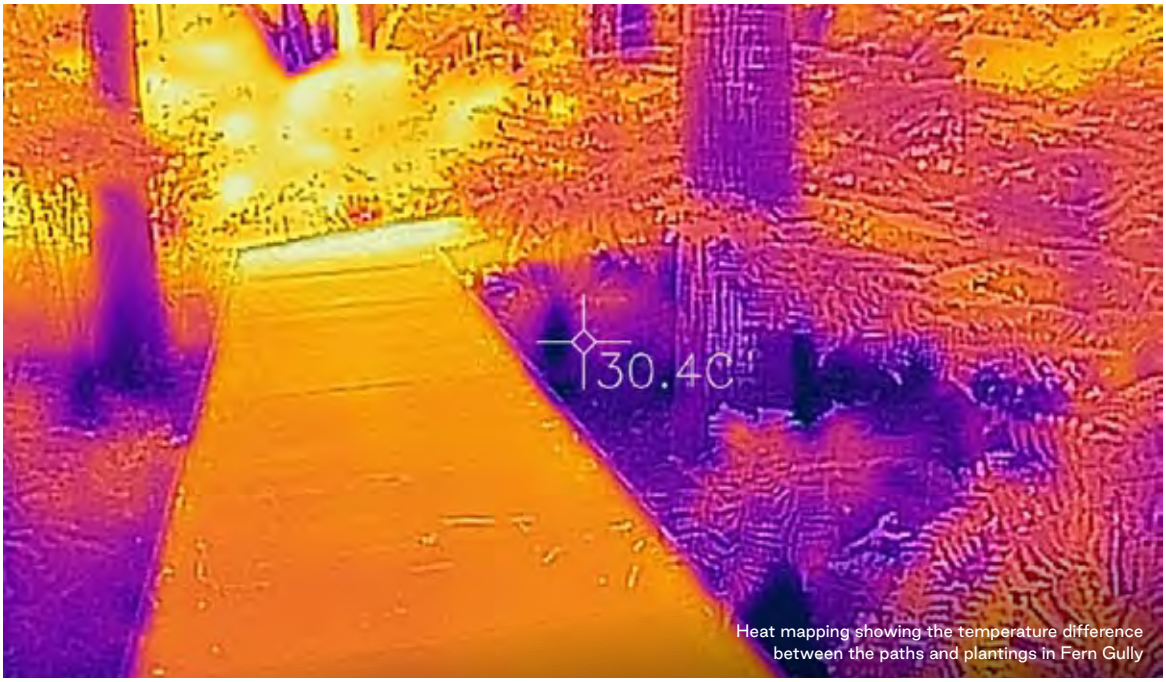
Scheduling Class L

Scheduling Class M

Scheduling Class H

Scheduling Class Hx

Scheduling Class Hxx




Heat mapping showing the temperature difference between the paths and plantings in Fern Gully

Current irrigation scheduling is partitioned into five regimes across the landscape that are adjusted monthly (60 different schedules annually). These regimes are illustrated in the Irrigation Scheduling Classes of Melbourne Gardens on the previous page. In the period between 2012–2013 and 2019–20, the mean precipitation aggregates of different areas across the landscape ranged from approximately 690 mm to approximately 1,200 mm. For the same period, unirrigated areas received an average 509 mm from rainfall.

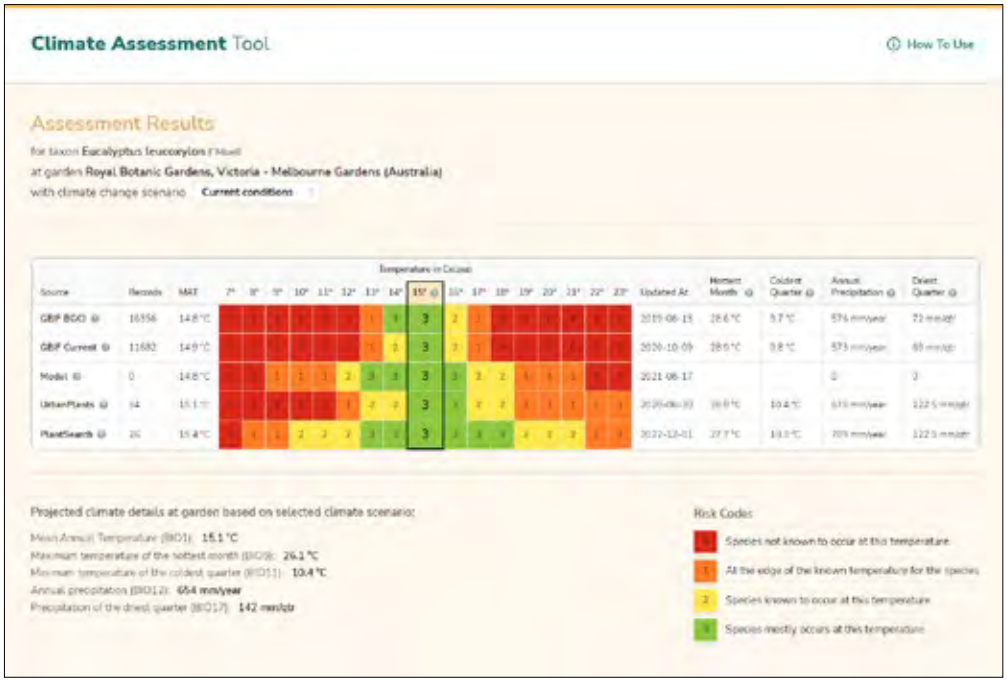
A scheduling variation to more typical irrigation applications is the Subsoil Moisture Storage and Recovery (SMSR) technique that applies any excess volumes arising from stormwater harvesting (usually winter–spring) to deeper soil profiles for later use by the landscape, primarily for trees.[64]

Increases in water delivery for specific areas should be balanced across the landscape to maintain a target annual precipitation aggregate of less than 1,020 mm. This is necessary for future water management sustainability and landscape resilience. An approach to this could include reducing water use in less water–intensive zones or increasing the proportion of non–irrigated areas in the landscape to offset any additional irrigation requirements.

However, if sustainable sources of water are available, one important consideration is using irrigation to increase the cooling capacity of vegetation.[65] With a warming climate and increased research on the dangers posed to human and environmental health by the urban heat island, vegetation cooling is an important part of urban forest management. A tree that transpires 100 litres of water per day has been equated to the cooling capacity of 70 kilowatt hours, or the rating of two residential air conditioners and larger trees in the Gardens can theoretically exceed this by several times.[66]

Nevertheless, sensitive irrigation management is still required to avoid promoting fungal diseases and or declines in plant health through overly wet soils. For example, it is surmised that the apparent relative lack of the symptoms of *Phytophthora* spp. disease, compared to the prevalence of the organisms in the landscape may be attributed, at least in part, to efficient irrigation practices which allow some drying of the plants' root zones.

It is also noteworthy that Melbourne Gardens monitors the local climate through a weather station and other instruments, regularly records its water consumption, and can quantify irrigation scheduling for every hydro–zone, thus providing a tangible research opportunity to inform actual precipitation needs for many taxa under a changing climate.




The Climate Assessment Tool as developed by the Climate Change Alliance of Botanic Gardens, BGCI, UTAS & IABG

### 7.1.4. Landscape Microclimates

Studies have found that in Melbourne Gardens the mean temperature differences arising from different microclimates are generally inadequate to compensate for the magnitude of temperature increases projected by 2090.[67] [68]

While selection of landscape microclimates can modify exposure to solar radiation and wind, and to some extent, mitigate the effects of more extreme temperatures, there are considerable constraints to applying this tactic across the entire landscape. Subsequently, it appears that microclimate–based approaches to mitigate against temperature rises are limited to controlled environments such as glasshouses, or niche landscape areas such as the Fern Gully, where landscape design can modify aspects such as exposure to direct solar radiation and wind.

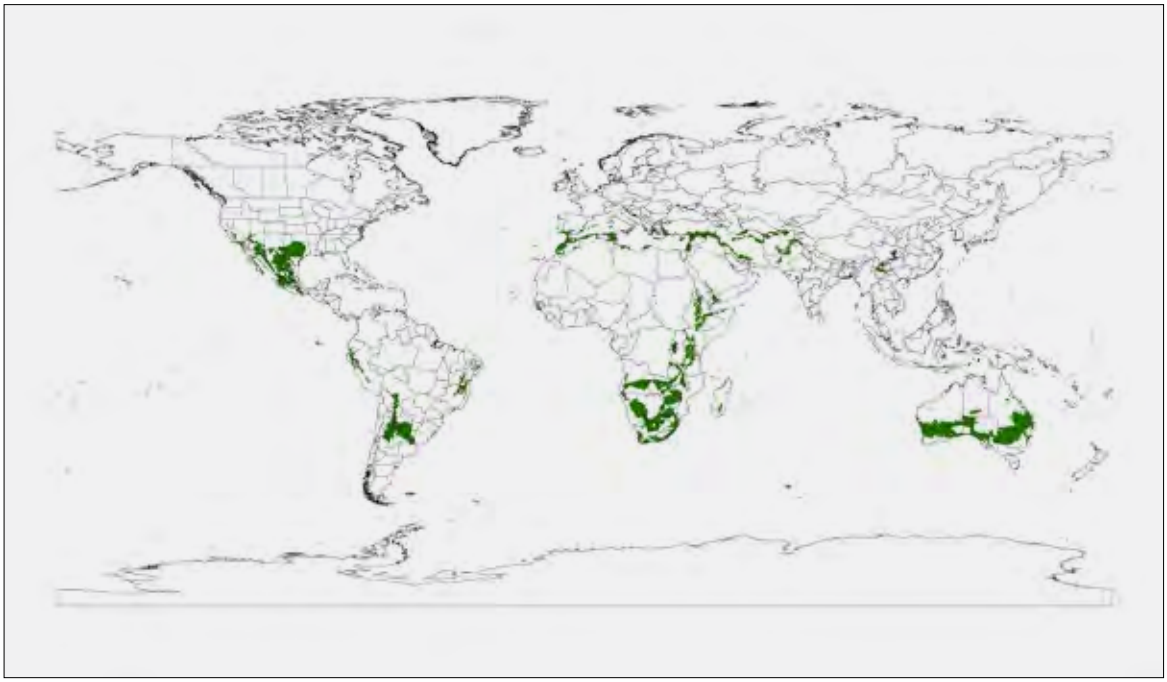
The Melbourne Gardens microclimate mapping program continues to be refined and at end of 2020–21 will have measured temperature and relative humidity profiles of almost 70 sites across the landscape, which can then be used to inform future selection of taxa and the design of new landscape projects.

## 7.2. Collections Selection Techniques

Botanical and horticultural expertise continues to be invaluable for informing plant selection and identifying the source environments and habitats of certain taxa. New approaches to support horticultural decision making are available, especially with dramatic advances in computing power and the availability of mega datasets. These include climate risk assessments and biodiversity platforms (i.e., Global Biodiversity Information Facility), species distribution modelling (SDM), and use of Geographic Information Systems (GIS) or combinations.

The nineteen BIOCLIM "variables" are derived from monthly temperature and precipitation values. This data is used to generate the variables which define the climate envelopes of ecological niches, and which are then used in species distribution modelling, or SDM. This information is publicly available as global GIS layers from online resources such as Worldclim. Simulations of different BIOCLIM spatial layers can be superimposed on regions, and indeed plant locations, to estimate growing conditions and inform plant selections.

There are caveats to consider when applying species distribution data to select new plants, as this may only capture the 'realised niche', or environmental envelope, for the natural distribution of a species. These niches are often constrained by competition, germination factors, pests, soil types, and other interactions, etc.[71] In botanic gardens, it has been observed that many species are readily grown outside their natural range. This can demonstrate the 'fundamental niche',[72] or the potential of a given species to grow beyond its natural distribution when competition and other inhibitory factors are removed, such as when artificial horticultural practices, irrigation for example, are applied.[73] This means in cultivation, plants may readily grow at higher temperatures and lower rainfall than what they would have naturally experienced. Botanic Gardens have an important role to play in providing data on a plant's 'fundamental niche' to improve potential distribution modelling. This makes them a rich resource for researchers and the public, with the opportunity also existing to incorporate this knowledge into RBGVs' HortFlora project.



In 2017 Kendal and Farrar made use of global tree inventories as additional sources of information for undertaking the climate vulnerability risk assessments in Melbourne Gardens. This research incorporated some aspects of fundamental niches for plants, but for many rare species this data is limited or not available. In implementing the climate risk assessments, it has been observed that the risk from higher temperatures may be overstated for taxa that are geographically isolated or unable to spread to warmer climates; taxa that have very broad distributions across many climates but dominating in colder ones (skewing the result), thus indicating potential susceptibility but may indeed be a mix of ecotypes, and taxa that are just very poorly known.[74]

These exceptions need to be defined further to inform implementation of the risk assessment results. For example, there may be provenance selections of the given taxa occurring in warmer climates that could be used as new sources of material. Further research is needed, and as an example, the holdings of over 1770 botanic gardens and arboreta in 148 countries around the world could provide a robust dataset of species adaptability in cultivation across variable environmental conditions. This would allow the fundamental niche of specific taxa to be better defined and further support predictive climate modelling tools, for example, the Climate Assessment Tool developed for the Climate Change Alliance of Botanic Gardens.

Many of the results from previous climate risk assessments are now incorporated within the Living Collections Database and can be accessed through various reports, as well as being exportable into spreadsheet–compatible formats to inform collections management. It is expected that these resources will continue to be developed in line with the latest science and information technology.

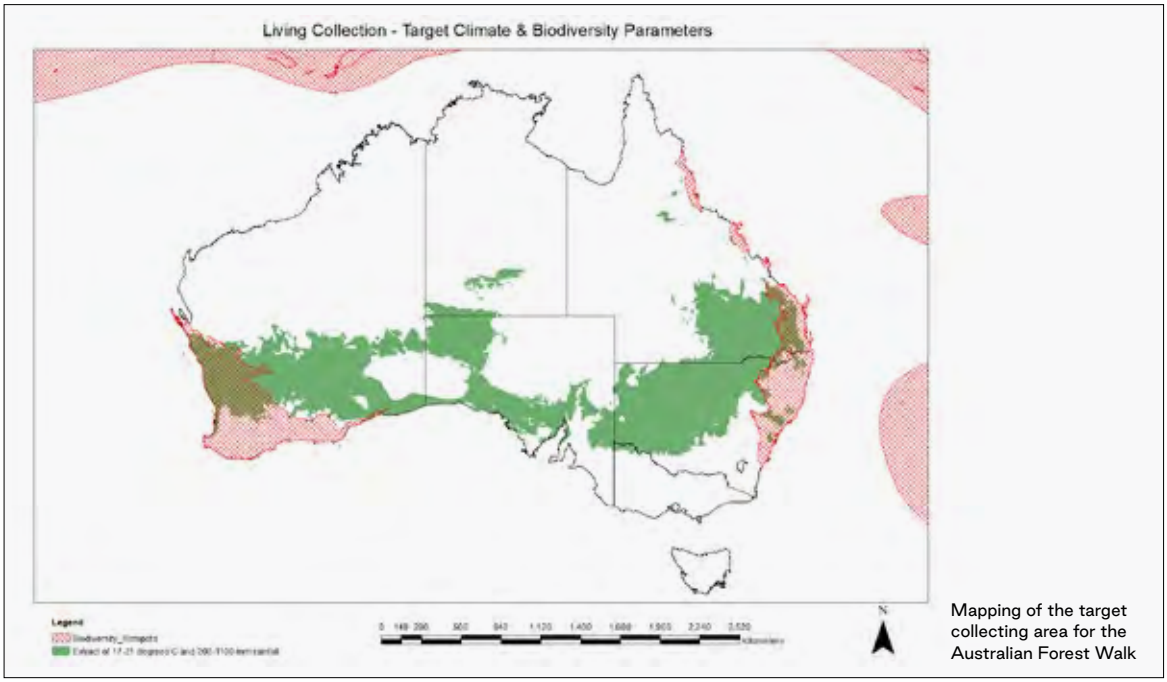
### 7.2.1. Geographic Collections Selection

GIS analyses identified potential geographic regions that may be sources of suitable taxa for the collections, with these regions identified in figure **Map of world regions matching MAT 17–21 C and MAP 200–1100mm** Undoubtedly though, there will be plants found outsite these regions that will tolerate the future climate conditions in Melbourne.

Extracts of suitable countries can also be obtained from GIS analysis, and be used to define regions for future collection development. Applying the parameters outlined in **Figure 8**,[76] countries with potential for collection development are highlighted with the top 35 countries listed in Table 5. A full country listing can be found at Appendix 7 Potential Geographic Focus Zones for Future Climate–suited Collections.

**Table 5 – Top 35 countries with areas matching climate niches of Mean Annual Precipitation of 200–1100 mm and Mean Annual Temperature of 17–21°C**

| Country | State / Region | Approximate Potential Collection Area in km2 |
|---|---|---|
| Australia | NSW, NT, QLD, SA, VIC WA, | 1,036,360 |
| Argentina | Southern South America | 319,611 |
| South Africa | Sub-Saharan Africa | 290,374 |
| Mexico | Latin America and the Caribbean | 286,270 |
| USA | Arizona, California, Georgia, New Mexico, Oklahoma, Texas, Utah | 276,721 |
| Namibia | Sub-Saharan Africa | 132,163 |
| Zambia | Sub-Saharan Africa | 115,811 |
| Zimbabwe | Sub-Saharan Africa | 112,576 |
| Angola | Sub-Saharan Africa | 103,494 |
| Iran | Southern Asia | 77,992 |
| Tanzania | Sub-Saharan Africa | 74,763 |
| Morocco | Northern Africa | 70,309 |
| Ethiopia | Sub-Saharan Africa | 68,423 |
| Botswana | Sub-Saharan Africa | 66,608 |
| Syria | Western Asia | 47,039 |
| Brazil | Latin America and the Caribbean | 40,575 |
| China | Eastern Asia | 36,178 |
| Pakistan | Southern Asia | 34,595 |
| Turkey | Western Asia | 34,008 |
| Tunisia | Northern Africa | 32,144 |
| Algeria | Northern Africa | 27,565 |
| Iraq | Western Asia | 27,056 |
| Kenya | Sub-Saharan Africa | 25,821 |
| Afghanistan | Southern Asia | 25,557 |
| Spain | Southern Europe | 24,825 |
| Bolivia | Latin America and the Caribbean | 23,710 |
| Turkmenistan | Central Asia | 22,192 |
| Libya | Northern Africa | 20,176 |
| Malawi | Sub-Saharan Africa | 19,263 |
| Peru | Latin America and the Caribbean | 16,293 |
| Yemen | Western Asia | 13,097 |
| Israel | Western Asia | 8,479 |
| Mozambique | Sub-Saharan Africa | 8,353 |




Mapping of the target collecting area for the Australian Forest Walk

Out of the top five countries, Australia has approximately 29% of the potential climate matched geographic area; while Argentina (9%), South Africa (8%), Mexico (8%), and USA (8%) share about 33% of the total. These regions collectively offer the most promise for developing more climate suited geographic collections.

Rather than using political boundaries, an application of broad biogeographic zones and/or taxa from certain adapted vegetation types may offer more opportunities for viable collections into the future. For example, focusing on the 'Californian Floristic Province', rather than simply 'California', enables a wider region with more climatically suitable areas to be targeted, including not only California, but also Nevada, Oregon, and the Mexican state of Baja California. Analyses using GIS layers can be readily customised for different climatic parameters, for example precipitation and temperature, vegetation types and geography. This can provide more specific detail if more detailed investigation is required.

## 7.3. Plant Acquisition

### 7.3.1. Collection Diversity

Traditionally, collection diversity was measured by the number of species in a collection, referred to as 'Alpha Diversity'. This approach is falling out of favour, with a move towards assessing against a measure called 'Phylogenetic Diversity', especially in conservation planning. Phylogenetic Diversity considers overall genetic diversity, not just the number of species, and is interested in conserving maximum genetic diversity. For example, there is more genetic variation if a garden introduces ten new plants from different families than if it introduces ten new Eucalyptus species. While the Alpha Diversity of the two acquisitions would be the same, the Phylogenetic Diversity of the first scenario is much higher.

Royal Botanic Gardens Victoria is using Phylogenetic Diversity to measure the Herbarium Collection, the idea being that it allows the organisation to recognise areas of greater genetic diversity, and therefore places more likely to harbour useful genetic resources. As such, Phylogenetic Diversity is being factored into conservation planning over simple alpha diversity measures. If the Phylogenetic Diversity of the living collections is increased, then there is considered to be a greater likelihood of it holding taxa of interest to researchers. With further development, Phylogenetic Diversity could be included as a measure in the Living Collections Database.

### 7.3.2. Wild Provenance Plants

To meet the targets expressed in the Landscape Succession Strategy and botanical preferences, new acquisitions for living plant collections should primarily be plants of known wild provenance and identity. Taxa collected from wild populations provide a scientific baseline and invaluable reference point for original habitats and plant populations. This then informs botanical research into areas such as population distribution mapping, genetic sampling, plant conservation and ecological restoration. Further, a known origin provides the means to identify a given species' environmental parameters, informing cultivation techniques, and making more meaningful comparisons with climate change resilience or susceptibility, especially if these plants are grown outside their natural range. This may assist with meeting the broader goals of Royal Botanic Gardens Victoria and other botanic gardens and herbaria. Currently, only 8% of current accessions and 19% of taxa are of wild collected quality (code 'W') in the Melbourne Gardens holdings.[77]

Plants of unknown provenance and/or human derived hybrid origin (e.g., garden hybrids), have minimal botanical and conservation value. While some of these taxa are appropriate for use in ornamental and cultural collections, or in some general areas of the landscape, and can have economic or horticultural value, a stronger focus is now required to increase the proportion of known wild–origin taxa within the overall collection.

Threatened *Acacia amoena* in the Australian Rare and Threatened Collection

### 7.3.3. Rare and Threatened Species

The Victorian Conservation Seedbank is housed in the National Herbarium of Victoria and currently holds 750 out of 1,600 (or 47%) of the recognised Victorian rare or threatened taxa. According to national listings, the Victorian Conservation Seedbank holds 96 of the 130 (74%) of Victorian taxa listed under the *Environment Protection and Biodiversity Conservation Act*. Melbourne Gardens Nursery and the Science Division have also been involved in propagation restoration and recovery projects with example species such as *Olearia passerinoides* subsp. *glutescens, Nematolepis wilsonii,* Silky Swainson–pea (*Swainsona sericea*), Southern Shepherds Purse (*Ballantinia antipoda*), Small Purple–pea (*Swainsona recta*), Leafy Anchor Plant (*Discaria nitida*), Turnip Copperburr (*Sclerolaena napiformis*), Spiny Rise–flower (*Pimelea spinescens*), and Tall Astelia (*Astelia australiana*). These are mostly through propagation agreements with State Government agencies such as DEECA.

A report commissioned by Royal Botanic Gardens Victoria defined the temperature and precipitation envelopes of rare and threatened species worldwide for suitability against projected climate change scenarios. From 20,000 threatened species, a total of 12,145 species (60%) were able to be assessed, with 2,991 species indicated as likely to be suitable for cultivation in Melbourne under a 'business as usual' climate scenario by 2070.[78] However, about 47% of the 479 rare and threatened species cultivated in Melbourne Gardens are estimated to be at the highest risk from the 2070 climate scenario,[79] therefore should be considered for duplication to other botanical sites to better protect this genetic material.[80]

An expansion of rare and threatened collections is an opportunity for collections development while also meeting global and national plant conservation targets such as defined in the *Global Strategy for Plant Conservation*. It also provides valuable prospects for community education, and there is opportunity to strengthen the educational role in current living collections management.

Some plants however cannot be effectively conserved through conventional seed banking methods. These are known as 'exceptional species' and include many threatened plants.[81] Reasons for seed bank failures include plants which do not produce seeds, or which have propagules which are recalcitrant, including some oaks, palms and cycads. Exceptional species require specialised propagation techniques with an adequate number of individuals grown to conserve sufficient genetic diversity. More recently, in the RBGV's response to the devastating bushfires of the 2019–20 summer, the collection of both seed and propagation material was critical to respond to the urgency and scope of this disaster.

While collection and conservation of rare and threatened species is desirable, there are significant constraints to the use of ex situ curation of cultivated specimens in effective plant conservation[83], including:

— Limited landscape space and resources to grow enough individuals to conserve genetic diversity

— Risk of 'genetic drift', hybridisation and adaptation to cultivated conditions (domestication). This is especially problematic in short lived and seed–grown taxa

— Higher risk of key losses if the species is susceptible to a pest or pathogen.

Despite these limitations there is increasing interest in optimising ex situ conservation of threatened plants by pooling genetic diversity across a network of botanical organisations, in what are termed as 'metacollections'. These metacollections must be managed carefully to track genetic lineages and increase genetic variation.[84] [85] Some exceptional species may already be vulnerable to changing climatic conditions in their natural habitat and existing ex situ collections in botanic gardens. For these species, Melbourne Gardens could provide a better growing environment now, or in the future, to safeguard these plants.

Future expansion of the cultivation of rare and threatened species needs to examine suitable methods to reduce the risk of losses of unique genotypes e.g., by optimising replication of individuals and/or by duplicating this genetic material with other botanic gardens and reputable organisations. As highlighted, stringent record keeping is paramount to track and trace life histories and the locations of individual specimens. Melbourne Gardens can fulfil an important role by developing relationships with other organisations to curate these species of concern, especially those more suited to future climate conditions.

Myrtle Rust in *Rhodamnia rubescens*. This species is now critically endangered due to Myrtle Rust infiltration into their natural range

### 7.3.4. Australian Flora

As discussed in Section 6.3, international importation of plant material can be difficult, and is likely to become more regulatory–complex due to globalisation and the associated spread of serious pests and diseases. Despite this, Melbourne Gardens has significant possibilities for enriching plant diversity by developing collections linked to its existing strengths, such as climatically suited Australian flora. There is also an imperative to achieve GSPC targets which focus on conserving threatened plant species in accessible ex situ collections, preferably in the country of origin.

The status of rare and threatened species can potentially change with the advent of new threats. In April 2010, Myrtle Rust (*Austropuccinia psidii*) was first reported in Australia.[86] This disease is limited to taxa within Myrtaceae, and primarily damages soft and young plant tissues such as new shoots, leaves, flowers, and fruits. This results in leaf lesions, foliage deformation or even defoliation, reduced seed viability, dieback, stunted growth, and ultimately death for some taxa.[87] Myrtle Rust is currently well established along most of the eastern coastal regions of Queensland and New South Wales, parts of the Northern Territory, and marginally established in Victoria and Tasmania. Over 380 Australian taxa are potentially at risk from infection, with 43 taxa severely affected.[88] The disease has impacted some relatively common taxa in their natural range, so severely that two species, *Rhodomyrtus psidii* and *Rhodamnia rubescens*, are now listed as critically endangered.[89] While Melbourne Gardens experiences isolated outbreaks of Myrtle Rust, it is seemingly a less suitable climate for the disease, providing a potential ex situ conservation opportunity for threatened species, especially those less suitable for seed banking. Preliminary work has already commenced in partnership with Royal Botanic Gardens and Domain Trust, Sydney to grow selected species threatened by Myrtle Rust, and this project is being expanded to develop a dispersed collection of these threatened Myrtaceae in botanic gardens around Australia.[90]

## 7.4. Gaps in Ex situ Botanic Gardens Collections

Research indicates latitudinal gaps in ex situ plant conservation by botanic gardens, particularly representing the Southern Hemisphere and tropical taxa. About 76% of tropical species are missing from botanic gardens collections worldwide. Melbourne Gardens is already growing some tropical species successfully in the landscape, and future warming is likely to increase this prospect—especially if coldest quarter temperatures increase. Previous bioclimatic modelling (see section 7.2.1) has already revealed opportunities around the 20th parallel (and closer to the equator) for regions within Africa, Central America, Mexico, and South America, and for some pockets within Australia. As there are over 500 taxa already in the collections originating from mean annual temperatures great than 19°C, there are considerable prospects to trial and include additional tropical species in the collections for meeting plant conservation and climate resilience targets.

Non–vascular cryptogams such as mosses, hornworts and liverworts are also poorly represented (or documented) in botanic gardens collections, sitting at less than 5%. It is known that Melbourne Gardens contains unusual species of these plants. While these early plant lineages may not be displayed as distinct landscape collections per se, they are important in telling the story of plant evolution and carryout key ecosystem roles. The opportunity exists for cryptogams to be more highlighted in the overall landscape collection.

## Weed Evaluations by Risk Level

| Plant Name | Risk | Evaluation Context | Evaluation Date | Score | Result | Rationale | Conditions On Cultivation | Reference | Updated By |
|---|---|---|---|---|---|---|---|---|---|
| Melica californica | HIGH | RBG | 20/11/2014 | 19 | ☑ | | | | TT |
| Melica ciliata | HIGH | RBG | 20/11/2014 | 20 | ☑ | | | | TT |
| Melinis repens | HIGH | RBG | 24/11/2014 | 25 | ☐ | | | | YS |
| Mentha pulegium | HIGH | RBG | 2/10/2019 | 24 | ☐ | | Moist conditions. Used in rockeries. | | YS |
| Miscanthus floridulus | HIGH | RBG | 24/11/2014 | 19 | ☑ | | | | TT |
| Miscanthus nepalensis | HIGH | RBG | 27/09/2013 | 21 | ☐ | | | | YS |
| Miscanthus sinensis 'Adagio' | HIGH | RBG | 24/11/2014 | 20 | ☑ | | | | TT |
| Miscanthus sinensis 'Ferner Osten' | HIGH | RBG | 24/11/2014 | 19 | ☑ | | | | TT |
| Miscanthus x giganteus 'Goteriba' | HIGH | RBG | 24/11/2014 | 20 | ☑ | | | | TT |
| Muhlenbergia capillaris | HIGH | RBG | 1/10/2014 | 20 | ☑ | | | | TT |
| Myriophyllum caput-medusae | HIGH | RBG | 11/12/2014 | 19 | ☑ | | | | SH |
| Myriophyllum crispatum | HIGH | RBG | 31/07/2008 | 21 | ☐ | | | | RDS |
| Myriophyllum simulans | HIGH | RBG | 17/12/2010 | 21 | ☐ | | | | RDS |
| Myriophyllum variifolium | HIGH | RBG | 31/07/2008 | 20 | ☐ | | | | RDS |
| Nelumbo nucifera | HIGH | RBG | 11/05/2010 | 20 | ☐ | | Plants are to be grown in containers to prevent further spread into water bodies. Biomass is to be reduced/managed each year. | | YS |
| Nolbea africana | HIGH | RBG | 21/04/2016 | 24 | ☐ | | Suckers extensively | | YS |
| Oenanthe javanica | HIGH | RBG | 8/10/2019 | 22 | ☐ | | Grows in water ways such as ponds, lake edges etc. | | YS |

Weed risk evaluations are carried out for all new introductions to the Gardens

## 7.5. Accessing Plant Material

### 7.5.1. International treaties

New living plant acquisitions must only be obtained in accordance with international treaties such as CITES and adhere to Access Benefit Sharing agreements with the Country of Origin. These protocols have arisen from the *Convention on Biological Diversity* and one of its instruments, the Nagoya Protocol, and these protocols, or their subsequent revisions, will need to be adhered to at all times. For further information see Sections 3.10 and 6.3.

### 7.5.2. Managing Invasive Species

Managing the risk of invasive plants is essential for botanic gardens. Melbourne Gardens has policy and procedures in place to assess and manage the risks of new accessions becoming weed species. The Weed Risk Assessment Procedure (WRAP) is a database-based system that is based on a technical review to develop a scientifically based, relatively seamless tool that is used to assess all new plant introductions to the Gardens.[92] Even if plants are permitted by the Department of Agriculture and Water Resources assessments, they still need to pass RBGV's internal review process. This includes introductions of plants native to Victoria and Australia, and these procedures will continue to be reviewed to incorporate emerging threats, particularly related to climatic changes.

### 7.5.3. Plant Acquisition Criteria

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

a) Plants collected in the wild with full provenance details that are expected to grow well within Melbourne's climatic conditions

b) Plants obtained from another botanic garden or reputable collector, either as progeny of plants collected in the wild, or grown material with reduced risk of hybridisation or genetic shift in the germplasm

c) Plants of known origin from a reputable source.

Plants in the following categories will not be acquired:

— Plants which contravene the Control of International Trade in Endangered Species (CITES) policy on plant collecting and trading, and/or do meet the terms of other international treaties and agreements

— Prohibited imports [Biosecurity Import Conditions System (BICON)]

— Declared noxious weeds, and or those plants that are deemed of unmanageable invasive risk according to RBGV Weed Risk Assessment Procedure (WRAP)

— Plants that require unsustainable resource inputs for their effective cultivation.

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

— Likely or known environmental or agricultural weeds (unless required for sound education and scientific rationale and are accompanied with a management plan addressing risk controls)

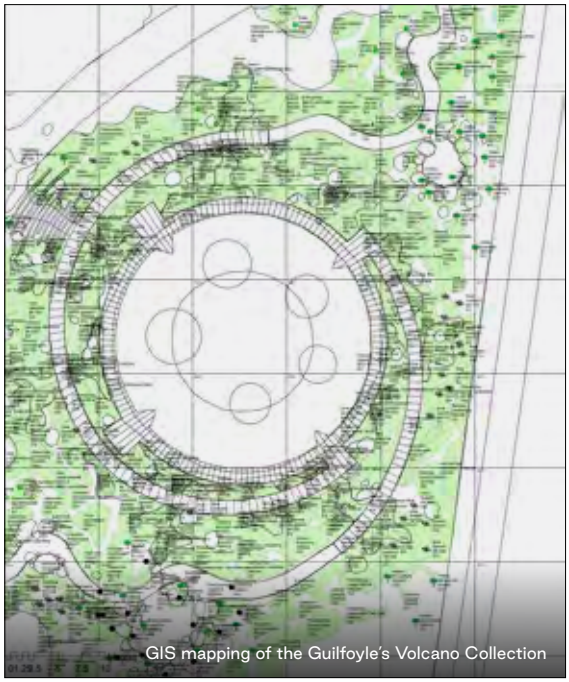
— Plants with the potential to facilitate the transmission of new serious pests to commercial crops, horticultural industries, and natural landscapes (unless part of a specific plant conservation program or directed management aim, or for which there are adequate management protocols)

— Species that are considered to be inordinately susceptible to, or significant hosts of, exotic pests and diseases (unless part of a specific plant conservation program or directed management aim)

— Likely sources of introgression problems (genetic contamination).

Introgression is the transfer of genetic information from one species to another as a result of hybridisation between them and repeated backcrossing.

Preparing a specimen of *Hibiscus divaricatus* in the field


GIS mapping of the Guilfoyle's Volcano Collection

### 7.5.4. Field Data Standards

For specimens to be useful for research and conservation they must be appropriately supported by quality data collection and record keeping. Herbarium voucher specimens will typically require descriptions that support quality data collection for specimens collected from the wild. Regardless, the following data should be included with the plant material acquisitions:[93]

- Voucher specimen with as many identifying features as possible including flowers, leaves, fruit, bark, roots, stems/rhizomes/stolons, and any storage structures (e.g., bulbs, corms, etc)
- Source of and type of material
- Description of the material
- Observed genetic variability
- Collector's number, details, and date of collection
- Country and locality with descriptive comments to nearest landmark
- Provenance including measured altitude and longitude/latitude (see box text)
- Habitat including substrate, aspect/exposure, Ecological Vegetation Class (or equivalent) and associated plants
- Images of the material in the wild and collecting locality.

A useful manual for collecting voucher specimens has been prepared by the Queensland Herbarium see *Collecting and preserving plant specimens, a manual*.[94]

Many GPS units are set to use the WGS84 datum by default—GDA94 is currently a more appropriate datum for Australia. Note that the GIS datum for Melbourne Gardens landscape is still linked to the ADG 1966 AMG_Zone 55 datum that coincides with the 10 × 10 grid system. It is important to always define the datum used to collect coordinates so that accurate transformations between coordinate systems can be achieved.

## 7.6. Record Keeping

Accurate and readily accessible plant records are paramount to the scientific integrity of botanic gardens and are crucial for effective management of the living collections. Effective record keeping procedures have been developed to manage Melbourne Garden's living collections, and it is imperative that these be maintained in order for the full scientific, education and conservation value of the collections to be realised.

Record keeping occurs through a multiuser, SQL–based and customisable Living Collection Database. This provides the capacity to run many types of queries and reports on the status of holdings, and to develop additional modules for management purposes. For example, modules have been developed for propagation, trees, pests and soil management, and more recently climate risk assessments reports.

Landscape plant specimens are mapped using a Geographic Information System (GIS) on a base plan overlayed with a 10 × 10 metre grid. Coordinates of all plant records are available through the GIS system. Selected data from the Living Collections Database is also publicly available on the RBGV website via the Living Plant Census, providing a valuable resource for industry and the public.

Whether plants are extant or have been de–accessioned, all initial accessions remain recorded on the Living Collections Database as 'live' (extant) or as 'dead' (de–accessioned) records. Maintaining a de–accessioned list is valuable for collections management, as it can potentially identify pest problem areas and indicate species that were unsuccessfully cultivated, or those which became unsuitable under changing climatic conditions.

Administration of the Living Collections Database records is primarily resourced by a Gardens Information Officer and Living Collections Developer (database programming), with nomenclature and plant distribution support from Horticultural Botanists. Arborists and horticulturists are also responsible to support field–based updates such as management records, planting details, deaths and removals, and submitting specimens for improved identification status.

Fruits of *Lomatia* spp. are provided under permit to extract Lomatiol for chemistry teaching

## 7.7. Living Collections Access and Use

Royal Botanic Gardens Victoria provides general access to its living collections for the purposes of study, research, and public enjoyment. Most plant collections are readily accessible during the opening hours of Melbourne Gardens, though some rare and valuable plant specimens may be secured in the nursery, and only accessed by appointment under supervision by RBGV employees. Entering actual garden beds or removing any live or dead plant material from the Gardens is prohibited under RBGV Regulations, unless by written approval or under supervision.

In accordance with the *Convention on Biological Diversity* and Nagoya Protocol, and CITES, seed or other plant material can be supplied for non–commercial purposes to other botanic gardens and research institutions to benefit plant conservation, scientific understanding, and development of collections. These transfers of plant material require the completion of Material Transfer Agreements (MTA) that are coordinated by the Senior Curator Horticulture and approved by the Executive Director, Melbourne Gardens.

Non–commercial scientific study of the plant collections and accessing plant materials for reputable research is encouraged, and generally administered through an MTA. There is clear scope to expand this benefit of the living collections in line with collections development targets, especially in regard to long–lived, botanically diverse species.

It is expected that recipients of plant material acknowledge RBGV as the source of such material in their publications and provide copies of these works to RBGV. Access to live plant tissue may be restricted if certain significant pests and diseases constitute a risk, if there are quarantine prohibitions, or where removal of the material will detrimentally impact plant health or appearance.

## 7.8. Collections Planning and Operations

Melbourne Gardens living collections are developed using a systematic process, drawing on the expertise of people across the organisation, including input from scientists, horticulturists, arborists, landscape architects and the Learning team.

To undertake this work, a Living Collections Reference Group (LCRG) is to be established, comprised of the Manager Horticulture, Senior Curator Horticulture, Landscape Architect, and a Plant Scientist to assist with strategic guidance relating to curation, management and development of all living collections. As required, this group will also have access to outside expertise and peer review. The group is to meet at least once annually for updates and as required during collection evaluations, and will provide recommendations to the Executive Director, Melbourne Gardens.

The responsibility for coordinating the overall development of the living collections rests with the Senior Curator Horticulture, under the direction of the Manager Horticulture, in liaison with Horticultural Team Leaders and relevant Managers. As part of this work the Senior Curator Horticulture has a key role in supporting Curators to:

— Deliver collection–related results (including professional development)

— Reviewing agreed collection plans

— Facilitating collaboration with stakeholders and other botanical institutions.

Documentation for individual collections will be developed collaboratively by the Senior Curator Horticulture working with the collection's Curator, with input from others as necessary. Each collection will have its own Living Collection Management Plan (LCMP) (see Appendix 1 Living Collection Management Plan Template). This LCMP will provide specific aims, objectives, and development priorities, and will be evaluated and reviewed every five years to make sure it remains relevant and up to date (see Section 8.1).

Soil Scientist undertaking soil testing with RBGV Horticulturists

Each collection will also have a Living Collection Action Plan (LCAP) that references the LCMP (see Appendix 2 Living Collection Action Plan Template). These are produced annually (traditionally in June), by the individual curators, and detail the goals for the collection for the following twelve months. The Senior Curator Horticulture will review the LCAPs each June in consultation with each collection's curator, and the deliverables are assessed with the relevant Team Leader and Manager.

## 7.9. Soil Management

The soil at Melbourne Gardens has been cultivated for over 100 years, and these long-term historical practices have had an impact on site soils. It is essential that soil testing and design is directly embedded within future living collection development to better align soil requirements with the needs of the taxa to be grown. This also requires expanding the organisations' soil test record keeping, currently embedded in the Living Collections Database through a 'beta module'. This is also needed to avoid exacerbating existing nutrient toxicity issues, as it is important that fertilisation practices are based on soil testing.

It is also important that soil investigation and management of soil health be embedded within the site analysis and concept design of all living collections development and landscape projects, as recently demonstrated with the new Arid Garden, where excellent drainage was a critical requirement for the collection. Long term, it would be beneficial to develop a soil recycling yard, as recommended in the *Melbourne Gardens Master Plan 2020–2040*. Until this can occur, it is essential that landscape soil is protected from undue compaction during development, and that imported soils are of acceptable quality. (For further details on the challenges facing soil management and plant nutrition see Sections 6.7 and 6.8).

## 7.10. Engagement and Storytelling

The development of the Living Collections Plan has been an important opportunity to better define the purpose of each living collection and how living collections can be used to better inform and engage the general public. This will give each of the collections' curators a more targeted focus for collections development and increase each collections' relevance and use.

With appropriate interpretation and learning programs, the living collections can be a dynamic doorway to fascinating stories about biodiversity, ecology, plant conservation, ethnobotany and plant use, First Nation's stories, evolutionary adaptation, horticultural techniques, health and wellbeing, plant morphology and much more.

The way plant collections are interpreted also has the opportunity to change. Recent leaps in technology and greater acceptance of its use in everyday life gives the Gardens the opportunity to move beyond the traditional static sign and website, or small-focused tour approach. These traditional forms still have their place, but the new Interpretation Framework, currently under development, will provide a valuable opportunity to embrace traditional, creative, and technological opportunities for unlocking the collections to as wide and diverse an audience as possible. These new approaches also generate interpretation that can cater for a wide range of audiences and interests and include more technical details.

Recently, work has been carried out testing new mediums, methods, and tools for visitor engagement, with this work showing promising results. For example, RBGV is in the process of testing audio experiences through commissioning episodes of *Sonica Botanica*, which tests a new medium (place-based audio experience), new delivery method (smart phones and QR codes) and provides links to RBGV expert voices and other members of RBGV community. These pieces are designed to be listened to in the collection and spaces they are about, and can also be accessed remotely, offering a way to connect with more people in more places and in more situations. The use of QR codes make this experience accessible in the landscape and provides quantifiable data. The project holds immense potential for place and collection interpretation, and an entry point into a deeper understanding of the importance of plants.

Events such as Lightscape introduce new audiences to the Gardens and their living collections

Other interpretation projects are planned to explore all layers of interpretation, from plant labels to digital and on–demand content. Respecting that not every story can be told everywhere, it is considered that RBGV is best placed to connect visitors more deeply through a layered curation of channels and experiences.

The Garden Gatherings suite of events and creative public programs was conceived for the 175th milestone year program to showcase 'featured' living collections. This model was very well–received and has potential to roll out across Melbourne Gardens on a regular and seasonal basis. As part of this work, self–guided inter–generational experiences for families, children and young people were developed. The Seek and Find Nature Cards series provides an opportunity for children and their families to explore collections together. Like a scavenger hunt, these cards prompt children to find specific plants or garden features, as well as offering more open–ended prompts for contemplating plants and nature. At time of writing, two Seek and Find Nature Cards had been developed. As more are developed, they offer a way to entice families and children to explore the Garden beyond the Children's Garden.

The Gardens continued leadership and involvement in Victoria's Nature Festival will provide annual engagement with the living collections. The Engagement and Impact team also play an important role in influencing behaviour in the safeguarding of rare and threatened plant species, with members of this team sitting on the Victorian Valuing Nature Working Group and other state agency working parties.

## 7.11. Resourcing

To better support the implementation of the Plan, workforce and career succession plans and pathways should be developed, with a focus on technical support for the living collections. Pending the management intensity and size of the collections involved, it is recommended that only 1–2 specific collections are assigned to any one curator, or that other options are explored as described above (see Section 6.6).

Continuing maintenance, management and development of living plant collections requires ongoing personnel and financial resources. Funding sources can include sponsorship, government funding, grants, philanthropic donations and recurrent funds.

Appropriate resources are required for the development and presentation of collections particularly to support landscape succession through climate change, and it may be necessary to flexibly manage collections on an as needs basis. For example, some collections may be in 'active development' while for others a focus on horticultural maintenance is sustained for periods of time. Resourcing can also affect the number of collections and the presentation of collections (see also, Section 6.6 Professional Development). In some cases, following an evaluation process, collections may be discontinued (see Section 8.3, Discontinuation and De–accessioning).

Additional expenses for future collection development are anticipated to include field expeditions and collecting trips, importation and quarantine costs, technical equipment and supported digital transition and training, and costs associated with internal propagation and growing on of plant material.

It is acknowledged that providing these extra resources may be complex, especially in the first five years with the financial impact of the global pandemic (see Section 6.9).

8

*Phebalium squamulosum* a native Australian shrub found along the east coast

# Evaluation and Review

The Living Collections Plan guides the development and management of Melbourne Gardens' plant collections over the next 20 years. As a document that responds to broader conservation and biodiversity aims, and which cares for living plants, it is important that it is regularly reviewed and evaluated. The production of the Plan includes a thorough analysis of the living collections, with the data presented in each collection snapshot providing a base line for future evaluation and collection development. The following chapter discusses the evaluation and review of the individual living collections, and the Plan as a whole.

## 8.1. Living Collections Evaluation

A literature review of collections policies and plans of many international botanic gardens found that while collection evaluation was claimed to be important, it was difficult to find evidence of any methodical process. One exception was Royal Tasmanian Botanic Gardens that applied a scoring matrix approach.[95] One survey found that of the gardens examined, only 20% carried out systematic evaluation, but it is not clear if this extended to the overall collection intent (e.g., including assessments of learning objectives, horticultural presentation, etc), or just focused on the botanical diversity of the holdings.[96]

Review and evaluation of living collections is important to:[97]

— Maintain compliance, both with the mission and objectives of RBGV, and the strategies, targets and actions of the Living Collections Plan

— To clearly identify components of the collections that require adjustment or improved management

— To provide the resources needed to support the quality of the collections and landscapes

— To remain relevant to contemporary botanical, horticultural and societal issues

— To improve response to environmental stresses and improve resilience of the holdings.

Each collection will be evaluated every five years, and immediately prior to any review of the Living Collections Plan (see Section 8.4). Although, a collection can be evaluated at any time, for example due to a significant change in circumstances or due to new threats from exotic pests or diseases. The evaluation will be coordinated by the Senior Curator Horticulture with input from the Living Collections Reference Group (LCRG) and the collection's Curator and will result in each Living Collection Management Plan being updated to any reflect shifts in development priorities.

Collections will be assessed by an expert panel comprising of the Living Collections Reference Group (see Section 7.8), the Curator of the collection and others as needed, following an agreed scoring matrix within a spreadsheet format (see Appendix 3 Scoring and Assessment Guide for Collections Evaluation). Proposed evaluation criteria for the Melbourne Gardens are as follows:

— Collection lifecycle

— Level of fit to RBGV priorities, and collection theme, objectives and criteria

— Uniqueness of collection and its holdings

— Number of distinct taxa

— Phylogenetic diversity

— Landscape heritage and conservation value

— Design intent and ornamental quality

— Effective learning outcomes and interpretation quality

— Scientific and research relevance

— Plant conservation value

— Percentage of accessions that are ID3

— Percentage of accessions and taxa that are wild–collected provenance

— Percentage of taxa that are rare or threatened

— Overall climate flag ranking against Melbourne SSP3 2090 conditions

— Mean annual temperature (°C) of entire collection holdings

— Mean annual precipitation (mm) of entire collection holdings

— Horticultural maintenance intensity

— Overall suitability of current or proposed site for collection

— Level of risk to collection from significant pest incursion.

## 8.2. Considering New Collections

New plant collections will be selected through the framework in the 'Evaluation of Living Collections', and according to collection themes and criteria within this Living Collections Plan, RBGV research priorities, landscape development priorities in the Master Plan and to support implementation of the Landscape Succession Strategy. Section 4.5 identifies a number of potential new collections which have emerged through the development of this Plan, and which could assist Royal Botanic Gardens Victoria's international conservation efforts and increase the climate resilience of the holdings. However, it is likely that other potential collections will emerge over time, with the number of collections being largely influenced by available resources.

## 8.3. Discontinuation and De–accessioning

Following an evaluation, if a collection does not meet the core criteria or is deemed to be a low priority against more significant collections, it may be recommended for discontinuation from further development. Such recommendations would only occur after the review of the relevant Living Collections Management Plan as described in Section 8.1, and would require approval from the Executive Director, Melbourne Gardens.

In some cases, consideration will be given to transferring plant material to botanical sites that are more suitable, and this may require a Material Transfer Agreement. However, unless the collection area is within a new landscape development zone, prone to incursions of significant pests and diseases or is highly vulnerable to climate change, then its holdings could conceivably be maintained to provide landscape display or be gradually replaced over time. Any material which is valuable from a genetic or plant conservation perspective may also be prioritised for transfer to other botanical gardens. Specific taxa may be de–accessioned due to climatic unsuitability, poor health or death, safety risks (typically tree removals) or invasiveness.

## 8.4. Review

As living documents, the Living Collections Plan and its associated Living Collection Management Plans need to be responsive to changes in scientific endeavour, socio–cultural attitudes towards botanic gardens and the environmental conditions of Melbourne Gardens site.

It is anticipated that the Living Collections Plan will require a 10–year review to assess how it has responded to targets, and to realign its aims with the organisation's mission, broader strategic plans and plant conservation needs. The entire Plan would then be reviewed in 20 years, parallel with related documents such as the Master Plan, Landscape Succession Strategy and Tree Plan. If circumstances change, such as a new iteration of climate change projections, or a significant shift in resourcing levels, then earlier review may be warranted.

# References


ALLEN, C. D., BRESHEARS, D. D. & MCDOWELL, N. G., 2015. On underestimation of global vulnerability to tree mortality and forest die–off from hotter drought in the Anthropocene. Ecosphere, 6, 1–55.

APLIN, D. M., 2014. A global survey of living collections. BGjournal, 11, 26–29.

BALDING, M., & WILLIAMS, K., 2016. Plant blindness and the implications for plant conservation. Conservation Biology. 30. 10.1111/cobi.12738.

BALLANTYNE, R., PACKER, J., and HUGHES, K., 2008. Environmental Awareness, Interests and Motives of Botanic Gardens Visitors: Implications for Interpretive Practice, *Tourism Management* 29, no. 3, 439–44, https://doi.org/10.1016/j.tourman.2007.05.006.

BECK, H. E., ZIMMERMANN, N. E., MCVICAR, T. R., VERGOPOLAN, N., BERG, A. & WOOD, E. F., 2018. Present and future Köppen–Geiger climate classification maps at 1–km resolution. *Scientific Data*, 5, 180214 DOI: 10.1038/sdata.2018.214.

BGCI, 2012. International Agenda for Botanic Gardens in Conservation: 2nd edition. Descanso House, 199 Kew Road, Richmond, Surrey, TW9 3BW, UK.

BGCI, 2016. GardenSearch online database. Botanic Gardens Conservation International. Richmond, U.K. Available at www.bgci.org/garden_search.php.

BGCI, 2018. *BGCI: About us, viewed 23 October 2018, http://www.bgci.org/about–us/ [Online]. Available: http://www.bgci.org/about–us/* [Accessed].

BGCI, 2021. *About Botanic Gardens.* Available: https://www.bgci.org/about/about–botanic–garden/

Bureau of Meteorology, 2021. Climate Data Online. Available at: http://www.bom.gov.au/climate/data/?ref=ftr

BOOTH, T. H., 2017. Assessing species climatic requirements beyond the realized niche: some lessons mainly from tree species distribution modelling. Climatic Change, 145, 259–271 DOI: 10.1007/s10584–017–2107–9.

BOOTH, T. H., NIX, H. A., BUSBY, J. R. & HUTCHINSON, M. F., 2014. Bioclim: The first species distribution modelling package, its early applications and relevance to most current MaxEnt studies. *Diversity and Distributions*, 20, 1–9 DOI: 10.1111/ddi.12144.

BRASIER, C. M., 2008. The biosecurity threat to the UK and global environment from international trade in plants. Plant Pathology, 57, 792–808 DOI: doi:10.1111/j.1365–3059.2008.01886.x.

BRESHEARS, D. D., ADAMS, H. D., EAMUS, D., MCDOWELL, N. G., LAW, D. J., WILL, R. E., WILLIAMS, A. P. & ZOU, C. B., 2013. The critical amplifying role of increasing atmospheric moisture demand on tree mortality and associated regional die–off. Frontiers in Plant Science, 4 DOI: 10.3389/fpls.2013.00266.

BRUMMITT, R., PANDO, F., HOLLIS, S. & BRUMMITT, N., 2001. *World Geographical Scheme for Recording Plant Distributions*, International Working Group on Taxonomic Databases for Plant Sciences (TDWG)

BULLERI, F., BRUNO, J. F., SILLIMAN, B. R. & STACHOWICZ, J. J., 2016. Facilitation and the niche: implications for coexistence, range shifts and ecosystem functioning. *Functional Ecology*, 30, 70–78 DOI: doi:10.1111/1365–2435.12528.

BUSH, A., CATULLO, R. A., MOKANY, K., THORNHILL, A. H., MILLER, J. T. & FERRIER, S., 2018. Truncation of thermal tolerance niches among Australian plants. *Global Ecology and Biogeography*, 27, 22–31 DOI: 10.1111/geb.12637.

CABI, 2020. Available: https://www.cabi.org/isc/datasheet/57195#tohostsOrSpeciesAffected [Accessed 14 March 2021].

CARNEGIE, A. J., LIDBETTER, J. R., WALKER, J., HORWOOD, M. A., TESORIERO, L., GLEN, M. & PRIEST, M. J., 2010. Uredo rangelii, a taxon in the guava rust complex, newly recorded on Myrtaceae in Australia. *Australasian Plant Pathology*, 39, 463–466 DOI: 10.1071/AP10102.

CBD, 2018a. *Convention on Biological Diversity (CBD), Strategic Plan for Biodiversity 2011–2020, including Aichi Biodiversity Targets.* https://www.cbd.int/sp/default.shtml

CBD, 2018b. *Convention on Biological Diversity (CBD), Updated Global Strategy for Plant Conservation 2011–2020*, https://www.cbd.int/gspc/strategy.shtml

CBD, 2018c. *Convention on Biological Diversity (CBD)*, https://www.cbd.int/

CHOMLEY, F., 2019. *Nature for health and wellbeing – A review of the evidence.* Melbourne, Victoria: Royal Botanic Gardens Victoria. https://www.rbg.vic.gov.au/media/ydgkcbk1/rbg260–nature–for–health–and–wellbeing–report–fa–r3–spreads.pdf

CITES, 2018. *Convention on International Trade in Endangered Species of Wild Fauna and Flora,* https://www.cites.org/eng

CLARKE J.M., G. M., THATCHER M., ROUND V. AND HEADY C., 2019. Greater Melbourne Climate Projections 2019. State of Victoria, Melbourne, Australia.

CONVENTION ON BIOLOGICAL DIVERSITY, 2021. *Development of a post-2020 global strategy for plant conservation as a component of the post-2020 global biodiversity framework*. https://www.cbd.int/meetings/SBSTTA-24

CORNARA, D., MORENTE, M., MARKHEISER, A., BODINO, N., TSAI, C.-W., FERERES, A., REDAK, R. A., PERRING, T. M. & LOPES, J. R. S., 2019. An overview on the worldwide vectors of Xylella fastidiosa. *Entomologia Generalis*, 157-181.

CRESWELL, G. C. & WEIR, R. G., 1997. *Plant Nutrient Disorders 5 - Ornamental Plants and Shrubs*, Melbourne, Victoria, Australia, Inkata Press Bureau of Meteorology, 2020. *State of the Climate*. http://www.bom.gov.au/state-of-the-climate/.

DODD, J. AND JONES, C., 2010. *Redefining the Role of Botanic Gardens: Towards a New Social Purpose*. Botanic Gardens Conservation International.

ELLISON, D., MORRIS, C. E., LOCATELLI, B., SHEIL, D., COHEN, J., MURDIYARSO, D., GUTIERREZ, V., NOORDWIJK, M. V., CREED, I. F., POKORNY, J., GAVEAU, D., SPRACKLEN, D. V., TOBELLA, A. B., ILSTEDT, U., TEULING, A. J., GEBREHIWOT, S. G., SANDS, D. C., MUYS, B., VERBIST, B., SPRINGGAY, E., SUGANDI, Y. & SULLIVAN, C. A., 2017. Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, 43, 51-61 DOI: https://doi.org/10.1016/j.gloenvcha.2017.01.002.

ENSSLIN, A. & GODEFROID, S., 2019. How the cultivation of wild plants in botanic gardens can change their genetic and phenotypic status and what this means for their conservation value. *Sibbaldia: The International Journal of Botanic Garden Horticulture*, 51-70.

FANT, J. B., HAVENS, K., KRAMER, A. T., WALSH, S. K., CALLICRATE, T., LACY, R. C., MAUNDER, M., MEYER, A. H. & SMITH, P. P., 2016. What to do when we can't bank on seeds: What botanic gardens can learn from the zoo community about conserving plants in living collections. *American Journal of Botany*, 103, 1541-1543 DOI: doi:10.3732/ajb.1600247.

FEELEY, K. J., BRAVO-AVILA, C., FADRIQUE, B., PEREZ, T. M. & ZULETA, D., 2020. Climate-driven changes in the composition of New World plant communities. *Nature Climate Change*, 10, 965-970 DOI: 10.1038/s41558-020-0873-2.

GRATZFELD, J., 2017. What is conservation horticulture? *BGjournal*, 14, 14-17.

GRATZFELD, J. E., 2016. From Idea to Realisation – BGCI's Manual on Planning, Developing and Managing Botanic Gardens. *In:* GRATZFELD, J. E. (ed.). Botanic Gardens Conservation International, Richmond, United Kingdom.

GRIFFITH, M. P., CLASE, T., TORIBIO, P., PIÑEYRO, Y. E., JIMENEZ, F., GRATACOS, X., SANCHEZ, V., MEEROW, A., MEYER, A., KRAMER, A., FANT, J., HAVENS, K., MAGELLAN, T. M., DOSMANN, M. & HOBAN, S., 2020. Can a Botanic Garden Metacollection Better Conserve Wild Plant Diversity? A Case Study Comparing Pooled Collections with an Ideal Sampling Model. *International Journal of Plant Sciences*, 181, 485-496 DOI: 10.1086/707729.

HANDRECK, K. & BLACK., N., 2010. *Growing media for ornamental plants and turf*, Sydney, Australia, University of NSW Press

HARTMANN, H., MOURA, C. F., ANDEREGG, W. R. L., RUEHR, N. K., SALMON, Y., ALLEN, C. D., ARNDT, S. K., BRESHEARS, D. D., DAVI, H., GALBRAITH, D., RUTHROF, K. X., WUNDER, J., ADAMS, H. D., BLOEMEN, J., CAILLERET, M., COBB, R., GESSLER, A., GRAMS, T. E. E., JANSEN, S., KAUTZ, M., LLORET, F. & O'BRIEN, M., 2018. Research frontiers for improving our understanding of drought-induced tree and forest mortality. *New Phytologist*, 218, 15-28 DOI: doi:10.1111/nph.15048.

HUANG, J., MA, K., & HUANG, J., 2017. Species Diversity Distribution Patterns of Chinese Endemic Seed Plants Based on Geographical Regions. *PloS one, 12*(1), e0170276. https://doi.org/10.1371/journal.pone.0170276

IKEDA, D., MAX, T., ALLAN, G.J., LAU, M.K, SHUSTER, S.M., & WHITHAM, T.G., 2016. Genetically informed ecological niche models improve climate change predictions. *Global Change Biology*. 23. 10.1111/gcb.13470.

INSPIRING PLACE, 2009. Royal Tasmanian Botanical Gardens Living Collections Plan. Hobart, Tasmania.

JENERETTE, G. D., CLARKE, L. W., AVOLIO, M. L., PATAKI, D. E., GILLESPIE, T. W., PINCETL, S., NOWAK, D. J., HUTYRA, L. R., MCHALE, M., MCFADDEN, J. P. & ALONZO, M., 2016. Climate tolerances and trait choices shape continental patterns of urban tree biodiversity. *Global Ecology and Biogeography*, 25, 1367-1376 DOI: doi:10.1111/geb.12499.

JOHNSTON C., & DYKE, J., 2017. *Aboriginal Heritage Values Report: Melbourne Gardens*, Context Pty Ltd, Melbourne, pg 47

KENDAL, D., 2017. Climate risk assessment of potential threatened species for the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria. Burnley Campus, School of Ecosystem and Forest Sciences, University of Melbourne & Clean Air and Urban Landscape hub of the National Environmental Science programme & School of Technology, Environments and Design, University of Tasmania.

KENDAL, D., DOBBS, C., GALLAGHER, R. V., BEAUMONT, L. J., BAUMANN, J., WILLIAMS, N. S. G. & LIVESLEY, S. J., 2018. A global comparison of the climatic niches of urban and native tree populations. *Global Ecology and Biogeography*, 27, 629-637 DOI: doi:10.1111/geb.12728.

KENDAL, D. & FARRAR, A., 2017. Assessment of the climate change risk to the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria. *National Environmental Science Program*.

KOTTEK, M., GRIESER, J., BECK, C,. RUDOLF, B., & RUBEL, F., 2006. World Map of the Köppen-Geiger Climate Classification Updated. *Meteorologische Zeitschrift*. 15. 259-263. 10.1127/0941-2948/2006/0130.

LANZA, K. & STONE, B., 2016. Climate adaptation in cities: What trees are suitable for urban heat management? *Landscape and Urban Planning*, 153, 74-82 DOI: 10.1016/j.landurbplan.2015.12.002.

LEAKE, S., 2018. *Urban Soil Science — Principles & Practices*, Pennant Hills, NSW, Australia: Sydney Environmental & Soil Laboratory Available: http://sesl.com.au/publications/

LEWIS, S. C. & KING, A. D., 2017. Evolution of mean, variance and extremes in 21st century temperatures. *Weather and Climate Extremes*, 15, 1–10 DOI: https://doi.org/10.1016/j.wace.2016.11.002.

LUGHADHA, E.N., BACHMAN, S., LEÃO, T., FOREST, F., HALLEY, J., MOAT, J., ACEDO, C., BACON, K., BREWER, R., GÂTEBLÉ, G., GONÇALVES, S., GOVAERTS, R., HOLLINGSWORTH, P., KRISAI-GREILHUBER, I., LIRIO, E., MOORE, P., NEGRÃO, R., ONANA, J., RAJAOVELONA, L., RAZANAJATOVO, H., REICH, P., RICHARDS, S., RIVERS, M., COOPER, A., IGANCI, J., LEWIS, G., SMIDT, E., ANTONELLI, A., MUELLER, G. AND WALKER, B., 2020. Extinction risk and threats to plants and fungi. *PLANTS, PEOPLE, PLANET*, 2(5), pp.389–408.

MAKINSON, R., 2018. Myrtle Rust reviewed: the impacts of the invasive pathogen Austropuccinia psidii on the Australian environment. *Plant Biosecurity Cooperative Research Centre, Canberra*.

MAKINSON, R. O., PEGG, G. S. & CARNEGIE, A. J., 2020. Myrtle Rust in Australia — a National Action Plan. Canberra, Australia.: Australian Plant Biosecurity Science Foundation.

MANKGA, L. T. & YESSOUFOU, K., 2017. Factors driving the global decline of cycad diversity. *AoB PLANTS*, 9 DOI: 10.1093/aobpla/plx022.

MARTÍN, M. P., BARREIRO, G., DUQUE, A. M., MAGALHÃES, Z. & MANRIQUE, E., 2020. Botanical Gardens Facing Biodiversity Conservation and Climate Change. *Life on Land. Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham. https://doi.org/10.1007/978-3-319-71065-5_124-1

MCDOWELL, N., ALLEN, C. D., ANDERSON-TEIXEIRA, K., BRANDO, P., BRIENEN, R., CHAMBERS, J., CHRISTOFFERSEN, B., DAVIES, S., DOUGHTY, C., DUQUE, A., ESPIRITO-SANTO, F., FISHER, R., FONTES, C. G., GALBRAITH, D., GOODSMAN, D., GROSSIORD, C., HARTMANN, H., HOLM, J., JOHNSON, D. J., KASSIM, A. R., KELLER, M., KOVEN, C., KUEPPERS, L., KUMAGAI, T. O., MALHI, Y., MCMAHON, S. M., MENCUCCINI, M., MEIR, P., MOORCROFT, P., MULLER-LANDAU, H. C., PHILLIPS, O. L., POWELL, T., SIERRA, C. A., SPERRY, J., WARREN, J., XU, C. & XU, X., 2018. Drivers and mechanisms of tree mortality in moist tropical forests. *New Phytologist*, 219, 851–869 DOI: doi:10.1111/nph.15027.

MOUNCE, R., SMITH, P. & BROCKINGTON, S., 2017. Ex situ conservation of plant diversity in the world's botanic gardens. *Nature Plants*, 3, 795–802 DOI: 10.1038/s41477-017-0019-3.

MOSKWA, E.C., and CRILLEY, G., 2012. Recreation, Education, Conservation: The Multiple Roles of Botanic Gardens in Australia, *Annals of Leisure Research* 15, no. 4, 404—21, https://doi.org/10.1080/11745398.2012.744276.

NORTON, B. A., COUTTS, A. M., LIVESLEY, S. J., HARRIS, R. J., HUNTER, A. M. & WILLIAMS, N. S. G., 2015. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. *Landscape and Urban Planning*, 134, 127–138 DOI: 10.1016/j.landurbplan.2014.10.018.

O'DONNELL, K. & SHARROCK, S., 2017. The contribution of botanic gardens to ex situ conservation through seed banking. *Plant Diversity*, 39, 373–378 DOI: https://doi.org/10.1016/j.pld.2017.11.005.

PEARSON, R. G. & DAWSON, T. P., 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology and Biogeography*, 12, 361–371 DOI: https://doi.org/10.1046/j.1466-822X.2003.00042.x.

PEGG, G., CARNEGIE, A., GIBLIN, F. & PERRY, S., 2018. *Managing myrtle rust in Australia*, Plant Biosecurity Cooperative Research Centre

PERKINS-KIRKPATRICK, S. E. & GIBSON, P. B., 2017. Changes in regional heatwave characteristics as a function of increasing global temperature. *Scientific Reports*, 7, 12256 DOI: 10.1038/s41598-017-12520-2.

QUEENSLAND HERBARIUM, 2016. Collection and preserving plant specimens, a manual. 2nd edition. Department of Science, Information Technology and Innovation, Brisbane.

RAE, D., BAXTER, P., KNOTT, D., MITCHELL, D., PATERSON, D. & UNWIN, B., 2006. Royal Botanic Garden Edinburgh: Collection Policy for the Living Collection. Royal Botanic Garden Edinburgh, Edinburgh, Scotland.

RAE, J., 2013. Botanic Garden Horticulturists — A Threatened Species?. *Sibbaldia: The Journal of Botanic Garden Horticulture*, 11, 5–13.

RBGV, 2016. Landscape Succession Strategy 2016–2036 — Adapting a World-renowned Botanical Landscape to Climate Change. South Yarra, Melbourne.

RBGV, 2021. Living Collections Database.

RBGV, 2020. Royal Botanic Gardens Victoria Melbourne Gardens Master Plan 2020–2040. Melbourne, Australia: Royal Botanic Gardens Board Victoria.

ROHLI, R. V., ANDREW JOYNER, T., REYNOLDS, S. J., SHAW, C. & VÁZQUEZ, J. R., 2015. Globally Extended Köppen—Geiger climate classification and temporal shifts in terrestrial climatic types. *Physical Geography*, 36, 142–157 DOI: 10.1080/02723646.2015.1016382.

RUTHROF, K. X., BRESHEARS, D. D., FONTAINE, J. B., FROEND, R. H., MATUSICK, G., KALA, J., MILLER, B. P., MITCHELL, P. J., WILSON, S. K., VAN KEULEN, M., ENRIGHT, N. J., LAW, D. J., WERNBERG, T. & HARDY, G. E. S. J., 2018. Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses. *Scientific Reports*, 8, 13094 DOI: 10.1038/s41598-018-31236-5.

SACHINDRA, D. A., NG, A. W. M., MUTHUKUMARAN, S. & PERERA, B. J. C., 2016. Impact of climate change on urban heat island effect and extreme temperatures: A case-study. *Quarterly Journal of the Royal Meteorological Society*, 142, 172-186 DOI: 10.1002/qj.2642.

SAX, M. S., BASSUK, N., VAN ES, H. & RAKOW, D., 2017. Long-term remediation of compacted urban soils by physical fracturing and incorporation of compost. *Urban Forestry & Urban Greening*, 24, 149-156 DOI: https://doi.org/10.1016/j.ufug.2017.03.023.

SMITH, P.P. AND HARVEY-BROWN, Y., 2017. BGCI Technical Review: Defining the botanic garden, and how to measure performance and success. Botanic Gardens Conservation International, Richmond, United Kingdom.

SOMMERVILLE, K. D., CUNEO, P., ERRINGTON, G., MAKINSON, R. O., PEDERSON, S., PHILLIPS, G., ROLLASON, A., VILER, V. & OFFORD, C. A., 2020. Conservation in the wake of myrtle rust — a case study on two critically endangered Australian rainforest plants. *Pacific Conservation Biology*, 26, 218-229 DOI: https://doi.org/10.1071/PC19026.

SYMES, P., 2011. Biosecurity Royal Botanic Gardens Melbourne. *BGjournal*, 8, 7-13.

SYMES, P., 2017. Guiding landscape transition for climatic change: planning in the Royal Botanic Gardens Victoria, Australia. International Society for Horticultural Science (ISHS), Leuven, Belgium, 137-142 DOI: 10.17660/ActaHortic.2017.1189.27.

SYMES, P. & CONNELLAN, G. J., 2013. Water management strategies for urban trees in dry environments: Lessons for the future. *Arboriculture & Urban Forestry*, 39, 116-124.

UN, 2018. *United Nations, Transforming our world: the 2030 Agenda for Sustainable Development, viewed 29 September 2018, https://sustainabledevelopment.un.org/post2015/transformingourworld* [Online]. Available: https://sustainabledevelopment.un.org/post2015/transformingourworld [Accessed 29 September 2018 2018].

VAN REES, H., JACKMAN, A., WILIAMSON, J. & CUMMINGS, D., 1993. Royal Botanic Gardens Soil Survey. Bendigo.

VIRTUE, J., SPENCER, R., WEISS, J. & REICHARD, S., 2008. Australia's Botanic Gardens weed risk assessment procedure. *Plant Protection Quarterly*, 23, 166.

VOLIS, S., 2017. Conservation utility of botanic garden living collections: Setting a strategy and appropriate methodology. *Plant Diversity*. 39. 10.1016/j.pld.2017.11.006.

WEBB, H., 2014. *Carbon Storage and Accumulation in the Royal Botanic Gardens Melbourne Tree Population Thesis (Masters)*. Masters Masters, University of Melbourne.

WEBB, L. B. & HENNESSY, K., 2015. Climate Change in Australia: Projections for selected Australian cities. CSIRO and Bureau of Meteorology, Australia..

WOOD, J., BALLOU, J. D., CALLICRATE, T., FANT, J. B., GRIFFITH, M. P., KRAMER, A. T., LACY, R. C., MEYER, A., SULLIVAN, S., TRAYLOR-HOLZER, K., WALSH, S. K. & HAVENS, K., 2020. Applying the zoo model to conservation of threatened exceptional plant species. *Conservation Biology*, 34, 1416-1425 DOI: https://doi.org/10.1111/cobi.13503.

WYSE JACKSON, P.S, CHENEY, J., & NAVARRETE NAVARRO, J., 2000. Action Plan for Botanic Gardens in the European Union. *Scripta Botanica Belgica*. 19. 1-68.

ZHAO, J., HARTMANN, H., TRUMBORE, S., ZIEGLER, W. & ZHANG, Y., 2013. High temperature causes negative whole-plant carbon balance under mild drought. *New Phytologist*, 200, 330-339 DOI: doi:10.1111/nph.12400.

# End Notes


1 WYSE JACKSON, P.S, CHENEY, J., & NAVARRETE NAVARRO, J. (Eds), 2000. Action Plan for Botanic Gardens in the European Union. *Scripta Botanica Belgica*. 19. 1–68.

2 LUGHADHA, E.N., BACHMAN, S., LEÃO, T., FOREST, F., HALLEY, J., MOAT, J., ACEDO, C., BACON, K., BREWER, R., GÂTEBLÉ, G., GONÇALVES, S., GOVAERTS, R., HOLLINGSWORTH, P., KRISAI-GREILHUBER, I., LIRIO, E., MOORE, P., NEGRÃO, R., ONANA, J., RAJAOVELONA, L., RAZANAJATOVO, H., REICH, P., RICHARDS, S., RIVERS, M., COOPER, A., IGANCI, J., LEWIS, G., SMIDT, E., ANTONELLI, A., MUELLER, G. AND WALKER, B., 2020. Extinction risk and threats to plants and fungi. *PLANTS, PEOPLE, PLANET*, 2(5), pp.389–408.

3 KOTTEK, M., GRIESER, J., BECK, C,. RUDOLF, B., & RUBEL, F., 2006. World Map of the Köppen-Geiger Climate Classification Updated. *Meteorologische Zeitschrift*. 15. 259–263. 10.1127/0941-2948/2006/0130.

4 BECK, H. E., ZIMMERMANN, N. E., MCVICAR, T. R., VERGOPOLAN, N., BERG, A. & WOOD, E. F., 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data*, 5, 180214 DOI: 10.1038/sdata.2018.214.

5 ROHLI, R. V., ANDREW JOYNER, T., REYNOLDS, S. J., SHAW, C. & VÁZQUEZ, J. R., 2015. Globally Extended Köppen–Geiger climate classification and temporal shifts in terrestrial climatic types. *Physical Geography*, 36, 142–157 DOI: 10.1080/02723646.2015.1016382

6 BOM, 2018. *Bureau of Meteorology*, Climate Data Online, http://www.bom.gov.au/climate/data/

7 VAN REES, H., JACKMAN, A., WILIAMSON, J. & CUMMINGS, D., 1993. Royal Botanic Gardens Soil Survey. Bendigo.

8 JOHNSTON C., & DYKE, J., 2017. *Aboriginal Heritage Values Report: Melbourne Gardens*, Context Pty Ltd, Melbourne, pg 47

9 RBGV, 2020. Royal Botanic Gardens Victoria Melbourne Gardens Master Plan 2020–2040. Melbourne, Australia: Royal Botanic Gardens Board Victoria.

10 CBD, 2018c. Convention on Biological Diversity (CBD), https://www.cbd.int/

11 CBD, 2018a. Convention on Biological Diversity (CBD), Strategic Plan for Biodiversity 2011–2020, including Aichi Biodiversity Targets, https://www.cbd.int/sp/default.shtml

12 CBD, 2019. Convention on Biological Diversity (CBD), Post-2020 Biodiversity Framework, https://www.cbd.int/conferences/post2020/post2020-prep-01/documents

13 CBD, 2018b. Convention on Biological Diversity (CBD), Updated Global Strategy for Plant Conservation 2011–2020, viewed 29 September 2018, https://www.cbd.int/gspc/strategy.shtml

14 SHARROCK, S. pers. comm., 2021, 6 February Convention on Biological Diversity. *Development of a post-2020 global strategy for plant conservation as a component of the post-2020 global biodiversity framework*.

15 UN, 2018. *United Nations, Transforming our world: the 2030 Agenda for Sustainable Development*, https://sustainabledevelopment.un.org/post2015/transformingourworld

16 CBD, 2018e. Convention on Biological Diversity (CBD), Preparations for the Post-2020 Biodiversity Framework

17 CITES, 2018. *Convention on International Trade in Endangered Species of Wild Fauna and Flora*, https://www.cites.org/eng

18 BGCI, 2018. BGCI: *About us*, http://www.bgci.org/about-us/

19 BGCI, 2012. International Agenda for Botanic Gardens in Conservation: 2nd edition. Descanso House, 199 Kew Road, Richmond, Surrey, TW9 3BW, UK.

20 MARTÍN, M. P., BARREIRO, G., DUQUE, A. M., MAGALHÃES, Z. & MANRIQUE, E., 2020. Botanical Gardens Facing Biodiversity Conservation and Climate Change. *Life on Land. Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham. https://doi.org/10.1007/978-3-319-71065-5_124-1

21 HUANG, J., MA, K., & HUANG, J., 2017. Species Diversity Distribution Patterns of Chinese Endemic Seed Plants Based on Geographical Regions. PloS one, 12(1), e0170276. https://doi.org/10.1371/journal.pone.0170276

22 MANKGA, L. T. & YESSOUFOU, K., 2017. Factors driving the global decline of cycad diversity. AoB PLANTS, 9 DOI: 10.1093/aobpla/plx022.

23 KENDAL, D. & FARRAR, A., 2017. Assessment of the climate change risk to the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria. National Environmental Science Program.

24 WEBB, L. B. & HENNESSY, K., 2015. Climate Change in Australia: Projections for selected Australian cities. CSIRO and Bureau of Meteorology, Australia.

25 CLARKE J.M., G. M., THATCHER M., ROUND V. AND HEADY C., 2019. Greater Melbourne Climate Projections 2019. State of Victoria, Melbourne, Australia.

26 Bureau of Meteorology, 2021. *Climate Data Online*. http://www.bom.gov.au/climate/data/?ref=ftr

27 JENERETTE, G. D., CLARKE, L. W., AVOLIO, M. L., PATAKI, D. E., GILLESPIE, T. W., PINCETL, S., NOWAK, D. J., HUTYRA, L. R., MCHALE, M., MCFADDEN, J. P. & ALONZO, M., 2016. Climate tolerances and trait choices shape continental patterns of urban tree biodiversity. *Global Ecology and Biogeography*, 25, 1367–1376 DOI: doi:10.1111/geb.12499

28 KENDAL, D., DOBBS, C., GALLAGHER, R. V., BEAUMONT, L. J., BAUMANN, J., WILLIAMS, N. S. G. & LIVESLEY, S. J., 2018. A global comparison of the climatic niches of urban and native tree populations. Ibid.27, 629–637 DOI: doi:10.1111/geb.12728

29 LANZA, K. & STONE, B., 2016. Climate adaptation in cities: What trees are suitable for urban heat management? *Landscape and Urban Planning*, 153, 74–82 DOI: 10.1016/j.landurbplan.2015.12.002.

30 LEWIS, S. C. & KING, A. D., 2017. Evolution of mean, variance and extremes in 21st century temperatures. *Weather and Climate Extremes*, 15, 1–10 DOI: https://doi.org/10.1016/j.wace.2016.11.002;

31 PERKINS-KIRKPATRICK, S. E. & GIBSON, P. B., 2017. Changes in regional heatwave characteristics as a function of increasing global temperature. *Scientific Reports*, 7, 12256 DOI: 10.1038/s41598-017-12520-2

32 ALLEN, C. D., BRESHEARS, D. D. & MCDOWELL, N. G., 2015. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. *Ecosphere*, 6, 1–55.

33 RUTHROF, K. X., BRESHEARS, D. D., FONTAINE, J. B., FROEND, R. H., MATUSICK, G., KALA, J., MILLER, B. P., MITCHELL, P. J., WILSON, S. K., VAN KEULEN, M., ENRIGHT, N. J., LAW, D. J., WERNBERG, T. & HARDY, G. E. S. J., 2018. Subcontinental heat wave triggers terrestrial and marine, multi-taxa responses. *Scientific Reports*, 8, 13094 DOI: 10.1038/s41598-018-31236-5.

34 CLARKE J.M., G. M., THATCHER M., ROUND V. AND HEADY C., 2019. Greater Melbourne Climate Projections 2019. *State of Victoria,* Melbourne, Australia.

35 Bureau of Meteorology, 2020. *State of the Climate*. http://www.bom.gov.au/state-of-the-climate/

36 BRESHEARS, D. D., ADAMS, H. D., EAMUS, D., MCDOWELL, N. G., LAW, D. J., WILL, R. E., WILLIAMS, A. P. & ZOU, C. B., 2013. The critical amplifying role of increasing atmospheric moisture demand on tree mortality and associated regional die-off. *Frontiers in Plant Science*, 4 DOI: 10.3389/fpls.2013.00266.

37 MCDOWELL, N., ALLEN, C. D., ANDERSON-TEIXEIRA, K., BRANDO, P., BRIENEN, R., CHAMBERS, J., CHRISTOFFERSEN, B., DAVIES, S., DOUGHTY, C., DUQUE, A., ESPIRITO-SANTO, F., FISHER, R., FONTES, C. G., GALBRAITH, D., GOODSMAN, D., GROSSIORD, C., HARTMANN, H., HOLM, J., JOHNSON, D. J., KASSIM, A. R., KELLER, M., KOVEN, C., KUEPPERS, L., KUMAGAI, T. O., MALHI, Y., MCMAHON, S. M., MENCUCCINI, M., MEIR, P., MOORCROFT, P., MULLER-LANDAU, H. C., PHILLIPS, O. L., POWELL, T., SIERRA, C. A., SPERRY, J., WARREN, J., XU, C. & XU, X., 2018. Drivers and mechanisms of tree mortality in moist tropical forests. *New Phytologist*, 219, 851–869 DOI: doi:10.1111/nph.15027.

38 ZHAO, J., HARTMANN, H., TRUMBORE, S., ZIEGLER, W. & ZHANG, Y., 2013. High temperature causes negative whole-plant carbon balance under mild drought. *New Phytologist*, 200, 330–339 DOI: doi:10.1111/nph.12400

39 HARTMANN, H., MOURA, C. F., ANDEREGG, W. R. L., RUEHR, N. K., SALMON, Y., ALLEN, C. D., ARNDT, S. K., BRESHEARS, D. D., DAVI, H., GALBRAITH, D., RUTHROF, K. X., WUNDER, J., ADAMS, H. D., BLOEMEN, J., CAILLERET, M., COBB, R., GESSLER, A., GRAMS, T. E. E., JANSEN, S., KAUTZ, M., LLORET, F. & O'BRIEN, M., 2018. Research frontiers for improving our understanding of drought-induced tree and forest mortality. *New Phytologist*, 218, 15–28 DOI: doi:10.1111/nph.15048

40 SACHINDRA, D. A., NG, A. W. M., MUTHUKUMARAN, S. & PERERA, B. J. C., 2016. Impact of climate change on urban heat island effect and extreme temperatures: A case-study. *Quarterly Journal of the Royal Meteorological Society*, 142, 172–186 DOI: 10.1002/qj.2642.

41 WYSE JACKSON, P.S, CHENEY, J., AND NAVARRETE NAVARRO, J., 2000. Action Plan for Botanic Gardens in the European Union. *Scripta Botanic Belgica*, 19: 1–68. Scripta Botanica Belgica. 19. 1–68.

42 ROYAL BOTANIC GARDENS VICTORIA, 2022, *Living Collections Database*

43 ENSSLIN, A. & GODEFROID, S., 2019. How the cultivation of wild plants in botanic gardens can change their genetic and phenotypic status and what this means for their conservation value. *Sibbaldia: The International Journal of Botanic Garden Horticulture*, 51–70.

44 SYMES, P., 2011. Biosecurity Royal Botanic Gardens Melbourne. *BGjournal*, 8, 7–13.

45 BRASIER, C. M., 2008. The biosecurity threat to the UK and global environment from international trade in plants. *Plant Pathology*, 57, 792–808 DOI: doi:10.1111/j.1365-3059.2008.01886.x.

46 RBGV, 2016. Landscape Succession Strategy 2016–2036 – Adapting a World-renowned Botanical Landscape to Climate Change. South Yarra, Melbourne..

47 SYMES, P., 2011. Biosecurity Royal Botanic Gardens Melbourne. *BGjournal*, 8, 7–13.

48 CORNARA, D., MORENTE, M., MARKHEISER, A., BODINO, N., TSAI, C.-W., FERERES, A., REDAK, R. A., PERRING, T. M. & LOPES, J. R. S., 2019. An overview on the worldwide vectors of Xylella fastidiosa. *Entomologia Generalis*, 157–181.

49 RAE, J., 2013. Botanic Garden Horticulturists – A Threatened Species?. *Sibbaldia: The Journal of Botanic Garden Horticulture*, 11, 5–13.

50 GRATZFELD, J., 2017. What is conservation horticulture? *BGjournal*, 14, 14–17.

51 SAX, M. S., BASSUK, N., VAN ES, H. & RAKOW, D., 2017. Long-term remediation of compacted urban soils by physical fracturing and incorporation of compost. *Urban Forestry & Urban Greening*, 24, 149–156 DOI: https://doi.org/10.1016/j.ufug.2017.03.023.

52 LEAKE, S., 2018. *Urban Soil Science – Principles & Practices*, Pennant Hills, NSW, Australia: Sydney Environmental & Soil Laboratory Available: http://sesl.com.au/publications/

53 HANDRECK, K. & BLACK., N. 2010. *Growing media for ornamental plants and turf*, Sydney, Australia, University of NSW Press

54 CRESWELL, G. C. & WEIR, R. G., 1997. *Plant Nutrient Disorders 5 – Ornamental Plants and Shrubs*, Melbourne, Victoria, Australia, Inkata Press

55 DODD, J. AND JONES, C., 2010. *Redefining the Role of Botanic Gardens: Towards a New Social Purpose*. Botanic Gardens Conservation International.

56 MOSKWA, E.C., and CRILLEY, G., 2012. Recreation, Education, Conservation: The Multiple Roles of Botanic Gardens in Australia, *Annals of Leisure Research* 15, no. 4, 404–21, https://doi.org/10.1080/11745398.2012.744276.

57 BALLANTYNE, R., PACKER, J., and HUGHES, K., 2008. Environmental Awareness, Interests and Motives of Botanic Gardens Visitors: Implications for Interpretive Practice, *Tourism Management* 29, no. 3, 439–44, https://doi.org/10.1016/j.tourman.2007.05.006.

58 VOLIS, S., 2017. Conservation utility of botanic garden living collections: Setting a strategy and appropriate methodology. *Plant Diversity*. 39. 10.1016/j.pld.2017.11.006.

59 BALDING, M., & WILLIAMS, K., 2016. Plant blindness and the implications for plant conservation. *Conservation Biology*. 30. 10.1111/cobi.12738.

60 CHOMLEY, F., 2019. *Nature for health and wellbeing – A review of the evidence*. Melbourne, Victoria: Royal Botanic Gardens Victoria. https://www.rbg.vic.gov.au/media/ydgkcbk1/rbg260-nature-for-health-and-wellbeing-report-fa-r3-spreads.pdf

61 SMITH, P.P. AND HARVEY-BROWN, Y., 2017. BGCI Technical Review: Defining the botanic garden, and how to measure performance and success. Botanic Gardens Conservation International, Richmond, United Kingdom.

62 SYMES, P., 2017. Guiding landscape transition for climatic change: planning in the Royal Botanic Gardens Victoria, Australia. *International Society for Horticultural Science* (ISHS), Leuven, Belgium, 137–142 DOI: 10.17660/ActaHortic.2017.1189.27.

63 BECK, H. E., ZIMMERMANN, N. E., MCVICAR, T. R., VERGOPOLAN, N., BERG, A. & WOOD, E. F., 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Scientific Data*, 5, 180214 DOI: 10.1038/sdata.2018.214.

64 SYMES, P. & CONNELLAN, G. J., 2013. Water management strategies for urban trees in dry environments: Lessons for the future. *Arboriculture & Urban Forestry*, 39, 116–124.

65 NORTON, B. A., COUTTS, A. M., LIVESLEY, S. J., HARRIS, R. J., HUNTER, A. M. & WILLIAMS, N. S. G., 2015. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. *Landscape and Urban Planning*, 134, 127–138 DOI: 10.1016/j.landurbplan.2014.10.018.

66 ELLISON, D., MORRIS, C. E., LOCATELLI, B., SHEIL, D., COHEN, J., MURDIYARSO, D., GUTIERREZ, V., NOORDWIJK, M. V., CREED, I. F., POKORNY, J., GAVEAU, D., SPRACKLEN, D. V., TOBELLA, A. B., ILSTEDT, U., TEULING, A. J., GEBREHIWOT, S. G., SANDS, D. C., MUYS, B., VERBIST, B., SPRINGGAY, E., SUGANDI, Y. & SULLIVAN, C. A., 2017. Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, 43, 51–61 DOI: https://doi.org/10.1016/j.gloenvcha.2017.01.002.

67 SYMES, P., 2017. Guiding landscape transition for climatic change: planning in the Royal Botanic Gardens Victoria, Australia. *International Society for Horticultural Science* (ISHS), Leuven, Belgium, 137–142 DOI: 10.17660/ActaHortic.2017.1189.27

68 CLARKE J.M., G. M., THATCHER M., ROUND V. AND HEADY C., 2019. Greater Melbourne Climate Projections 2019. State of Victoria, Melbourne, Australia.

69 PEARSON, R. G. & DAWSON, T. P., 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology and Biogeography*, 12, 361–371 DOI: https://doi.org/10.1046/j.1466-822X.2003.00042.x

70 BOOTH, T. H., NIX, H. A., BUSBY, J. R. & HUTCHINSON, M. F., 2014. Bioclim: The first species distribution modelling package, its early applications and relevance to most current MaxEnt studies. *Diversity and Distributions*, 20, 1–9 DOI: 10.1111/ddi.12144

71 BULLERI, F., BRUNO, J. F., SILLIMAN, B. R. & STACHOWICZ, J. J., 2016. Facilitation and the niche: implications for coexistence, range shifts and ecosystem functioning. *Functional Ecology*, 30, 70–78 DOI: doi:10.1111/1365-2435.12528

72 BOOTH, T. H., 2017. Assessing species climatic requirements beyond the realized niche: some lessons mainly from tree species distribution modelling. *Climatic Change*, 145, 259–271 DOI: 10.1007/s10584-017-2107-9.

73 BUSH, A., CATULLO, R. A., MOKANY, K., THORNHILL, A. H., MILLER, J. T. & FERRIER, S., 2018. Truncation of thermal tolerance niches among Australian plants. *Global Ecology and Biogeography*, 27, 22–31 DOI: 10.1111/geb.12637.

74 IKEDA, D., MAX, T., ALLAN, G.J., LAU, M.K, SHUSTER, S.M., & WHITHAM, T.G., 2016. Genetically informed ecological niche models improve climate change predictions. *Global Change Biology*. 23. 10.1111/gcb.13470.

75 BGCI, 2021. *About Botanic Gardens*. https://www.bgci.org/about/about-botanic-garden/

76 BRUMMITT, R., PANDO, F., HOLLIS, S. & BRUMMITT, N., 2001. *World Geographical Scheme for Recording Plant Distributions,* International Working Group on Taxonomic Databases for Plant Sciences (TDWG)

77 RBGV, 2021. Living Collections Database.

78 KENDAL, D., 2017. Climate risk assessment of potential threatened species for the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria. Burnley Campus, School of Ecosystem and Forest Sciences, University of Melbourne & Clean Air and Urban Landscape hub of the National Environmental Science programme & School of Technology, Environments and Design, University of Tasmania.

79 RBGV, 2022, *Living Collections Database*

80 KENDAL, D., 2017. Climate risk assessment of potential threatened species for the living plant collections in the Melbourne Gardens, Royal Botanic Gardens Victoria. Burnley Campus, School of Ecosystem and Forest Sciences, University of Melbourne & Clean Air and Urban Landscape hub of the National Environmental Science programme & School of Technology, Environments and Design, University of Tasmania.

81 O'DONNELL, K. & SHARROCK, S., 2017. The contribution of botanic gardens to ex situ conservation through seed banking. *Plant Diversity*, 39, 373–378 DOI: https://doi.org/10.1016/j.pld.2017.11.005.

82 FANT, J. B., HAVENS, K., KRAMER, A. T., WALSH, S. K., CALLICRATE, T., LACY, R. C., MAUNDER, M., MEYER, A. H. & SMITH, P. P., 2016. What to do when we can't bank on seeds: What botanic gardens can learn from the zoo community about conserving plants in living collections. *American Journal of Botany*, 103, 1541–1543 DOI: doi:10.3732/ajb.1600247.

83 VOLIS, S., 2017. Conservation utility of botanic garden living collections: Setting a strategy and appropriate methodology. *Plant Diversity*. 39. 10.1016/j.pld.2017.11.006.

84 GRIFFITH, M. P., CLASE, T., TORIBIO, P., PIÑEYRO, Y. E., JIMENEZ, F., GRATACOS, X., SANCHEZ, V., MEEROW, A., MEYER, A., KRAMER, A., FANT, J., HAVENS, K., MAGELLAN, T. M., DOSMANN, M. & HOBAN, S., 2020. Can a Botanic Garden Metacollection Better Conserve Wild Plant Diversity? A Case Study Comparing Pooled Collections with an Ideal Sampling Model. *International Journal of Plant Sciences*, 181, 485–496 DOI: 10.1086/707729,

85 WOOD, J., BALLOU, J. D., CALLICRATE, T., FANT, J. B., GRIFFITH, M. P., KRAMER, A. T., LACY, R. C., MEYER, A., SULLIVAN, S., TRAYLOR-HOLZER, K., WALSH, S. K. & HAVENS, K., 2020. Applying the zoo model to conservation of threatened exceptional plant species. *Conservation Biology*, 34, 1416–1425 DOI: https://doi.org/10.1111/cobi.13503.

86 CARNEGIE, A. J., LIDBETTER, J. R., WALKER, J., HORWOOD, M. A., TESORIERO, L., GLEN, M. & PRIEST, M. J., 2010. Uredo rangelii, a taxon in the guava rust complex, newly recorded on Myrtaceae in Australia. *Australasian Plant Pathology*, 39, 463–466 DOI: 10.1071/AP10102.

87 PEGG, G., CARNEGIE, A., GIBLIN, F. & PERRY, S., 2018. *Managing myrtle rust in Australia*, Plant Biosecurity Cooperative Research Centre

88 MAKINSON, R. O., PEGG, G. S. & CARNEGIE, A. J., 2020. Myrtle Rust in Australia — a National Action Plan. Canberra, Australia.: Australian Plant Biosecurity Science Foundation.

89 MAKINSON, R., 2018. Myrtle Rust reviewed: the impacts of the invasive pathogen Austropuccinia psidii on the Australian environment. *Plant Biosecurity Cooperative Research Centre, Canberra.*

90 SOMMERVILLE, K. D., CUNEO, P., ERRINGTON, G., MAKINSON, R. O., PEDERSON, S., PHILLIPS, G., ROLLASON, A., VILER, V. & OFFORD, C. A., 2020. Conservation in the wake of myrtle rust — a case study on two critically endangered Australian rainforest plants. *Pacific Conservation Biology*, 26, 218–229 DOI: https://doi.org/10.1071/PC19026

91 MOUNCE, R., SMITH, P. & BROCKINGTON, S., 2017. Ex situ conservation of plant diversity in the world's botanic gardens. *Nature Plants*, 3, 795–802 DOI: 10.1038/s41477-017-0019-3.

92 VIRTUE, J., SPENCER, R., WEISS, J. & REICHARD, S., 2008. Australia's Botanic Gardens weed risk assessment procedure. *Plant Protection Quarterly*, 23, 166.

93 RAE, D., BAXTER, P., KNOTT, D., MITCHELL, D., PATERSON, D. & UNWIN, B., 2006. Royal Botanic Garden Edinburgh: Collection Policy for the Living Collection. Royal Botanic Garden Edinburgh, Edinburgh, Scotland.

94 QUEENSLAND HERBARIUM, 2016. Collection and preserving plant specimens, a manual. 2nd edition. Department of Science, Information Technology and Innovation, Brisbane.

95 INSPIRING PLACE, 2009. Royal Tasmanian Botanical Gardens Living Collections Plan. Hobart, Tasmania.

96 APLIN, D. M., 2014. A global survey of living collections. BGjournal, 11, 26–29.

97 GRATZFELD, J. E., 2016. From Idea to Realisation — BGCI's Manual on Planning, Developing and Managing Botanic Gardens. Botanic Gardens Conservation International, Richmond, United Kingdom.

*Pterostylis nutans*