Journal of Botanic Gardens Conservation International

BGjournal

Volume 17 • Number 2 • July 2020

Botanic Gardens: Working towards the achievement of the GSPC Targets

BOTANIC GARDENS CONSERVATION INTERNATIONAL

EDITORS

Suzanne Sharrock
Director of Global Programmes

Paul Smith
Secretary General

Cover Photo: The Endangered *Hibiscus kokio* ssp. *Saintjohnianus* is being conserved *in situ* and *ex situ* by the National Tropical Botanical Garden in Hawaii. (Chipper Wichman)

Design: Seascape www.seascapedesign.co.uk

BGjournal is published by **Botanic Gardens Conservation International (BGCI)**. It is published twice a year. Membership is open to all interested individuals, institutions and organisations that support the aims of BGCI.

Further details available from:

- Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey TW9 3BW UK. Tel: +44 (0)20 8332 5953, Fax: +44 (0)20 8332 5956, E-mail: info@bgci.org, www.bgci.org
- BGCI (US) Inc, The Huntington Library, Art Collections and Botanical Gardens, 1151 Oxford Rd, San Marino, CA 91108, USA. Tel: +1 626-405-2100, E-mail: usa@bgci.org Internet: www.bgci.org/usa
- BGCI (China), C/O South China Botanical Garden, CAS 723 Xingke Rd. Guangzhou, 510650, Guangdong, China Tel: (86)20-85231992, Email: xiangying.wen@bgci.org www.bgci.org/china/
- BGCI (Southeast Asia), c/o Singapore Botanic Gardens, 1 Cluny Road, Singapore 259569
- BGCI (Africa), Kirsty Shaw, BGCI Africa Office, IUCN Eastern and Southern Africa Regional Office (ESARO), P.O. Box 68200 - 00200, Nairobi, Kenya, Tel. +254 (0)725295632 Skype: bgci_kirsty, Email: kirsty.shaw@bgci.org, Internet: www.bgci.org
- BGCI (Russia), c/o Main Botanical Gardens, Botanicheskaya st., 4, Moscow 127276, Russia. Tel: +7 (095) 219 6160 / 5377, Fax: +7 (095) 218 0525, E-mail: seed@aha.ru, www.bgci.ru

BGCI is a worldwide membership organisation established in 1987. Its mission is to mobilise botanic gardens and engage partners in securing plant diversity for the well-being of people and the planet. BGCI is an independent organisation registered in the United Kingdom as a charity (Charity Reg No 1098834) and a company limited by guarantee, No 4673175. BGCI is a tax-exempt 501(c)(3) non-profit organisation in the USA and is a registered non-profit organisation in Russia.

Opinions expressed in this publication do not necessarily reflect the views of the Boards or staff of BGCI or of its members.

United Nations Decade on Biodiversity

IN THIS ISSUE...

Begonia 'Orange Rubrua'. *(Fairy Lake Botanical Garden, China)*

EDITORIAL: THE GLOBAL STRATEGY FOR PLANT CONSERVATION

I don't think that 2020 has turned out quite the way that anyone expected. This was meant to be the year of biodiversity in which we looked back over the past decade, assessed our plant conservation achievements (and failures), and set new targets for the coming decade. Planning for the next decade has been set back considerably by the COVID-19 pandemic (see pages 7-8) but I am hopeful that this enforced recalibration will have some positive outcomes for biodiversity, including a re-think about whether we can continue to exploit nature without suffering the consequences. Only time will tell whether this happens but one thing is clear – we are running out of time rapidly if we are to address the twin existential challenges for humanity represented by climate change and the loss of biodiversity.

At the request of the parties to the Convention on Biodiversity, BGCI has carried out a review of achievements against the targets of the Global Strategy for Plant Conservation over the past decade, which are captured in the Plant Conservation Report appended to the Global Biodiversity Outlook to be published in September. Although, there is no question that we have failed in our main aim to halt the loss of biodiversity, there are also causes for optimism – particularly in the way that the Global Strategy for Plant Conservation has galvanised the botanical community. Unlike the Aichi targets, the GSPC targets are set out in a logical way that recognises the need for information on threatened species as a first step to enable prioritisation of effort and effective plant conservation. The GSPC is also characterised by measurable, action-oriented targets (Targets 4-9).

As I write, I have some hope that the new Global Biodiversity Framework (GBF), currently in draft, will adopt these principles of a logical framework comprising SMART targets that all Governments can sign up to. This will also help us to align revised GSPC targets to the GBF.

In this edition of BGJournal, we celebrate the way in which our community has responded to the GSPC. We start by featuring Singapore Botanic Garden (p.9-12), one of only three botanic gardens in the world that is a World Heritage Site and, more importantly a garden that is not content to sit on its laurels. Its newest development is a seed bank with the capacity to store 25,000 species, which will significantly boost capacity in the region to achieve Target 8 of the GSPC. We follow this with an interview with Chipper Wichman, President of the National Tropical Botanical garden in Hawai'i (p. 13) and long time champion of the GSPC. Chipper outlines how Hawai'i has adapted the GSPC to drive conservation action across the archipelago with truly spectacular results.

Fundamental to prioritising conservation action is information on which plants are out there (Target 1 of the GSPC), and we are now close to achieving that through the World Flora Online (p.15-18), now a consortium of 43 institutions, and an online, consensus-based flora of >350,000 accepted taxa. The next step is to know which species are most threatened (Target 2) and, here, we have made less progress. Only 10% of plants are represented on IUCN's Red List and, although that figure is more than doubled if national and non-IUCN assessments are taken into account (see BGCI's ThreatSearch database), we are still a long way short of Target 2 which aims for an assessment of all plant species. In our article on this topic (p.19-22), the authors explore ways in which new technologies and approaches can enhance the IUCN red listing process or complement it. The importance of assessments cannot be overstated. In the same way that testing for COVID-19 is essential for directing efforts to manage the disease, conservation assessments are essential for directing conservation effort. If we don't have this information, then we can't effectively meet Targets 7, 8 and 9 of the GSPC and, more importantly, species will be going extinct without us knowing about it. Essential to effective *ex situ* conservation (Targets 8 and 9) are genetically comprehensive collections, and Sean Hoban and Patrick Griffith make a compelling case for this on page 23-26.

Where we do have good threat assessment data, very significant progress has been made, and in this edition we present a number of case studies focused on Target 8 of the GSPC in Austria (p.43-44), Hungary (p.44-46) and Proteaceae species in South Africa (p.35-37). What is clear from all of these efforts is that partnership and collaborative working are fundamental to success. This is recognised in the GSPC (Target 16), and two articles in this edition of BGJournal, one from Australia (p.27-30) and one from Malawi (p.38-41), demonstrate this perfectly. Finally, individual institutional commitments to plant conservation, based on key organisational strengths and focus, are illustrated by Fairylake Botanical Garden in Shenzhen, China (p.31-34) who have concentrated their efforts on under-represented taxa such as ferns and bryophytes as well as highly threatened groups of flowering plants such as Magnolias and Begonias.

I hope that this edition of BGJournal is as inspiring to you as it is to me.

Paul Smith
Secretary General BGCI

FEATURES

NTBG Drone Specialist Ben Nyberg (foreground) and Adam Williams, botanist with the State of Hawaii Division of Forestry and Wildlife, set up drones and other equipment to search for rare plants on Kauai.(National Tropical Botanical Garden, Hawai'i)

NEWS FROM BGCI

Here we present a selection of the most recent news stories from BGCI. Please browse our website to keep up-to-date with the latest news and events from BGCI and the botanic garden community. **www.bgci.org**

Supporting the global botanic garden community during the Covid-19 pandemic

BGCI has put in place a number of measures to support the global community during the COVID-19 pandemic. Most notable is the considerable expansion of the Global Botanic Garden Fund, with up to 72 grants likely to be awarded this year (compared to 17 in 2019). A special category for applications this year is support to cover the impact of COVID-19. Another new initiative is the establishment of an on-line forum for BGCI members to allow the sharing of experiences in coping with the impact of the pandemic.

Find out more: https://www.bgci.org/

New partnership: the Botanist X BGCI

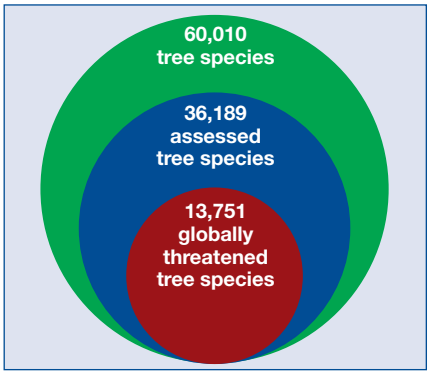
BGCI is delighted to announce a new partnership with The Botanist to further the conservation of endangered and rare plants species, through BGCI's Global Botanic Garden Fund. The Botanist is a dry gin conceived, distilled and handcrafted on the Scottish island of Islay using 22 foraged island botanicals at Bruichladdich Distillery. Through its own sustainable foraging on the Isle of Islay, the brand recognises the significance of plant conservation and biodiversity, which is why they set up their own foundation, with a mission "to work with the people of Islay and beyond to further the understanding and conservation of the island's biodiversity." The partnership launches with the sponsorship of four gardens that will benefit significantly from support to promote conservation practices, policy and education and infrastructure development. These gardens are:

- Stellenbosch University Botanical Garden, South Africa.
- National Tropical Botanical Garden, Hawaii.
- Clavijero Botanical Garden, Mexico
- Tooro Botanic Gardens x MUSE (Italy), a collaborative project between two gardens in Uganda and Italy – Mountains of the Moon (Rwenzori mountains) Uganda.

Find out more: https://www.thebotanist.com/

Global Tree Assessment (GTA) makes good progress

The GTA is making strong head way towards its goal of assessing the conservation status of every known tree species by 2020. The latest analysis (13/07/2020) shows that 61% of all trees have a conservation assessment. This includes all known published tree conservation assessments as listed on ThreatSearch which includes all tree assessments found on the IUCN Red List of Threatened Species (23,491 assessments).



Around 45% of the already assessed trees are assessed as threatened to some level and 38% of all assessed trees are threatened globally. This means that at least 22% of all tree species are threatened with extinction globally.

Find out more: Progress in global tree assessments (from https://www.globaltreeassessment.org/progress/)

Agrilus planipennis. *(emerald ash borer)*

Calling all *Fraxinus* Collections in Eastern Europe

BGCI's International Plant Sentinel Network has recently initiated a new project focused on monitoring for Emerald Ash Borer beetle in eastern European countries. Funded by the UK's Department for the Environment, Food and Rural Affairs (Defra) the project is being run in partnership with the UK's Food and Environment Research Agency (Fera) and Forest Research. We are currently looking for botanic gardens and arboreta in eastern Europe that have *Fraxinus* species in their collections. If your institution is interested in being involved in the project, please do get in touch with us.

Global Conservation Consortium for Oak – US regional meeting

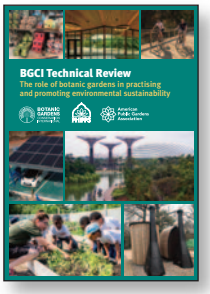
The Morton Arboretum and BGCI hosted a very productive kick-off meeting for the U.S. Region of the Global Conservation Consortium for Oak (GCCO), a coordinated and collaborative network working to prevent the extinction of the world's oak species. Over 60 people from across the U.S. (and five other countries) attended the two-day virtual conference on May 28th and 29th, 2020. Invited speakers provided important context for the state of oak conservation in the U.S., and sub-regional group discussions sparked many ideas for new research and conservation projects

Find out more: https://www.bgci.org/news-events/kick-off-meeting-for-the-u-s-region-of-the-global-conservation-consortium-for-oak/

New website for IUCN Seed Conservation Specialist Group

The newly designed IUCN Seed Conservation Specialist Group website is now live! The mission of the group is to promote seed conservation by providing a network for knowledge-sharing in different ecosystems around the world, and aiding in prioritisation, capacity building, and development of best practices. The Group has more than 100 members, from over 25 countries on 6 continents, including seed bank managers, academic researchers, conservation practitioners, national and international coordinators, and other specialists from around the world. The Group works with the IUCN Species Survival Commission to achieve *"a just world that values and conserves nature through positive action to reduce the loss of diversity of life on earth."* The goal with this newly designed website is to create a user-friendly browsing experience for members and the general public interested in seed conservation. If you have any feedback about your experience with the website, or if you would like to be a member of the specialist group, please feel free to contact BGCI.

Visit the website; https://seedconservationsg.org/



BGCI Technical Review on environmental sustainability

BGCI's 4th Technical Review was launched in April and focuses on the role of botanic gardens in practising and promoting environmental sustainability. The review provides an overview of the wide range of sustainability practices carried out by botanic gardens worldwide, looking at both in-house practices and the way in which gardens motivate and incentivise visitor behaviour change. It includes over 40 case studies encompassing water management, energy consumption, carbon offsetting, waste, recycling and composting and sustainable food.

Download a copy of the review at: https://www.bgci.org/wp/wp-content/uploads/2020/04/ReviewMedRes.pdf

BGCI joins Global Coalition for Biodiversity

BGCI has joined the European Commission's Global Coalition for Biodiversity. The announcement was made on World Day for Biodiversity (May 20) following the launch of the EU Biodiversity Strategy for 2030. The Global Coalition has adopted a common pledge, citing the IPBES Global Assessment finding that 1 million species are already at risk of extinction, and appeals to visitors to each of the coalition's institutions to "*raise their voice for nature.*" BGCI joins organisations such as IPBES, WAZA, Ecsite, EAZA, CETAF, Eurosite and Europarc all of whom have endorsed the aims of the Coalition. With their collections, education and conservation programmes, research centres, national parks, aquariums, botanic gardens, zoos, science and natural history museums are the best ambassadors to raise public awareness about the dramatic effects of the biodiversity crisis. The coalition offers the opportunity for all such institutions to join forces and boost public awareness about the nature crisis, ahead of the crucial COP-15 of the Convention on Biological Diversity in China in 2021 when nations will adopt a new global framework to protect and restore nature. Find out more and read the pledge here:

https://ec.europa.eu/commission/presscorner/detail/en/IP_20_348

BGCI ACCREDITATION SCHEME

BGCI's Accreditation Scheme distinguishes botanic gardens from non-botanic gardens and recognises achievements in plant conservation.

The following botanic gardens achieved BGCI Botanic Garden Accreditation since the last issue of *BGjournal*:

Universitetshagene Bergen
Rotterdam Zoo (and Botanic Gardens)
Jardín Botánico de Cartagena 'Guillermo Piñeres'

The following botanic gardens achieved BGCI Advanced Conservation Practitioner Accreditation since the last issue of *BGjournal*:

Leon Levy Native Plant Preserve
National Tropical Botanical Garden

Author: Kenna Castleberry

Kadoorie Farms and Botanic Gardens in Hong Kong.

THE IMPACT OF COVID-19 ON BOTANIC GARDENS GLOBALLY

The spread of COVID-19 has caused the temporary closure of many businesses around the world and botanic gardens have not been immune. From country to country, gardens have had to temporarily shut their doors and, when cases of COVID-19 start to wane, think of creative solutions to safely reopen. I was curious to find out how botanic gardens were differing in their approaches to staying safe during the pandemic, as well as if there had been an increase in interest in virtual gardens. I know my local botanic garden, the Denver Botanic Gardens, has seen more people take up gardening during this pandemic, trying to escape the lockdown lifestyle and enjoy the outdoors. I also wanted to know if this increase in local gardening was being experienced in other places around the world, not just in Colorado, USA.

From my investigations and interviews, I found that around the world, there has been an increase in virtual engagement with botanic gardens while they have been closed. This virtual interest may decrease once gardens begin to slowly re-open to the public. Some gardens, such as the Kadoorie Farms and Botanic Garden in Hong Kong, are being cautious with their opening, ensuring people wear masks and distance themselves by at least 2 metres. Hong Kong was not as badly hit by the virus as the rest of the country, and the Kadoorie Farms and Botanic Gardens were only closed for a couple weeks. In my interview with Gunter Fischer, Head of Flora Conservation at Kadoorie Farms and Botanic Gardens, he mentioned that they have noticed an increase in interest in their online education programmes.

Other places around the world have been more negatively affected by the virus. In Latin America for example, COVID-19 has economically impacted many of the gardens causing funding cuts for some. I interviewed Hugo Romero-Saltos, a professor at the Jardín Botánico Yachay in Ecuador. Hugo told me that many botanic gardens in Ecuador are having financial difficulties due to lack of visitors. However, many of them are also trying to work with Universities to try to relieve funding costs and be rebranded as academic institutions. Hugo was nervous about the reopening of the gardens but hoped that people would return, and through their visits help their local gardens become more financially stable. The Botanic Garden in Yachay is one of the most popular areas for both tourists and locals to visit to enjoy the diversity of Ecuador's ecosystems.

Top:Jardín Botánico Yachay in Ecuador.
Above: Museo y Jardín Botánico in Montevideo Uruguay.

Moving north to the United States, I talked to Alicia LaVire, Vice President of Marketing and Communications at Morton Arboretum in Illinois. Alicia said that with COVID-19 closures, the staff at Morton Arboretum have worked hard to provide online activities for their patrons. "*Among our most popular virtual offerings while closed were the daily photos and videos of the Arboretum showcasing spring blooms.*" Alicia stated. "*We also offered virtual plant advice from Arboretum experts via Facebook Live and online courses. Positive comments poured in from those missing the respite of the Arboretum and enjoying the restorative outlet trees and nature provide.*" Along with virtual offerings, the Morton Arboretum hosts an Urban Forestry Program, focusing on tree health and diversity within the urban Chicago area. I spoke to Lydia Scott, the Director of the Chicago Region Trees Initiative, to discuss how the Urban Forestry Program helps people to focus on the trees within their neighbourhood. While allowing for social distancing, participants can get involved in conservation and biodiversity initiatives. The Urban Forestry Program provides online activities using interactive maps, as well as working with local nurseries at the Morton Arboretum which provide trees to increase biodiversity within the Chicago area – resulting in positive change during this negative pandemic.

Other botanic gardens, like the Museo y Jardín Botánico in Montevideo Uruguay, have also noticed an increase in virtual engagement since the closures due to COVID-19. I spoke to Fabian Muñoz, the Director of the Museo y Jardin Botanico with the help of Noelia Alvarez as a translator to ask Fabian about the virtual offering. Fabian told me that the garden has had an increase in viewers on virtual tours and online classes. He noted that it was encouraging to see that people are interested in plants and the Botanic Garden during the pandemic. He hopes that with the increased participation, more patrons will visit the Gardens once they reopen, but of course, such visits will need to be managed in a safe way.

Like many museums or concert venues, botanic gardens have also had to postpone events. One such garden is the Royal Botanic Garden, Edinburgh, where I spoke to Simon Milne, Regius Keeper, about the postponement of the 350th anniversary of the Garden. Simon was positive despite the closure of RBG Edinburgh, stating that he put safety before visitor numbers. Considering that RBG Edinburgh is already recognised as an important garden for both tourists and scientists alike, he believes that anniversary celebrations can be held at any time with little loss in audience size. Simon gave me a detailed history of RBG Edinburgh and was hopeful that it would continue to serve as an important conservation centre in the future.

In my research of the effects of COVID-19 on botanic gardens, I couldn't help but be impressed by the positive spirit most staff had about their gardens reopening, as well as their patrons continuing to support their gardens through virtual platforms. Alicia LaVire of Morton Arboretum summarized the mood of gardens during the pandemic perfectly by stating: "*These are difficult times for botanical gardens, requiring us to adapt many aspects of operations and how we deliver on our missions. It is up to us, as garden leaders, to see the opportunity in this difficult disruption--to innovate engagement offerings, provide invaluable respite for the returning public, and to come together as a community of gardens to support one another.*" I was inspired by Alicia's statement and hoped that this pandemic would bring further awareness of the importance of botanic gardens, not just as refuges from urbanisation, but also as fortresses of biodiversity and conservation.

Kenna Castleberry
BGCI Intern
kenna.castleberry@gmail.com

The Temperate Palm House of the Royal Botanic Gardens Edinburgh under construction in 1857.

Author: Nura Abdul Karim

FEATURED GARDEN

SINGAPORE BOTANIC GARDENS

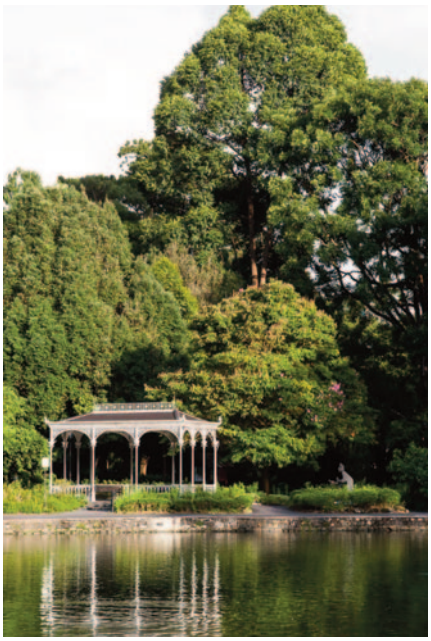
The Tyersall Learning Forest which opened in 2017 provides an opportunity to visitors to learn about ecological process in tropical forests. (Benjamin Aw)

History

The Singapore Botanic Gardens was first established in 1859 by the Agri-Horticultural Society on an abandoned plantation of 23 ha (57 acres). It began as an ornamental leisure garden to be enjoyed by the local gentry. In 1874, when faced with financial constraints, it was taken over by the British colonial government and added to the network of tropical botanic gardens largely run out of the Royal Botanic Gardens Kew. This handover marked the beginning of the Gardens' journey to becoming the iconic botanic gardens it is today.

From 1875 onwards, the management of the Gardens came under botanists sent out from Kew. Whilst maintaining the Gardens for recreational use, these early botanists were also instrumental in transforming the Gardens into an important regional botanical research institution. The Gardens performed an important role in fostering agricultural development in Singapore and the region through collecting, growing, experimenting and distributing potentially useful plants. One of the most significant achievements was the introduction, improvement and promotion of Pará Rubber, *Hevea brasiliensis*. This species became a major crop that brought economic prosperity to Southeast Asia in the early 20th century.

The Gardens is also recognised worldwide for its exceptional work on orchid breeding and conservation through its *in vitro* and micropropagation techniques. The successful breeding and hybridisation experiments that began in 1928 laid the foundation for a multi-million dollar cut-flower orchid industry in Asia. Since then, orchid hybrids of outstanding quality have been cultivated in the Gardens, many of which were displayed in the Gardens' Orchid Enclosure from 1955 and the National Orchid Garden from 1995.



The tranquil setting of the Gardens' Swan Lake. Built in 1866, it is the oldest ornamental water feature in the Gardens and in Singapore. (Benjamin Aw)

Today, the Gardens is 82 ha (203 acres) in size and receives around 5 million visits annually. It is a division under the National Parks Board (NParks), a statutory board of the Singapore Government which is the national authority on nature conservation, urban greenery and veterinary care. The Gardens and its staff have played a key role in Singapore's highly successful urban greening programme that began in 1967. Through the introduction and trialing of plants of potential horticultural and botanical interest, and the training of people to care for them, the Gardens was instrumental in ensuring that trees and other plants were included in all aspects of Singapore's urban development.

Singapore Botanic Gardens was inscribed as a UNESCO World Heritage Site (WHS) on 4 July 2015 in recognition of its outstanding universal value. It is one of only three botanic gardens with this status and the only one in Asia. It is the first and only tropical botanic garden on the UNESCO WHS list.

Aerial image of the iconic Bandstand surrounded by the Yellow Rain Trees (Samanea saman). The Bandstand used to stage early evening performances by military bands during the colonial era. (Benjamin Aw)

Collections and research

Living plant collections are at the heart of the Gardens' research, conservation and education programmes. These living collections are maintained and displayed throughout the Gardens, many of them also scientifically important plants. Striking the balance between creating a stunning landscape to attract visitors whilst at the same time building a collection of conservation and research importance is a challenge for all botanic gardens. Amongst its 37,200 unique accessions from over 250 plant families, the Gardens now boasts some of the world's best collections of tropical plant families, including Apocynaceae, Arecaceae, Dipterocarpaceae and Zingiberaceae.

Botanical research began with the establishment of a Library and Herbarium in 1875. The Library is one of the oldest in Southeast Asia and holds over 30,000 botanical publications. The Herbarium houses a collection of over 750,000 herbarium specimens, of which about 10,000 are type specimens. The specimens are mostly from Singapore, Peninsular Malaysia and other parts of continental Southeast Asia and Malesia.

The Singapore Botanic Gardens Seed Bank. (Benjamin Aw)

The Herbarium is a centre of research on the plant diversity of Singapore and the wider region. As habitat destruction and climate change continue to threaten many species, it is increasingly important that the plants of the region are known and named in order for conservation efforts to be based on sound data. The Gardens' researchers are engaged in cataloguing, describing and understanding the plants of the region, including the description of many species previously unknown to science.

The Symphony Lake is a favourite venue for the Gardens' many free open air concerts that are very popular with the local and foreign visitors. (Lumiere Photography)

As well as encouraging researchers to come and visit and use the collections, the Gardens is also committed to making these collections more accessible by exploring a digitisation programme for the herbarium specimens and through collaboration with the Biodiversity Heritage Library to have botanical literature served online.

The Gardens also has a molecular laboratory for plant genomic studies and a micropropagation laboratory for propagating orchid hybrids and plants of conservation interest. For example, as part of the Flora of Singapore project, the molecular lab has begun the task of sequencing the DNA of all plants in the country in order to aid in plant identification, better understand the relationships of the species and vegetation to those of the neighbouring regions, and better manage conservation efforts in the future.

A Seed Bank was established in 2019 to safeguard the germplasm of threatened plant species in Southeast Asia. The Seed Bank can store seeds of up to 25,000 plant species, which is about fifty percent of the total number of plant species in the region. It will also support vital research and training into optimal storage conditions.

One of the main attractions of the Gardens is the National Orchid Garden. In this beautifully landscaped setting, over 1000 orchid species and 2000 hybrids are carefully displayed for visitors to admire. (Benjamin Aw)

Education and outreach

The Gardens is also a place for visitors to learn about plants, the history of the Gardens, and the research and conservation work undertaken by Gardens' staff. Simple plant labels with basic information on names and distributions, along with various levels of interpretative signs with more in-depth messaging, all provide information for the Gardens' visitors and seek to ignite a greater interest in plants, their uses and their importance to us and the environment. There are also currently around 100 active volunteers in the Gardens who support horticultural work, databasing, and who run the Gardens' guided tours at weekends.

Young children discovering aquatic plants at the Jacob Ballas Children's Garden. (Winnie Wong)

The Gardens' Education and Outreach Branch offers over 50 educational programmes aimed at preschoolers right up to university students, along with programmes catering to adults. Most of the Gardens' educational programmes take the form of outdoor guided tours, educational talks, classes and hands-on workshops. The centre of many of these educational programmes is held at the Jacob Ballas Children's Garden which was launched in 2007.

The Gardens also organises training and capacity building for local and overseas horticulturists and botanists, through internships and fellowships in Singapore, as well as *in situ* training at overseas botanic gardens and forest departments. These training events include general horticulture, plant documentation and botanic gardens establishment and management.

The future

With the support of the Singapore Government, the Gardens continues to revitalise itself with new developments. In 2021, it will open a Forest Discovery Centre and a Botanical Art Gallery in a new part of the Gardens called the Gallop Extension. The Gallop Extension also includes experimental plots with environmental sensors to learn more about the growth of tropical forest trees. In the neighbouring part of the Garden, the Tyersall Learning Forest, the public has an opportunity to learn more about ecological processes in tropical forests.

The Gardens is a member of the BGCI International Advisory Council. From this year, it will be hosting the BGCI Southeast Asian Botanic Gardens Network (SEABG) office thus making it possible to establish better collaborations with BGCI and regional gardens in promoting conservation and capacity building. Singapore Botanic Gardens holds a unique and significant place in the history of Singapore and the region. Along with our many supporters and collaborators, the Gardens will continue to contribute to an understanding of the region's immense plant diversity and foster a love of nature so that the public will become advocates for conservation.

References

- Middleton, D. 2017. The Flora of Singapore. Gardenwise, Vol. 49: 25-26.
- Turner, I.M., Tan, H.T.W., Wee, Y.C., Ali bin Ibrahim, Chew, P.T. & Corlett, R.T. 1994. A Study of Plant Species Extinction in Singapore: Lessons for the Conservation of Tropical Biodiversity. Conservation Biol. 8(3): 705-712.

Nura Abdul Karim
Singapore Botanic Gardens
National Parks Board
1 Cluny Road
Singapore 256569

Flora of Singapore Project

The archipelago of islands stretching from Southeast Asia towards Australia, referred to as Malesia, is a region of high biodiversity. Nestled within this Archipelago is the tropical island city-state of Singapore, with a **land area of about 710 km²**. It was once covered by dense tropical rain forest, but Singapore has since become one of the world's most densely populated countries and is heavily urbanised. However, Singapore does still have four Nature Reserves and another 20 Nature Areas. These remnant forests are strongly protected, even though they are fragmented and small in size, as they continue to harbour rich biodiversity (Turner *et al.*, 1994).

Perhaps surprisingly, given that Singapore has arguably the highest number of collections per unit area of any tropical country (Middleton, 2017), new species and new records of native plants continue to be found and described from the forested reserves. Despite Singapore's urbanisation and small size, there are five species of plants found nowhere else in the world: *Zingiber singapurense, Hanguana rubinea, Hanguana triangulata, Nervilia singaporensis* and *Splachnobryum temasekensis*. Several of these species are now part of NParks' species recovery programme and are being cultivated and reintroduced back into the wild.

In 2017 the Gardens' researchers also embarked on a 10-year project to research and write a Flora of Singapore. The first three volumes were published in 2019. Another 11 volumes are planned. Although plant diversity has been extensively catalogued over many decades, Singapore lacks a modern comprehensive Flora that would allow botanists and interested public alike to better know the plants to be found in the country. The new Flora will document all native, naturalised and casual plant species in Singapore from mosses to flowering plants and will include detailed descriptions and keys, photographs and illustrations, distributions, and the conservation status of each species. Unsurprisingly, this massive research undertaking by the Gardens is also involving many overseas institutions and researchers. The Flora will certainly be an invaluable resource for biodiversity conservation and will lay the foundations for other biological and ecological research in Singapore.

The first volumes of the Flora of Singapore series. The Flora is an extensive 10 year project that attempts to catalogue and describe the more than 3,000 plants in Singapore. (Tok Yin Xin)

INTERVIEW
TALKING PLANTS

Above: Metrosideros polymorpha. *(Ken Wood). Above right:* Lobelia gloria-montis. *(Ken Wood)*
Below: Juliet Rice Wichman photographed in 1971. (Chipper Wichman)

For this issue of *BGjournal*, we were delighted to interview **Chipper Wichman**, President of the National Tropical Botanical Garden (NTBG) in Hawai'i and one of the main architects of the Hawai'i Strategy for Plant Conservation.

This issue of BGjournal focuses on the role of botanic gardens in implementing the Global Strategy for Plant Conservation (GSPC). Can you tell us a bit about how the GSPC has influenced the work of NTBG?

Plant conservation is at the core of the mission of NTBG. After first being introduced to the power of the GSPC by Peter Wyse Jackson about 12 years ago, we realised that this provided a great framework around which to build portions of our strategic plan. We are now in our third 5-year strategic plan and we have really embedded GSPC targets into the core mission of the garden – both in terms of plant conservation as well as education and public outreach. It has been extremely effective in helping to focus the conservation work of the garden.

Hawai'i has developed its own Strategy for Plant Conservation based on the GSPC. How did this come about and what do you see as the main benefits of developing such a strategy?

This all started in 2008/9, when Christopher Dunn was Director of the Lyon Arboretum in Hawaii. Together we realised how important it would be to align the plant conservation work in Hawai'i with international frameworks. Stimulated by attending a conference of the Global Partnership for Plant Conservation and supported by Peter Wyse Jackson, we really wanted to tell the story of the amazing work being done in Hawai'i and to ensure that this work was being counted towards the global effort.

There are huge challenges for plant conservation in Hawaii. There are so many unique species and so many threats, as well as a large number of agencies and NGOs active in conservation. One of the main benefits of developing the Hawai'i Strategy for Plant Conservation (HSPC) was the establishment of the Hawai'i Plant Conservation Network (Laukahi) which has been really effective in bringing people together and providing coordination for all our work.

What do you see as the main achievements in plant conservation in Hawai'i over the past 10 years and do you think these would have happened without the GSPC?

One of the main achievements has been the focused effort on doing the conservation assessments needed to add Hawaiian plants to the IUCN Red List. The need for this was highlighted by the HSPC and the initiative was taken forwards by the Hawai'i Plant Specialist Group under IUCN. Another great achievement has been the development of our seed bank network. Prior to the development of the HSPC, NTBG and Lyon Arboretum were the primary seed banks in Hawai'i. Several others existed but were out on their own. As a result of developing the HSPC, seed banking efforts across the islands were brought together, the quality of seed banking data and curation was improved and activities (and seeds) were dispersed across the network. The HSPC also caused us to look deeper at the quality of our *ex situ* collections State-wide. We realised that although we had 'on paper' achieved Target 8 (75% of threatened plant species conserved *ex situ*), in fact the genetic diversity of many species was not adequately represented in our collections. The HSPC/GSPC has really helped to focus our attention and our research efforts on improving genetic representation in the conservation collections of our rare species.

On a more personal note, what first caused you to become interested in plant conservation and to pursue a career in this field?

Both my father and grandmother were fantastic horticulturists so I grew up with horticulture in my blood and surrounded by plants. My grandmother was particularly visionary in this respect and beginning in the 1950s worked on the creation of NTBG. She was the one who first persuaded me to work at the garden, and I started here in 1976. I then met Steve Pearlman who was an extraordinary field botanist and a great influence on me. Together we went out botanising and we discovered a number of species new to science together. This was so inspirational for a young botanist. Thanks to Steve, I became aware of the amazing uniqueness and fragility of the Hawai'ian flora, and this launched me into a passion for plant conservation that has been the focus of my career ever since.

Finally, I know you think it is important for the GSPC to continue beyond 2020; why is this?

The GSPC as not only helped Hawai'i in its efforts to save its unique flora, it has done the same for the whole world. It has given a focus for activities and helped to direct scarce resources to where they are most needed. It has broken down what is an immense task into manageable units and allowed multiple stakeholders to take responsibility, especially at a local level. It is a really important tool for mainstreaming plant conservation – and without public and policy support, we will not achieve our goals. The GSPC helps people at all levels to understand the issues and see where the solutions lie. It is important not to let the momentum we have developed so far, slip away.

(Barney Wilczak)

ARTICLES

Authors: Peter Wyse Jackson and Pierre-André Loizeau
Co-chairs, World Flora Online Consortium

DEVELOPING A WORLD FLORA ONLINE: ACHIEVING TARGET 1 OF THE GLOBAL STRATEGY FOR PLANT CONSERVATION

WFO Council meeting in Missouri, Nov. 2019.

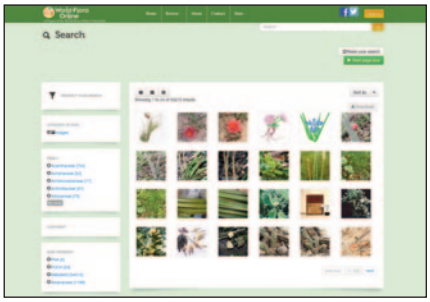
The preparation of a world flora will be the first modern and large-scale attempt to produce a comprehensive overview and baseline of knowledge on the world's plant diversity. This article outlines efforts to document the world's known flora.

In 2002 the Convention on Biological Diversity (CBD) adopted a Global Strategy for Plant Conservation (GSPC), with the aim of halting the loss of plant diversity worldwide. It has now been endorsed by almost all of the countries of the world, and was renewed and updated on 29th October, 2010 for the period up to 2020. Incorporating 16 global targets, the Strategy includes within its objectives the need to document and understand plant diversity, to provide a baseline of knowledge on which plant conservation actions can be based.

As recognized in the GSPC, there is a tremendous need for a comprehensive documentation resource on the world's plant species, as a baseline to guide conservation effort and for plant resource planning and management. Information on the world's plants is presently dispersed in hundreds of journals and thousands of books, and indeed is by no means complete. It is generally retrieved by geographic location in various Floras that cover particular regions, which vary from Floras that cover small areas up to ones that are continental in scope. There are also monographic works available that cover individual plant groups, generally genera or, less frequently, families, in a comprehensive manner. As a consequence of the dispersed nature of available literature, it is often difficult for secondary users of information about plants to find what they need.

Target 1:

An online flora of all known plants



Images from www.worldfloraonline.org

Polyscias bisatenuata. *(National Tropical Botanical Garden, Hawai'i)*

The conservation community, for example, cannot easily retrieve information about the conservation status or comprehensive geographic distributional information of plants. Recent efforts to scan historical literature about plants and make it available electronically via the internet, such as the Biodiversity Heritage Library (http://www.biodiversitylibrary.org/), have improved access to the relevant literature, but it is still generally necessary to consult large numbers of references to retrieve any comprehensive information for the plants of a particular area, and the large number of names in use, often for the same species, is confusing for non-specialist users.

The last 50 years have seen knowledge of the plant kingdom grow to where there are presently between 300,000 and 400,000 known plant species. These have been described via both floristic and monographic works and most parts of the world have had significant floristic activity in recent years so information on most of the world's plants is there to be synthesized. In the last 30 years, the assembly of various electronic databases and the development of the software to run them has again made it possible to assemble a comprehensive digital catalogue of plants. Today the capacity to compile information from modern floras and incorporate rigorous review by specialists on various plant groups is an approachable project. The tools that were needed to produce a World Flora Online (WFO) exist today when they didn't before.

The first phase of the Global Strategy for Plant Conservation, up to 2010, included as its first target to prepare "*A working list of known plant species, as a step towards a complete world flora*". That target was completed through the collaboration between the Missouri Botanical Garden, the Royal Botanic Gardens, Kew, U.K. and other partners, when 'The Plant List' was launched at the end of 2010 (http://www.theplantlist.org/). This represented the culmination of major efforts made to bring together multiple projects into this first ever global checklist. It aimed to be comprehensive for species of Vascular plant (flowering plants, conifers, ferns and their allies) and of Bryophytes (mosses and liverworts). The Plant List was clearly a work in progress but aimed to be a 'best effort' list, to demonstrate progress and to stimulate further work. 'The Plant List' included 1,064,035 scientific plant names of species rank. Of these 350,699 (33.0%) were accepted species names. 470,624 (44.2%) names included were synonyms and 242,712.22 (22.8%) were unresolved. It contained contributions from the Royal Botanic Gardens, Kew, the Missouri Botanical Garden, Global Compositae Checklist, the International Legume Database and Information Service (ILDIS), the Royal Botanic Garden, Edinburgh, the South African National Botanical Institute and the Conservatoire et Jardin botaniques, Genève.

When the GSPC was updated in 2010, a new Target 1 was adopted, to prepare "*An online flora of all known plants*" by 2020 (https://www.cbd.int/gspc/strategy.shtml).

In January 2012 in St Louis, Missouri, U.S.A., representatives from four institutions: the Missouri Botanical Garden, the New York Botanical Garden, the Royal Botanic Garden Edinburgh, and the Royal Botanic Gardens, Kew — all members of the Global Partnership for Plant Conservation (GPPC) (www.plants2020.net) took the initiative to meet and discuss how to achieve GSPC Target 1 by 2020. The meeting resulted in a proposed outline of the scope and content of a WFO, as well as a decision to form an international consortium of institutions and organizations to collaborate on providing that content (https://www.cbd.int/doc/meetings/sbstta/sbstta-16/information/sbstta-16-inf-38-en.pdf).

The WFO project was subsequently launched in India, at an event held during the 11th Conference of the Parties (COP) to the Convention on Biological Diversity in October, 2012 where the COP also adopted a decision welcoming the WFO initiative:

The 11th Conference of the Parties of the Convention on Biological Diversity "*Welcomes the initiative of the Missouri Botanical Garden, the New York Botanical Garden, the Royal Botanic Garden, Edinburgh, and the Royal Botanic Gardens, Kew, and their partner organizations and supporters worldwide, to lead the development of a "World Flora Online" by 2020 to facilitate the achievement of Target 1 of the Global Strategy for Plant Conservation.* (UNEP/CBD/COP/DEC/XI/26) (https://www.cbd.int/doc/decisions/cop-11/cop-11-dec-26-en.pdf).

In January, 2013, a Memorandum of Understanding on the WFO was opened for signature. Today (July 2020) 43 institutions and organizations have signed the MOU, becoming part of this voluntary project and members of the WFO Consortium (www.worldfloraonline.org)

Labordia waialealae. *(National Tropical Botanical Garden, Hawai'i)*

Through the MOU, a WFO Council was created, including representatives from each of the members of the Consortium. The Council has met regularly since 2012, usually twice a year. Two major working groups (a Taxonomic Working Group and a Technical Working Group) were established which guide the implementation of the project, proposing recommendations and guidance for adoption by the WFO Council. A Communications Working Group was also formed.

It was agreed that the WFO would be an open-access, web-based compendium of the world's plant species. It was agreed in the earliest organizational meetings that it would be impossible to generate all new information, particularly descriptions, for the approximately 350,000 currently known plant species therefore it would need to rely primarily on existing descriptions, distributional information and identification tools. In line with The Plant List, the focus of the WFO has been on providing open access to comprehensive species level information for species of Vascular plant (flowering plants, conifers, ferns and their allies) and of Bryophytes (mosses and liverworts), but not including algae, fungi or plants only known as fossils. Rather than initially investing in the development of a new database system to present the WFO, the WFO Council decided to use software provided by the Royal Botanic Gardens Kew which had been prepared for a previous database project, *the eMonocot project*. This software has been used for the development of the WFO portal (www.worldfloraonline.org). A further database system, *Botalista*, developed by the Conservatoire et Jardin botaniques, Genève, Switzerland was also chosen as a data management system to support the preparation of data for ingestion into the portal database.

Already very extensive data provided by a wide variety of botanical organizations and institutions worldwide have been incorporated in the WFO portal (www.worldfloraonline.org). As of July, 2020, the WFO includes 1,325,205 plant names, of which 350,510 are from accepted species. Of those 165,000 taxa already have descriptions included. There are also 55,272 images, 31,683 plant species distributions and 1,154,754 references. Many more data are continuing to be added so that the WFO becomes ever more comprehensive. Notable datasets already incorporated from a variety of countries include the Floras of Brazil, China, Colombia, Costa Rica, Madagascar, Nicaragua, Panama, South Africa and Switzerland, as well as continental and regional Floras including Mesoamerica, North America, Tropical East and West Africa. Additional datasets currently being prepared for incorporation include the Floras of Australia, the Bahamas, Central Africa and Nepal. Data are also incorporated from available monographic accounts too, and already include accounts of the Solanaceae and Zingiberaceae families.

While this collaborative international project currently builds upon existing floras, checklists, monographs, and other published research, it also aims to collect and generate information on poorly-known plants and plant groups and unexplored regions by engaging botanists with field experience and expertise in these plants or regions.

Central to the project is the development of a curated and updatable synonymized checklist of all plant species, as well as other taxon categories (families, genera, subspecies, etc.) – the 'Taxonomic Backbone'. The Taxonomic Backbone aims to provide the most up to date source of scientific plant names and their synonyms and become a consensus classification of the world's plants. The Plant List initially provided the basis of this Taxonomic Backbone, which is now being curated, revised and updated, particularly with the support on a growing network of experts (TENs –Taxonomic Expert Networks) which will turn this into a unique, dynamic, living resource.

Magnolia kwangsiensis. *(Fairy Lake Botanical Garden, China)*

Primulina hochiensis. *(Fairy Lake Botanical Garden, China)*

The WFO is also including descriptions from previously published sources, with their source clearly identified. In the future, keys may be included when available. Vouchered images of living plants, images of specimens, and images of illustrations are also included. Conservation assessments are included when available. The descriptions and other data included in the WFO database are presented in the language in which they were provided, primarily in English at this time. Basic information on geographic distribution is gradually being added to the WFO portal. A particular emphasis is on providing baseline data at country level, which supports the use of such information by countries implementing national-level biodiversity conservation programmes.

The incorporation of data for each species is often complex. A first step is to undertake the matching of names in a contributed dataset with the names included in the Taxonomic Backbone. In general, most datasets require considerable manipulation and adjustment before a large proportion of the records in the database can be incorporated. However, such matching is essential so that, for example, descriptions can be assigned to an existing accepted name or synonym or to an unresolved name included in the database. This is undertaken in a staging part of the database before these data are incorporated into the public portal.

The WFO is not intended to provide critical, monographic treatments of all of the world's plant species, nor will it be a detailed local Flora with vouchered distributional data. Nevertheless, it will provide the first widely-accessible and all-inclusive global overview of the world's plants.

It has been more than 150 years since any attempt came close to assembling a comprehensive catalogue of all of the world's plant species. The WFO will provide for the first time in modern history, a single information resource that presents basic information on all of the world's plants. This will undoubtedly become the most regularly consulted resource by the world's plant research community and will probably serve the ongoing function of continuing to incorporate all new advances in plant science. But it will also serve many other important functions. For the first time ever, it will be available to the conservation community to provide information at the species level and it will be the foundation for achieving a comprehensive list of the world's threatened plant species.

The WFO is a critical initiative required to meet the world's needs for knowledge on which to base plant conservation, ecological restoration and to sustain human use of plant species for a multitude of socio-economic purposes. It will also provide a fundamental resource to clarify where conservation needs are greatest and what gaps in knowledge exist. The entire botanical research community will benefit greatly from having a comprehensive information resource on the world's plants available and it would be of immediate and direct benefit to advancing research efforts.

As we approach the end of the U.N. Decade on Biodiversity and the 2020 deadline for the achievement of the targets of the Global Strategy for Plant Conservation, it is notable that the WFO has accomplished what it set out to do, to create a comprehensive 'Flora of the World'. Of course, it is not complete. For example, there are c. 2,000 plant species being described new to science each year and more data on known plant species become available annually. For that reason, the WFO Consortium has committed itself to continuing to develop and maintain the project beyond 2020, ensuring that a fully accessible global database on all of the world's plants is available to all users, increasing its content, scope and usefulness over the coming years as a vital resource to support the conservation of plant diversity worldwide.

Dr Peter Wyse Jackson,
President
Missouri Botanical Garden
4344 Shaw Blvd.
St Louis
MO 63110 USA

Dr Pierre-André Loizeau
Directeur
Conservatoire et Jardin botaniques
de la Ville de Genève
ch. de l'Impératrice 1 / CP 71
1292 Chambésy/Genève
Switzerland

Petrocosmea xingyiensis. *(Fairy Lake Botanical Garden, China)*

Authors: Malin Rivers and Steve Bachman

UP-LEVELLING PLANT ASSESSMENTS: NEW AND INNOVATIVE WAYS TO DRIVE CONSERVATION ASSESSMENTS FOR PLANTS

Progress towards Target 2 of the GSPC

Barleria seyrigii. *(Guy, KMCC)*

Introduction

The publication of 43,556 assessments of plant species on the global IUCN Red List of Threatened Species (IUCN Red List version 2020.2) [https://www.iucnredlist.org], more than the combined total for birds, mammals, reptiles and amphibians, should be recognised as a considerable achievement, based on the collective effort of thousands of plant experts. However, the reality is that this represents only slightly more than10% of known plants. There is an urgent need to assess all remaining plant species.

Assessing extinction risk

Plant experts have long relied on the IUCN Red List to assess the extinction risk of plants. The IUCN Red List is rightly recognised as the 'gold standard' for assessing species' extinction risk, although it is not the only approach utilised. Plant experts have been assessing extinction risk and conservation status of plant species using different approaches, such as the NatureServe threat ranking system [https://www.natureserve.org/], or have carried out assessments at different scales, from local to national to global. Opting for an alternative to the global IUCN Red List system may be because a national system takes priority, because the data requirements needed to support a Red List assessment are perceived too high, or a lack of training on how to apply the quantitative criteria. Nevertheless, all kinds of evidence-based assessment of a plant can be useful to support conservation prioritisation or actions at any scale. The goal of achieving an assessment for all plants was spelt out with the second global target of the Convention on Biological Diversity (CBD) - Global Strategy for Plant Conservation, which aimed to reach, by 2020:

Target 2:

An assessment of the conservation status of all known plants as far as possible, to guide conservation action

"*An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action*".

Assessments are published in disparate databases and across the literature, and previously it was difficult to determine the current progress in generating assessments for all plants in response to this global target.

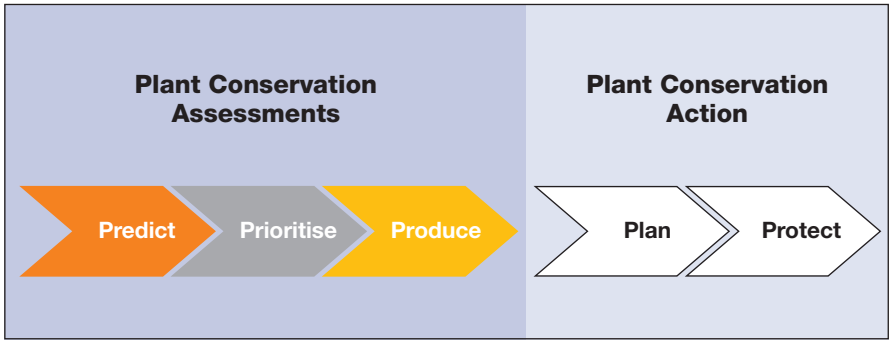


Figure 1: Plant species assessment and action pipeline.

In 2016, Botanic Gardens Conservation International (BGCI) released the ThreatSearch database [https://tools.bgci.org/threat_search.php] that contained our best estimate of all known, digitally available conservation assessment for plants (Bachman *et al*., 2018). ThreatSearch has grown in subsequent years and as of June 2020, 178,700 global assessments had been completed, of which 37% are of threatened status, covering more than twice the species on IUCN Red List.

Even so, by the end of 2020, when the target is due to be delivered, the majority of plant species will remain unassessed, especially in many megadiverse countries. And by the time we have assessed all species, we will likely need to start again because conservation status is not static and species need to be reassessed. We know that conservation interventions based on our assessments can help to improve the status of species, whilst the continuation or even intensification of threats can lead to higher risk for other species. Therefore, we need to ensure conservation status is being kept up-to-date and reflecting the current level of extinction risk on the ground.

It has taken considerable amounts of financial resources and human capacity to achieve this progress with plant assessments, and the true effort to assess all plants has yet to be calculated. Further expansion and regular reassessment will need further resources, and perhaps a change of tactics.
In order to address the shortfalls in assessment coverage and frequency we need to develop new and innovative approaches. We can illustrate this with a simplification of the species assessment and conservation action pipeline (Figure 1).

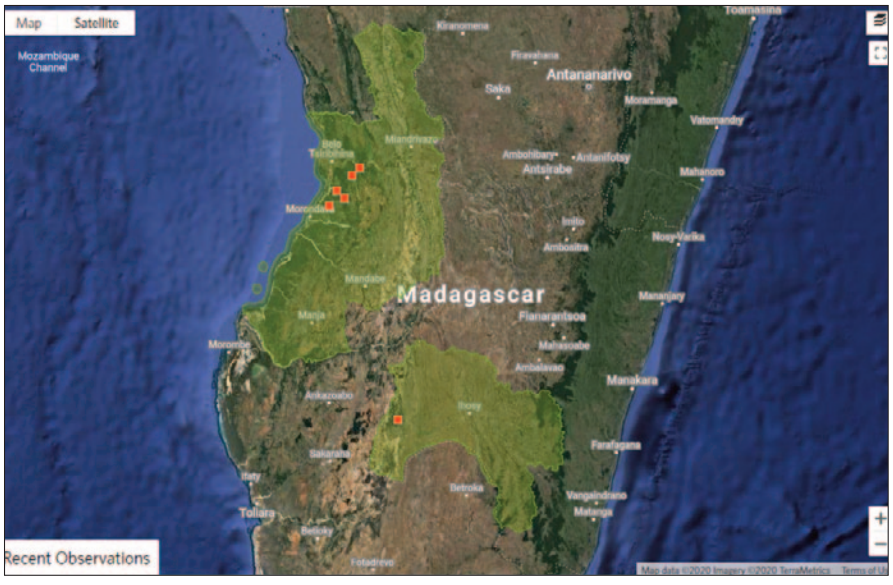


Figure 2: Map of observations on iNaturalist for Barleria seyrigii*, one of the species yet to be assessed. With ~14,000 species, Madagascar is one of the plant mega-diversity countries. Good progress has been made with ~10% of species already assessed on the Red List, but many more still to assess.*

PREDICT: Recent research has shown considerable promise for the prediction of extinction risk using spatial metrics and models that utilise machine learning techniques (Nic Lughadha *et al*., 2019, Darrah *et al*., 2017), although we need to be cautious with the results (Walker *et al*., 2020). A first-pass prediction, although often not sufficient to support a full Red List assessment, may be enough to categorise a species as likely to be threatened or not, with a very good level of accuracy [up to 90%].

PRIORITISE: These predictions can then be used to prioritise our efforts - focusing on the species or regions predicted to be at most risk, whilst grouping together those species predicted to be at low risk

PRODUCE: This is obviously a critical stage, as all species require an assessment. Thankfully, in recent years there have been advances in three key areas:

1) Data collection for Red List assessment.
2) Carrying out the Red List assessment.
3) Packaging data in the required format.

1) Data collection for Red List assessment

In the last decade, data collection for Red List assessments have been developed, both in terms of new data being generated (i.e. expansion of citizen science projects) as well as improved access to relevant data (i.e. access to remote sensing data).

Citizen science

The concept of citizen scientists is not new, but advances in technology have led to an explosion of activity. Projects such as iNaturalist [https://www.inaturalist.org/], that allow users to upload and identify their photo (or sound/video) observations of any organism in nature, have fused together the fun of exploring, monitoring and identifying nature, with a platform that provides a social media style community. Recent developments include the use of 'Computer Vision', a form of artificial Intelligence (AI) to aid identification. This observation data, when verified, has already been used to document extensions of known species ranges (Figure 2), and importantly for conservation assessments, it can help to confirm that a species is still extant in an area (Gardiner and Bachman 2016).

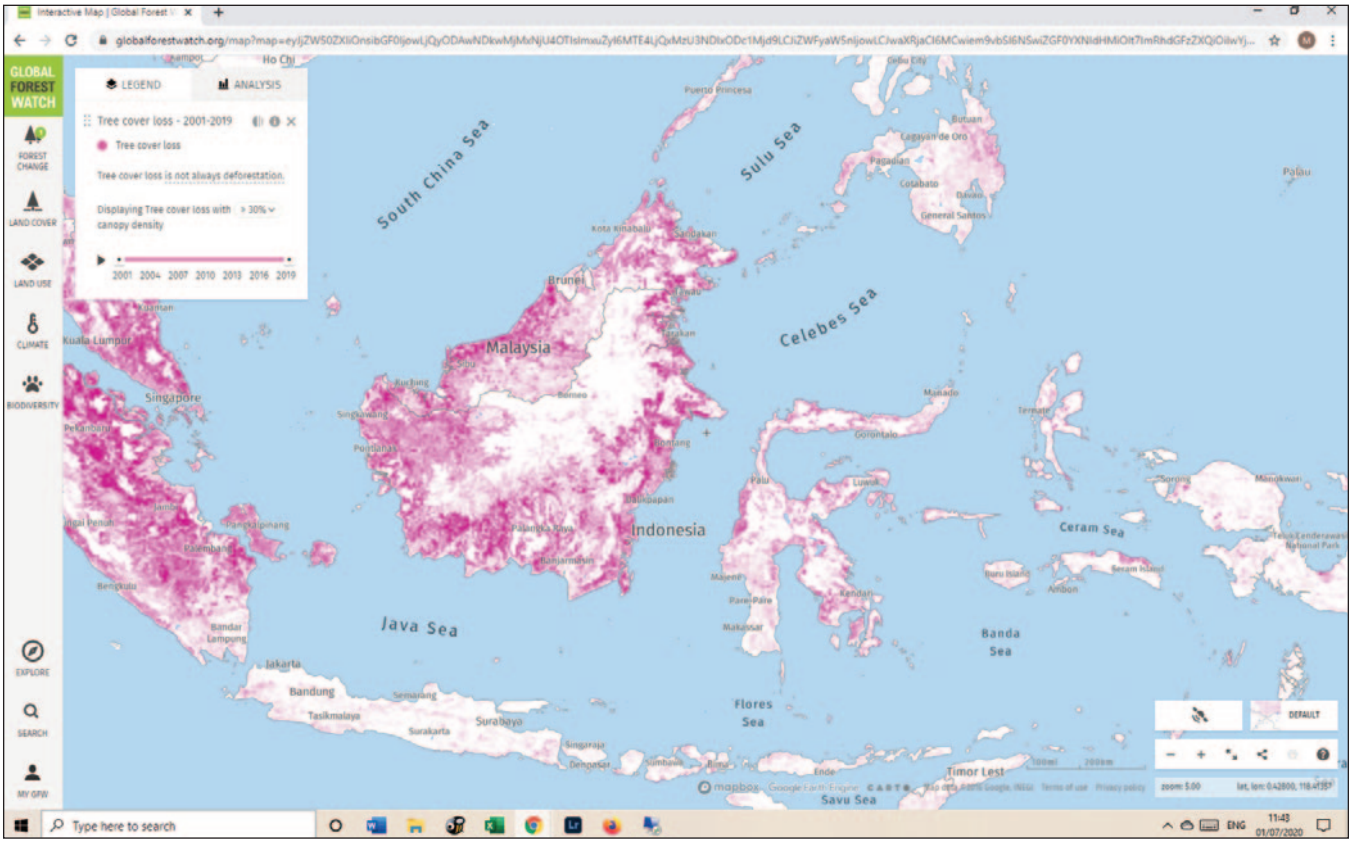


Figure 3: GlobalForestWatch.

Remote sensing

A vital component of producing conservation assessments is to understand the threats facing a species. The remotely sensed monitoring of the planet through satellites, has led to growth of high quality, free and open, global datasets. From maps of land cover and land cover change, such as deforestation, to the growth of urban areas and the frequency and magnitude of fires, the use of remote sensing data can make a huge impact on our ability to assess plant conservation status.

Previously, the field of geographic information systems/science required specialist skills and expensive software to gather and analyse these data, but the launch of initiatives such as Global Forest Watch [https://www.globalforestwatch.org/] in 2014, has opened up this kind of data to a much broader audience (Figure 3). For the first time, high resolution and up-to-date global deforestation data has been made available online in a user-friendly format, thereby providing conservation assessors with evidence of threats to support their assessment of species.

NTBG scientist collecting field data for Red List assessments. (National Tropical Botanical Garden, Hawai'i).

2) Carrying out the Red List assessment

There have also been several methods developed to speed up the assessment of plants for the IUCN Red List. Lately, this has been deployed in assessing species that are considered not at risk of extinction – Least Concern. In groups that are being comprehensively assessed (taxonomic or geographic) for the IUCN Red List, there is likely to be a high proportion of Least Concern species that could be assessed in a more cost-effective way

Least Concern workflow (GTA)

The Global Tree Assessment recognised that a large proportion of the unassessed trees, may indeed be unassessed as they were considered common, widespread and not at risk of extinction. Therefore, a workflow was developed, with data scientists at Cardiff University to identify Least Concern (LC) trees. Starting with names from the GlobalTreeSearch database [https://tools.bgci.org/global_tree_search.php], occurrence records were extracted from online sources and filtered by native countries of occurrence. After taxonomic checks and error cleaning, two spatial metrics that reflect threat exposure known as the extent of occurrence (EOO) and area of occupancy (AOO) were estimated. Several thresholds were set to classify species into a potentially Least Concern group. For example, species with EOO estimates above 30,000 km2, with more than 10 collections more than 10 km apart were flagged as potentially Least Concern. Other data such as lists of timber species, medicinal plants or species considered threatened in national and regional Red Lists were also used to exclude potentially threatened species. All potentially Least Concern species go through review, which are obtained by taxonomic and geographic experts. Following on from this methodology, tools have been developed to allow users to carry out their own assessments for plant species that are at low risk of extinction, for example Rapid LC [https://spbachman.shinyapps.io/rapidLC/].

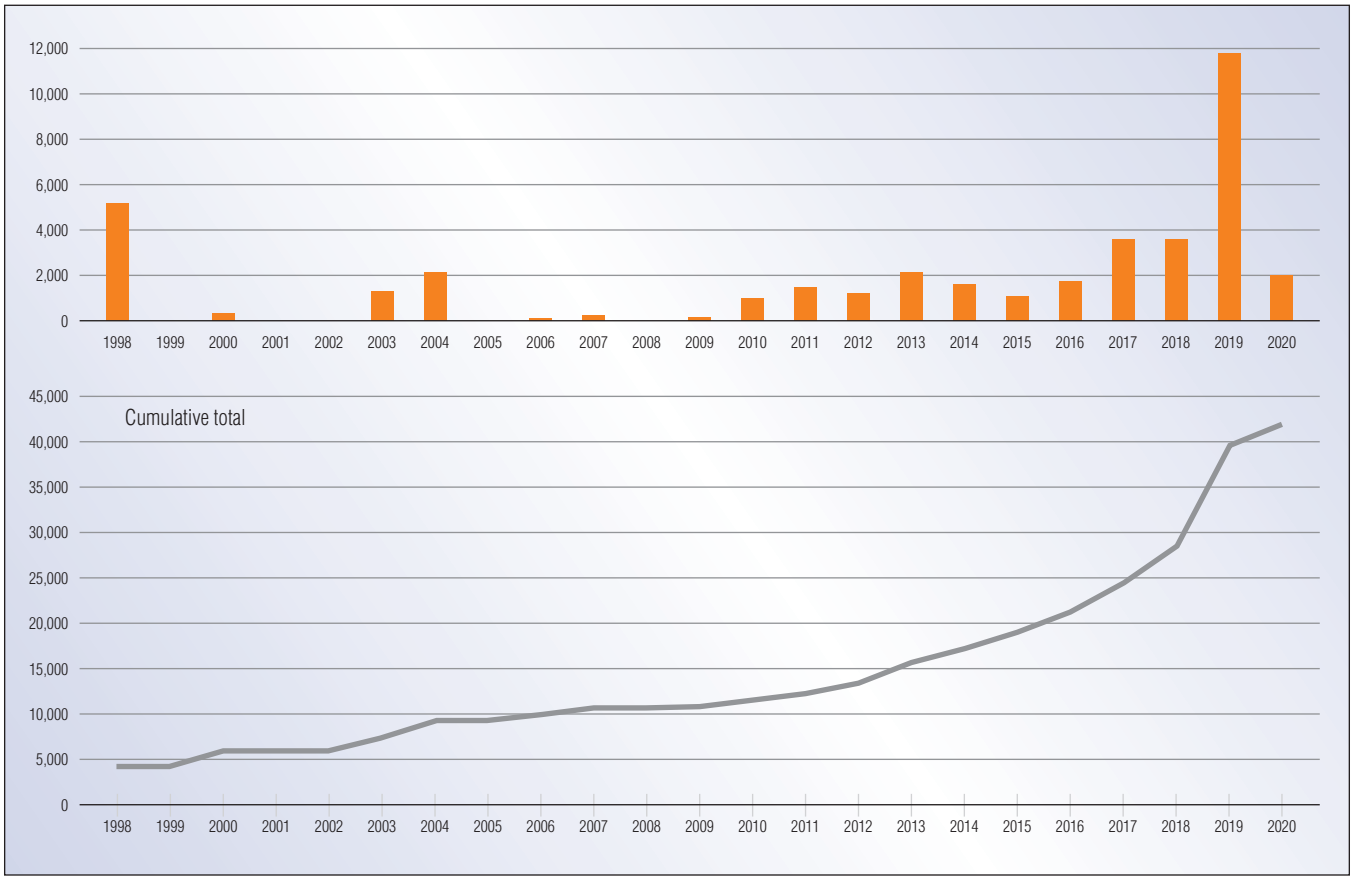


Figure 4: The number of plants on the IUCN Red List (2020.1) and their publication year.

3) Converting data and prediction into assessment and/or reassessment

SIS connect

SIS Connect [https://connect.iucnredlist.org/] is a data uploader tool that allows assessments from external databases to be imported into the IUCN Red List database of Red List assessments - Species Information Service (SIS). This data uploader tool enables the bulk import of Red List assessments held in external databases. This tool allows the user to import process and publish a large number of species assessments on the IUCN Red List.

Both the Least Concern workflow from the Global Tree Assessment and the RapidLC programme generate files for uploading into SIS Connect. SIS Connect is also used by national plant Red List initiatives, such as in New Caledonia, Cuba, Colombia and Brazil. Endemic plant species, with assessments for national Red Lists, are also global assessments, and can be transferred to the global IUCN Red List using SIS Connect.

Conclusion

More than half of the world's plants, may still be missing a conservation assessment, however, without new innovative ways of conducting robust and up-to-date conservation assessments we would not have seen the increase in conservation assessments of plants in the last ten years (Figure 4). These advances have enabled more plant conservation assessments to have been produced, which will form an important part in moving beyond predictions, prioritising and producing actual assessment to planning conservation action and protecting the world's most threatened species.

References

- Bachman, S.P., Nic Lughadha, E.M. and Rivers, M.C. 2018. Quantifying progress toward a conservation assessment for all plants. *Conservation Biology,* 32(3), pp.516-524.
- Bachman, S.P., Field, R., Reader, T., Raimondo, D., Donaldson, J., Schatz, G.E. and Lughadha, E.N. 2019. Progress, challenges and opportunities for Red Listing. *Biological Conservation*, 234, pp.45-55.
- Darrah, S.E., Bland, L.M., Bachman, S.P., Clubbe, C.P. and Trias-Blasi, A. 2017. Using coarse-scale species distribution data to predict extinction risk in plants. *Diversity and Distributions*, *23*(4), pp.435-447.
- Gardiner, L.M. and Bachman, S.P. 2016. The role of citizen science in a global assessment of extinction risk in palms (Arecaceae). *Botanical Journal of the Linnean Society, 182*(2), pp.543-550.
- Nic Lughadha, E., *et al*., 2019. The use and misuse of herbarium specimens in evaluating plant extinction risks. *Philosophical transactions of the Royal Society B, 374*(1763), p.20170402.
- Nic Lughadha, E., *et al*. (in press) Extinction risk and threats to plants and fungi. *Plants, People, Planet*.
- Walker, B.E., Leão, T.C., Bachman, S.P., Bolam, F.C. and Nic Lughadha, E. 2020. Caution Needed When Predicting Species Threat Status for Conservation Prioritization on a Global Scale. *Frontiers in Plant Science*, 11, p.520.

Malin Rivers
BGCI
199 Kew Road
TW9 3BW
UK

Steve Bachman
Royal Botanic Gardens Kew
Richmond,
TW9 3AE
UK

Authors: Sean Hoban, Nicole Cavender and Patrick Griffith

CONSERVATION THROUGH COLLABORATION: ENSURING GENETIC DIVERSITY IN GARDEN COLLECTIONS

Genetic diversity is central to conservation objectives. Gardens need clear frameworks, tools, and metrics to make progress towards this goal. In this article we show how to measure genetic diversity in collections, why more wild-sourced accessions are needed to meet targets, and why we MUST coordinate our efforts to work towards the achievement of GSPC Targets 8 and 9.

Target 8:

At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Target 9:

70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.

Figure 1: Collaboration between the Botanical Garden of the University of Crete (Ourania Grigoriadou, Center) and Montgomery Botanical Center (Patrick and Tonya Griffith) is helping to safeguard Phoenix theophrasti*, an ancient relictual species.*

Safeguarding botanical diversity- all species

Botanical diversity is disappearing! Gardens are responding to this crisis, guided by the Global Strategy for Plant Conservation (GSPC). Several GSPC Targets focus on safeguarding plants *ex situ*. Target 8 calls on gardens to cultivate imperiled plants and make them available for species' and ecosystem recovery programs, and Target 9 commits to conserving 70% of genetic diversity within socio-economically important plant species. Because so many plants have known uses – and undiscovered uses – and because plants underpin every ecosystem, we argue that a commitment to conserve genetic diversity applies to all plant species.

Do we have the space?

The challenge of these Targets is clear: *strive for high genetic diversity in well-managed collections that are useful for conservation purposes*. This is a massive challenge, but the network of thousands of botanical gardens worldwide – holding millions of accessions – can achieve the goal, especially if we work together (Figure 1). Botanical gardens, collectively, have the capacity, the horticultural and ecological expertise, and the ambition.

Why genetic diversity?

Genetic diversity is critical for a species to thrive. It helps plants avoid inbreeding, better adapt to environmental change, and better resist pests and diseases. Genetic diversity underlies resilient ecosystems and food security. Keeping high genetic diversity within botanical gardens preserves this critical potential for the future. Genetic diversity also helps show the public the remarkable variation within species and connects audiences to ecology, evolution, plant breeding, and conservation. In the past two decades, botanical gardens have embraced the importance of this *vital measure of biodiversity*.

Figure 2: Sean Hoban on a plant exploration trip for Quercus boyntonii *in Alabama USA. Our work shows that 77* ex situ *plants of* Quercus boyntonii *safeguard about 70% of the species' genetic diversity – meeting GSPC Target 9. (Emma Spence)*

A straightforward measurement

For most plant species we do not yet know how much genetic diversity is conserved in botanic gardens. However, scientists have started to make such measures with a simple approach: compare the genes found in wild plant populations to those found in collections. This comparison is a metric for tracking progress towards meeting GSPC Targets. For example if an *ex situ* collection has 7 out of every 10 genetic variations found in the wild (i.e. 70%), it meets Target 9, and contributes to Target 8. We can ask: have collections of *Quercus boyntonii* met this goal (Figure 2)? In this case, yes!

Genetic assays are cheaper and more accessible every year. A recent project (results freely available online, see further reading below) funded by the US Institute of Museum and Library Services measured progress in 11 taxa in 5 genera across diverse plant lineages (Figure 3). This broad collaboration among gardens, universities and agriculture agencies found that most species with focused, targeted, large conservation collections by numerous gardens met Target 9 (70% of genetic diversity held – a few hold 95%), but some have not.

The main message of our work is that large numbers of plants are needed to capture genetic diversity. Achieving the goal is possible but will take more carefully targeted wild sourced material.

We must collect more, and more systematically.

Using this same approach – comparing wild and garden populations – we can identify collection sizes that balance resource investment and conservation success. A collection of 100 to 200 plants should meet GSPC Target 9 in many rare plant species. However, considering species' traits is important. Self-pollination, limited dispersal, long generation times, and infrequent reproduction can make larger collection sizes necessary. Species with larger geographic ranges and more populations also need larger collections. Continued genetic studies can illuminate how these biological factors influence *ex situ* conservation effectiveness.

Therefore, some plants need larger collections – but even a thousand seedlings from a single maternal plant won't meet the goal! *The first priority is to collect from throughout a species' natural distribution, gathering seed or cuttings from as many plants as possible*. Second, a stable long-term living collection needs redundancy (multiple backups): even with the best care, some seeds won't germinate, some seedlings die, and some saplings don't establish. Finally, even mature plant collections change much faster than people notice. Losses accumulate from lightning, wind damage, flooding, fires, pests, and accidents. At Montgomery Botanical Center (Coral Gables, Florida, USA), over half the collection dies and is replaced in only 14 years! Thus, our collections are not so different from wild populations, as no plant is immortal. All of this emphasizes that plant exploration must continue – as opposed to sourcing from another garden, which does not capture new genetic diversity.

Metacollections are the solution

With the huge numbers of plants needed to capture genetic diversity, and the need to mitigate against inevitable losses, gardens must work together. Our research shows that genetic diversity can be best maintained by pooling multiple collections into a shared resource – a metacollection of all botanical gardens holding a given species. This metacollection concept was introduced by BGCI in 2019 (freely available online, see below).

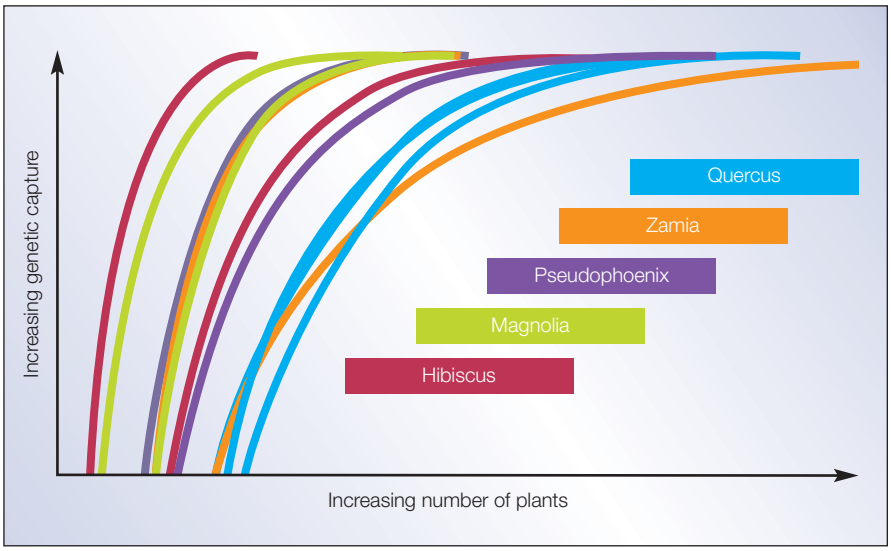


Figure 3: To see if gardens adequately conserve genetic diversity, we studied species across the plant kingdom – emphasizing "charismatic megaflora" to galvanize public enthusiasm. We found a general pattern of steep increase but diminishing returns in genetic capture. We also discovered that taxonomic similarity can't always predict how well collections capture genetic diversity. (adapted from Griffith et al.*, 2019 and Hoban* et al.*, 2020; see further reading, below).*

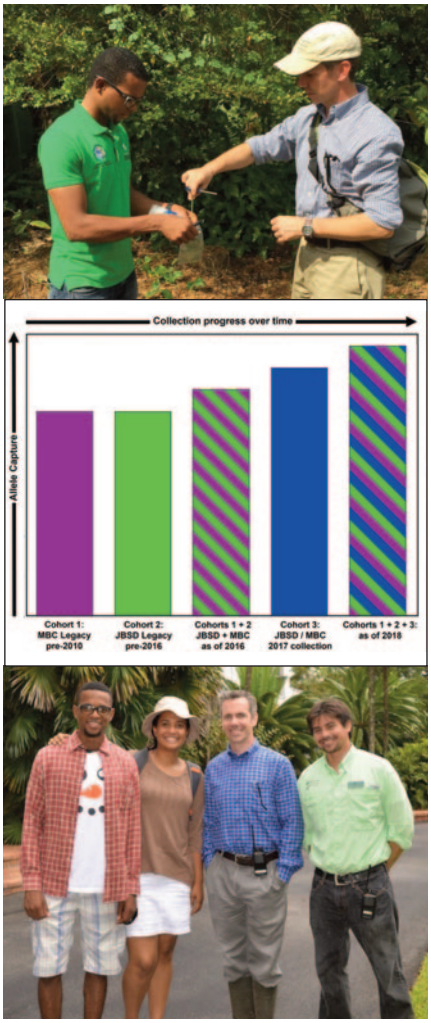


Figure 4: Top: Lemuel Familia and Patrick Griffith sample leaflets at Jardin Botanico Rafael Moscoso (JBSD). Middle: A metacollection of Cacheo Palm at JBSD and Montgomery Botanical Center (MBC) captures the most genetic diversity. Bottom: Lemuel, Yuley Encarnacion Piñyero, Patrick, and Xavier Gratacos at MBC. By working together, gardens can readily achieve GSPC targets.

Using one model species (*Pseudophoenix ekmanii*; Figure 4), we found that combining collections from all gardens can better meet GSPC Targets – gardens can't work alone. This work also showed that legacy (older) plants from general collections development efforts performed more poorly than a single, well-planned effort, but those legacy plants still contribute unique diversity. *In other words, every plant and every garden in the metacollection helps*.

Metacollections do need to be coordinated. An emerging model to share resources and data is the *Conservation Consortium*. These consortia recognize that we achieve more together. BGCI is establishing Global Conservation Consortia for Oaks, Magnolias, Maples, Rhododendrons and Cycads to share accession data, identify taxonomic and geographic gaps (e.g. what and where needs to be sampled next), plan collections development, distribute seed, and evaluate research needs (such as knowledge about seed storage or germination). Keeping good records and sharing data is especially important to managing the metacollection- number of plants, where they came from, and health and age of plants. There is a role for everyone. Gardens with greater capacity can help coordinate efforts across networks and can "champion" a species, growing many plants with deep genetic diversity for restoration and recovery (see Figure 5). Smaller gardens can contribute unique diversity through maintaining smaller numbers of plants of targeted provenance, and by contributing to other conservation efforts, such as collecting new wild germplasm in their region or providing additional expertise. Coordination ensures complementarity - each garden has a role.

Genetic goals match our missions

These genetic diversity goals are often fully aligned with most garden mission statements. For example, the Montgomery Botanical Center advances science, education and conservation through living plants, and the mission of the Morton Arboretum is to collect, study and display trees and shrubs from around the world "*for people to study and enjoy, and to learn how to grow them in ways that enhance our environment*." These statements emphasize conservation of biological diversity, science, teaching and learning, benefits to people and nature, and plant exploration. Measuring and advancing genetic diversity in gardens advances not only the GSPC but also our unique missions.

Simple rules illustrated

In this article we emphasized areas to consider when adding specimens to a garden: new collections, representing a diversity of environments, for the most endangered species, and for species which are currently in the fewest gardens. In summary, *the conservation value of a collection depends on more than the number of species kept*.

Several examples in *Quercus* illustrate this. In the absence of population genetic data, a simple rule is to acquire seed from multiple populations in distinct habitats or ecoregions, as these may represent unique adaptations and will add genetic diversity. For instance, *Quercus austrina* occurs in a variety of southeastern USA habitats, including wooded bluffs, ravines, sandy plains, and closed canopy upland forests.

Figure 5a. Quercus acerifolia *is quite secure in collections – with 79 individuals in 21 gardens globally (additionally The Morton Arboretum has more than 100 seedlings for a planned conservation grove).*


Jon Rebman


Cheryl Birker

Figure 5b. Quercus cedrosensis *has only 1 plant in 1 garden to our knowledge.*

Collections from such habitats can also show visible diversity, which connects to public interpretation.

Species also differ in their representation in garden metacollections (Figure 5). Two IUCN Red List Threatened oaks show this disparity: *Quercus acerifolia* is represented by 79 trees in 21 gardens, but *Quercus carmenensis* only has 2 individuals in a single garden and *Quercus cedrosensis* has 1 individual in a single garden, making these latter species in essence much more endangered. The latter species are a higher priority for new seed collections; California Botanic Garden is currently working to sample seed from *Quercus cedrosensis* for a conservation grove.

We all have a role in the metacollection

To achieve these targets and truly safeguard plants for the long term, we need more material from the wild -- distributed and grown across multiple gardens. The work summarized above guides these efforts: Collections should occur across a species' native distribution, in a variety of habitats, and represent as many maternal plants as possible to maximize environmental and genetic diversity. Seed from the wild must be well documented and fully permitted, and shared among gardens to decrease risk of loss. Research is needed to prioritize species by conservation risk and further measure genetic diversity in collections.

Coordination among gardens is the clear path forward for meeting the GSPC. All gardens can contribute by:

- Participating in metacollections to ensure genetic diversity is conserved
- Measuring genetic diversity in collections with genetic studies.
- Sharing these data to improve collective knowledge and refine collecting protocols
- Messaging the importance of genetic diversity and plant exploration.

Thank yous

These ideas spring from projects supported by the Institute for Library and Museum Services (MG-30-16-0085-16, MA-05-12-0336-12, MA-30-14-0123-14, MA-30-18-0273-18), but also build upon the foundational work of many who came before, including Brown, Marshall, Guerrant, Havens, Maunder and Allenstein, among many others. We are deeply grateful to many colleagues and partners in these efforts: technicians, curators, gardeners, landscapers, support staff, botanists, permitting officials, scientists, and leaders.

For Further Reading:

These documents present examples of pooled collections which maximize conservation value:

- Toward the Metacollection: a guide to coordinating conservation collections.
- Oak Gap Analysis: A conservation survey of holdings across botanical gardens.

These scientific studies present the primary data discussed above:

- Taxonomic similarity does not predict necessary sample size for *ex situ* conservation
- Can a Botanic Garden Metacollection Better Conserve Wild Plant Diversity

These papers highlight future directions for botanical gardens to conserve genetic diversity:

- Applying the zoo model to conservation of threatened exceptional plant species
- The Development of Plant Conservation in Botanic Gardens and the Current and Future Role of Conservation Genetics for Enhancing Those Conservation Efforts (includes guidance on how to establish a population genetic programme at a botanical garden).

Sean Hoban
Tree Conservation Biologist
and
Nicole Cavender
Vice President of Science and Conservation
The Morton Arboretum
Lisle, Illinois, USA
mortonarb.org

M. Patrick Griffith
Executive Director
Montgomery Botanical Center
Coral Gables, Florida, USA
montgomerybotanical.org

Authors: Damian Wrigley, Brett Summerell, Lucy A. Sutherland and Judy West

ILLUSTRATING THE IMPORTANCE OF TARGET 16

AUSTRALIAN NETWORKS DELIVERING TOWARDS THE GLOBAL STRATEGY FOR PLANT CONSERVATION

Target 16:

Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy

Introduction

The conservation of native flora is for many individuals a lifelong endeavour, requiring much collaboration, knowledge sharing and in-kind support. Botanic gardens are no exception with networks and partnerships critical to many conservation and research projects. The Council of Heads of Australian Botanic Gardens (CHABG) is one of Australia's many botanical networks, representing the major capital city botanic gardens in each state and territory.

For the past two decades the CHABG has supported both *in situ* and *ex situ* conservation outcomes for Australian flora through botanic gardens and seed banks with the help of numerous project collaborators and partners. The CHABG was established to support *'the protection, conservation and enhancement of Australian Plants and their ecosystems' through the provision of 'information and education and undertaking research about plants and plant communities'*. Now more than ever this national network of like-minded conservation institutions is playing a critical role in supporting the delivery of the Global Strategy for Plant Conservation as Australia responds to the recent catastrophic bushfires.

The Australian Bushfires

Before COVID-19 became a global emergency, Australia was dealing with unprecedented fires across the continent. The spring and summer of 2019-2020 brought with it a fire season of staggering intensity and extent. Fires blazed across millions of hectares including rainforests that are likely to require up to 50 years between burns to sufficiently recover (Gallagher, 2020). The fires encouraged an incredible groundswell of support for Australia's native flora with a diversity of national and international governments, philanthropic organisations, businesses and individuals offering resources to support recovery efforts.

In response, botanic gardens have actively mobilized, along with countless other botanical and conservation organisations and government agencies, to respond to the devastating impacts across the continent. These responses are varied in focus and location, and while native fauna predominantly require immediate interventions to ameliorate physical injuries and loss of habitat, many native plants require time to respond and recover post-fire. The most pressing actions for flora post-fire include assessing and monitoring native plant recovery (Auld *et. al*., 2020), which should be complemented by actions to remediate invasive pests and disease that threaten their survival. Over the coming seasons, germplasm capture and active restoration efforts will significantly increase, with a reliance on monitoring playing a key role in prioritising future recovery efforts.

Collecting Lenwebbia "Main Range" in Northern New South Wales. (RBGDT)

COUNCIL OF HEADS OF
AUSTRALIAN BOTANIC GARDENS INC.

STATEMENT

Australia's major botanic gardens united to assist ecosystem restoration in response to recent bushfires

The impact of the recent bushfires on our native plants and animals has been severe. Millions of hectares of native habitat have been burnt, putting at risk the survival of plant and animal species.

While much of the Australian bush and its plants are well adapted to fire, the ferocity and extent of the bushfires this summer, and predicted frequency for coming years due to climate change, are unprecedented. Some plants will recover depending on the timing and extent of rains, but some ecosystems require carefully managed intervention. For those animals that did not perish in the fires, loss of plant habitat and food presents a particular risk. However, it is critical that any reintroduction of native species to the environment delivers the right plant species, in the right place, at the right time, in a manner that has no detrimental impacts on the environment.

The **Council of Heads of Australian Botanic Gardens** is a not-for-profit Association established for the purpose of supporting the protection, conservation and enhancement of Australian plants and their ecosystems, including research about plants and plant communities to provide information and education for communities around Australia.

Council members stand ready to work with the Australian Government's Threatened Species Commissioner and with all Commonwealth, State and Territory research and management agencies and organisations to assist delivery of a measured, targeted, timely and sustained response to this ecological emergency.

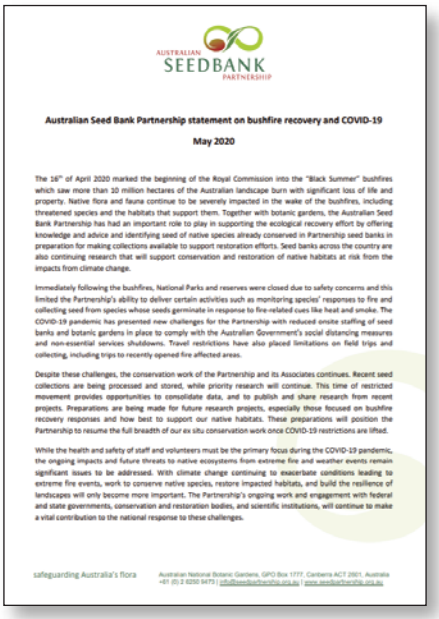
The Council, working with Australian Government and State Environment Departments, is well positioned to contribute to the recovery effort through the combined expertise and experience held in the country's major Botanic Gardens and Conservation Seed Banks coordinated by the Australian Seed Bank Partnership.

Partner members, accessing insurance populations of seeds held in Partnership facilities and the living collections of all Botanic Gardens will work hand-in-hand with government departments, NGOs and academia to reduce threats to recovery (such as from invasive species like weeds, pests and pathogens), and to collect seed and cuttings from fire threatened regions. Such efforts give our plants – and the animals that depend on them - the best chance of recovery.

The network of seed banks and propagated resources are Australia's insurance policy for its flora, and we must continue to invest in their maintenance and growth. The Council of Heads of Australian Botanic Gardens members share the goal to protect and use these collections for the benefit of future generations. In achieving this, members are committed to the most impactful use of our collective resources and capabilities, and to minimise any duplication of effort.

Recently, the Council welcomed the UK Government's support, and Partnership members will work with Royal Botanic Gardens Kew in London to implement targeted emergency bushfire seed conservation and research.

We do not underestimate the scale of the task ahead. It will take a sustained, coordinated effort over many years to restore impacted ecosystems. CHABG members will steadfastly advocate for action based on sound scientific analysis of needs. We will use our expertise and influence to support effective decisions and coordinated action to give the best chance of successful ecosystem-based restoration of our precious native plant species.



AUSTRALIAN SEEDBANK PARTNERSHIP

Australian Seed Bank Partnership statement on bushfire recovery and COVID-19

May 2020

The 16th of April 2020 marked the beginning of the Royal Commission into the "Black Summer" bushfires which saw more than 10 million hectares of the Australian landscape burn with significant loss of life and property. Native flora and fauna continue to be severely impacted in the wake of the bushfires, including threatened species and the habitats that support them. Together with botanic gardens, the Australian Seed Bank Partnership has had an important role to play in supporting the ecological recovery effort by offering knowledge and advice and identifying seed of native species already conserved in Partnership seed banks in preparation for making collections available to support restoration efforts. Seed banks across the country are also continuing research that will support conservation and restoration of native habitats at risk from the impacts from climate change.

Immediately following the bushfires, National Parks and reserves were closed due to safety concerns and this limited the Partnership's ability to deliver certain activities such as monitoring species' responses to fire and collecting seed from species whose seeds germinate in response to fire-related cues like heat and smoke. The COVID-19 pandemic has presented new challenges for the Partnership with reduced onsite staffing of seed banks and botanic gardens in place to comply with the Australian Government's social distancing measures and non-essential services shutdowns. Travel restrictions have also placed limitations on field trips and collecting, including trips to recently opened fire affected areas.

Despite these challenges, the conservation work of the Partnership and its Associates continues. Recent seed collections are being processed and stored, while priority research will continue. This time of restricted movement provides opportunities to consolidate data, and to publish and share research from recent projects. Preparations are being made for future research projects, especially those focused on bushfire recovery responses and how best to support our native habitats. These preparations will position the Partnership to resume the full breadth of our ex situ conservation work once COVID-19 restrictions are lifted.

While the health and safety of staff and volunteers must be the primary focus during the COVID-19 pandemic, the ongoing impacts and future threats to native ecosystems from extreme fire and weather events remain significant issues to be addressed. With climate change continuing to exacerbate conditions leading to extreme fire events, work to conserve native species, restore impacted habitats, and build the resilience of landscapes will only become more important. The Partnership's ongoing work and engagement with federal and state governments, conservation and restoration bodies, and scientific institutions, will continue to make a vital contribution to the national response to these challenges.

safeguarding Australia's flora

CHABG and ASBP Statements about shared approaches to responding to bushfires and COVID-19. (CHABG)

Working collaboratively

Immediately following the fires, the CHABG released a statement drawing attention to the importance of utilising the knowledge and expertise in the botanical community, confirming their commitment to working with environment agencies and supporting recovery efforts. Since February, member institutions have directed expertise in botanic gardens, seed banks and herbaria to support conservation planning and on-the-ground actions. This includes data acquisition from rapid flora assessments of burnt areas, to planning or undertaking opportunistic seed and germplasm capture from fire ephemerals and at-risk species. These efforts also extend to the Australian National Botanic Gardens and the Australian Seed Bank Partnership representing CHABG to the Australian Government's bushfire recovery response for seed banking under the aptly named Project Phoenix.

Bushfires aren't the only challenge

While COVID-19 has delayed many urgent response actions, this additional time has enabled further planning for those interventions that presented significant safety concerns. Many national parks and conservation areas affected by the fires have been inaccessible due to the risks of injury from compromised infrastructure such as roads and bridges, as well as burnt vegetation that, following the preceding severe drought, are at greater risk of dropping limbs.

The Australian Seed Bank Partnership meets annually to plan future projects and share breakthroughs, techniques and challenges with delivering ex situ *seed conservation programs. (ASBP)*

Australia's existing networks and collaborations have been instrumental in developing complementary restoration approaches and avoiding duplication. The social nature of our networks has enabled Australian botanic gardens and seed banks to capitalize on limited funding opportunities and challenging environmental conditions for many years. Our institutions and facilities have evolved with collaboration as a key feature of their success. Recent physical distancing requirements have presented challenges; however, the existing social infrastructure supports ongoing delivery of our work in-person and through online and physically distant interactions.

Through CHABG's largest conservation program, the Australian Seed Bank Partnership (the Partnership), botanic gardens and flora-focused conservation organisations are supporting the continuation of seed collecting, storage and research by exchanging knowledge on managing conservation and research programs through these uncertain times. The Partnership has actively shared and explored the various approaches to managing collections, field work and research with a focus on institution-level responses. These shared learnings provide visibility of the various approaches to maintaining conservation and research programs across the country during 2020. These discussions have also helped identify issues for collection maintenance not previously considered, including the need to rethink formerly practical approaches to building design, materials and management.

Furthermore, access to critical infrastructure that support seed banks, such as liquid nitrogen for storage of germplasm, were identified as potentially high-risk elements of conservation programs as supply chains faced possible collapse. COVID-19 travel restrictions, border closures and competition with medical research facilities meant regular deliveries of liquid nitrogen to seed banks were likely to be disrupted. These risks present a real threat to decades of investment in *ex situ* seed programs across the continent. The exploration and remediation of issues such as this have been possible largely due to the willingness of partners to share experiences and support colleagues through these uncertain times.

Enough information to achieve the targets

The CHABG's national network of botanists and researchers are proving to be an invaluable resource throughout Australia, supporting the flow of botanical information and knowledge that underpins contributions to other targets under the Strategy. For much of the native Australian flora impacted by the fires, observations in previous years such as recent fires in Victoria, have shown that with the exception of fire ephemerals and some early post-fire sprouters, the period two to three years post-fire is likely to be the most productive in terms of seed availability. This knowledge provides the Partnership with additional data on opportunities and threats to strategically plan for seed collections in the seasons to come.

The CHABG members meeting for their annual face to face meeting in 2019 at Kings Park and Botanic Gardens in Western Australia (South Australia and Tasmania absent from photo). (CHABG)

Target 10[2] – monitoring for biological invasions post-fire

A significant threat to the availability of seed is post-fire biological invasion. Since 1788 there have been a great number of incursions of exotic plant pathogens into Australia, many of which have impacted Australia's native flora, some with devastating consequences. Diseases like Phytophthora root rot (caused by *Phytophthora cinnamomi*) were introduced in the early stages of colonisation, whilst others like Myrtle Rust (caused by *Austropuccinia psidii*) were only introduced in 2010. In all cases the impact on selected species of plants has been to reduce populations and send species towards extinction.

Members of the Partnership have focussed on the *ex situ* protection of impacted species through seed banking, research on cryopreservation and *in situ* management to ensure the protection of these at-risk species.

Austropuccinia psidii attacks the new shoots and tips of many species in the Myrtaceae family causing individuals of highly susceptible species to wither and die as they are unable to continue to produce sufficient food to maintain new growth, exhausting reserves and in a relatively short amount of time, dying. For those that do survive, the ability of an individual to produce flowers is limited as new shoots and flowers are favoured by the fungus, significantly compromising an individual, and in many cases entire stands of a species, to develop viable seed (Carnegie *et al*., 2016).

Dr Brett Summerell, Royal Botanic Gardens Sydney preparing to enter a 'Dieback Disease Risk' area at Mt Imlay National Park in New South Wales. Educating the public about the risks can help alleviate some of the impacts of soil and water borne diseases impacting native species. (RBGDT)

Rapid flora assessments are already underway following the fires throughout various parts of Queensland and New South Wales with the aim of identifying suspected incursions of *A. psidii* and its impact on susceptible species. In some cases, germplasm capture is necessary in order to ensure vegetative material is secured to support future restoration efforts. Efforts to support Target 10 are reliant on the identification of incursions, providing critical data to underpin management interventions that aim to ameliorate the impacts of biological invasions

Target 14[3] - Helping others find our fascinating flora

The ongoing engagement and education of the public is essential to improving the understanding and support for plant conservation, particularly following natural disasters and the associated threats that follow. Previous efforts by botanic gardens provide a solid foundation for continuing these efforts in a post-COVID-19, physically distant world. South Australia's Botanic Gardens and State Herbarium (BGSH) has a long history of educating the community about the importance of plant diversity and its conservation by leveraging the global awareness created through World Environment Day.

[2]Target 10: Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.
[3]Target 14: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes

Students from a local school talking to ABC Gardening Australia presenter's Costa Georgiadis and Sophie Thompson in 2019 about the SEEDS program. (BGSH)

Each year the BGSH event welcomes 2,000 primary school students, who learn about biodiversity and protecting Australia's natural heritage. The BGSH's annual World Environment Day event was reimagined for 2020 with physical distancing measures necessitating the celebrations and educational engagement activities delivered as web-based content.

High school students have had the opportunity to be involved in authentic science, which resolves real problems and produces tangible results through the SEEDS program (Stewardship of Endemic Endangered Species). Led by the BGSH's South Australian Seed Conservation Centre, students are mentored on how to grow threatened plant species from seed, successfully isolate the mycorrhizal fungus from rare orchids to test seed germination and they then work with land managers to re-introduce them back into their natural habitat. They are also contributing to knowledge through undertaking pollination experiments and developing and managing seed orchards. University students gain direct experience in documenting and supporting conservation efforts through practical training and project work, working alongside the herbarium's botanical experts.

Learnings from each botanic gardens' online activities throughout the pandemic will help build greater digital engagement opportunities that lead to physically welcoming a broader audience when botanic gardens can once more offer on-site programs.

New targets for a new world

There is no doubt this year has presented challenges for delivering final contributions to the existing targets of the Global Strategy for Plant Conservation. While we may remain physically distant for some time, it is reassuring to see so many maintain and strengthen remote social and professional engagements with collaborators, partners and colleagues as we all continue working to conserve our diverse global flora.

As we move through this last year of the Strategy and prepare for the third decade of targets to guide global efforts, it is abundantly clear that the networks, partnerships and global community of botanic gardens and flora focused conservation organisations form the trunk of this universally important framework for plant conservation.

For more information on the response to the bushfires and COVID-19:

CHABG Statement:
https://www.seedpartnership.org.au/australias-major-botanic-gardens-united-to-assist-ecosystem-restoration-in-response-to-recent-bushfires/

ASBP Statement:
https://www.seedpartnership.org.au/partnership-statement-on-seed-banks-responding-to-bushfires-and-covid-19/

Project Phoenix:
https://www.greeningaustralia.org.au/projects/projectphoenix/

Australian Government Bushfire Recovery:
http://www.environment.gov.au/biodiversity/bushfire-recovery

References

- Auld, Tony D; Zimmer, Heidi C and Commander, Lucy E. 2020. *Plant conservation and fire* [online]. Australasian Plant Conservation: Journal of the Australian Network for Plant Conservation, Vol. 28, No. 4: 3-5. Availability: <https://search.informit.com.au/documentSummary;dn=194379174791994;res=IELNZC> ISSN: 1039-6500. [Accessed 24 June 20].

- Carnegie, A.J., Kathuria, A., Pegg, G.S. *et al*. 2016. Impact of the invasive rust *Puccinia psidii* (myrtle rust) on native Myrtaceae in natural ecosystems in Australia. Biol Invasions **18**, 127–144. https://doi.org/10.1007/s10530-015-0996-y.

- Gallagher, R. 2020. *Interim National Prioritisation of Australian Plants Affected by the 2019-2020 Bushfire Season*. Version 1.3. Macquarie University. PP. 1-55. Availability: http://www.environment.gov.au/system/files/pages/289205b6-83c5-480c-9a7d-3fdf3cde2f68/files/interim-report-plants-requiring-urgent-management-intervention.pdf. [Accessed on 12 June 2020].

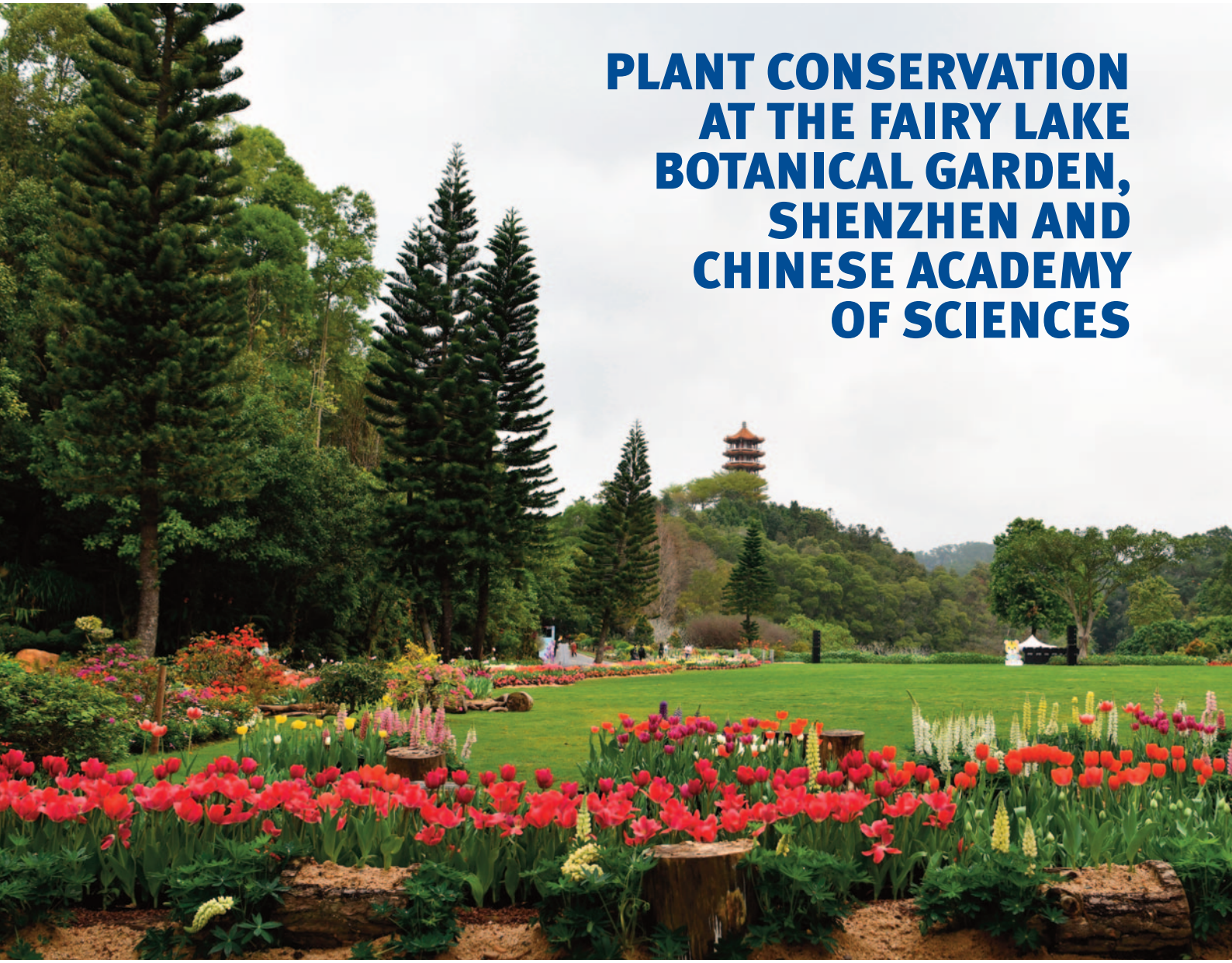
Damian Wrigley
National Coordinator
Australian Seed Bank Partnership
(Corresponding Author)

Dr Brett Summerell
Director, Research and Chief Botanist,
Australian Institute of Botanical Science,
Royal Botanic Gardens and Domain Trust

Dr Lucy A. Sutherland
Director, Botanic Gardens and State Herbarium
South Australia.
Dr Judy West,
Executive Director
Australian National Botanic Gardens

Authors: Zhi-Jing Qiu, Li Zhang, Shou-Zhou Zhang, Hui Wang, Nan Li, Rui-Xing Xie and Hong Jin

PLANT CONSERVATION AT THE FAIRY LAKE BOTANICAL GARDEN, SHENZHEN AND CHINESE ACADEMY OF SCIENCES



Paradise scenery.

Introduction to the Fairy Lake Botanical Garden

The Fairy Lake Botanical Garden, Shenzhen and Chinese Academy of Sciences (SZBG) was established in 1983 in Shenzhen, Guangdong Province, along the coast of southern China. The Garden is located on the edge of the Wutong Mountain, the highest peak of Shenzhen (944 m.a.s.l.), and contains a private body of water, called Fairy Lake. It is a comprehensive botanical garden that integrates plant conservation, landscape design, scientific research, and public education.

There are 21 themed gardens as well as conservation facilities at SZBG. The Garden has developed rapidly and has become well-known in southern China and even across the rest of the country. It has received visits from three national leaders and more than a dozen national politicians and has received international recognition.

The year 2017 was a turning point for the Garden when it hosted the 19th International Botanical Congress (IBC). The IBC is the world's largest and highest-level conference in the botanical community and is held every six years. This meeting was the first time in more than 100 years that the IBC had been held in a developing country. The Garden took the opportunity to improve many aspects of its work, including plant conservation, landscape construction, scientific research and nature education activities.

Target 8:

At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Conservation Center of SZBG.

The SZBG successfully hosted the IBC and received unanimous praise from the scientific community.

To mark the event, the *Shenzhen Flora*, which had taken over ten years of hard work, was published in 2017. This ambitious project required an in depth investigation of the area's botanical background and even included re-delineation of the line drawings for each species in the Flora.

Due to the outstanding work of SZBG, it was awarded the "Fenghuai Award" by the Chinese Botanical Society in 2018, the highest award in the world of Chinese botanical gardens and was rated the most beautiful botanical garden in China. Accordingly, the international influence of the Garden has been greatly enhanced.

Plant conservation at Fairy Lake Botanical Garden

Staff of the Plant Conservation Center of SZBG systematically sorted and investigated the plants preserved in the garden after the 19th International Botanical Congress. At present, there are 12,380 taxa (including species, sub-levels of species, and varieties) of live plants. These include 7,322 Chinese indigenous plants and 936 taxa of rare and endangered plants (including species and sub- species), and they are preserved in the various themed gardens at the SZBG and in the greenhouses of the Conservation Center department.

The Fairy Lake Botanical Garden is mainly interested in collecting and conserving plants from similar latitudes in global tropical and subtropical areas. Combined with SZBG's scientific research and the focus of technical staff, the garden has gradually formed a collection of bryophytes, ferns, cycads, gesneriads, magnolias, begonias, and medicinal plants. The number of collected species is at the forefront of domestic and even international collections.

Major taxa being conserved

Bryophytes

Bryophytes are often overlooked, not just in China but around the world, because of their small size and lack of direct economic value. SZBG set up the first bryophyte nursery in mainland China in 2009. The aims were not only for conserving species *ex-situ* but also for supplying materials for research, education, and horticulture purposes. Species conserved belong to the following three categories: 1) species from vulnerable habitats; 2) phylogenetic importance, rare and endangered species; and 3) species with horticultural, educational, or medicinal prospects.

The location of the bryophyte nursery had to move several times until early 2017. However, when a new shade greenhouse at the Conservation Center became available, it was relocated there. The new facility, with an indoor area of about 400 m^2, was also equipped with an automatic spray system. About 90 species are cultivated there, mostly from south and southwest China, including *Atrichum undulatum, Campylopus umbellatus, Fissidens dubius, Hedwigia ciliata, Hypnum plumaeformae, Hypopterygium flavolimbatum, Leucobryum boninense, Plagiomnium vescicatum, Pyrrhobryum dozyanum, Rhodobryum giganteum*, and more.

Ferns

The Fairy Lake Botanical Garden has been collecting and conserving ferns since 1988 and now possesses nearly a thousand species of fern from tropical and subtropical regions all over the world. These include rare and endangered species such as *Isoetes sinensis, Adiantum reniforme* var. *sinense, Ceratopteris thalictroides, Brainea insignis*, and *Osmunda mildei*. SZBG also has China's most complete collection of plants belonging to the Cyatheaceae, all members of which are wild plants under special national protection. Based on these collections, research on taxonomy, reproductive biology, morphology, systematic and evolution biology, and the fern research group's floristic geography of ferns are carried out.

Bryophytes in the shade garden.

Fern greenhouse.

Cycads

Cycas is one of the oldest extant seed plant groups. The earliest cycad fossil record comes from the late Permian stratum about 280 million years ago in Shanxi, China. Cycads flourished in the Mesozoic era and were around during the age of dinosaurs. There are only about 300 living cycad species in 3 families and ten genera, scattered in the tropical and subtropical regions of the globe. They are of great significance for the study of the origin and evolution of seed plants, paleogeological and paleoclimatic changes, as well as the co-evolution of plants and other creatures. Therefore, most of them are under critical protection all over the world. In secular life, cycads are precious ornamental plants in gardens and have always been loved by people.

Fairy Lake Botanical Garden has been collecting and cultivating cycads from all around the world since 1989. Cycads are considered a core conservation group in the garden. More than 240 species in 3 families and ten genera of cycad have been collected. The main conservation site is in the National Cycas Germplasm Conservation Center.

Cycas debaoensis Y. C. Zhong et C. J. Chen is a nationally protected species and listed as critically endangered in the IUCN Red List Status (CR B2.) The "Reintroduction Program of *Cycas debaoensis*" was the first plant reintroduction program led by the National Forestry & Grassland Administration in China. The program lasted for eight years. Every year, the reintroduced cycad population produced cones and thousands of seeds. Over 30,000 seedlings of *C. debaoensis* were propagated in a small nursery built at Huanglian Mountain Nature Reserve. Even though some seeds were eaten by local rodents, they also scattering the seeds to the surrounding areas and some young plant of *C. debaoensis* have already been found outside of the reintroduced site.

Gesneriaceae

Gesneriaceae is a large family of angiosperms, with more than 3,600 species in 150 genera. Gesneriaceae are mainly distributed in the tropical and subtropical regions of the world. China is one of the major centers of diversity of Gesneriaceae, with about 760 species (including sub-levels of species) in 44 genera, and nearly a quarter of the native species are endemic to China. Most plants are shade-loving perennial herbs, with beautiful flowers. They grow mainly on humid limestone rock cliffs, often intermingled with begonias and bryophytes.

The Gesneriad Conservation Center of China-Shenzhen (GCCC-Shenzhen), a branch of the main GCCC in Guilin, China, was established at the Fairy Lake Botanical Garden on 5 May 2017. The organization aims to promote the conservation, research, propagation, exploration, documentation and protection of Gesneriads, along with educating the public about the family. The GCCC-Shenzhen conserves more than 400 species in 20 genera from China (including three species of protected plants, 200 rare and endangered species and more than 100 medicinal plants) as well as over 700 cultivars and more than 100 artificial hybrids.

The Conservation Center of SZBG has the most complete collection of species of the genus *Petrocosmea*. Almost all of the 53 species are maintained here in a constant temperature greenhouse. A significant and broad research programme has been developed at the Centre based on the rich collection of Gesneriads.

Cycas debaoensis Y.C.Zhong & C.J.Chen.

Magnoliaceae

To date, 180 Magnoliaceae taxa have been collected and conserved at SZBG (including 50 cultivated varieties) and a magnolia garden covering an area of about 10 hectares has been established. Conservation biology research focuses on *Magnolia sinostellata, M. guangdongensis*, and *M. maudiae* var. *rubicunda*. With the support of BGCI a project on the reintroduction of *M. sinostellata* has been completed. Based on the collection, SZBG has conducted research on systematics, cytology, embryology, and genomics. Twelve new varieties such as Magnolia 'IBC 2017' were created, and a new taxon was described. The whole-genome sequencing of *M. biondii* was completed, and the specific genome doubling of Magnoliaceae was determined.

Primulina lutea *(Yan Liu & Y.G.Wei) Mich.Möller & A.Weber.*

Primulina yungfuensis *(W.T.Wang) Mich.Möller & A.Weber.*

Begonia greenhouse.

Magnolia hodgsonii (Hook.f. & Thomson). H.Keng

The pathways involved in nucleic acid metabolism, secondary metabolite synthesis, and plant-pathogen interaction were analyzed. The phylogenetic genomics have reconstructed the phylogenetic history of Magnoliaceae and analyzed the causes of its discontinuous distribution.

Begonias

Fairy Lake Botanical Garden started to conserve Begoniaceae plants in 2008 and the collection now includes 270 wild species (140 of them originated from China), and 120 cultivars. The plants, which are propagated by seeds, leaf and branch cutting, and tissue culture are grown in specific gardens and landscapes. Three new species, *Begonia zhongyangiana* W.G. Wang et S. Z. Zhang, *Begonia daunhitam* W.G. Wang, C.X.L. Wang, S.Z. Zhang & A. Randi, and *Begonia puerensis* W.G. Wang, X.D. Ma & J. Y. Shen have been published. The genetic transformation system of more than ten species have been completed and will be used in germplasm enhancement. Whole genome sequencing has been completed for four *Begonia* species and genome skimming carried out for 74 species. Synteny analysis revealed a *Begonia* specific whole-genome duplication (WGD) before the burst of the lineage. Phylogenomic reconstructions and genomics studies suggest that introgression and hybrid speciation might play essential roles in the evolution of *Begonia* diversity.

Medicinal plants

The collection and study of medicinal plants is one of the main focuses of Fairy Lake Botanical Garden. More than 700 species of medicinal plants from South China are grown in the medicinal plants garden, of which 74 species are endemic to China. Studies are mainly focused on plant micropropagation and phytochemical constituents. *A Catalogue of Medicinal Plants in Guangdong-Hong Kong-Macao Greater Bay Area* has been published recently, which is vital for the conservation of medicinal plants in the area. The medicinal plant garden displays a collection of these essential plants for visitors. The living plants displayed in the medicinal plant garden have played an important role in educating the public and college students about the use of medicinal plants in traditional Chinese medicine and their identification.

The future and prospects for plant conservation at Fairy Lake Botanical Garden

Through research and focusing on particular plant families, Fairy Lake Botanical Garden has achieved promising initial results in the exploration and collecting of plants, plant protection, and plant use. SZBG will collect and conserve plants from all over the world on this basis in the future. Moreover, SZBG will work to expand the taxa groups it conserves in order to make the conservation of plants in the garden more comprehensive, in-depth, and unique.

Acknowledgments

We would like to thank Stephen Maciejewski (The Gesneriad Society), Michael LoFurno (Adjunct Professor, Temple University, Philadelphia PA, the USA), and Dr. Baskaran Xavier-Ravi (post-doctoral fellow, School of Life Sciences, Sun Yat-sen University, Guangzhou and Fairy Lake Botanical Garden, Shenzhen & CAS) for their editorial assistance.

Hong Jin (Corresponding author)
Key Laboratory of Southern Subtropical Plant Diversity
Fairy Lake Botanical Garden
Shenzhen and Chinese Academy of Sciences
Shenzhen
518004, China.

Herb garden.

Author: Robbie Blackhall-Miles

PRIORITISING WILD COLLECTIONS OF SOUTH AFRICAN *PROTEACEAE* FOR *EX SITU* CONSERVATION

Spatalla nubicola.

Target 8:

At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Even the smallest gardens have a role to play in addressing Target 8 of the GSPC

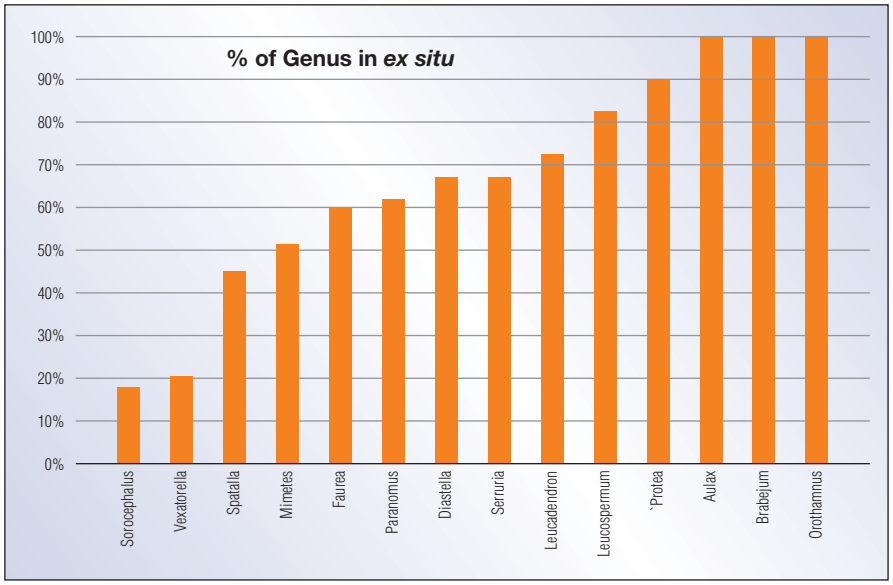
As one of BGCI's smallest institutional members, Fossil Plants inevitably requires a targeted approach when actively assisting efforts to protect threatened plants through *ex situ* conservation. Driven by guidelines produced by the Species Survival Commission (SSC) of the IUCN (IUCN/SSC, 2002) one of the ways this is achieved is through the creation of cultivation protocols for Proteaceae suited to growing in cooler climates, as part of our 'Proteas with Altitude' project. Much of the material with which we produce these protocols comes from our 2015 and 2017 collections from South Africa's Western Cape Province (see BGjournal Vol. 15, No. 2). Planning for these was informed by Target 8 of the GSPC along with further guidelines laid out by the SSC (IUCN/SSC, 2014). Analysis of the threat status of a species along with its absence from global *ex situ* living collections and seed banks helped prioritise taxa for which wild collections were made.

The following data was used in this analysis:

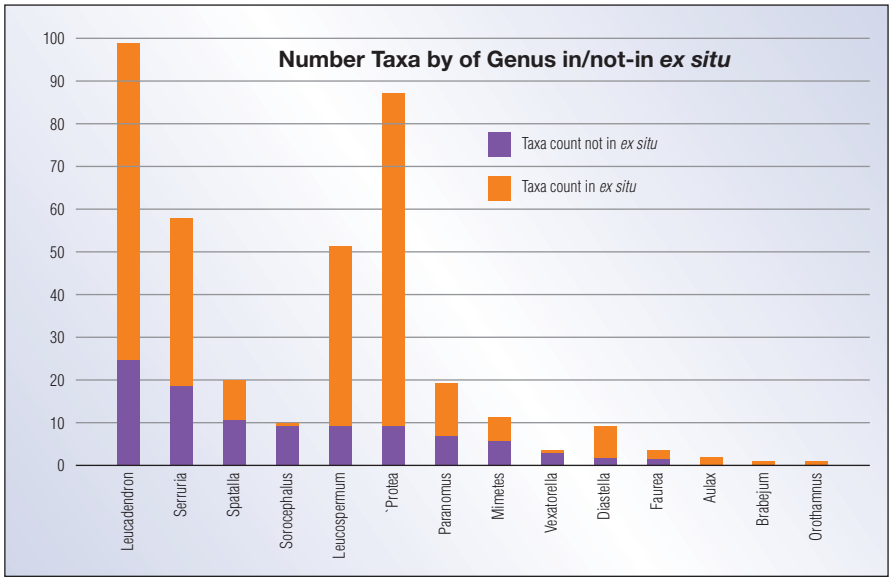
- A local red list for the target plant family, in this case Proteaceae, downloaded from http://redlist.sanbi.org/. BGCI's 'ThreatSearch' data could have been used to equal effect.
- A list of synonyms for names used by the local red list, from 'The Plant List' http://www.theplantlist.org/
- For each taxon in the local red list, including any of its synonyms, a count of institutions holding that taxa in *ex situ* collections was obtained by interrogating BGCI's PlantSearch data.

Initially, analysis of the data found that almost all South African Proteaceae were in cultivation, including species well known to not yet be in cultivation. Further investigation found incorrect data from one institution to be the cause of this anomaly. This issue was swiftly fixed by the garden's curatorial team, allowing more accurate analysis of the data.

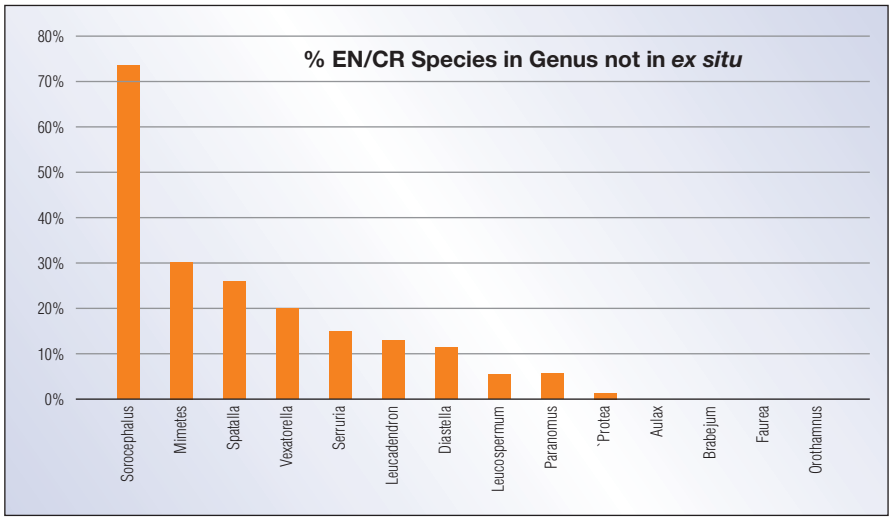
The genus *Sorocephalus* was highlighted as being of highest priority, with over 70% of Endangered and Critically Endangered species not in *ex situ*. For this small genus, just two species out of 11 were, at the time of analysis, being conserved *ex situ*. This is worrying given *Sorocephalus* has 5 species which are Endangered and 4 which are Critically Endangered. These are unassuming plants which are often difficult to find in the field even when they are in flower. They also often grow at high altitude, making them good subjects for our research. *Vexatorella, Mimetes* and *Spatalla* were also prioritised, though to a lesser extent.



Break down by genus showing proportion of the taxa held in ex situ *collections, including both seed banks and living collections at the time of analysis.*



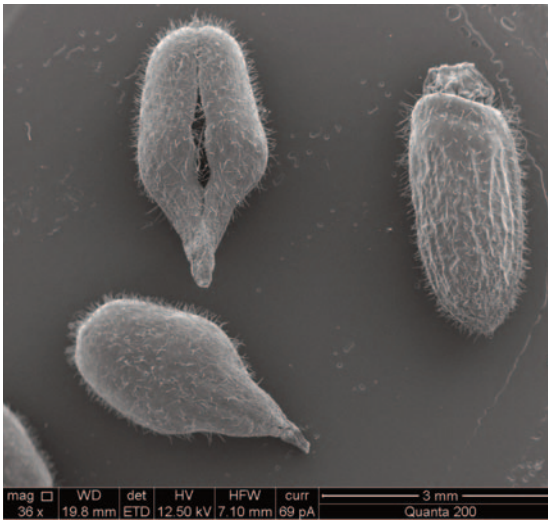
Breakdown by genus using actual number of taxa split by 'In ex situ' (blue) and 'Not in ex situ' (red), ordered by the latter.



Proportion of endangered/critical taxa not in ex situ by genus.

They, along with *Sorocephalus*, suffer inconsistent (almost non-existent) germination *ex situ* and have troubled subsequent cultivation on their own roots (Thomas *et al*., 201). Our work in the creation of cultivation protocols aims to understand and document these mechanisms. *Leucadendron*, the largest South African genus in the family, held the greatest number of species not in *ex situ* collections.

Of the seed collections made in 2015 and 2017, 6 were new to *ex situ* both in and outside of South Africa. In this respect the aims were more than met, however difficult germination of seed is the next hurdle. Populations of *Spatalla nubicola* (VU) were found in 2015 and revisited in 2017 at a time that allowed collection of seed, however germination proved difficult. Collaboration with artist Raji Salan (Salan, 2018; Roughley *et al*., 2019) has enabled further understanding of these germination requirements, leading to this species now forming part of our living collections. A further 4 species of *Spatalla* were collected and 3 have subsequently germinated. *Leucospermum winteri*, a species not previously held *ex situ*, was also collected and has subsequently germinated well. *Leucadendrons* new to *ex situ* and collected in 2017 are *L. singulare* and *L. rourkei*; two species with a small distribution range and fairly high altitudinal range. *Mimetes pauciflorus* was collected in both 2015 and 2017 and while we had some germination initially, plants soon died while still young, so further work is needed there.



ESM image of Spatalla nubicola *seed showing viable and inviable seed.*

Leucospermum winteri.

Stellenbosch University Botanic Gardens has assisted with the importation of material to the UK of several species of *Mimetes, Serruria* and a single species of *Vexatorella* (*V. alpina*). Additionally, some other *Leucadendron* species have also since been brought into cultivation, notably *L. dregei* and *L. radiatum*. Collections have not yet been made of *Sorocephalus* as these would require additional permits and more extensive fieldwork.

Our data and analysis have been shared with The Western Cape Nature Conservation Board (Cape Nature), SANBI and the MSBP to help inform future *ex situ* prioritisation.

Some of the high-altitude growing members of South Africa's Proteaceae are at serious risk from the impacts of climate change. We hope our work supports efforts for their conservation and provides options for their future.

With thanks to Cape Nature, Stellenbosch University Botanic Gardens, the RHS, BGCI, the MSBP, APHA and SANBI.

References

- IUCN/SSC. 2002. Technical Guidelines on the Management of *Ex situ* Populations for Conservation. Gland, Switzerland: IUCN Species Survival Commission. URL https://portals.iucn.org/library/efiles/documents/Rep-2002-017.pdf),
- IUCN/SSC. 2014. Guidelines on the Use of *Ex Situ* Management for Species Conservation. Version 2.0. Gland, Switzerland: IUCN Species Survival Commission.URL https://portals.iucn.org/library/sites/library/files/documents/2014-064.pdf
- Roughley, M., Smith, K and Wilkinson, C. 2019. Investigating new areas of art-science practice-based research with the MA Art in Science programme at Liverpool School of Art and Design. Higher Education Pedagogies. 4. 226-243. DOI 10.1080/23752696.2019.1583072.
- Salan, R. 2018. UNDER THREAT, URL https://rajisalan.wixsite.com/underthreat/seeds-under-threat
- Thomas. R., Duncan. G., Brown. N. and Nurrish. L. 2013. Grow Proteas, A Guide to the Cultivation and Propagation of South African Proteaceae. South African National Biodiversity Institute. ISBN: 978-1-919976-80-8

Robbie Blackhall-Miles FLS
Fossil Plants
Llanberis
Gwynedd
United Kingdom

Authors: Alex Hudson and Ibrahim Mitole

MULANJE CEDAR CONSERVATION AND GSPC TARGET 16

Networks and partnerships have been vital to improving the conservation chances for the Critically Endangered Mulanje Cedar, *Widdringtonia whytei*, Malawi's national tree. The complex social, biological and ecological issues have required cross-sectoral and cross boundary support to share experiences, data and build conservation capacity within Malawi.

Target 16:

Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy

SAVE OUR CEDAR
MALAWI'S NATIONAL TREE

Introduction

Mulanje Cedar is a large tree, growing to 40m tall, once dominant in the evergreen afromontane forests on Mulanje Mountain, its endemic natural home. People have exploited the tree for over a century because of its valuable timber, which is durable and highly resistant to termites, borers and fungi (Chapman, 1994). In recent years, governmental changes to the mountain's management have led to the decimation of remaining populations on Mulanje. Fewer than 10 adult trees are left.

Logging has not been the only challenge for the tree though: the illegal use of fire is altering forest succession; propagation practices were not fully investigated and in widespread use; and natural regeneration was shown to be poor for unknown reasons (Chanyenga *et al*., 2011). At the same time, local communities living around Mount Mulanje are extremely poor and many rely heavily on the mountain resources for their livelihoods, which causes overexploitation.

In Malawi, the Mulanje Mountain Conservation Trust (MMCT) and the Forestry Research Institute of Malawi (FRIM) are leading the conservation work on the tree and Mulanje mountain with support from BGCI and funding from the UK's Darwin Initiative. This partnership has provided access to global networks with plant propagation, restoration and sustainable use experience to start to deal with the multifaceted conservation issues.

Above: Innocent collecting soil sample from around planted Mulanje Cedar on Mulanje mountain. Top: ERA experts, Stuart Hall, Louise Egerton-Warburton and Carole Elliott, in front of Chambe peak, Mount Mulanje.

ERA experts join staff from MMCT, Department of Forestry and FRIM in fieldwork and to plan future restoration trials on Mount Mulanje, September 2019.

Improving propagation practices

The Mulanje Cedar tree is a mast-seeding tree, which means in some years seed production is high whilst in others it is extremely low. With removal of the natural population of adult seed-bearing trees on Mulanje, only two seed sources remain, Zomba and Chikangawa. This means seed availability can be relatively low and so higher propagation rates are key to improving the future survival of the species. From 2016-2019, organisations from across the globe were involved in just that - improving the propagation of Mulanje Cedar.

A fire rages through the vegetation on Mount Mulanje, reaching across the firebreak, maintained by MMCT to try to reduce the damage caused.

The Department of Forestry for Malawi led seed collection trips with FRIM. They sent some seeds to the Bedgebury National Pinetum to carry out germination trials under laboratory conditions in the UK. Bedgebury National Pinetum used their X-ray facilities to investigate insect infection rates of the seed and the results showed that on average 65% of wild collected seeds are viable for propagation.

Forestry Research staff from the UK also supported FRIM to establish new provenance field trials across Malawi. Seeds collected from different populations were propagated and planted at 8 sites, in Mulanje, Blantyre, Zomba, Dedza and Viphya. Associated local data on temperature and monthly rainfall is being recorded to investigate how seedlings performed under the varying environmental conditions seen across sites to start to understand what is important for improving growth. Finally, the team worked together to begin trials for testing propagation methods in the field around Mulanje under local community run nursery conditions. All this research has been combined to produce new horticultural protocols that MMCT and FRIM have used to train community members in nurseries around Mulanje. Using this knowledge, they propagated over 500,000 seedlings that were planted back on Mount Mulanje.

The impacts of soil on regeneration

The impact of soil conditions on Mulanje Cedar growth was also an unknown. In 2017, a fieldwork expedition was held including a soil and microbial ecology expert from Chicago Botanic Garden. She analysed samples from different sites, including those that most recently had populations of wild Mulanje Cedar trees, completing some tests not available in Malawi.

The research showed wild trees have unique arbuscular mycorrhizal fungal communities, the symbiotic fungi that help trees. These were not found in the soils of propagated nursery seedlings or in the planted sites and so this could be impacting on growth. It also showed soils tended to have high soil organic carbon, low pH, and low nitrogen levels and that microbe decomposition and fungal biomass levels were different in recently planted sites, which could represent root degradation.

In September 2019, further fieldwork with FRIM and Chicago Botanic Garden collected more soil samples for analysis, with training provided in the field to a Malawian soil scientist. This continued partnership with the Chicago Botanic Garden, will investigate other soil factors that could be important to Mulanje Cedar restoration.

Chicago Botanic Garden can also support the set-up of an inoculant system in Mulanje to provide the right arbuscular mycorrhiza communities to seedlings as they establish.

Improving restoration practices

The network working to support the conservation of Mulanje Cedar was expanded to investigate ways to improve growth and survival of seedlings planted in the mountain. Members of BGCI's Ecological Restoration Alliance for Botanic Gardens and WeForest, a restoration NGO starting to work in the Mulanje, have become involved as advisors.

Restoration experts from South Africa, Zambia, the United States and Australia have joined the national expertise from the Forestry Department, FRIM, the National Herbarium and Botanic Gardens of Malawi and MMCT. This has provided the team with a much broader understanding and experience of landscape scale restoration in many different contexts. Seed science, forestry, fire adapted ecosystems, rare plant restoration and landscape natural resource management skills have all contributed to this.

The team visited the mountain in September 2019 to get first-hand experience of the ecology and problems before contributing ideas in a workshop to start to design new trials that will investigate how to improve restoration practices on the mountain. The decision made was to test the impacts of local vegetation by planting companion species (trees, shrubs and herbs) with the Mulanje Cedar and the impact of planting fire resistant buffers, monitoring the impacts of shade, soil conditions, and slope positions. These are set to be finalised and planted in December 2020.

Widdringtonia whytei.

Improving the benefits to people

Other short-term benefit options for local communities that could come from the natural resources on Mulanje Mountain are also being investigated. The goal is to identify and manage these sustainably, to take pressure off the remaining natural resources. This again requires a diversity of experience and partnerships.

Firstly, investigations of essential oils from Mulanje Cedar tree are underway. A socio-economic expert in wild plant products provided some initial analysis, engaged with business across Malawi and advised on research needed to understand how the oils change from different areas, parts (e.g. twigs, stumps and leaves) and age classes of trees.

The research has needed expertise from Mzuzu University in Malawi with facilities at Chancellor College, University of Malawi. Both have been engaged to complete phytochemical analysis to understand the essential oil composition from Mulanje Cedar trees collected from Zomba and Mulanje. The results will then be used to build partnerships with businesses that can use the oils in their products (e.g. soaps, pesticides, cleaning products).

To allow management and production by local Mulanje communities to benefit, the project also needs specialist distillation equipment and training. No producers of such equipment exist in Malawi at this time, so a provider, Essential Distillation Equipment, from South Africa has been engaged. They will be able to provide the equipment and to lead training with locals to use it to produce essential oils from not just Mulanje Cedar, but potentially other plants too.

Kazembe nursery group with Mulanje Cedar seedlings ready for planting, Jan. 2018.

Nagoya Protocol workshop in Mulanje.

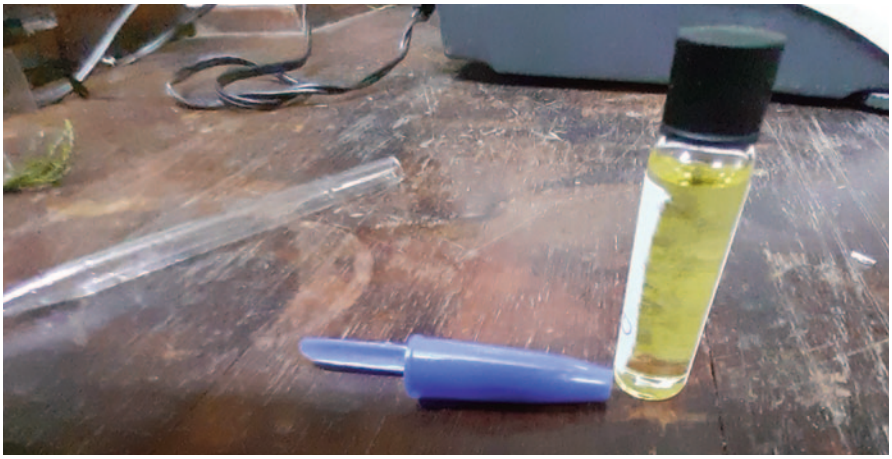
In January 2020, a workshop was run with local public (Malawi Environmental Affairs Department, National Commission of Science and Technology, Department of National Parks and wildlife), civil society (Malawi University of Science and Technology, National Herbarium and Botanic Gardens) and private sector institutes on the considerations of the Nagoya Protocol on managing natural resources in sustainable industries. This included assessment of the Mulanje Cedar using the Convention on International Trade of Endangered Species Non Detrimental Findings process (Rosser & Haywood, 2002). Training was provided by the Director of the Southern Africa Programme at TRAFFIC so that the process can be used by attendees for Mulanje Cedar and other plant species in the future.

Finally, to investigate other options for conservation and sustainable use, in 2020 an ethnobotanist from the UK is working with staff from MMCT and FRIM to engage local communities in groups and household surveys. She will identify other plant resources from the mountain that are important to local communities for foods, medicines, horticultural purposes or other livelihood importance uses.

These partnerships mentioned have all been backed up by Non-Disclosure Agreements to ensure information for any future developments remain in country and within the Mulanje area.

Sharing experiences for the future

For the future, the team have also been investigating ways to share experiences in Afromontane regions throughout southern Africa. Other situations are similar, like the Clanwilliam cedar (*Widdringtonia cedarbergensis*; Mustart *et al*., 1995) and so further shared experiences across borders could be beneficial both ways. BGCI have contacted the Afromontane Research Unit from University of the Free State, South Africa and aims to support the establishment of the first conference for Afromontane conservation, being planned for 2022.



Mulanje Cedar essential oil.

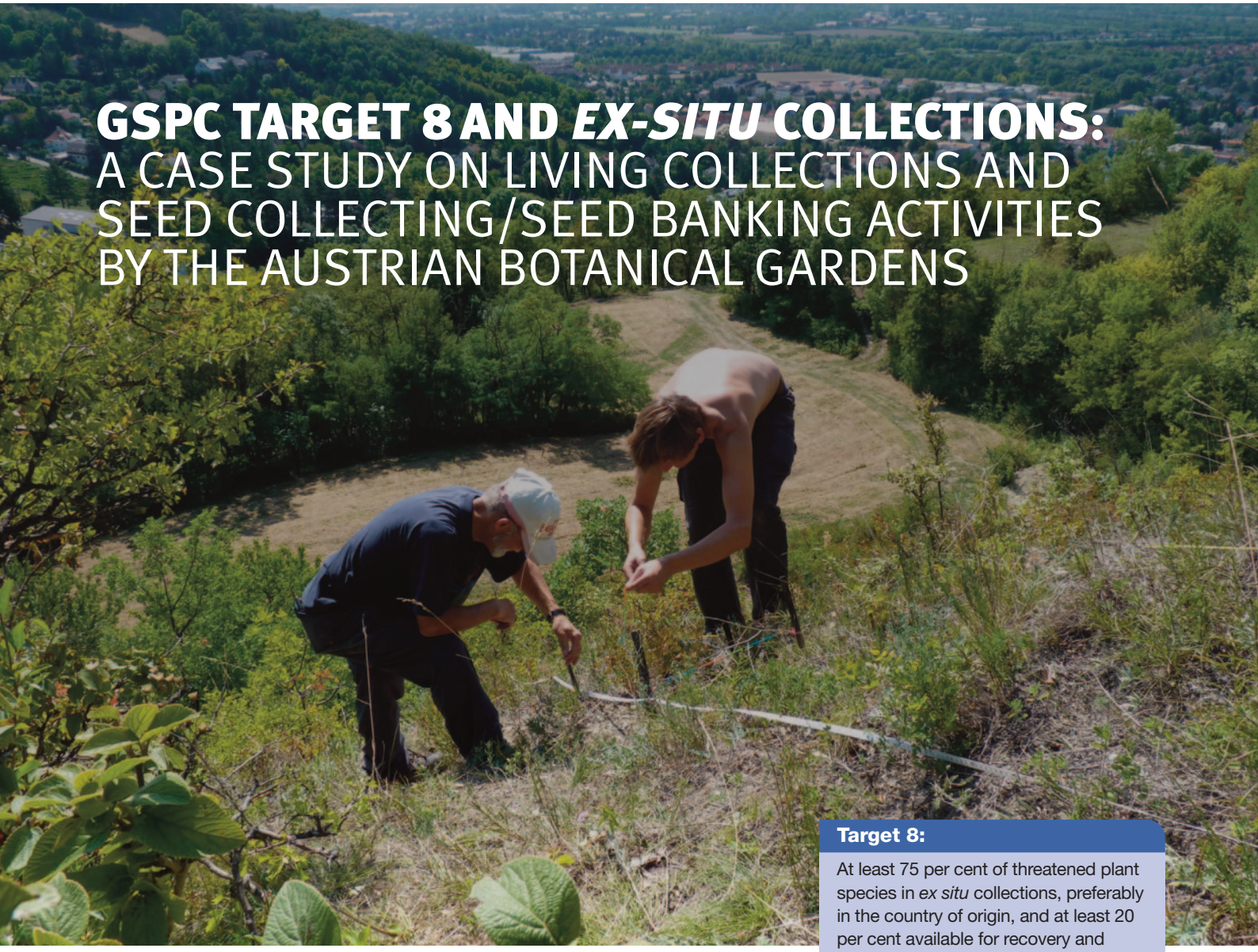
References

- Chapman, J. D. 1994. Notes on Mulanje cedar - Malawi ' s national tree. The Commonwealth Forestry Review, 73(4), 235–242.
- Chanyenga, T. F., Geldenhuys, C. J., & Harvey, J. 2011. Variation in seed rain from Widdringtonia whytei growing in different conditions on Mulanje Mountain in Malawi. Southern Forests, 73(3–4), 123–129. https://doi.org/10.2989/20702620.2011.639484
- Mustart, P., Juritz, J., Makua, C., Van der Merwe, S. W., & Wessels, N. 1995. Restoration of the Clanwilliam cedar Widdringtonia cedarbergensis: The importance of monitoring seedlings planted in the Cederberg, South Africa. Biological Conservation, 72(1), 73–76. https://doi.org/10.1016/0006-3207(94)00066-Y
- Rosser, A. R., & Haywood, M. J. 2002. Guidance for CITES Scientific Authorities: Checklist to assist in making non-detriment findings for Appendix II exports. Gland, Switzerland and Cambridge, UK: IUCN.

Alex Hudson
BGCI
199 Kew Road
Richmond
TW9 3BW
UK

Authors: Stephanie Socher, Christian Berg, Barbara Knickmann and Michael Kiehn

GSPC TARGET 8 AND *EX-SITU* COLLECTIONS: A CASE STUDY ON LIVING COLLECTIONS AND SEED COLLECTING/SEED BANKING ACTIVITIES BY THE AUSTRIAN BOTANICAL GARDENS



Monitoring Artemisia pancicii *after the transfer from the Botanical Garden, University of Vienna, to a natural site. (B. Knickmann)*

Target 8:

At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Introduction

The implementation of GSPC Target 8 triggered a focus on the assessment of current plant holdings in the Austrian Botanical Gardens and the development of strategies for filling gaps towards reaching this target by 2020. The overall aim is the establishment of a long-term *ex situ*/*in situ* actions network amongst the Austrian gardens to exchange knowledge, share projects and establish a platform similar to German and Swiss initiatives. This shall ensure meaningful contributions to the long-term protection of endangered native Austrian species including a coordinated extension of the *ex situ* collections. The present paper describes some relevant activities of the Austrian Botanical Gardens and their results.

Seed collecting/seed banking activities:

Based on a gap analysis of taxa missing or not well represented in current *ex situ* holdings of Austrian Botanical Gardens (Hölbling 2013, Master thesis) taxa were prioritised according to conservation needs (with special focus on endemics and red list species). Herbarium databases were consulted for the distribution of these taxa and their fruiting periods.

Seeds of native Austrian plants stored at the seedbank of the Botanical Garden, Karl-Franzens-Universität Graz. (Christian Berg)

Rare Pannonian dryland plant species displayed at the Botanical Garden, University of Vienna – also used in school education programs. (R. Hromniak)

This helped to optimize the effectiveness of collecting trips. Collecting activities were carried out in a regionally coordinated way by several Austrian Botanical Gardens following the instructions of the ENSCONET Seed Collecting Manual (ENSCONET, 2009). Every seed collection is well documented and accompanied by voucher specimens. Seeds are stored in Austrian seedbanks (especially at the University Graz and the University for Applied Life Sciences Vienna), but also at the Millennium Seed Bank at Wakehurst Place, UK. The collaboration with the MSB has been very fruitful, as it also filled gaps in the MSB holdings: since 2012, seeds of more than 400 species collected by the staff of the Botanical Garden of the University of Vienna have been stored at the MSB, about 180 species of which are listed in the Austrian Red Lists (Knickmann, 2019). The Austrian seedbank data have been incorporated In a recent analysis of the status of Target 8 in Europe (Rivière *et al*., 2018). Based on the gaps indicated there and the collections carried out in 2019 and 2020, Target 8 is likely to be met by in Austria by the end of 2020.

Living collections:

In autumn 2019 a questionnaire among all Austrian Botanical Gardens on currently ongoing *ex situ* projects revealed that each garden holds an impressive stock of native Austrian plants. While most of these *ex situ* holdings are long-time cultures with no initial aim to transplant them back into natural habitats, many of them are at least potentially valuable for conservation purposes. Plants are either cultivated in pots, mostly in non-public areas, or are planted in near natural habitats which are freely accessible to the public. Numbers range from a few plants to more than 100 plants per species. Experiences in the cultivation of rare and endangered taxa are documented and used to understand biological characteristics, such as viability, germination pattern, or seedling establishment.

Use of *ex situ* material for *in situ* conservation:

Several Austrian gardens are running temporarily limited projects aiming to re-establish or refresh populations of rare or endangered species in the wild, partly supported by NGOs or governmental organisations. Many of these *in situ* activities are also the subject of regular monitoring. As an example, the BG Graz started a project in 2017 with the target species *Prunella laciniata, Cirsium pannonicum*, and *Hypochaeris maculata*, in collaboration with the Naturschutzbund Steiermark. After successful cultivation at the garden, planting out into carefully chosen natural habitats took place twice so far. Newly created clusters harbour between 18 and 36 plants with a distance of 1m between individual plants. According to the needs and local situations new sites are managed before (e.g., mowing) and after (e.g., watering in summer) the planting out for some time.

Creation of new clusters of rare Styrian plant species in the wild by the Botanical Garden, Karl-Franzens-Universität Graz. (Christian Berg)

References

- ENSCONET. 2009.: ENSCONET Seed Collecting Manual for Wild Species. https://www.luomus.fi/sites/default/files/files/collecting_protocol_english.pdf.
- Hölbling, M. 2013. Die “Global Strategy for Plant Conservation” in Österreich. Master Thesis, University of Vienna. http://othes.univie.ac.at/30444/
- Knickmann, B. 2019. Seed collecting experiences to fulfil Target 8 of the Global Strategy for Plant Conservation. BGJournal 16 (2), 39-41.
- Rivière, S., Breman, E., Kiehn, M., Carta, A. & Müller J. V. 2018. How to meet the 2020 GSPC Target 8 in Europe: priority-setting for seed banking of native threatened plants. Biodiversity and Conservation 27, 1873–1890.

Michael Kiehn (corresponding author);
Barbara Knickmann
University Vienna, Core Facility
Botanical Garden
Rennweg 14,
1030 Wien
Austria

Stephanie Socher
University Salzburg, Botanical Garden
Hellbrunnerstrasse 34
5020 Salzburg.

Christian Berg
Karl-Franzens-Universität Graz
Botanical Garden
Holteigasse 6
8010 Graz.

Authors: Vince Zsigmond, Mária Höhn and László Papp

GSPC TARGET 8 AND *EX-SITU* COLLECTIONS: CASE STUDY: THE MOST IMPORTANT RESULTS OF *EX SITU* PLANT CONSERVATION OF NATIVE TAXA IN HUNGARY IN THE PERIOD 2011-2020

Pulsatilla flavescens *(syn.* P. hungarica*), protected steppe species of the Pannonian flora involved in a long-term* ex situ *conservation process. (László Papp)*

Target 8:

At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

In 2012 and in 2020, the Hungarian Association of Arboreta and Botanic Gardens (HAABG) implemented surveys on the *ex situ* activities in member institutes, with a particular focus on the conservation of endangered/protected[1] vascular plant taxa. Based on data supplied by more than 30 member gardens, one of the most important improvements is that the number of conserved taxa in botanic gardens has been increased by more than 50 per cent in Hungary over the last decade. This is due to several projects for *ex situ* conservation that have been co-financed by the EC and the Hungarian Government. By these efforts, the Hungarian botanic garden community, with 77.9 per cent of endangered plants in *ex situ* conservation, has overstepped the actual Target 8 of GSPC at the national level. (Fig.1).

A summary of *ex situ* plant conservation activities and the results of the survey with lists of taxa was published in 2012 in: 'Ex situ *plant conservation – BGs for saving Plant Kingdom*' by HAABG. The Association has supported not only *ex situ* activities in botanic gardens, but also nature conservation in a much wider sphere as well. Preparation of the 2nd edition is now under way and is going to be published in 2020.

[1]As Hungarian experts revise the list of endangered species from time to time, the Hungarian Government regularly modifies (index or cancel) the list of native protected species as a statute. It means, that protected species by law have been synchronized with endangered species.

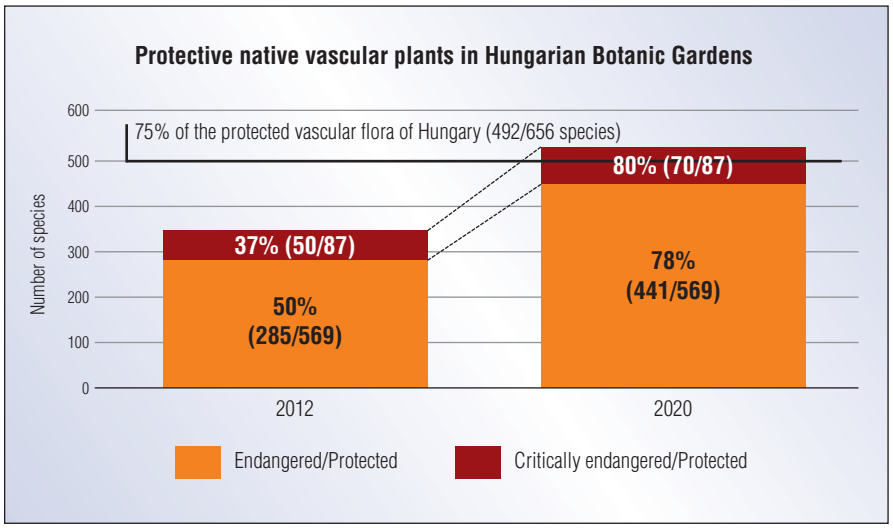


Fig.1. Number of protected plant species maintained in BGs of Hungary in years 2012 and 2020. 75% is the objective in Target 8 of GSPC.

Important successful projects

The Pannonian Seed Bank

'Establishment of the Pannonian Seed Bank for the long-term ex situ *conservation of Hungarian vascular wild plants'* co-financed by the EC and by the Hungarian Government in the frame of a LIFE+ programme aimed to ensure the long-term seed conservation of native vascular flora of the Pannonian Biogeographical Region (PBR).

The whole procedure of collecting seed samples was carried out in compliance with the Collection Strategy and the Seed Collecting Methodology developed under the project. The task was managed by the **National Botanic Garden Vácrátót (NBGV)**, as the Department of Institute of Ecology and Botany, which manages the richest gene bank of living plant individuals of wild origin in Hungary.

As a result of the systematic collecting work, 1,853 seed samples of 910 native taxa, including 204 protected and 45 strictly protected taxa by Hungarian law were collected with precise documentation. Thanks to the project

- around 38% of Hungarian native vascular flora,
- more than 60% of strictly protected taxa,
- and more than 40% of protected taxa

had been conserved by at least one accession by the end of the project.

Although the project officially finished at the end of 2014, data processing, collecting, manipulating and storing of limited accessions are continuing.

Botanical Garden of Szeged University

In cooperation with the Kiskunság National Park in the Botanical Garden of Szeged University, *in situ* field studies were initiated on the highly protected rare species, *Astragalus dasyanthus*, a species of open and closed sandy grasslands in Hungary. In addition, an *ex situ* collection was established in the garden. In the frame of a Life-Nature project, declining natural populations of *Dianthus diutinus*, a highly threatened endemic species of sandy grasslands, were strengthened and stabilized by *ex situ* conservation methods. Altogether 124 individuals were successfully reintroduced from *Astragalus dasyanthus* to three native locations, of which one, considered to be vulnerable, is further maintained actively, providing restoration support for the reintroduced individuals. In the case of *Dianthus diutinus*, over four years more than 6,558 individuals were reintroduced to three native locations and live populations were actively sustained and monitored during the following years.

Soroksár Botanical Garden

Ex situ and *in situ* comparative studies were initiated by the Soroksár Botanical Garden of Szent István University starting from 2015. Three protected species of the Pannonian flora were involved in the studies: (1) *Plantago maxima* a species of the Eurasian steppes having its easternmost distribution edge in Hungary and represented by highly fragmented populations; (2) *Dianthus serotinus*, an endemic species of the inland sandy dunes and; (3) *Linum flavum*, a loess indicator steppe species.

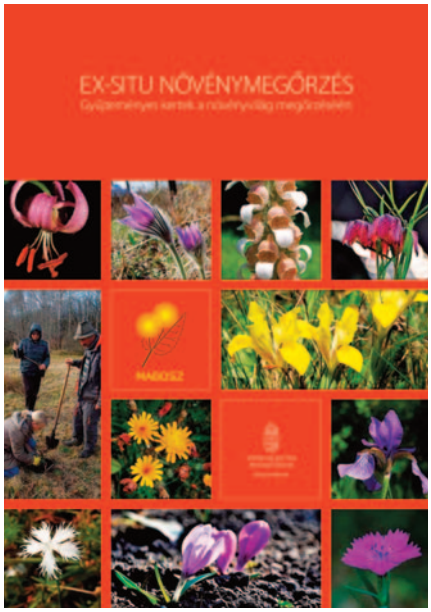
Astragalus dasyanthus, *protected steppe species of the Pannonian flora involved in a long-term* ex situ *conservation process. (László Papp Jr.)*

Outplanting of seedlings in the target area. (Botanical Garden of Szeged)

The last two species were first introduced into the garden in the late 1970s (historical *ex situ*) and with the newly outplanted individuals the stands seem to have been stabilized by a reinforced gene stock.

Botanic Garden of Eötvös Loránd University

In the 250-year long history of the Botanic Garden of Eötvös Loránd University, many endangered plants have been introduced and maintained by professional conservation activities. As result of *ex situ* actions, populations of 31 species are ready to be reintroduced to their natural habitats. In collaboration with the Pilis Park State Forestry and Őrségi National Park, 24 species (e.g. *Potentilla palustris, Eriophorum angustifolium, Drosera rotundifolia, Crepis pannonica*) have already been planted for acclimatization in controlled gardens in the vicinity of the target habitats, having the same mesoclimate, (multistage reintroduction), and the first individuals have already been planted out to strengthen two native populations.



Front page of 'Ex situ plant conservation – BGs for saving Plant Kingdom' *published by HAABG in 2012.*

Botanical Garden of University of Debrecen

The Botanical Garden of University of Debrecen has accomplished the reintroduction of several endangered plant species native to the eastern part of Hungary. Natural habitats were reconstructed in the botanical garden (e.g. open and closed lowland steppe oak forests) where 20,000 *ex situ* individuals were multiplied. Up to now, more than 6,000 individuals of 30 protected species e.g. *Pulsatilla flavescens* (syn. *P. hungarica*), *Onosma arenaria, Iris aphylla* subsp. *hungarica* have been planted out.

Conclusions

Botanic Gardens in Hungary have realized important efforts in ex situ conservation of endangered native plant taxa in consideration of updated targets of GSPC for the period 2011-2020.
As a result of relevant *ex situ* projects implemented in the last 10 years, the rate of protected taxa of Hungarian vascular flora conserved in Hungarian botanic gardens has been increased significantly and objective of Target 8 has been achieved on a national level.

Accessions of the Pannonian Seed Bank Project in cold storage of National Botanic Garden Vácrátót / Institute of Ecology and Botany / Research Centre for Ecological Research (Vince Zsigmond)

Zsigmond Vince
National Botanic Garden Vácrátót
Institute of Ecology and Botany, Centre for Ecological Research / Hungarian Association of Arboreta & Botanic Gardens
H-2163 Vácrátót
Alkotmány u. 2-4
Hungary

Maria Höhn
Soroksár Botanic Garden of Szent István University
H-1238, Budapest
Thúry István út 2
Hungary

László Papp
Eötvös Loránd University Botanic Garden
H-1083 Budapest
Illés u. 25
Hungary

The ConservePlants working group leaders and action chair: Filippos A. Aravanopoulos, Sílvia Castro, Andreas Ensslin, Živa Fišer, Peter Glasnović, Sandrine Godefroid, Jasmin Joshi, Michael Kiehn, Marcin Klisz, Boštjan Surina, Justyna Wiland-Szymańska.

CONSERVEPLANTS – A NEWLY ESTABLISHED NETWORK FOR THE CONSERVATION OF EUROPEAN THREATENED PLANTS

A REGIONAL CONTRIBUTION TO GSPC IMPLEMENTATION

ConservePlants MC and working group meeting in Průhonice, Czech Republic in February 2020. (Martin Senič)

Target 2:

An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action

Target 3:

Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared

Target 4:

At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration

Target 5:

At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.

Target 8:

At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes

Target 9:

70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge

Target 14:

The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes

Target 15:

The number of trained people working with appropriate facilities sufficient according to national needs, to achieve the targets of this Strategy

Target 16:

Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy

Pannonian drylands as important habitat of threatened plants, displayed in the Botanic Garden of Vienna, Austria. (Rudolf Hromniak)

Despite the high goals set by conservationists to protect the native European flora, conservation initiatives for threatened species in Europe have not yielded the desired results. One of the major challenges is the large difference between regions and countries within regions in terms of financial resources, equipment and technical knowledge available for plant conservation.

To overcome this obstacle, a set of motivated researchers and conservationists developed a framework to gather information, share and discuss ideas and obstacles, and train experts to promote plant conservation across the European continent. This is how the COST Action network "ConservePlants" (COST Action) was born.

Already embracing 38 countries in Europe and beyond, the network is still growing, providing tools and funds to connect and support conservation practitioners, scientists, and other stakeholders. More specifically, ConservePlants is organising meetings, workshops, conference sessions, training schools, short research visits, and dissemination events.
By concentrating on the gathering, synthesis and dissemination of knowledge and information as well as on connecting and training staff amongst countries, ConservePlants is essentially implementing GSPC targets 3, 14, 15 and 16.
The network is structured into five thematic working groups, which develop programmes to tackle specific challenges in plant conservation related to the various targets of the GSPC:

WG1: Improving knowledge in plant species biology for appropriate *in situ* conservation. Plant conservation actions crucially depend on in-depth knowledge of the biology, ecology and population dynamics of the target species; however, this information is often not available for local conservation interventions. In this WG, we aim to collect relevant information for the *in situ* conservation of European threatened plants and to make this information publicly available to improve the knowledge transfer to conservation practitioners. In collaboration with WG2 and WG4, we will moreover evaluate the efforts and success of conservation actions across Europe and identify successful strategies and geographic areas in need for further support. With this, we strongly contribute to Target 7 of the GSPC, which aims to an effective *in situ* conservation of threatened species.

The compiled data will also be used to evaluate the value of biological traits and key 'mutualist' or 'antagonist' interactions as well as the role of global change drivers or biological invasions. By this, we will provide guidelines for a wider use of these data in practical conservation, thus contributing to Targets 2, 3, 4 of the GSPC.

WG2: Sharing knowledge and experience in *ex situ* plant conservation. *Ex situ* conservation is at some point indispensable for preventing extinction of many plant species, but progress is hampered by a) insufficient awareness of the potential of *ex situ* conservation practices by stakeholders, b) unclear quality and coverage of *ex situ* collections c) lack of synthesized, up-to-date protocols and d) lack of understanding of the cornerstones of reintroduction success. In this working group, we focus on fostering the network, knowledge accumulation, dissemination and implementation of *ex situ* conservation practices such as seed banking and cryopreservation, plant conservation translocations and an integrated approach of *ex situ* and *in situ* conservation techniques.
More specifically, we will analyse the added value of the *ex situ* approach in *in situ* conservation, gather information on the coverage and utilization of *ex situ* seed bank collections, and review the potential and implementation of conservation translocation strategies such as reintroductions, reinforcements, and assisted migrations. By this, we are contributing to the fulfilment of the targets 3, 8 and 9 of the GSPC.

Conservation translocations are key instruments of threatened species recovery. An example of a reintroduction of the rare Prunella laciniata *in the Swiss Jura mountains. (Sarah Bürli)*

WG3: Filling the gaps in plant conservation. A major gap in plant conservation is the still existing lack of data on the conservation status of European plant species, especially in biodiversity hotspots as the Balkan Peninsula. An additional problem, notably for conservation actions across national borders, is the inconsistency between Red List criteria and evaluation protocols in different countries. A brief review of the IUCN assessment reveals a geographical inequality, largely neglecting species-rich Southeast Europe.

Also, large differences exist between regions and countries in terms of financial resources, human expertise, or funding programs for conservation measures *in situ* and *ex situ*. Based on an in-depth data collection and evaluation of the status-quo, this working group will help to harmonize conservation status, evaluation procedures, and protocols across countries and identify inconsistencies and gaps in protection of species. With this information, we will develop tools for capacity building and coherent strategies in plant conservation across Europe. These activities are a contribution to Target 2, but also Target 3 and 5 of the GSPC.

WG4: Human dimension in plant conservation. Raising the awareness of the precarious situation of endangered plants as well as their usefulness for human well being is a central strategy in outreach targeted projects (see e.g. BigPicnic by BGCI) and is also well rooted in the GSPC in Target 14. WG4 strives to collect and disseminate information about best practices in raising awareness of plant conservation amongst the public. To do so, we are compiling scientific evidence on the economic value of endangered plant species and their role in supporting local livelihoods in Europe, but also on the actual effects on their conservation status. By including a list of possible funding bodies and donors, we hope to activate private and institutional practitioners to promote sustainable strategies in species conservation. We also aim to promote citizen science by evaluating initiatives in their success in reaching the general public and in supporting specific conservation aims. The communication of the beauty, ecology and importance of rare and endangered plants to a general public is very much connected with the mission and vision of botanic gardens. The results of our work may hence be of great importance for the botanic garden community.

Pollinators as key mutualists for threatened plants. An example of scientific work on the pollination of the endangered Dracocephalum austriacum. *(Sílvia Castro)*

WG5: Genomic approaches in plant conservation. Genomic approaches are an increasingly utilized tool in informing and refining species conservation strategies and conservation practice (Hoban *et al*., 2018). They are also central to the goal of conserving all relevant genetic diversity *in situ* and *ex situ*, as formulated in Targets 5 and 8 of the GSPC. To serve these goals, WG5 reviews approaches such as gene conservation unit selection, assisted migration and translocation by evaluating the contribution of genomics to their application and effectiveness. For instance, the sampling of a genetically representative amount of seeds is decisive for the establishment of *ex situ* collections and strongly depends on the genetic structure across populations. But also for *in situ* species conservation, state of the art technologies in mining plant genomes can harness conservation efforts by translating genomic particularities into practical plant conservation programmes. A particular focus will be on the relationship between the number of samples and genetic diversity as well as on the effectiveness of different sampling designs in capturing rare or site specific alleles.

ConservePlants is an open network, where any country, institution or person can take part (see COST rules). If you are interested in joining our network, please contact the authors or go to our website www.conserveplants.eu.

References

- BGCI: https://www.bgci.org/our-work/projects-and-case-studies/bigpicnic/
- COST Action: https://www.cost.eu/cost-actions/what-are-cost-actions/
- Hoban, S., Kallow, S. and Trivedi, C. 2018. Implementing a new approach to effective conservation of genetic diversity, with ash (*Fraxinus excelsior*) in the UK as a case study. Biol. Cons. 225: 10-21.

Andreas Ensslin
(Corresponding author)
Conservatoire et Jardin botaniques
de la Ville de Genève
ch. de l'Impératrice 1 / CP 71
1292 Chambésy/Genève
Switzerland

BENEFITS OF BGCI MEMBERSHIP

Botanic Gardens Conservation International (BGCI) is a membership organisation, representing botanic gardens in more than 100 countries around the world.

MEMBERSHIP BENEFITS INCLUDE

By joining BGCI you will be part of the largest network of botanic gardens in conservation, and have access to a range of dedicated services:

- Grants through the Global Botanic Garden Fund
- The Botanic Garden Accreditation Scheme
- Botanic Garden technical support and advisory services
- Discounted Congress attendance (BGCI Global and Education Congresses)
- BGCI's electronic publications, including BGjournal (conservation) and Roots (education)
- Access to an exclusive Members' Area Website and extra features to our global database resources: PlantSearch, ThreatSearch and GlobalTreeSearch.
- Use of the new BGCI website to promote your events, news, and job listings
- Permission to use BGCI's logo and name
- A membership pack and Certificate of Membership
- Subsidized training courses
- Prizes and awards

To join as an institutional member visit: www.bgci.org/membership/become-a-member

New members that join today get membership through the end of 2020!

2019 Membership Categories

Category		GBP	USD	EUR
F	Institution Member (budget below USD 100,000)	£ 125	$ 150	€ 135
E	Institution Member (budget USD 100,000 - 750,000)	£ 270	$ 350	€ 325
D	Institution Member (budget USD 750,000 - 1,500,000)	£ 500	$ 650	€ 575
C	Institution Member (budget USD 1,500,000 - 2,250,000)	£ 675	$ 900	€ 800
B	Institution Member (budget more than USD 2,250,000)	£ 1,250	$ 1,500	€ 1,375
Patron	Patron Garden Institutional Membership	£ 6,000	$ 7,750	€ 6,750

BOTANIC GARDENS CONSERVATION INTERNATIONAL

Descanso House, 199 Kew Road,
Richmond, Surrey, TW9 3BW, U.K.

Tel: +44 (0)20 8332 5953
E-mail: info@bgci.org
Internet: www.bgci.org
https://twitter.com/bgci

ISSN 1811-8712

INFLUENCE & ACTION

Botanic Gardens as Agents of Change

7th Global Botanic Gardens Congress

27 September – 1 October 2021
Melbourne
Australia

Influence and Action: Botanic Gardens as Agents of Change will explore how botanic gardens can play a greater role in shaping our future. With accelerated loss of biodiversity across the globe, increased urbanisation, population growth and climate change, our need to work together to find new solutions for the future has never been greater.

Hosted in the glorious city of Melbourne, Australia, the 7th Global Botanic Gardens Congress (7GBGC) will run from 27 September – 1 October 2021.

Explore our most liveable city and Royal Botanic Gardens Victoria's stunning and contrasting landmark gardens at Melbourne and Cranbourne. Together we will celebrate Royal Botanic Gardens Victoria's 175th anniversary at this important international gathering.

Join inspiring speakers, fascinating workshops, panel discussions, and symposia, in addition to a specially curated evening cultural program focusing closely on Australian aboriginal culture and the vibrant contemporary creative and food scenes for which Melbourne is globally renowned.

With a focus on influencing the future, for the first time in the history of the Congress, 7GBGC will deliver a Youth Program for future Gardens' leaders aged 18-24 – young people actively involved in horticulture, ecology, environmental and conservation science, and land management.

ROYAL BOTANIC GARDENS VICTORIA

VICTORIA State Government

bganz

BOTANIC GARDENS CONSERVATION INTERNATIONAL

BGCI 7th Global Botanic Gardens Congress

Register your interest at 7GBGC.ORG