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OPINION

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R-E-S-P-E-C-T: How Royal Botanic Gardens Victoria is responding to climate change

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Societal Impact Statement

Botanic gardens have a *responsibility* to lead, encourage, and contribute to research into climate change, particularly relating to plants and their habitats. We must *educate*, in the broadest sense of that word, and *safeguard* plants through seedbanking and other ex situ collections, and contribute to restoration. Good p*lanning* is essential to prepare for the succession of our living landscapes. We can e*ngage* on many levels, but most importantly with policy, politicians, and public opinion. *Partnerships* are essential and we should *collaborate* within regional networks. Finally, we must show *tenacity*. In short, R-E-S-P-E-C-T, *respect*.

Summary

Climate change is our "biggest challenge," "most pressing issue" or simply, and starkly, "a crisis." As expressed in *The Xishuangbanna Declaration on Botanical Gardens and Climate Change*, there is much we can do as botanic gardens to help the world mitigate and adapt to global warming. We have a responsibility to lead, encourage, and contribute to *research* into the causes, consequences, and controls of climate change, particularly relating to plants and their habitats. Our core function, I think, is to *educate*, in the broadest sense of that word. We must *safeguard* plants through seedbanking and other ex situ collections, and contribute to restoration. Good *planning* is essential and we need to prepare for the succession of our living landscapes. We can *engage* on many levels, but most importantly perhaps with policy, politicians and public opinion. Partnerships are essential and I would encourage botanic gardens to participate actively in peak bodies such as the International Association of Botanic Gardens and Botanic Gardens Conservation International, and to *collaborate* within regional networks. Finally, show *tenacity*—hold firm and true to our purpose, to safeguard plants and to care for people and our planet. In short, R-E-S-P-E-C-T, *respect*.

KEYWORDS

adaptation, botanic gardens, climate change, International Association of Botanic Gardens (IABC), partnerships, planning, seedbanking, weeds

1 | INTRODUCTION

All I'm askin' is for a little respect
O. Redding, adapted A. Franklin (1967)

Climate change is a threat to life on Earth. Or more accurately, to some life on Earth today. Human accelerated changes to the world's climate will lead to the extinction of some species, perhaps *Homo sapiens*, and the flourishing of others (Figure 1). This has been the impact of climatic change since the planet first sustained life more than 3.5 billion years ago. For human civilization, increasingly crowded into cities and with a total population considered unsustainable on this planet, the impacts are likely to be dramatic. Some people will lose their homes through rising sea levels, some will lose their food through inability to adapt to new agricultures, some will lose their lives or be dispossessed through increased severe weather events and social disruption. And so on. We may, in time, be able to innovate our way through the transition, assuming that is we can mitigate carbon and other climate-change pollutants to reach some sort of plateau. If we fail to mitigate the innovation and adaptation will be all the harder.

So this is a bleak scenario. Climate change has been described as our "biggest challenge," "most pressing issue" or simply, and starkly, "a crisis" (Pink, 2018). As expressed in *The Xishuangbanna Declaration on Botanical Gardens and Climate Change* (Xishuangbanna International Symposium participants, 2014), there is much we can do as botanic gardens to help the world mitigate and adapt to global warming. I am not suggesting botanic gardens can save the world on their own but they are definitely part of the solution.

Indeed by default botanic gardens contribute to many things that either reduce the severity of climate change or help people adapt to its consequences. Every large tree we plant stores a tonne or so of carbon (Ecometrica, 2011), and there is almost as much again in the soil and microorganisms surrounding its roots in a botanic garden such as Melbourne Gardens, Royal Botanic Gardens Victoria (Cremins, 2016). By selecting particular species to plant, we adjust the dial on that carbon sink (Cremins, 2016). A lawn or a garden in any location reduces the temperature compared to an expanse of concrete: on a summer's day with maximum temperatures of 30 degrees Celsius, lawns in the Royal Botanic Gardens Victoria are about 24 degrees at their surface and nearby paths 40 degrees. Different parts of our landscape are cooler than others (Fern Gully in Melbourne Gardens is up to six degrees Celsius cooler than the nearby Central Business District of Melbourne) and we can plant to lower temperatures locally. While fine-tuning our plantings and landscape design to help mitigate climate change locally is admirable, there is much more botanic gardens can and should do.

In this adaptation of my plenary lecture at EuroGard VIII (the Eighth European Botanic Gardens Congress, Lisboa, May 2018) for the session "Botanic Gardens and Global Change," I propose seven themes, coerced into the mnemonic sung with such vigour by Franklin (1967): R-E-S-P-E-C-T, respect.

2 | RESEARCH

Nearly a decade ago now, Primack and Miller-Rushing (2009), provided an excellent summary of the ways a botanic garden could contribute to climate change research. The capacity of a major botanic garden includes controlled growing conditions, living collections with broad taxonomic representation, meticulous record-keeping, networks spanning wide geographic areas, and knowledgeable staff. These resources are brought to bear on discovering the biological responses to climate change such as timing of flowering and leaf-out; understanding of the relationships among climate, physiology, and anatomy; use of herbarium specimens and historical photographs to understand past plant behaviour; biology and distribution of invasive species; and comparative studies of responses to climatic variation providing insights on important ecological, evolutionary, and management questions. Botanic gardens are also increasingly important meeting and study places for citizen scientists, and there are many climate monitoring programs worldwide: in Australia, ClimateWatch (www.climatewatch.org.au; Figure 2), run by EarthWatch and

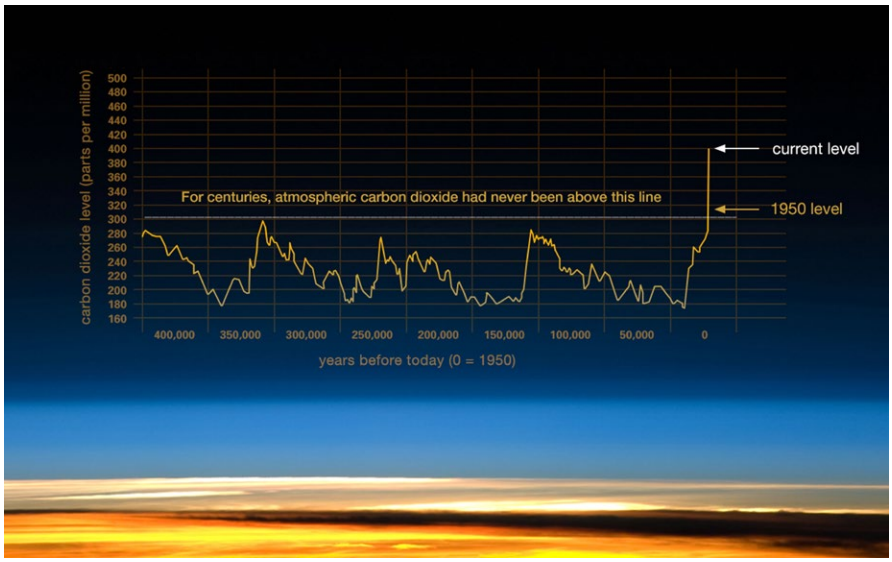

FIGURE 1 Comparison of atmospheric samples contained in ice cores and more recent direct measurements, providing evidence that atmospheric CO_2 has increased since the Industrial Revolution. (image courtesy of NASA/JPL-Caltech, https://climate.nasa.gov/evidence/)

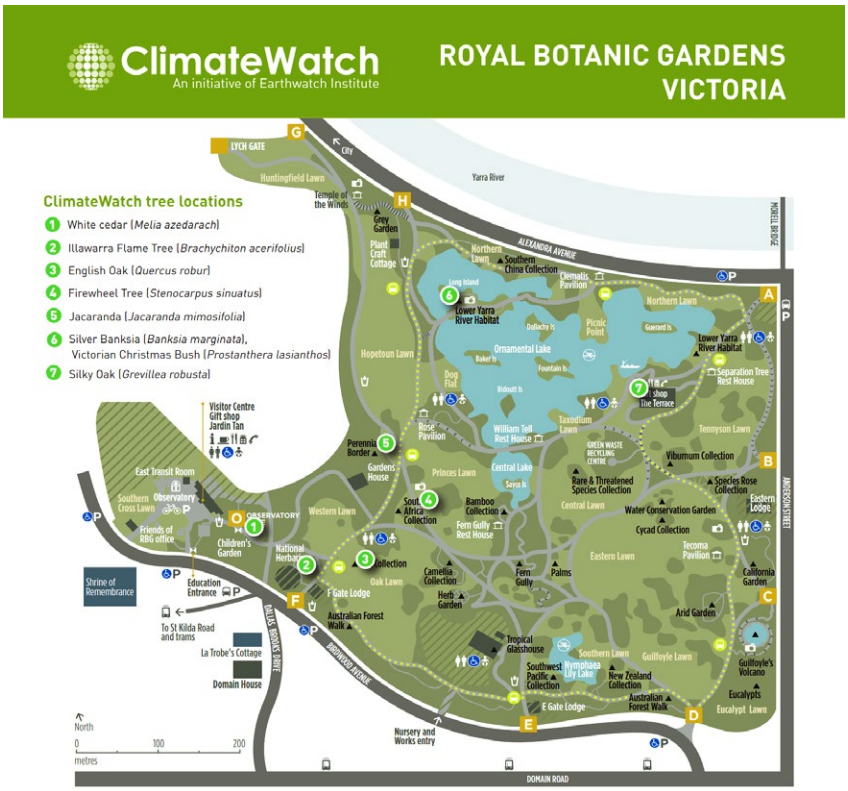

FIGURE 2 ClimateWatch trail at Melbourne Gardens, Royal Botanic Gardens Victoria (from http://www.climatewatch.org.au/uploads/trail/field_recording_sheet/4f6c0f8ceebda963fb000002/Revised_CWRBGVicTrailMapRecordingSheet.pdf)

supported by many Australian botanic gardens. Botanic Gardens have a responsibility to lead, encourage, and contribute to research into the causes, consequences, and controls of climate change, particularly relating to plants and their habitats.

3 | EDUCATION

A core botanic garden function, and perhaps where they should have their greatest impact, is education, in the broadest sense. In 2013, at a conference *Encountering the Anthropocene* (Sydney Environment Institute, 2013), I gave a talk on "Curing Plant Blindness and Illiteracy" which is still available online (Entwisle, 2013; Figure 3). In that talk, I argued that humans display symptoms of two potentially life-threatening diseases: plant blindness and plant illiteracy. We either take plants for granted, viewing them as a kind of green wall-paper, or we fail to appreciate just how important they are to life on Earth. Botanic gardens have always celebrated plant life, displaying its variety and beauty. I said then (and now), they must do more. Without losing their whimsy and charm, botanic gardens have a job to do. I then ran through the capacity of the organization to which I had just been appointed Director and Chief Executive, the Royal Botanic Gardens Victoria. It includes two truly iconic botanic gardens; a State Botanical Collection of 1.5 million specimens, historically and scientifically the richest collection of preserved plants, algae and fungi in Australia; the Victorian Conservation Seedbank as an insurance policy and investment bank for our State's flora (and part of the Australian Seedbank Partnership, a collaboration with Royal Botanic Gardens Kew's Millennium Seed Bank in London); and over two hundred staff, volunteers, and associates who are experts in horticulture, systematics, ecology, conservation, and education. These are the kind of assets you find in most large botanic gardens, to varying degrees of size and impact, and all are positioned perfectly to contribute to a cure for plant blindness and illiteracy. Further, we must surely be obliged to do so. I used the talk to demonstrate how botanic gardens worldwide will help us survive the Anthropocene and one of its defining characteristics, human-induced climate change, and why plants, algae and fungi are really in control of this planet. This was education pure and simple, and the kind of case every botanic garden should make, as often as possible.

Of course every plant in a botanic garden should have a story (the key words in any useful definition of a botanic garden are that each plant, collection, or landscape should have a "purpose";

FIGURE 3 Title slide from "Curing Plant Blindness and Illiteracy" presentation in 2013

Entwisle, 2018) so every plant is an opportunity to educate. Indeed, every interaction with a visitor—real or virtual—is a chance to inform, encourage, and inspire. Some displays will be directly related to climate change, such as the Water Saving Garden at Cranbourne Gardens, Royal Botanic Gardens Victoria, where plants requiring less water are gathered together and interpreted. While drought and water shortages have always been part of gardening in Australia, the changes to Victoria's climate due to global warming are predicted to accentuate this limitation. Similarly with invasive species: weeds are a major threat to the environment and economy of Australia, and a changing climate will allow new incursions and extensions to existing ranges (as well of course as contractions and losses of other species, we hope). So when as a botanic garden, we assess new acquisitions for their weed potential (Virtue, Spencer, Weiss, & Reichard, 2008), as we should and must, it is useful to explain that to the visiting public (particularly if we decide to grow a species with strict horticultural protocols in place such as a "de-heading" to avoid any seed set).

This is not the place to discuss the philosophy and pedagogy of learning programs, but whether they are aimed at informing or inspiring, a core message for botanic gardens in the 21st century must be the need to mitigate and adapt to climate change, and the role plants play in this response.

4 | SAFEGUARDING

Most botanic gardens contribute in some way to the physical protection of the world's flora. They do this through living collections of rare and threatened species, through seed and germplasm banks, or through direct management of natural or restored vegetation. There are many examples of integrated conservation programs involving botanic gardens, but the shining example is that of the extremely rare and only recently discovered conifer, Wollemi Pine (*Wollemia nobilis*), from New South Wales in Australia (Woodford, 2000). Climate change is yet another threat, adding to and sometime compounding land clearing, grazing, invasive species, inappropriate fire regimes, and so on. In the case of the Wollemi Pine with less than 100 individual trees growing in a small area north of Sydney, the existence of a widely distributed ex situ collection (in botanic, as well as home and other public, gardens) is essential for the continuation of this species should there be any impediment to the survival of the natural populations.

Another good, integrated example, is the Orchid Conservation Program at Royal Botanic Gardens Victoria, which relies on human, and other, partnerships. Australia has around 1,300 species of native orchid, with three-quarters of these terrestrial (ground dwelling). The south-eastern corner of the continent is particularly rich in terrestrial orchids, with many species under threat of extinction. To conserve these species and reduce their risk of extinction, many recovery plants include a reintroduction component. However, until recent years it has been extremely difficult to propagate and successfully translocate most terrestrial orchid species. Each terrestrial orchid species has its own complex relationship with the environment, including particular requirements for mycorrhizal fungi, pollinators, and microhabitat. To restore populations under threat, a thorough understanding of a plant's ecology and biology are required, as well as the support of relevant land managers and community groups. The Royal Botanic Gardens Victoria is leading an innovative conservation partnership to collect, store, propagate, and reintroduce threatened terrestrial orchids into their native habitat. It has many partners, including Catchment Management Authorities, national parks, conservation NGOs such as Trust for Nature, universities and various government departments and community groups. The community groups and many volunteers are critical to the project, providing expertise and resources to complement the support from government. The Australasian Native Orchid Society (Victoria), in particular, has assisted with almost every reintroduction to date and its members have been a major part of the program's success. The society also made a major contribution to a crowd-sourcing campaign (Figure 4) to establish laboratory facilities in the Royal Botanic Gardens Victoria at Cranbourne.

While seedbanks and genetically diverse living collections are the best ways to safeguard a species outside its natural habitat, even one or two specimens of the "living dead," as they are sometimes called are better than nothing. The Toromiro (*Sophora toromiro*) is extinct on Easter Island, the only place on Earth where it grew naturally, but is now grown in many botanic gardens worldwide. While we have some genetic variation in our collection at Royal Botanic Gardens Victoria, mostly the plants grown do not represent much of the natural variation that would have existed once on Easter Island. Still, better to keep a representative of a particular lineage, in this case a species, than to lose it. Much as the books lost in the burning of the library at Alexandria in 391 AD are irreplaceable, so is a particular evolutionary outcome, a species. Of course given limited space and resources, a botanic garden must triage the value of each specimen or sample if we are to safeguard the diversity of plant life on Earth.

FIGURE 4 Crowd sourcing poster for Royal Botanic Gardens Victoria's Orchid Conservation Program

5 | PLANNING

When we plant a tree it is not for the life of a corporate plan or a government. It will be with us for 10–100 years, and quite possibly more. So the tree we plant today must be the tree that will survive and thrive in, say, 2090. This is at the heart of Royal Botanic Gardens Victoria's *Landscape Succession Strategy* (RBGV, 2016; Figure 5). As outlined in a recent paper (Entwisle, Cole, & Symes, 2017), the strategy recognizes that with 1.6 million visitors each year, responsibility for a heritage-listed landscape and the need to care for a collection of over 8,000 plant species of conservation and scientific importance, planting and planning must take into account anticipated changes to rainfall and temperature. Specifically, the Strategy sets out the steps needed over the next 20 years to transition the botanic garden to one resilient to the climate modelled for 2090. The document includes a range of practical measures and achievable (and at times somewhat aspirational) targets. Climate analogues are being used to identify places in Australia and elsewhere with conditions today similar to those predicted for Melbourne in 2090, to help select new species for the collection. Modelling of the natural and cultivated distribution of species will be used to help select suitable growth forms to replace existing species of high value or interest. Improved understanding of temperature gradients within the botanic garden, water holding capacity of soils, and plant water use behaviour is already resulting in better targeted planting and irrigation. The goal is to retain a similar diversity of species but transition the collection so that by 2036 at least 75% of the species are suitable for the climate in 2090. At all times there will be a strong focus on assisting the broader community in their response to climate change. An international Climate Change Summit was held late in 2018 with representatives for 10 allied botanic gardens from around the world, mostly in climates similar to those of Melbourne in 2018 or 2090. It is anticipated an alliance will be established to further encourage the sharing of knowledge and skills.

While the *Landscape Succession Strategy* is thought to be a world-first in terms of its focus on the botanical living collection and landscape, botanic gardens in Australia and elsewhere have been planning for climate change for at least the last 10 years: for example, *Role of Australia's Botanic Gardens in Adapting to Climate Change* (CHABG, 2008), *Australian National Botanic Gardens Climate Change Strategy* (ANBG, 2010), and Botanic Gardens in the Caribbean and Central American region are already experiencing an increase in the

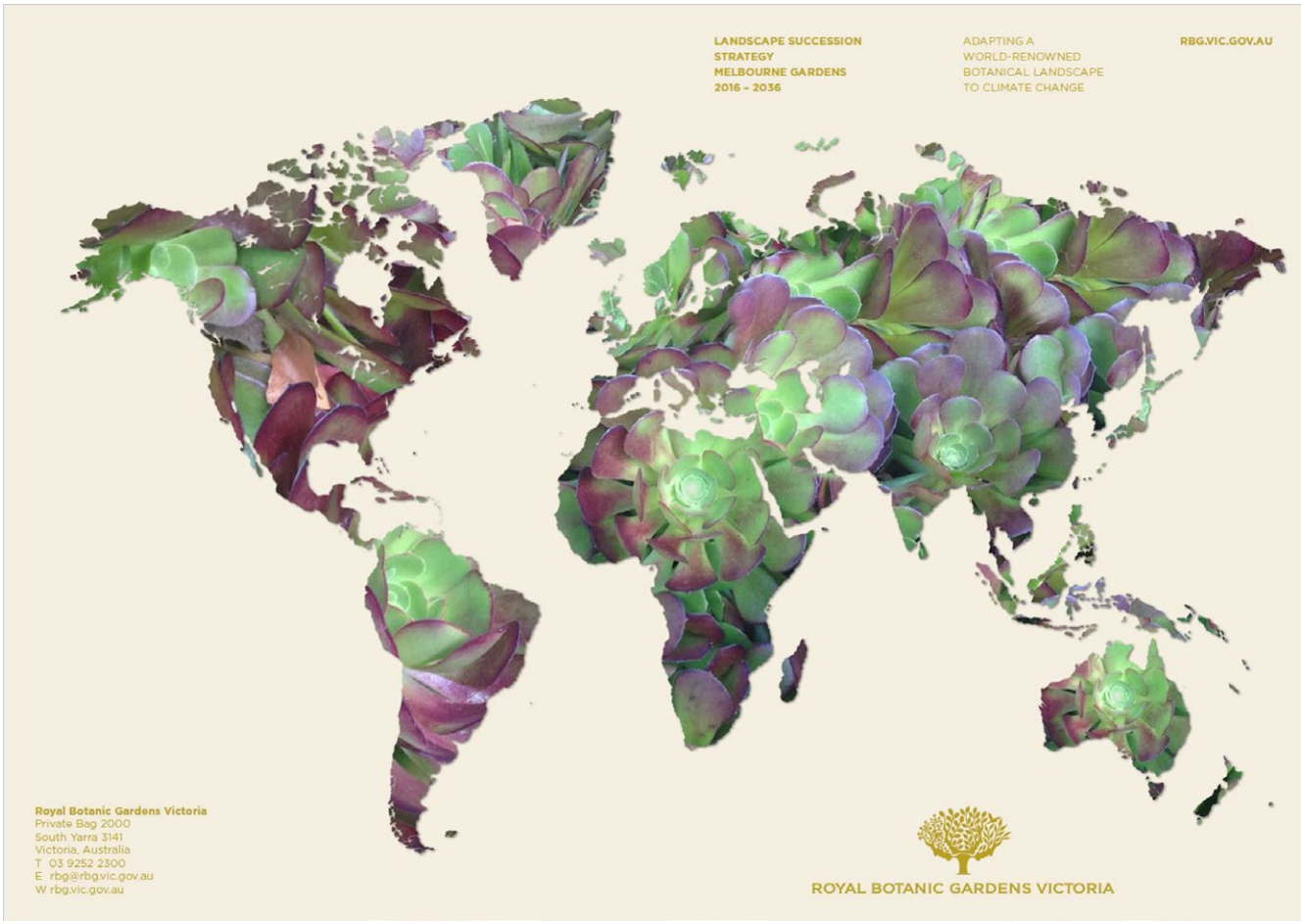

FIGURE 5 Responding to climate change in the management and planning of a botanical living collection and landscape: the Landscape Succession Strategy for Melbourne Gardens, Royal Botanic Gardens Victoria

frequency and severity of hurricanes, and there and elsewhere rising sea levels are displacing land and horticultural options.

6 | ENGAGEMENT

Botanic gardens engage on many levels, starting with our visitors of course. Here, I want to focus on government policy and community projects. Each botanic gardens must respond to the needs and requirements of its owners, whether private or public. For those with a broader public remit, and funded primarily through taxes of some kind, there will be obligations to assist in the implementation of "election promises" and various high level strategies and commitments. I would encourage botanic gardens to extend this further and reach over the garden fence, to work on projects that help the government(s) respond to climate change. In my State of Victoria, Australia, we have *Protecting Victoria's Environment—Biodiversity 2037* (Victoria DELWP, 2017) and *Victoria's Climate Change Adaptation Plan* (Victoria DEWLP, 2016) as two key drivers for our Government.

Botanic Gardens can also provide leadership and expertise for "community greening" projects, which while not always responding directly to climate change will strengthen a city's ability to maintain a liveable climate and make a contribution to carbon storage. In my own case, I was invited in 2016 by the Victorian Minister for Public Transport to chair what was called a Community Open Space Expert Panel (COSEP, 2017; Figure 6). The Panel was established to advise the minister on the best use of 22.5 hectares of open space created by elevating the rail network in outer Melbourne. It included representatives of the local community (selected through an expression of interest), combined with expertise from Victoria Police, Bicycle Network, local council, and the Office of the Victorian Government Architect. The Panel met monthly over 12 months, reviewing, and advising on plans for this open space which include parks, gardens, play and sports equipment, walking and cycling pathways, car parking, and community art. Planting in this park had to be suitable for Melbourne's emerging climate as well as safety, amenity, and community cohesion.

FIGURE 6 Report from the Community Open Space Expert Panel, chaired by the author

FIGURE 7 Visual identities for two international botanic garden networks (International Association of Botanic Gardens and Botanic Gardens Conservation International) and one regional network (Botanic Gardens Australia and New Zealand)

7 | COLLABORATION

Collaboration will be essential for everything I have mentioned so far, whether with colleagues inside or outside a botanic garden. Research, education, safeguarding plants, and planning all depend on partnerships of some kind, and engagement is always a collaboration when done well. As current President of the International Association of Botanic Gardens (iabg.scbg.cas.cn), I would encourage membership of this peak international body, as well as Botanic Gardens Conservation International (www.bgci.org), plus regional networks (e.g., Botanic Gardens Australia and New Zealand; www.bganz.org.au) (Figure 7). Little more need be said about collaboration other than to encourage more of it.

8 | TENACITY

Finally, we should be tenacious: taking a firm grip on things, being determined, persisting (en.oxforddictionaries.com). "Like a limpet" (example of tenacity; en.oxforddictionaries.com) we must stick to our commitment to a life sustained and enriched by plants. Perhaps more aptly for our audience, we could model ourselves on the South American Ombú (*Phytolacca dioica*), a favourite specimen tree in many botanic gardens (Figure 8). It has a firm and unshaking grip on the Earth, with limbs reaching out as far as it can in all directions. It is also a tough plant, able to withstand drought and fire. Tough but tender: the Ombú, or Bella Sombra ("beautiful shade" in Spanish), provides comfort and shelter for those travelling through the extensive grasslands of Argentina and Uruguay. Not a bad role model for botanic gardens as they navigate their way through the climate change crisis.

9 | R-E-S-P-E-C-T

These seven themes—*research*, *education*, *safeguarding*, *planning*, *engagement*, *collaboration*, and *tenacity*—sum up neatly how botanic

FIGURE 8 Ombú (*Phytolacca dioica*) in Jardín Botánico de Ajuda, Lisbon, Portugal. Photograph: Tim Entwisle

gardens should respond to climate change. Conveniently, the first letters of these themes combine to spell "respect". If we show respect to each other, and to other life forms on this planet, we will be well on the way to dealing responsibly to crises such as climate change. Without that respect, our botanic gardens can become mere curious historical artefacts and our work philatelic rather than philanthropic. Not that there is anything wrong with the collecting and studying of stamps! It's just that we have a higher calling, to save the planet as well as celebrate the life on it.

At the broadest level, respect applies to the diversity of life and to the value of each species as a unique outcome of evolution (or if you like, something more spiritual). It applies to the way we view nature in the whole, but also a tree in the singular. It also applies to how we respond to dissenting or disinterested views. Rather than respond in anger or frustration, or give up on a particular cohort, we must remember the Ombú and persist. Through research we can provide the evidence to make sound decisions, through education we build an informed and committed community, by safeguarding we project our precious plant life, with adequate planning we leave a lasting legacy, by engaging with governments and community leaders we expand our influence, by collaborating we multiply our impact, and, through tenacity will prevail. As the young folk say, "respect!"

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