

Journal of Botanic Gardens Conservation International

BGjournal

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Conservation horticulture: Making a garden a botanic garden

Features in this issue:

- Talking plants: an interview with a plant conservation champion
- Plant hunting tales from Fiji
- Featured garden: focus on Geneva

30
YEARS
1987-2017



BGCI

Plants for the Planet

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Cover Photo: Nursery with seedlings for reforestation of the Atlantic Forest, in Rosario do Limeira, Brazil (Alf Ribeiro / Shutterstock.com)

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EDITORIAL: CONSERVATION HORTICULTURE: MAKING A GARDEN A BOTANIC GARDEN



In a recent analysis carried out by the Cambridge University Botanic Garden and BGCi we show that the world's botanic gardens conserve and manage 93% of

vascular plant families, 56% of genera and 30% of species in their living collections and seed banks. These are minimum figures as they are based on BGCi's PlantSearch database which only includes accession names from around a third of the world's botanic gardens. These statistics show unequivocally that our professional community grows a wider range of plant diversity than any other sector. It is also testament to the skills and knowledge of our horticulturists, many of whom are specialists in growing specific taxa. Such skills will become increasingly important as humanity struggles to meet the needs of an increasing human population and as we destroy more and more of the terrestrial landscape. It is surely inevitable that restoration of degraded landscapes, creation of novel species assemblages, and bringing new species into cultivation will become ever more important in meeting human needs in the future. Put simply, our ability to grow a wide range of plant diversity enables human innovation, adaptation and resilience.

However, despite the fact that these unique skills are found in botanic gardens, BGCi's recent Technical Review on 'Defining the botanic garden, and how to measure performance and success' (<http://bgci.org/news-and-events/news/1418/>) suggests that few institutions define themselves by their horticultural knowledge or collections. Nor do gardens measure these specialisms at the institutional level. In the Review BGCi strongly recommends that botanic gardens make much more of their unique skills and ability to grow plants that nobody else can. The Review also finds that horticulturists are poorly paid

compared to managers, scientists and educators in botanic gardens, all of which suggests that the recognition due to horticulturists is still lacking. If we don't recognise and reward these business-critical skills ourselves, how can we then expect policymakers and funders to do so, and how can we persuade our supporters that botanic gardens are especially important to the future of humanity?

Of course, not all gardens carry out exemplary, innovative horticulture. Many gardens buy in ornamentals and don't focus at all on the broader taxonomic array of plants. BGCi argues strongly that if botanic gardens want to differentiate themselves from public parks, then specialist horticultural skills, diverse and interesting collections and rigorous professional standards related to documentation and collections management are prerequisites.

Conservation horticulture, which this edition of BGjournal celebrates, is perhaps one way in which specialist horticulturists can raise their own professional standards, be appropriately paid and achieve a higher profile. On pages 14-17, we learn about the differences and specific challenges of conservation horticulture as compared to amenity horticulture and understand how these differences have impacted on the development of horticulture over more than two centuries at the Royal Botanic Gardens, Edinburgh (pages 18-23). Edinburgh was one of the first botanic gardens to computerise its living collections records and to make the link between its horticultural collections and scientific research. From the 1980s onwards, the importance of living collections to plant conservation was increasingly recognised, and the development of the *International Agenda* and the *Global Strategy for Plant Conservation* have since helped to shape Collections Policy at the garden.

This trajectory will be familiar to many gardens, and it has helped to drive the

professionalization of acquisition, documentation, management and use of living collections. Today, specialist horticulturists are saving an ever increasing roster of threatened species all over the world (pages 34-39) as *in situ* conservation approaches struggle to save plants in fragmented and transformed landscapes. As botanic gardens step into this void, we are increasingly seeing botanic gardens go outside their walls, engaging with *in situ* conservationists and other land managers to carry out integrated conservation work. For example, Auckland Botanic Garden describes its integrated approach to conservation horticulture which comprises a native species garden with 17 replica habitats for public outreach, a seed conservation programme with the Millennium Seed Bank and seed orchards used to bulk up seed collections for long term storage and for species recovery (pages 24-27).

Understanding the importance of nurturing the specialist skills required to grow a wider range of plant species, the South African National Biodiversity Institute has instigated a specialist horticulture career ladder that values and recognises specific knowledge and skill sets that horticulturists can aspire to (pages 40-44). Finally, even our plant hunting tale is focused on the progenitors of horticulturally important cultivars, taking us to Fiji in pursuit of *Hibiscus rosa-sinensis* (pages 8-9).

If you enjoy reading BGjournal, or you have comments you would like to make, I would like to encourage you to email us at info@bgci.org. We would like to introduce a 'Letters' page to BGjournal, so your contributions would be welcome. We would also like to hear from you with suggestions about future editions of BGjournal, features you would like to see, and how we can make this publication more relevant to you.

Dr Paul Smith
BGCi Secretary General



FEATURES

NEWS FROM BGCI

**INTERVIEW:
TALKING PLANTS**

**PLANT HUNTING TALES:
RARE RUBY REVEALED – A NEW
SPECIES OF ENDEMIC HIBISCUS
IN FIJI**

**FEATURED GARDEN:
THE CONSERVATORY AND
BOTANICAL GARDEN OF THE
CITY OF GENEVA, SWITZERLAND**

NEWS FROM BGCI

BGCI CELEBRATES 30TH ANNIVERSARY

BGCI was first established in 1987 and our influence has grown considerably over the past 30 years. To mark our anniversary, we have produced a video highlighting the progress we have made, working to save threatened plants and linking botanic gardens worldwide. Watch the video here: <https://www.youtube.com/watch?v=mqxAi8zb8ls&feature=youtu.be>.



Coline Amos



Mélanie Zogheb



Case studies presented by participants demonstrated the impressive achievements of botanic gardens around the world. They showed how botanic gardens can be leaders in their communities in social and environmental issues; how they can showcase sustainability solutions; how they can bridge the gap between science and society; how they can engage people with nature; how they can influence policy and how they can really make a difference in conserving and restoring species and ecosystems. Abstracts of presentations and key conclusions of the Congress are available on the BGCI website, together with videos of all plenary sessions: <http://bgci.org/news-and-events/6gbgc>.

6TH GLOBAL BOTANIC GARDENS CONGRESS

6GBGC was hosted by the Conservatory and Botanical Garden of the City of Geneva (CJBG), Switzerland, from the 26th-30th June. The Congress, which had the theme '*Botanic gardens in society: visions for the future*', attracted over 550 participants from 65 countries. As well as a varied and stimulating scientific programme, participants enjoyed a range of social activities, including a gala dinner that celebrated the 200th anniversary of CJBG and the 30th anniversary of BGCI.

All aspects of the work of botanic gardens were discussed during the week, through a mix of plenary speeches, oral presentations (over 200 were delivered), round table and panel discussions, workshops and posters.

One of the key themes that emerged from the Congress was the importance of partnerships. Time and again, presentations highlighted how partnerships are key to ensuring success - be it in conserving threatened species, restoring damaged ecosystems or engaging with the public. Botanic gardens are involved in partnerships at all levels, from local community-level networks to large international initiatives, working through such partnerships with organisations across sectors and across continents.

Plenary speakers discussed the importance of botanic gardens in engaging with and addressing major societal issues – such as food security, climate change, sustainability and biodiversity conservation – and by doing this contributing to the achievement of the Sustainable Development Goals.



Coline Amos



TREE TUESDAY

Tuesday 27 June was designated 'Tree Tuesday' at the Congress. Sponsored by The Morton Arboretum and organised by the Global Trees Campaign, the day was dedicated to highlighting the latest developments towards ensuring zero tree extinctions. Sessions focused on the importance of trees to humankind, tools that are available to support tree conservation, the opportunities and challenges for botanic gardens in conserving tree species and progress towards the Global Tree Assessment.

Read more about Tree Tuesday here: <http://globaltrees.org/news-blog/getting-threatened-trees-trending/>.

NEW STAFF AT BGCI

BGCI is delighted to welcome Paola Andreoni as our new Head of Membership. After 15 years helping organisations with structuring content and sharing knowledge, Paola decided to take her passion for plants forward and train in horticulture. Following an internship at RBG Kew and a trainee position at the RHS School of Horticulture, Paola became Deputy Head Gardener for a private organic estate. Paola has joined BGCI to lead the strategic development of the membership programme and coordinate communications with members.

RECOGNISING SUCCESS

Marsh Awards

The Marsh Awards are awarded annually by the Marsh Christian Trust, in partnership with BGCI, in recognition of excellence in International Plant Conservation and Botanic Garden Education. The awards for 2017 were announced at 6GBGC.



Kunle Olasupo (D. Bown)



Kunle Olasupo, Field Supervisor in the Forest Unit at the International Institute for Tropical Agriculture, Nigeria won the award for International Plant Conservation. His skills and commitment have been crucial in the development of Nigeria's first arboretum for *ex situ* conservation of threatened trees, and he plays a key role in guidance and capacity building for staff, conservation partners, teachers, students and postgraduates.

The award for Botanic Garden Education was won by **Amy Padolf**, Director of Education at the Fairchild Tropical Botanical Garden, USA. Amy oversees national and international multidisciplinary environmental science education



*Top: Amy Padolf receiving the Marsh Award
Above: The Million Orchid Project STEMLab
(Amy Padolf)*



programmes for pre-kindergarten through to post graduate studies as well as teacher professional development, adult education and community gardening. A notable success for Amy is the project 'Growing Beyond Earth', which will help expand ongoing NASA research into a citizen science program for students that includes experimental design and data collection and analysis, with a special emphasis on scientific communication.

For further information see: <http://www.bgci.org/news-and-events/news/1420/>

Seed conservation awards

The first set of awards under the Global Seed Conservation Challenge (GSCC) were presented at 6GBGC. These awards recognise excellence in seed banking with winners identified in 5 different categories:

- **Greatest progress in seed banking** was awarded to the **Australian PlantBank** at the Royal Botanic Gardens, Mount Annan. The seed bank has been open for 4 years and currently stores more than 50 per cent of New South Wales' threatened flora as seed.

- The award for **conserving the greatest proportion of threatened species in their collection** went to **Bok Tower Gardens**, which maintains a National Collection of endangered plants and seeds from central and northern Florida.
- The **Oman Botanic Garden** was awarded the prize for **conserving the most useful species**, based on its work with the species *Aloe dhufarensis*, one of the most important and versatile medicinal plants in Dhofar, southern Oman.
- The **Conservatory and Botanical Garden of the City of Geneva** won the award for **conserving the most difficult species to collect**. The Garden has developed a system to collect and conserve *Typha minima*, a species with very short-lived seeds using a drying cabinet in the field to dry seeds immediately after harvest.
- The award for **conserving the most threatened species** went to the **Harold L. Lyon Arboretum** in Hawaii for the conservation and reintroduction of *Silene perlmantii*, a species that is thought to be extinct in the wild.

Further information about the GSCC awards is available at: www.bgci.org/plant-conservation/seedawards

HOW MANY TREE SPECIES ARE THERE IN THE WORLD?



BGCI has been working for over two years, consulting over 500 published sources and liaising with experts all over the world to find the answer – 60,065 tree species.

'GlobalTreeSearch' is the first list of its kind, documenting all of the world's known tree species and their country level distributions. With over 375,500 records, the database also reveals that more than half of all tree species occur in a single country, and many of these species are threatened with extinction.

Of all the countries in the world, Brazil has the most tree species, with 8,715 species, followed by Colombia (5,776) and then Indonesia (5,142). Apart from the Arctic and the Antarctic (which have no trees whatsoever), the region with the fewest tree species is the Nearctic region of North America, with less than 1,400 species.

GlobalTreeSearch will form the backbone of the Global Tree Assessment, an initiative to assess the conservation status of all the world's tree species by 2020.

Find out more at: www.bgci.org/news-and-events/news/1400/.



TECHNICAL REVIEW

In response to a request from its International Advisory Council, BGCI has recently published a Technical Review that looks at the criteria by which botanic gardens define themselves and reviews how botanic gardens measure success. Based on an on-line survey carried out early in 2017 and a literature review, the report incorporates data from over 200 botanic gardens in more than 50 countries. The Review includes an updated list of criteria that define a botanic garden and a number of recommendations to aid botanic garden strategic planning. For more information and to download a copy of the report, please visit www.bgci.org/news-and-events/news/1418/

BGCI/ARBNET BOTANIC GARDEN PARTNERSHIP PROGRAMME

This international partnership building initiative aims to facilitate the exchange of knowledge, skills and resources within the botanic garden and arboretum community. A first phase of the Partnership Programme is now coming to an end, and a number of pilot partnerships have been established. These include partnerships between:

- Vilnius University Botanic Garden, Lithuania and the Tasmanian Arboretum, Australia
- Botanic Garden of Rome, Sapienza University, Italy and the South London Botanical Institute, UK
- Stellenbosch University Botanical Garden, South Africa and Shanghai Chenshan Botanical Garden, China.

BGCI and ArbNet are now working on the framework for the second phase of the Partnership Programme. Further information about Phase 2 will be available from BGCI shortly. To find out more, visit: www.bgci.org/joinin/partnership-programme/

BGCI EDUCATION CONGRESS

BGCI's 10th International Congress on Education in Botanic Gardens will be hosted by the University of Warsaw Botanic Garden from 10-14 September, 2018. Themed on 'Bringing nature to the city' the Congress will celebrate 200 years of the University of Warsaw Botanic Garden. For further information, visit: www.ogrod.uw.edu.pl/en/congress2018

EIGHTH EUROPEAN BOTANIC GARDENS CONGRESS - EUROGARD VIII

EuroGard VIII – 'Botanic Gardens, People and Plants for a Sustainable World' will be held in Lisbon, Portugal from May 7-11, 2018. Organised by the European Botanic Gardens Consortium, the University of Lisbon and the Botanic Garden of Ajuda, the Congress will be held in association with the 15th Symposium of the Ibero-Macaronian Association of Botanic Gardens and celebrates the 250th anniversary of the Jardim Botânico da Ajuda (Botanic Garden of Ajuda). www.eurogard2018.org/



INTERVIEW TALKING PLANTS

In this issue of BGjournal we talk to **Pierre-André Loizeau**, who has been Director of the Conservatory and Botanic Garden of the City of Geneva, Switzerland for the past ten years and has recently hosted the 6th Global Botanic Gardens Congress.

We know you are passionate about plants, but who or what first inspired your love of plants?

As a child, we lived in the countryside, nature was my playground. My father, passionate about nature, helped me to discover ornithology and the pleasure of observation. As a teenager, I spent my holidays in the mountains with my family, drawing up lists of flowers growing on either the south face or the north face of small valleys.

As a taxonomist, you have specialised in the Aquifoliaceae. What is it about this group of plants that attracted you?

I had an opportunity when choosing a subject for my doctoral thesis to study this family as part of the Flora Neotropica. There was also a PhD Professor who was passionate about South America, heading the Flora of Paraguay. And, as everyone knows, Mate, Paraguay's national drink, is made from a species in the Aquifoliaceae - *Ilex paraguariensis*.

You have been Director of the Conservatoire et Jardin botaniques de la Ville de Genève for the last ten years. This must be a very varied job, but what aspects of your work do you enjoy most and why?

I particularly enjoy the great diversity of responsibilities, especially in the context of a medium-sized institution such as ours. I need to be involved in everything, from

human resources to accounting, vehicle management, watering systems, scientific strategy and the organization of the herbarium or library. But what is most appealing to me today is the opportunity to make Geneva's voice heard on the great issues of our society concerning the environment, and thus to contribute modestly to building a future for us all.

You have just hosted the very successful 6th Global Botanic Gardens Congress. What do you think made the Congress such a success and what advice would you give to a botanic garden director who is thinking about hosting such an event?

We have received much positive feedback, and we are very pleased. I believe that success is linked to the commitment and professionalism with which we have tackled this challenge, not only at the level of the organizing committee, but also of all the employees of the institution and our partners. I think that such an event should be celebrated by the whole institution. My advice is to encourage directors to invite all the collaborators of the host institution to participate proactively, soliciting ideas from all and allowing staff at all levels - gardeners, scientists, librarians, administrators etc. to actively participate in all events.

As well as a passionate botanist, you are also an accomplished musician. Do you think music can be used to inspire an interest in plants amongst the young?

I see a parallel between music and botany in the rigor with which one must work, either with an instrument, or in inventorying a site; in the creativity necessary for the reproduction of a musical score or the understanding of the plant world; in the capacity to marvel at a musical piece as at a flower. On the other hand, I do not see any link that would allow a young person to associate music and botany, if not by indirect contact. This is what we are pursuing in Geneva with our playground, the carousel of fables, the animal park or the organization of concerts: to attract a public *a priori* not interested in botany, possibly young, who in contact with our presentations, discovers a world of wild plants, creating a link with nature.

The Conservatoire et Jardin botaniques de la Ville de Genève is already one of the most important gardens in the world, but what plans do you have to further develop the garden in the future?

In 2016 we reached the end of six years of renovations of some of the thematic gardens and buildings, and the expansion of the herbarium, thus providing a remarkable framework for horticulturists and botanists. At the level of the Garden and in the spirit of creating an environment conducive to observation, we would now like to reconstruct an aviary 16m high and over 3000m², in which the public could circulate, devoted to breeding and multiplication of threatened animal and plant species of wetlands.

Author: Lex Thomson

PLANT HUNTING TALES

RARE RUBY REVEALED – A NEW SPECIES OF ENDEMIC HIBISCUS IN FIJI

Researching endemic *Hibiscus* in Fiji is as much serendipity as science, and more akin to a detective story than typical botanising

In May 2015 I had the immense good fortune to be in Kenya with Dr Paul Smith, BGCI Secretary-General, where we were working on a review of the World Agroforestry Centre's Genebank. One of our discussions touched on the origins of *Hibiscus rosa-sinensis* and whether it had come from southern China (Rose of China), South Asia (type specimen from Sri Lanka), East Africa (given its relationships with the Kenyan & Tanzanian *H. schizopetalus*), Madagascar and Indian Ocean Islands (likely origin of Lilibiscus species) or perhaps Melanesia. We also talked about Fiji's *Hibiscus storckii*, long lost since its discovery on Taveuni in 1860 by German Botanist Berthold Seemann, and synonymised under *H. rosa-sinensis*.

In November of the same year, I was working in Fiji collecting sandalwood leaf samples for DNA analysis with Mr Sonu Dutt of the Fiji Department of Forestry and Dr David Bush from the Commonwealth Scientific and Industrial Research Organization. At the end of a full day of collecting sandalwood leaves we took the precarious four-wheel drive climb to Mount Delaikoro in Vanua Levu. On a steep rocky slope I was stunned to see a pink *Hibiscus* flower glowing in the last rays of sunshine. Further down the slope was another similar *Hibiscus* bush. Could this be the elusive *Hibiscus*



Hibiscus sp. aff. *storckii* (Mt Delaikoro), Rukuruku Village, Ovalau (Cultivated) (Nicholas Perrault)

storckii? I was excited by this prospect but also concerned at how to utilise this opportunistic botanical find.

Developing a project

In February 2016, I was contacted by Paul Smith of BGCI and together a project on "Survey, inventory and conservation of *Hibiscus storckii*, a highly threatened Fijian species" was developed and supported by the Mohamed bin Zayed Species Conservation Fund. A key aim was to locate wild populations of *H. storckii* and also establish the relationship of *H. storckii* with the Mt Delaikoro Hibiscus. The local partners were NatureFiji-MareqetiViti, University of South Pacific Regional Herbarium and the Savurua Botanical Gardens.

Three weeks after Tropical Cyclone Winston in early 2016 – the strongest storm ever recorded to make landfall in the Southern Hemisphere – I was back in

my beloved Fiji on the Garden Island of Taveuni. My plan had been to undertake a preliminary search for *H. storckii* but with mountain vegetation defoliated by TC Winston there seemed no hope of locating Storck's *Hibiscus*.

First glimpses

On the Saturday morning of 12th March I planned to visit Lavena on the east coast of Taveuni. Having just missed the bus at Wairiki, and not wanting to wait several hours for the next one, I ran flat out eventually catching up with the bus after a kilometre of stops, starts and gasps – thus providing amusement to locals watching on. It was a hot, steamy, sweaty and dusty slow ride on a packed market-day bus. Arriving in Lavena it was shocking to see the structural damage to this seaside village. Lavena had taken the full force of the Category 5 TC Winston, with many buildings damaged or totally destroyed. Their remnants were draped in



Hibiscus storckii (Lex Thomson)

tarpaulins. On a bright note, it was heartening to hear and witness the resilient attitude of the locals to rebuilding, some in the wake of having just lost everything, before the bus quickly turned around and, with no shops open, I really appreciated the local generosity in sharing a bottle of Fiji Water. On the return bus journey I caught a fleeting glimpse of a dark-eyed, pink-flowered *Hibiscus* which I thought may have been *Hibiscus storckii*.

It was late in the afternoon when Tutu's Father Michael McVerry drove me back to have a closer look at the pink *Hibiscus*. There were two plants growing in the Villa Maria Settlement, which on closer inspection I determined to be the *Hibiscus* known internationally as 'Ruby Rose'. We met with Mr Suliano Manabua, who was well-known to Father Michael as both Suliano and his parents had previously attended Tutu's married couples programs. It was then that Suliano dropped a bombshell. He said that his father, Sepo, had collected the cuttings of 'Ruby Rose' from a remote location in the Waibula River catchment in 2004 and that it was growing wild. The wild origins of 'Ruby Rose' – one of the most spectacularly beautiful miniature

flowered *Hibiscus* – were beginning to emerge. Following our discussions with Suli, Father Michael promised to arrange for Tutu's young farmers from Villa Maria to find the location of the wild *Hibiscus* and I determined to visit the isolated site to confirm its wild origin.

A long hike

It was the second week of June before I could get back to Taveuni. On the 8th June Father Michael arranged for Suli and his son Sepo to be my guides on the quest to locate 'Ruby Rose' in the wild. I had been told that the Reality TV program 'Survivor' had cut a new road that led to near where the 'Ruby Rose' grew, and that only a 30 minute hike was needed, but alas this turned out not to be the case. Due to land dispute and damage to the walking track by TC Winston, the walk turned out to a difficult hike up and down several precipitous valleys. During the walk I was sustained and revitalised by bush foods and medicines, including young tubers of a wild ginger (*Zingiber zerumbet*) and the fresh leaves of an excellent blood tonic, wild sarsaparilla (*Smilax vitiensis*), an aromatic Fijian cinnamon and a primitive gymnosperm tree with edible leaves and fruit (*Gnetum gnemon*).

The wonderfully diverse tropical forest included timber trees *Podocarpus nerifolius* and *Syzygium* spp., the edible Tahitian chestnut (*Inocarpus fagifer*), epiphytic orchids and the perfumed woody *Fagraea beteroana*, with a rich understorey of endemic palms and ferns. The walk through the forest was punctuated by the calls of songbirds

Ms Nancy Penibera with Hibiscus storckii. Wai Village, Taveuni, (Cultivated) (Lex Thomson)

including the orange dove and Fiji bush warbler and occasional screeches of the red shining parrots and collared lorries. We traversed an elevated pathway or tua which fell away steeply on both sides. This was used to trap hapless strangers during the cannibal era, and I was glad to be alive today. After several hours we reached the impressive broad valley of the Waibula River. This river is the largest on Taveuni. After a rest we made the final half-hour scamper over the boulder-strewn Waibula River to the site where the jungle *Hibiscus* was known to occur. Two of the *Hibiscus* plants had died or been destroyed by TC Winston but to my delight one plant with a single unmistakably beautiful 'Ruby Rose' *Hibiscus* flower had survived. 'Ruby Rose' *Hibiscus* was reported to be more plentiful in the upper reaches, but that entailed an arduous and treacherous five or six hour walk. We collected cuttings and botanical specimens of the new *Hibiscus* before returning in the late afternoon to Villa Maria – fatigue and aches kept at bay by a thoroughly exhilarating day of discovery. The undescribed species is being named in honour of Father Michael McVerry and in recognition of his assistance in finding 'Ruby Rose' and for his contributions to Taveuni, including the local Garden Club and the work of Marist Tutu Rural Training College.

Where are we now?

My research has determined that Fiji now has at least two endemic and critically endangered species of *Hibiscus* – with both arguably having the most attractive flowers of any tropical *Hibiscus* species. The Mt Delaikoro *Hibiscus* is morphologically readily distinctive but genetically close to *H. storckii* and more research is needed to clarify whether it should be recognised at species or sub-specific level. There are almost certainly at least one more undescribed Fiji *Hibiscus* species, and more field and genetic research is urgently needed before they disappear entirely from the wild due to extreme climatic events and competition from invasive species.

So where does *Hibiscus rosa-sinensis* originate?...Well that is another story, but certainly its origins are closer to Melanesia than Asia or Africa.

The support of the Mohamed bin Zayed Species Conservation Fund is gratefully acknowledged.



Authors: ?



FEATURED GARDEN THE CONSERVATORY AND BOTANICAL GARDEN OF THE CITY OF GENEVA, SWITZERLAND

Host of the recent 6th Global Botanic Gardens Congress, the Conservatory and Botanical Garden of the City of Geneva (CJBG) is celebrating its 200th anniversary this year. Originally created in 1817 by the renowned botanist Augustin Pyramus de Candolle, the botanic garden expanded so much during the 19th Century that in 1904, it was forced to leave the city centre and was re-established at its present, 28 hectare site on the banks of Lake Geneva, in the heart of the international organisations district of the city.

Living collections

The botanical garden includes a living collection of nearly 10,000, mainly wild species coming from countries worldwide. The plants are displayed in forty geographical, taxonomic, morphological / ecological or thematic collections, with a special rockery being dedicated to the threatened plants of Switzerland. The most recently completed thematic garden is the ethnobotanic garden, which was officially opened on June 26, with an inauguration event held during

the 6th Global Botanic Gardens Congress. The ethnobotanic garden is arranged under four main themes:

- **The food garden:** herbs, spice plants, functional food, forgotten vegetables and foraged plants
- **The medicinal garden:** medicinal plants, plant-based medicines, herbalism
- **The economy botany garden:** perfumes, dyes, fibers, sugar, oils and resins

- **The garden of useful plants:** fermented beverages, wood, domestic uses, organic pest control, sacred and poisonous plants.

The institution has a special interest in the medicinal plants of Paraguay. Here the Guaraní people recognise around 5,000 medicinal plants and information about these has been preserved by the Jesuit missions and the collections of Emil Hassler. The Paraguayan Ethnobotany Project was established in the mid-1990s in collaboration with the Botanical Garden and Zoo of Asunción. This collaborative



Pierre-André Loizeau

framework has facilitated the creation of a large herbarium of Paraguayan medicinal plants and the creation of the Centro de Conservación y Educación Ambiental (Center for Conservation and Environmental Education: CCEAM), located within the Botanical Garden of Asunción.

Seedbank

The seedbank at CJBG recently won the Global Seed Conservation Challenge award for conserving the most difficult species to collect. The award was based on the work of the garden in conserving *Typha minima*, a species with very short-lived seeds. Most seeds of this species germinate before winter or die during winter if not germinated. As a result, the seeds have the reputation of being unable to be stored. By performing harvest techniques and post storage germination tests, CJBG proved that it is possible to collect and store *Typha minima* seeds in a conventional seed

bank and use them for cultivation or reintroduction. The method involved using a drying cabinet in the field to dry seeds immediately after harvest.

Sustainability

Sustainability is taken very seriously at CJBG with the gardens being managed organically since 2015 (it was the first public establishment in Switzerland to adopt organic garden management) and its energy supply is 100% from renewable sources. The water used for watering the greenhouses is principally rainwater that is obtained from the roofs of the greenhouses and the “maison des jardiniers.” It is collected in two cisterns situated underneath the greenhouses that hold about 1,000 cubic metres. An installation for demineralisation by inverse osmosis is used when there is little or no rainfall. The water is warmed to 77° F (25°C).

Herbarium

The Garden includes one of the world’s most important historical herbaria. With nearly 6 million specimens, the collection is derived from a long tradition of botany in Geneva that dates back to the 1800’s. It contains plants and fungi from across the whole world, but in particular, those of the Mediterranean, the Near and Far East, South America and Europe.

Library

The library at CJBG was established in 1824 and now contains over 120,000 volumes. Initially the collections

developed slowly through acquisitions, gifts, and bequests. Its expansion began at the beginning of the 20th century, and more precisely when Emile Burnat, a botanist from Vaud, donated his valuable botanical collection of 3,000 volumes to the City of Geneva. It contained elements of the collections of Louis Leresche, Samuel Bridel and Judge Abraham Thomas.



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In 1920, the famous library of De Candolle was donated by the family of the last living botanist of this name. This marvellous family collection can be compared to those of the largest national museums. Another valuable element to be added to the Conservatory was the Boissier library: it was given as a permanent gift in 1943 by the University of Geneva who had received it through the generosity of the Boissier family. Afterwards, the Library was able to acquire useful complements to its collection, such as the library of the “Société botanique de Genève” and the “Société genevoise d’horticulture” as well as those of the “Institut de botanique générale” and of the “Laboratoires de pharmacognosie et de pharmacie galénique” of the University. Since then the City of Geneva, the guardian of these riches, has kept the Library up to date through regular acquisitions.



Rémy Gindroz



ARTICLES

WHAT IS CONSERVATION HORTICULTURE?

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PLAYING TO OUR STRENGTHS: APPLYING HORTICULTURE AND ADVOCACY TO THREATENED PLANT CONSERVATION

BRYOPHYTE HORTICULTURE: MYTH OR REALITY?

HORTICULTURE AND THE CONSERVATION OF THREATENED SPECIES

CAREER LADDER FOR HORTICULTURISTS IN THE SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE (SANBI) "HORT LADDER"





Rémy Gindroz

Author: Joachim Gratzfeld



Training in conservation horticulture, Yachay Botanic Garden, Ecuador, October 2016.

WHAT IS CONSERVATION HORTICULTURE?

Growing one plant in one pot is a certain, rather limited challenge. To grow 200 plants for an indefinite period and maintain the genetic diversity among them is not the same challenge 200 times over. It is a quantitatively and qualitatively different challenge, and a far more difficult one. *Susan Wallace (1992)*

with these terms. While gardens, throughout history, were established to serve various functions, whether for contemplation and aesthetics, study and supply of herbal medicine, or propagation trials and cultivation of food crops and other socio-economically important species, botanic gardens in the 21st century have become the vanguard for the conservation of plant diversity.

Defining conservation horticulture

With documented, living plant collections at their heart – *A botanic garden is an institution holding documented collection of living plants for the purposes of scientific research, conservation, display and education* (Wyse Jackson, 1999) – horticulture concerned with integrated conservation and environmental awareness is taking centre stage in today's botanic gardens (Figure 1).

Introduction

Conservation and horticulture, two terms that have been brought together in fairly recent history to articulate a vital, yet understated function spearheaded by botanic gardens. Whilst the unabated decline of biodiversity over the last two centuries is imparting a new sense of urgency to the concept of

conservation, the science and techniques of horticulture were developed millennia ago with the onset of human innovation to domesticate and cultivate wild plant species for sustained provision of food and medicine. This may have paved the way for the notions of garden (Latin: *hortus*) and gardening (Latin: *colere* and *cultura*), and the many forms and uses known today associated

Based on this characterisation, conservation horticulture in botanic gardens aims at *ex situ* plant holdings that:

- are representative of the genetic diversity of target populations in the wild as an insurance policy for the future, i.e. to source germplasm for *in situ* conservation measures, including population reinforcement programmes and reintroductions, as well as introductions; and
- support conservation education and environmental awareness-raising.

This purpose and vocation unmistakably differentiate conservation horticulture from horticultural practices employed elsewhere, such as in production areas, urban parks, amenity gardens, recreation grounds or other managed, green spaces (Table 1).

Technical challenges and opportunities in conservation horticulture

The fundamental endeavour for conservation horticulture to maintain live-plant collections that are genetically representative of natural populations is plausible (Kay *et al.*, 2011), yet there remain technological and/or methodological challenges. To name a few, these may range from species-specific propagation and cultivation problems, such as breaking deep seed dormancy in *exceptional species* (Pence, 2011) or overcoming pathogens and invasive species, to spatial limitations in allowing the full genetic diversity in populations to be represented, or avoiding inbreeding. Establishing different, distant populations in one location, or preventing hybridisation of closely related species present further challenges conservation horticulturalists have to consider. Thus, there is a vital need to understand the genetic diversity present in natural populations and how botanic gardens can mirror this diversity (Griffiths *et al.*, 2015; Mirancho *et al.*, 2012; Namoff *et al.*, 2010; Maunder *et al.*, 2001). This will inform the effective management of germplasm as an insurance policy for the future (Rao and Hodgkin, 2002).

Despite these challenges, there are also many instances of the direct value of *ex situ* collections in botanic gardens for

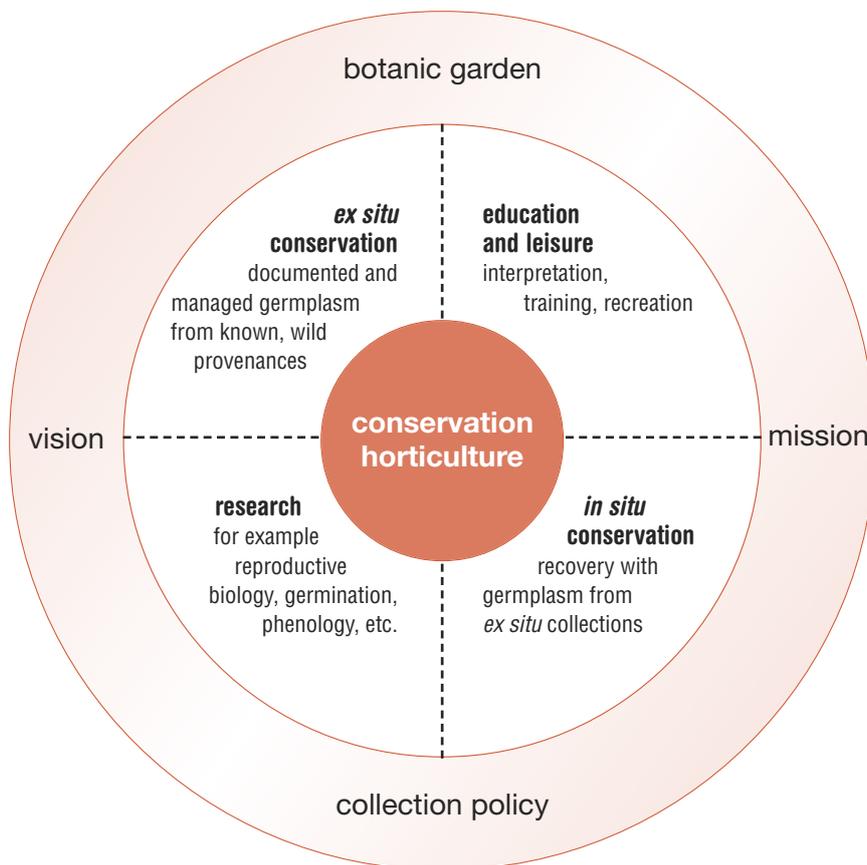


Figure 1: Conservation horticulture in botanic gardens serving integrated conservation.

Commercial horticulture	Conservation horticulture
<ul style="list-style-type: none"> • Management of plants for production (e.g. food, ornamentals) and amenity 	<ul style="list-style-type: none"> • Management of documented, collection policy and conservation science-based plant holdings
<ul style="list-style-type: none"> • Representation of fewer taxa, often major emphasis on provision and display of cultivars 	<ul style="list-style-type: none"> • Representation of a wide range of wild taxa from diverse climates and habitats, genetically representative of natural populations for research, conservation, education and display
<ul style="list-style-type: none"> • Focus on grounds maintenance and display 	<ul style="list-style-type: none"> • Aimed at integrated <i>ex</i> and <i>in situ</i> conservation (species recovery and ecological restoration)
<ul style="list-style-type: none"> • More mechanised approaches serving large-scale production, commercialisation and amenity management, short-term or frequently changing displays 	<ul style="list-style-type: none"> • Specialised skills to determine requirements for wild species collection, reproduction and long-term maintenance

Table 1: Selected areas of emphasis of horticultural principles and practices in the commercial and botanic garden sectors.

global conservation, and the vital contribution and difference that conservation horticulture has made (BGCI, 2010). The long list of examples of horticultural innovations in growing plants, as well as species saved from extinction in the wild thanks to the knowledge, practical skills and enthusiasm for empirical work of

conservation horticulturists, speaks for itself. For instance, the discovery by Kirstenbosch National Botanical Garden, South Africa, that smoke, rather than heat and ash from wild-fires is the main trigger in germination, resulted in a revolution in seed propagation for threatened species, restoration ecology and species for commercial horticulture (Dixon, 2007).



National Parks and Conservation Service nursery 'Robinson', where several species endemic to Mauritius are being propagated (Stéphane Buord).

Emblematic cases of germplasm held in *ex situ* collections from populations that no longer exist, let alone of species gone extinct in the wild include the frequently quoted *Sophora toromiro* (Fabaceae) from the Easter Island, or *Encephalartos woodii* (Zamiaceae) in southern Africa. Plant material of both these species has survived in botanic gardens in Chile and Germany, and South Africa respectively, and is used in population reintroduction trials. Other iconic examples include *Cylindrocline lorencei* (Compositae) in Mauritius, *Normania triphylla* (Solanaceae) in Madeira and *Erica verticillata* (Ericaceae) in South Africa (Gratzfeld, 2016).

Influencing environmental sensitisation

Conservation horticulture also supports a more holistic approach to environmental education. This goes beyond the mere tagging of plants in display and conservation collections with the right names and interpretational materials as a means of public outreach. Unlike in commercial, ornamental horticulture where a natural temptation to select the 'best-looking' individuals may be a priority (Aplin, 2016), conservation horticulture presents an opportunity to showcase and learn about the diversity and wider genetic array within a population or species. 'The old horticulturist in me would naturally have favoured the most compact and floriferous clone and disdained the rest [of the clonal differences in the collection of *Conradina grandiflora*]. Today the revised horticulturist in me celebrates these differences and the story they tell to our visitors about genetic diversity.' (Wallace, 1992).

'Quo colis?' – A future for conservation horticulture?

Horticulture in general is facing a crisis in many countries (Hewett, 2015). There are insufficiently well-trained people available to service the broad range of occupations in the sector, while horticultural degree opportunities are disappearing from research organisations. Horticulture is losing appeal and suffering from a perceived lack of career progression prospects (RHS, 2014).

As with production horticulture, a decline of botanic garden horticulture staff and standards has been witnessed in the last 30 years (Rae, 2013). The fundamental role of conservation horticulture and of the personnel and volunteers who carry out this challenging work is not fully appreciated – both within the institutions themselves as well as amongst wider public. With limited resources, botanic gardens are struggling to maintain their living collections appropriately using horticultural science and principles that serve conservation.

Equally, few opportunities exist for advanced capacity building in conservation horticulture. While training programmes and grants are offered by some of the larger botanic gardens, affiliated institutions, universities and foundations (e.g. Royal Botanic Gardens Kew; Royal Botanic Garden Edinburgh; South African National Biodiversity Institute; United States Botanic Garden; University of Florida, University of Hawai'i Hilo; The Stanley Smith Horticultural Trust), countries with an important share in plant diversity and high levels of threatened species, often lack access to horticultural courses and/or resources

aimed at promoting *ex situ* conservation. Nevertheless, there are promising developments to boost the role and image of conservation horticulture through specialised curricula and career development tailored to the particular, institutional needs. For example, recognising the fundamental importance of retaining staff of horticultural excellence, the United States Botanic Garden, Washington, DC, has developed a four tier career progression system. Employees can move through the four levels (with commensurate pay increases) as skill sets improve. If staff are hired at tiers 1 or 2, they can progress to the next tier without competition as long as the required competencies are met. When there is an opening at a tier 4 position there is an internal competition for all eligible tier 3 employees (Smith and Harvey-Brown, 2017). The South African National Biodiversity Institute (SANBI) also offers a career progression programme for its staff. Comprising 8 tiers, SANBI's Career Ladder for Horticulturists is designed to recognise, attract, retain and develop horticulture and horticulturists in botanical gardens, to fulfil the organisation's mandate (See p 40). Another example is Francisco Javier Clavijero Botanic Garden in Xalapa, Mexico, which offers a diploma in horticulture structured in three certificate modules. They can be taken separately and are aimed at professionalizing the distinction in horticulture, such as in propagating native cloud forest trees for ecological restoration.

In times of rapid climate change, horticultural excellence is also of vital significance to plan and manage gardens and plants in response to increasing extreme weather events, including heat waves, prolonged dry or



Sophora toromiro, grown in the Jardín Botánico Nacional, Chile, and subject of an ambitious reintroduction programme (Óscar Fernández).

wet spells and frosts. Whilst a number of challenging hazards, such as a higher incidence of existing and new pests and diseases as well as alien invasive plants may have to be managed with mounting frequency, there are also opportunities arising from a changing climate. These may provide for more flexibility in gardening practices and innovation in plant choices (Webster *et al.*, 2017). However, this will require adaptation to changing environmental conditions, and remaining mindful of how the species planted now might be suited or not in the medium and longer term future.

Conclusion

Improving the perception and status of horticulture in conservation and society, as well as its relevance in times of fast global change, is not only a call for governments and the public at large. Ultimately, it is the horticulturists at botanic gardens themselves whose vital work not only must be seen, but who need to be better heard: still all too often, their wealth of knowledge and practical knowhow acquired by empirical effort and best practice based on trial and error, deserves and requires to be communicated and publicised more assertively. After all, it is they who provide, cultivate and monitor the plants that make a botanic garden now and in the future.

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Normania triphylla (Solanaceae) in the conservation collection of the Conservatoire botanique national de Brest, France (Loïc Ruellan).

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*The *Woodsia ilvensis* restoration project relied on close cooperation between horticulturists and scientists before plants could be returned to wild habitats (Heather McHaffie)*

Understanding the important role horticulture plays with respect to conservation, research, education, training and international capacity building has led to the development of an exemplary and integrated horticulture programme at RBG Edinburgh.

Introduction

There is one thing that all of the world's botanic gardens do and that is horticulture. Most also offer education at various levels, some undertake research and a few are actively engaged in conservation, but every botanic garden has a garden. Whatever the size or quality of cultivation the garden and the activity of horticulture are usually at the heart of every botanic garden. While gardening is seldom the stated purpose of botanic gardens,

most activities rely on the garden and horticulture for their delivery and in this sense:

“horticulture can be thought of as the glue that bonds all the gardens' activities together.”

It is, however, the quality and purposefulness of the horticultural endeavour that dictates the strength

of that glue and the extent to which horticultural practice can support the mission of the garden, be that a visitor attraction, research institute or both.

The purpose of this article is to describe how horticulture has developed at the Royal Botanic Garden Edinburgh (RBGE) over the last generation and explain current attitudes to collection management and how the Garden has promoted the importance of horticulture through its outreach, training and education programmes.

Brief historic overview

The Royal Botanic Garden Edinburgh (RBGE) started as a Physic Garden with the purpose of teaching apothecaries the identification and use of medicinal plants. Education and training have therefore been a core activity since the start. It was at the Garden's third site, when John Hope was Regius Keeper, that science and research flourished while education continued to be very important. Hope was an able and scholarly director of the garden, introducing the Linnaean system of nomenclature to the Garden, experimenting with the medicinal properties of rhubarb and carrying out numerous experiments in plant physiology at a time when the study of botany was emerging from under the wings of medicine. Significantly, and of special note for this article, he had a very close working relationship with his Head Gardener, John Williamson, and the two together accomplished a great deal. When he died in 1786 there was no doubt that RBGE was regarded as a leading botanic garden where botany and horticulture combined to deliver teaching and research.

Outstanding horticultural ingenuity and skill were clearly in evidence when the Garden moved to its fourth and final site in 1820. Many of the mature trees from the previous garden were successfully transplanted to the site and in 1834 a magnificent octagonal palm house, the

largest in Britain at the time (completed two years before Chatsworth's Great Conservatory), was constructed to house the increasing number of warm temperate and tropical plants that were now flowing into the Garden from foreign contacts. Other innovative buildings and garden areas followed in quick succession. The 'Golden Age of Plant Collecting' was the next significant phase with plant species new to science flooding into Europe. RBGE became one of the centres for the introduction and description of this material. Horticulturists were busy finding ways to cultivate these new plants while botanists were busy describing and classifying them and, again, the two disciplines clearly worked together closely to the benefit of both.

By the 1960s the horticultural emphasis of the Garden appeared to be focussed on amenity horticulture with little emphasis on 'botanical' or 'wild origin' material. That said, it is always important for botanic gardens to inspire visitors with beauty and diversity and the garden certainly did, and continues, to do that. Numerous cultivars were being grown and much of the student course was devoted to municipal horticulture. There was little coordination with botanical research with botanists focussing mostly on herbarium material and only a few (but with notable exceptions) using the Living Collection or glasshouses to support their work. At this time there was only the weakest of emerging interests in conservation.



Sowing and recording wild collected Chilean seeds for eventual research, education and display (David Rae)

During the 1970s attitudes started changing. Edinburgh was one of the first botanic gardens to computerise their Living Collections data, science staff were increasingly demanding that plants, particularly those used to support research, were of known provenance, a first Collection Policy was drafted and the two Kew conservation conferences of 1975 and 1978 (Synge, 1987) hinted that there could be a role for botanic gardens in plant conservation. The Garden started emerging from the period of what might be called 'amenity botanical gardening' where there was little connectivity between horticultural and scientific staff into an era where the Living Collection was increasingly being thought of as a resource to be actively used and there was increasing collaboration between staff across the whole institution. This, of course, is a bit of a generalisation and there were many exceptions, but it is true to say that this period was pivotal in moving to the Garden's current position where:

“horticulture is relevant and needed for fulfilling the Garden's mission.”

This partly stemmed internally from the strong personal friendship and collaboration between the Director of Science at the time and the Director of Horticulture and also from the fact that science staff were increasingly inviting horticultural staff to join them on fieldwork expeditions. Externally, there was a growing call for botanic gardens to mobilise their expertise to conserve plants.



International capacity building. Staff from Edinburgh teaching propagation and cultivation techniques to staff at the Oman Botanic Garden (Sadie Barber)



Collecting cuttings for the Biodiversity, Taxonomy, Genetics and Ecology of Sub-Arctic Willow project with long pruners to reach material growing free from sheep and deer grazing (Natacha Frachon)

For example, in his paper 'The changing role of the botanic garden' (Heywood, 1987) Vernon Heywood argued that botanic gardens, including their horticultural departments, were needed now more than ever to help stem the tide of plant extinctions and to start engaging actively in plant conservation, but they needed to coordinate their efforts more effectively.

Relevance of botanic garden horticulture

From the 1980s to the end of the century the increasing relevance of BGCI and the emergence of other networking groups such as PlantNetwork (the Plant Collections Network of Britain and Ireland) saw practitioners and scientists working together to discuss how best botanic gardens could engage with conservation. At first discussions focussed on what might be done but slowly transformed into practical action as those who were willing but didn't know how to act started to understand the unique and important role that botanic gardens could play in conservation (see, for instance, Bramwell, 1981, Thibodeau & Falk, 1987; Bramwell, 1991, Heywood and Wyse Jackson, 1991; Bramwell and Heywood, 1993). This galvanised botanic

garden horticulturists and, as the new millennium dawned, there was a growing realisation that living collections needed to be managed more professionally with objectives and targets if they were to be 'fit for purpose' and of any use to conservation. There was no doubt that at this time the Global Strategy for Plant Conservation (GSPC) had a profound impact on horticulture in botanic gardens as the Strategy was clearly written and contained targets and objectives, many of which relied on botanical horticulture, especially Target 8. This proved a catalyst for botanic garden horticulture with gardeners seeing a direct relevance of their work in delivering parts of the GSPC (Rae, 2004, Frachon, Jebb & Rae, 2005).

Living Collection management

RBGE had a draft Collections Policy from the late 1980s but it was never published and contained little description or rationale, comprising mostly lists of priority species to be cultivated. In the early 2000s horticulture management at the Garden decided that a comprehensive Collections Policy for the Living Collection, developed with input from all staff and all garden sectors, and recognising important external factors, such as international policies and

legislation, was vital for guiding the Living Collection into the future. After numerous meetings with horticultural, science and education staff, and after consultation with senior management and eventually with the Board of Trustees, a 69 page comprehensive and very descriptive Policy was eventually published in 2006 (Rae *et al*, 2006). The process and content are described in detail by Rae, 2006. One of the many new features of the Policy was an understanding that the Collection existed to be used and enjoyed by what we now refer to as user groups and the Horticulture Division existed to grow plants to help these user groups. The first section also listed relevant policies and conventions such as the Convention on Biological Diversity (CBD), GSPC and the Convention on Trade in Endangered Species (CITES), described their relevance to the Collection and then listing how the Horticulture Division would try and fulfil the requirements of these policies and conventions through the Living Collection. Using 'Investors in People' terminology the Policy was demonstrating that the Living Collection had internal and external 'customers' all of which had particular requirements and it was the job of the Horticulture Division to fulfil those requirements.

From the Collection Policy flowed a need to manage the Collection appropriately for a wide diversity of 'customers' and this required quality standards to ensure the Collection was 'fit for purpose' which in turn required monitoring (Rae, 2004). Up until this time the plant records system had not generally been used to *manage* the Collection, only to track plants and store field data, but it contained the ability to provide all sorts of statistics and analyses. To move the Collection towards being more useful it was decided that three figures or facts were of paramount importance: percent wild origin, percent verification and annual number of new accessions. The first was important because wild origin plants are more useful for conservation and research than plants that are of unknown origin, the second because it is important for all users to have confidence that plants in the collection are correctly identified and labelled (and this was aided by the 'Targeted Verification Process', see Cubey & Gardner, 2003), and the third to ensure that new material was entering the

Collection at a suitable rate to maintain numbers and diversity. Targets for these three figures were set and monitored annually. A five-yearly audit of 50 key families and genera was also established at this time to monitor change over a longer time period as was the 'Gold Standard' of curation termed 'Data Capture' (Frachon, Gardner & Rae, 2009) which strove for the highest standard of curation possible.

In tandem with raising the standards of collection management to better support research, conservation and education, experience had shown that the publication of a comprehensive Catalogue of the Living Collection approximately every five years was a highly worthwhile exercise (Rae, 2008). The discipline of producing a hard copy book of the Collection, while time consuming, creates the opportunity to stocktake the collection, update any nomenclatural changes, describe projects and changes to the Collection since the publication of the last catalogue and publicises collection statistics. Furthermore, the hard copy provided a 'snapshot' of the Collection at a particular time and, taken with the previously published Catalogues, provides an invaluable history of the Collection.

Landscape policy

While science, conservation and education are, arguably, the most important users of the Collection, so too are the visiting public and for them a botanic garden needs to be attractive, well maintained and informative. While most botanic gardens will have been professionally designed at some stage, most continue to grow and evolve in an unplanned and organic way meaning that, over time the coherence of the landscape can be lost. At Edinburgh, experience showed that the production of Landscape Assessment and Development Plans (which are less formal and prescriptive than fully developed Master Plans) for each of the four gardens that make up RBGE, were helpful in describing the history and development of each garden, assessing aspects such as views in and out, pedestrian and vehicular routes, integration between garden areas or features, and in highlighting problem areas where the landscape didn't 'work' well (Daniel & McDermott, 2006, 2008, 2008 and 2010).

The two policies, one for collection management and the other for garden landscape, involved numerous staff but were, perhaps, a fundamental step in developing horticulture at Edinburgh and integrating it more closely with other garden staff and departments. However, outputs such as international capacity building, the production of *Sibbaldia*, the journal of botanic garden horticulture and training and education were an important part of the process too.

International capacity building and fieldwork

While horticultural staff from the Garden had frequently been involved in garden advice and development in the UK, it was relatively uncommon for them to be involved in overseas capacity building projects. However, with the increased integration with science and education staff taking place from the late 1990s, coupled with targets in the GSPC calling for such projects, and opportunities for financial support offered by the Darwin Initiative, assignments of this type became increasing common, and increasingly asked for. Furthermore, it is probably fair to say that the increased scientific and methodical approach being given to the management of the Living Collection created a feeling of confidence and professional pride that gave horticultural staff the desire to take part in overseas projects. Horticultural staff therefore found themselves in places such

as Bhutan, China, Turkey, Chile and Nepal, working with science and education staff, helping to develop new botanic gardens, deliver training workshops or working hands-on in practical conservation projects. It also became increasingly common for horticulture and science staff to collaborate in foreign fieldwork where the primary purpose was to collect herbarium, seed and live plant material to support research projects. It has been particularly pleasing to see the strong bonds develop between staff in the two disciplines with both practical and personal benefits flowing from the collaboration.

Sibbaldia

Sibbaldia, the journal of botanic garden horticulture (named in honour one of RBGE's founders, Robert Sibbald) was launched in 2003 to provide an opportunity to share horticultural knowledge within the botanic garden community and also to encourage botanic garden horticulturists to commit their knowledge to paper. Many botanic garden horticulturists have valuable and detailed knowledge about particular species and their cultivation requirements but are often loathe to commit this knowledge to paper or believe that it is not particularly special or worth sharing. However, the information is often very worth sharing, particularly the cultivation requirements of threatened species that are demanding to cultivate.



Staff monitoring the fern Woodsia ilvensis a year after restoration back into the wild following ex situ propagation and cultivation in Edinburgh's nursery facilities (Heather McHaffie)



Research, in this case on the evolutionary development of Begonia, relies on both a comprehensive collection of the genus and also on detailed and accurate plant records (David Rae)

The growing realisation that horticulture had a worthwhile part to play in conservation only made this need to communicate more important. The editor was determined, however, that the journal would be a 'quality product', similar to RBGE's scientific publication the *Edinburgh Journal of Botany* (EJB) and papers are now procured, edited, peer reviewed and designed to the same high standard as the EJB, ensuring that horticultural output is of the same standard as science output. The journal also features a guest essay from a prominent botanic garden personality and papers on conservation, cultivation, policies relevant to botanic gardens, seed banking and restoration. It is freely available on-line and hard copies are available to purchase (<http://journals.rbge.org.uk>).

Education and training

Education and training have been at the heart of the Garden since the first apothecaries were trained in the 1670s. Later, in the 18th and 19th centuries medical students subscribed to lectures in botany and the medicinal properties of plants and in 1892 the 'Course of Instruction for Practical Gardeners and Foresters at the Royal Botanic Garden Edinburgh' was established (Oldham, 1992). This slowly morphed into a

training course for plantation crops to equip graduates to manage tea, coffee and fruit estates in the British Empire. The course was modernised in the 1960s and became the Diploma in Horticulture Edinburgh (DHE). While much of the content was based on municipal horticulture there was a strong practical botanic garden element and the ablest students found employment in botanic gardens around the world. The changing requirements of education in the late 1990s, such as validation and scrutiny by government education departments forced a change to a fully accredited Diploma course that was run in conjunction with the Scottish Rural University College (SRUC). While this reduced the practical content, the accreditation was welcomed by employers who could more easily understand the level of the course. Bespoke modules were created in subjects such as botanic garden management and conservation and the course's growing success led to the introduction of a four year BSc level course which articulated seamlessly with the two year Diploma and was made administratively easy through the existing accreditation system. Horticulture students from RBGE, whether graduating after two or four years, now enter the labour market with a range of skills and knowledge encompassing horticulture, botany, conservation, plantsmanship and an understanding of policies such as the CDB, CITES and the GSPC and how botanic gardens, and particularly botanic garden horticulturists, can contribute to their delivery and success.

These courses are taught and accredited within the British education system and, while they appeal to many overseas students, their duration and entry requirements are not really flexible enough to offer them as part of international training and capacity building projects. Staff therefore found themselves spending many days creating one-off courses in, for instance, propagation and cultivation, with the result that there was wasted time and duplication of effort. However, the Head of Education at the time, created an excellent, short, practical and easily understood course, tailored to botanic garden horticulture and called the Certificate in Practical Horticulture (CPH) (Morris & Cohen, 2010). A common set of notes, images, video clips and

powerpoint presentations were developed that staff could use if they attended a short familiarisation course. Furthermore, the course could be adapted to local situations and offered on a daily or weekly basis. Using minimal text and lots of visual material, the course was also relatively easy to translate into other languages and it has now been offered in more than seven countries and in five languages. It is endorsed by BGCI and offered in partner organisations such as the Eden Project and has proved incredibly valuable in capacity building projects as well as an entry level course in horticulture. The CPH has undoubtedly enhanced RBGE's horticultural reputation both at home and abroad.

In addition to horticulture courses RBGE has been offering an MSc in the Biodiversity and Taxonomy of Plants, run in conjunction with the University of Edinburgh, for many years. This course, which is especially popular with overseas students, equips graduates for a career in botanic gardens, universities, government conservation and environment departments and conservation NGO's. The Garden also offers an incredible diversity of schools and further education classes ranging from single days to courses lasting several weeks and aimed at students of all ages and abilities and ranging from well-being and recreational courses through to herbology, botanical art, photography and garden history. All these courses rely on horticulture to some extent for plant specimens, teaching materials and garden space and in this way horticulture underpins education and training at the Garden.



Teaching propagation techniques at Oman Botanic Garden (David Rae)

Conclusion

Attitudes and practices in horticulture at RBGE have changed a lot in the last 40 years and this has been brought about by an understanding that horticulture has an important part to play in conservation, research, education, training and international capacity building, and that horticulturists can work effectively in partnership with others to the benefit of all. This does not diminish the need for botanic gardens to look beautiful and contain interesting plants as it is always important to inspire visitors with the beauty and diversity of plants and this still requires the maintenance of good horticultural standards of cultivation. These factors, in turn, have led to a need for better collections and landscape management to support user groups and a need to disseminate specialist knowledge through publications, capacity building, training, presentations and networking groups. However, just at a time when the value and importance of horticulture in botanic gardens is being realised, it is also important to note that the number of trained botanic garden horticulturists is dwindling due to the decreasing number of students entering horticultural training (Rae, 2013; RHS, 2013), but that is a separate issue.

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The Scottish Government-funded Biodiversity, Taxonomy, Genetics and Ecology of Sub-Arctic Willow project, a collaboration between eight Scottish research institutes, required horticultural skills to collect and cultivate the material, in this case *Salix lanata* (Natacha Frachon)

Collection Policy for the Living Collection. Royal Botanic Garden Edinburgh.

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PLAYING TO OUR STRENGTHS: APPLYING HORTICULTURE AND ADVOCACY TO THREATENED PLANT CONSERVATION

Overlooking the water to the Euphorbia glauca beach habitat

For conservation purposes, the primary strengths of Auckland Botanic Gardens (ABG) are our horticultural expertise and high visitor numbers (~1 million annually). Applying these strengths in partnerships with other agencies has underpinned our conservation efforts for the past 25 years.

Introduction

A BG 'Plant Collections Guidelines' states that our primary conservation goal is to "conserve plant species with a particular emphasis on regionally and nationally threatened NZ native plants through using our resources and horticultural expertise in

relevant partnerships'. This primarily involves growing nationally and regionally threatened plants in cultivated collections for advocacy, education, research and for restoration of wild populations. It includes establishing seed orchards to provide plants for return to the wild, and to produce seeds for long term storage.

Our conservation goals are achieved mainly through *ex situ* collections of threatened NZ native plants. We also hold collections of threatened cultivars, both exotic and native. These collections also underpin our programmes to engage the broader community with the plight of threatened native plant species and generate widespread support for their protection.

Our plant conservation strategy requires the integration of many disciplines. Our expertise in horticulture underpins much of what we do, but environmental education programmes, garden design, marketing and interpretation are important contributors. To raise their profile and promote their use, we use threatened plants with ornamental qualities, such as *Tecomathe speciosa* and *Muehlenbeckia astonii* extensively in



Threatened Native Plant Garden

amenity situations. We have long understood that to harness the resources necessary to meet the challenges faced by threatened plants we must capture the hearts and minds of our community as well as community and political leaders. This is challenging when many NZ threatened native plants lack the beauty of similarly threatened native birds and therefore struggle for equivalent attention and resourcing.

Background

Over the past 25 years ABG has applied horticultural and propagation skills towards many threatened native plants species recovery projects, mainly in partnership with the Department of Conservation (DOC).



In these partnership projects ABG has traditionally undertaken the *ex situ* conservation component, but we also support some habitat-based threatened species recovery projects although this is primarily the responsibility of DOC. Our *ex situ* work involves both cultivating collections and seed banking, and we propagate threatened plant species for *in situ* restoration projects.

ABG is a member of Botanic Gardens Australia NZ (BGANZ), an umbrella group for Australasian botanic gardens. In April 2017 BGANZ signed a memorandum of understanding with DOC that will provide a framework for future cooperation and enable a more strategic approach to threatened plant conservation.

Threatened Native Plant Garden

Our Threatened Native Plant Garden (TNPG) is central to our endeavours to engage visitors with the plight of threatened plants in NZ as it affords visitors an easily accessible opportunity to view threatened plants and understand their stories.

The TNPG contains 17 replica habitats, each of which showcases one threatened plant species. Most New Zealanders are familiar with the chosen habitats that include a beach, wetland, rocky bluffs and a sand dune. The fact that most visitors recognise and have a strong emotional connection to such environments helps overcome the

Emma Bodley collecting Euphorbia glauca seed from the seed orchard

nondescript appearance of many of our threatened plants. Our aim is to transfer the community interest in these special places to the plant species now struggling to survive in them.

Examples include the 'Saltmarsh' habitat where we have highlighted *Tetragonia tetragonioides*, the edible NZ spinach that now rarely grows wild on shell banks and rocky foreshores. The 'Coastal rocky bluff' habitat is home to napuka (*Hebe speciosa*), a popular garden subject that is nationally threatened with very few remaining natural populations. Our 'Offshore island' features *Tecomanthe speciosa* which is common in cultivation but almost extinct in the wild on Three Kings Island. *Euphorbia glauca* can be found in the 'Pebble beach' habitat with other common associates. Once it would have been found on beaches all over Auckland but disappeared long ago.



Flowers of *Clianthus puniceus*

The story of each of the threatened plant species we showcase is told through interpretation that focusses on their plight, their relationships with other organisms such as birds and insects and their importance to plant diversity. We also highlight any medicinal properties or traditional indigenous uses.

To further engage visitor interest, the TNPG contains artworks by leading NZ artists that relate to the stories in this garden. 'Caught in the act of losing you' is a striking representation of the threatened rush *Sporadanthus ferrugineus* that sits within our 'Coastal wetland' habitat. 'Tuna' (a bronze representation of the threatened long finned eel) is located near the 'Wetland' and 'Stream' habitats.

Seed banking

In April 2012 NZ botanic gardens signed a seed banking agreement with The Millennium Seed Bank, and they also have a formal arrangement to supply seed to the New Zealand Indigenous Flora Seed Bank (NZIFSB) in Palmerston North. ABG also has established a long-term seed storage unit as required under the Millennium Seed Bank partnership.

In our experience seed production and collecting seed is much easier in cultivation than in the wild where plants are often difficult to access, particularly on a regular basis. Our agreement with the Millennium Seed Bank requires a



Edible leaves of *Tetragonia tetragonioides* can be added to a salad just like spinach

minimum of 10,000 seeds per collection so there is significant advantage in using botanic gardens for seed production.

Seed sent by ABG to the NZIFSB to date includes *Clianthus puniceus*, *Epilobium hirtigerum*, *E. glauca* and *Pomaderris hamiltonii*.

Clianthus puniceus

The beautiful kakabeak (*C. puniceus*) is widely cultivated in many countries, but only one population remains in the wild. Since 1995 ABG and DOC have collaborated on the recovery of this last known wild population on Moturemu Island in the Kaipara Harbour. Seed was collected in 1995 and the first translocation back to the island took place in 1997. All relevant information from the original collections of kakabeak is held at ABG.

To protect the genetic purity of this nationally critical species, ABG established a seed orchard of *C. puniceus* that continues today. No other forms of *Clianthus puniceus* are cultivated at ABG, and we also avoid the popular *C. maximus*.

With only one plant of *C. puniceus* known in the wild this species has minimal genetic diversity so our seed orchard is suitable for collection. Approximately 17,300 seeds of *C. puniceus* have been supplied by ABG to the NZIFSB to ensure sufficient viable seeds are available for germination testing during their long storage period.

Euphorbia glauca

In the mid 1990's a single plant of the shore splurge (*E. glauca*) was discovered growing on a sheer cliff on Motukorea (also known as Browns Island), just a short boat ride from central Auckland. It is considered extinct on the Auckland mainland, the only other known location being Hauturu, or Little Barrier Island.

The solitary wild *E. glauca* plant on Motukorea did not produce flowers or seeds, but fortunately plants cultivated in our seed orchard produce copious seed that has been used in many restoration projects. The seed orchard is located in the main ABG public carpark so it also connects visitors with the threatened shore splurge when they arrive.

Experimentation has resulted in an effective harvesting practice of picking whole seed heads and placing them string mesh bags to capture seeds when the capsules explode. It has proved



Euphorbia glauca seed orchard in the ABG carpark



Interpretative signage for *Tecomanthe speciosa* highlighting the threats to this plant



Children playing among the *Euphorbia glauca* habitat

much simpler to collect seed from cultivated plants than in the wild as the capsules distribute seeds widely when they explode.

Green mistletoe

Green mistletoe (*Ileostylus micranthus*) is regionally threatened in the Auckland area. A recovery partnership with DOC commenced in 1997 when seed was collected at Miranda in east Auckland. The initial ABG role was producing *Coprosma propinqua* plants for establishment at Miranda as mistletoe host plants. The first of these were planted in 1998. Over several years ABG and DOC successfully established a thriving mistletoe population in the original roadside habitat at Miranda, and

also in a nearby regional park. ABG has undertaken seed dispersal training and supplied mistletoe seed to the University of Auckland for research projects. Mistletoe plants have also been established at ABG, originally on *C. propinqua* hosts but they have since spread to other *Coprosma* species and *Plagianthus divaricatus*. In May 2017 material of *I. micranthus* was collected from a roadside population at Whakatiwai Regional Park in Auckland to re-establish a new population of mistletoe at ABG.

Experimental propagation of annual fern

The *Anogramma leptophylla* recovery project is another example of ABG applying horticultural and propagation skills to cultivate a nationally vulnerable plant species. We are researching the association this small annual fern has with a liverwort that grows with it and exploring techniques for spore containment and capture. In future we aim to restore this species into wild sites.

ABG collected spores in July 2014 from plants growing on the bare vertical south side of an ancient kumara pit on Maungarei (Mt Wellington) in Auckland. Material was collected and cultivated in a tray of sand with two scoria rocks collected from the translocation site set in the sand. We have successfully grown plants to produce spores and population numbers have multiplied.



Tuna sculpture in TNPG

Conclusion

ABG continues to play an important role in plant conservation through utilising our horticultural skills and the opportunity to advocate for threatened plants to a large audience. Our success to date has resulted from carefully prioritising which projects we become involved with, and working collaboratively to optimise threatened plant conservation outcomes.

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When leaving the visitors centre to the gardens are topiary *Muehlenbeckia astonii*, a threatened plant, which is utilised in amenity horticulture

Authors: Ulyana Spirina and Yuri Naumtsev



BRYOPHYTE HORTICULTURE: MYTH OR REALITY?

Part of the display "Secret Garden" with mosses, ferns and horsetails

Introduction

One of the most important goals of botanical gardens is the study and *ex situ* conservation of biodiversity. The creation of modern seed and spore banks is undoubtedly necessary for such conservation work. However, is there any guarantee that the material that has been stored in such banks for several decades will be able to adapt successfully to real environmental conditions in the future?

Changes in the environment can be significant: the atmosphere's composition, the temperature regime, the chemistry of soils and other

Tver State University Botanical Garden has developed cultivation techniques for over 50 species included in its bryophyte collection and has a special display dedicated to these and other spore plants.

substrates are all changed due to the influence of human activity. Where is the guarantee that the material grown from the spores and seeds from these banks will be able to adapt to these new conditions? And how to engage people in the importance of rare species conservation, with only seeds in a seed bank to see?

Another way for rare and endangered species to be conserved is through *ex situ* methods based on horticulture. This allows plants to adapt gradually to environmental changes and, importantly, it allows these plants to be displayed to people in the garden and for stories about plant vulnerability to be told. Growing plants *ex situ* also results in



Plagiommium cuspidatum with sporophytes in the display "Secret Garden"

improved horticultural practices, as gardeners work with plants of various ecological and taxonomic groups. Creation and maintenance of living plant collections is one of the traditional activities of botanical gardens, and it remains no less important today.

Bryophytes are the second most numerous group of land plants, and many of them are threatened. However, people are generally not familiar with them, because mosses are small and do not have bright eye-catching flowers or fruit. This group is highly specialised, rather difficult in horticulture but it can give new opportunities to gardens.

Beyond doubt, gardens bring beauty to our lives; they have an important aesthetic value. The monochrome aesthetics of mosses presents a special case, providing subtly and specialist interest. Moreover, garden designs today often seek to mimic natural ecosystems, and without a moss component, such displays cannot be complete.

Bryophytes also contribute to the education and outreach activities which are so integral to the activities of the

modern botanical garden. Living mosses allow children to get acquainted with the real biodiversity of their region, to see rare species and learn about them.

Cultivating bryophytes

Since 1994, the Botanical Garden of Tver State University has conducted experiments on *ex situ* conservation of rare and endangered plants of the Tver region.

“ In total 46 species of mosses, 4 species of liverworts and 1 species of hornwort have been cultivated since the living bryophyte collection was established in the garden 23 years ago. ”

With regard to bryophytes, initially these were studied extensively in natural ecosystems. The living collection was developed on scientific principles and aimed to determine the possibility of *ex situ* conservation of rare species of mosses and liverworts of Tver region.

Eight bryophytes from the collection are listed in the Red Data Book of Tver Region. All species are brought into the garden as living plants from natural habitats.

In Tver Botanical Garden, developing horticultural techniques for bryophytes follows a number of steps:

1. Preliminary studies of the bryophytes species in their natural habitats in order to understand their ecological preferences and biological characteristics;
2. Definition and choice of habitats allowing plants to be taken for experimentation without endangering the ecosystem or identification of habitats with rare species which will definitely be lost in the short term;
3. Preparation of a place in the garden with artificial substrate most appropriate to the ecological characteristics for the species;
4. Transfer of a fragment of moss turf to the garden and its establishment on artificial substrate;
5. Maintaining and recording the horticultural techniques used and monitoring the plant condition;
6. Estimating the stability of the species *ex situ* and determining the possibility of using it in the displays in the garden.

In order to determine the *ex situ* stability of bryophyte species, an 18-point estimation scale was created (Table 1).



Garden staff at work: weeding in the display "Secret Garden"



Anomodon viticulosus – rare species of Tver region in the display "Gateway to Staritsa"

Criteria	Estimation scale
Artificial vegetative reproduction	1 Species not well established, in most cases perishes at this stage; 2 Species well established (50 % of cases and more); 3 Species always well established.
Growth condition	1 General condition in the garden deteriorates; 2 General condition in the garden is stable, does not change; 3 General condition in the garden improves.
Competitive ability	1 Neighbouring plants substantially oppress the moss species; 2 Character of competitive relations is the same as in natural habitats; 3 Moss species becomes more dominant than in natural habitats.
Horticultural technique	1 Species demands creation of a specific niche environment and the constant control of conditions; 2 Species does not require creation of a specific niche environment, but the regular control of conditions is necessary; 3 Species does not require any special horticultural techniques or environment.
Vegetative proliferation	1 Vegetative proliferation is not observed; 2 Insignificant vegetative proliferation; 3 Active vegetative proliferation.
Sporophyte production	1 Sporophytes are not formed in the garden; 2 Sporophytes form sometimes in the garden; 3 Sporophytes form regularly in the garden.
Total estimation	1-7 Species is not stable in the garden; 8-13 Species in the garden is stable; 14-18 Species in the garden is very stable.

Table 1: Estimation scale to measure ex situ stability of bryophyte species



Encalypta spreptocarpa – rare calcephyllous moss of Tver region in the garden nursery



Fragment of artificial bog in the garden with *Betula nana*, *Malaxis monophyllous*, *Sphagnum* species and ferns: this display imitates an endangered ecosystem of Tver region

Ecological groups

We have identified five ecological groups. These groups are: calciphilous bryophytes; mosses of the basiphil-epiphytic group; species of minerotrophic marshes; mosses that favor habitats with discontinuous vegetation; and ground mosses of forests and meadows. Calciphilous bryophytes and ground mosses are most stable in the garden; bryophytes of minerotrophic marshes are less stable but can also be grown.

“ Growing bryophytes in botanical gardens requires special attention to the needs of these plants. ”

Horticultural techniques have been developed for all 51 species of the bryophyte species included in our living plants collection (estimation scales for all species are provided in Table 2). Alongside rare and endangered bryophytes, we also grow common species representing vulnerable ecological groups. This approach enables us to single out suitable model species that have the same ecological preferences as the rare ones, and to choose the best horticultural techniques.

Initially, the bryophytes were grown in the nursery. Later they were planted out in the garden displays, imitating the natural vegetation of the Tver region. Finally a special display “Secret Garden” dedicated to bryophytes and other spore plants was created.



Garden visitors interested in mosses in the display "Secret Garden"

Horticultural methods

Horticultural methods developed for vascular plants are not generally appropriate for bryophytes. The specific features of moss biology and life cycle need to be taken into account, as well as the fact that bryophytes have no roots. When collecting mosses, the plant material must be taken from natural habitats in large fragments with a layer of the substrate. If not, the appropriate substrate has to be created artificially but closely corresponding to that found in nature.

In our estimation scale (Table 1), we first take into account the possibility of artificial vegetative reproduction by tuft fragmentation. The success of this process essentially affects further horticultural results because all material comes into our collection as living plants.

Our experiments have shown that some bryophytes of the basiphil-epiphytic group can be planted on limestone substrate instead of tree trunks. For example, *Anomodon* species grow well on limestone powder. We are continuing the experiment and testing other basiphil-epiphytic species on carbonate substrates.

Another issue is that accompanying vascular plants become more vigorous and start to suppress the growth of bryophytes when planted into the rich garden soil. For this reason the substrate on which the mosses grow must be isolated from the soil with a layer of sand or non-woven fabric. This technique has proved its efficiency and also reduces weeds.

In the garden we witness changes in bryophyte vitality. Even in nature mosses have low competitive capacity in comparison with vascular plants. Therefore special attention has to be paid to the relationships between mosses and vascular plants. Our experiments have shown that ideal accompanying plants for bryophytes are terrestrial orchids, ferns and club-mosses. It is noticeable that graminaceous plants and *Marchantia* are very competitive with bryophytes and displace them in nearly all cases. In the garden *Cratoneuron filicinum* becomes rather vigorous and suppresses others species from minerotrophic marshes.

In relation to horticultural techniques, the focus needs to be on careful, regular weeding and removal of leaf litter. In the displays, we have not encountered pests and diseases, but there is a need to protect mosses from birds and mammals that mechanically disturb the integrity of the turfs. The species of minerotrophic marshes are the most difficult in horticultural terms, because this group of bryophytes requires a very specific substrate and watering regime. The main concern is an increase of eutrophication of the substrate, which these species do not tolerate.

The species studied in the garden exhibit different levels of vegetative proliferation. Intensive proliferation is

noted in *Anomodon viticulosus* and *Abietinella abietina*. The material obtained from such proliferation has been used for new displays.

Finally, we observe the possibility of sporophyte production. In the garden all acrocarpous mosses constantly produce sporophytes, as in the wild. Pleurocarpous mosses produce sporophytes irregularly, but we have observed sporophytes in *Helodium blandowii* and *Anomodon* species which never produce them in natural habitats in Tver region.

Displaying bryophytes

In 1998 we started the development of the living plant displays and exhibitions devoted to the unique natural vegetation of the Tver region.

The display "Gateway to Staritsa" demonstrates the most interesting fragments of the Volga Valley with its large outcrops and rich and heterogeneous flora. The display contains 25 species of vascular plant and 10 species of bryophytes. Over time, the display has evolved from imitation into natural landscape. Our goal is achieved when visitors refuse to believe that this is a man-made display, which has been systematically maintained for more than 15 years, and it is not a natural fragment of the territory.



Lesson on bryology for schoolchildren in the garden

The display “Flora of Minerotrophic Marshes” demonstrates the rare hydrophytes from the different districts of the region. Not all of them were successfully grown. This means that further work with these groups is needed, rather than indicating the failure of *ex situ* conservation.

The “Secret Garden”

In 2000 we created a special display named "Secret Garden" in which we collected both rare and common bryophytes, ferns, horsetails and club-mosses to introduce spore plants to visitors. The meaning of the display name is that in the world of plants, as well as in the human world, not all is spectacular, and there are things that only become apparent on close inspection.

Special classes and excursions in the garden allow children and adults to learn about the structure, life cycle and ecology of mosses. In modern times, people have lost the integrity of perception and attention to detail. Our "Secret Garden" is trying to return this.

It is a great pleasure to see people changing their customary patterns of observing living organisms: people viewing plants not from the level of the human height, but crouching and sitting down to see better. This display gives people the opportunity to explore the mysteries of spore plants and is a part of a multipurpose project dedicated to studying and conserving bryophytes entitled “Kneel down before the plant!”

Spore plants have considerable aesthetic potential, and this is noticeably different from the beauty of flowering plants. It is difficult to compare the subtle details of monochrome mosses with the splendor of colorful flower beds, but the development of aesthetic taste is of particular importance in the modern world, and it is one of the aims of botanical gardens.

One of the important trends in landscape architecture is "aesthetics with meaning", which is opposed to trivial embellishments. Any display in the garden should bear a semantic meaning, and we invite visitors to reflect on what they see.

Total estimation	Species	Total score
MOSESSES (BRYOPHYTA)		
Species in the garden are very stable (Score 14-18)	<i>Brachythecium salebrosum</i> (Hoffm. ex F. Weber & D. Mohr) Schimp.	16
	<i>Pogonatum dentatum</i> (Menzies ex Brid.) Brid.	16
	<i>Polytrichum strictum</i> Menzies ex Brid.	16
	<i>Anomodon viticulosus</i> (Hedw.) Hook. & Taylor	15
	<i>Bryum argenteum</i> Hedw.	15
	<i>Ceratodon purpureus</i> (Hedw.) Brid.	15
	<i>Plagiomnium cuspidatum</i> (Hedw.) T.J. Kop.	15
	<i>Amblystegium serpens</i> (Hedw.) Schimp.	14
	<i>Anomodon longifolius</i> (Schleich. ex Brid.) Hartm.	14
	<i>Brachythecium rotaeaeum</i> De Not.	14
	<i>Funaria hygrometrica</i> Hedw.	14
	<i>Polytrichum juniperinum</i> Hedw.	14
	<i>Pylaisia polyantha</i> (Hedw.) Schimp.	14
	Species in the garden are stable (Score 8-13)	<i>Abietinella abietina</i> (Hedw.) M. Fleisch.
<i>Calliergon giganteum</i> (Schimp.) Kindb.		13
<i>Climacium dendroides</i> (Hedw.) F. Weber & D. Mohr		13
<i>Encalypta streptocarpa</i> Hedw.		13
<i>Eurhynchium hians</i> (Hedw.) Sande Lac.		13
<i>Leskea polycarpa</i> Hedw.		13
<i>Orthotrichum pumilum</i> Sw.		13
<i>Orthotrichum speciosum</i> Nees		13
<i>Rhytidiadelphus triquetrus</i> (Hedw.) Warnst.		13
<i>Sanionia uncinata</i> (Hedw.) Loeske		13
<i>Seligeria campylopoda</i> Kindb.		13
<i>Barbula unguiculata</i> Hedw.		12
<i>Brachythecium oedipodium</i> (Mitt.) A. Jaeg.		12
<i>Brachythecium populeum</i> (Hedw.) Schimp.		12
<i>Brachythecium rutabulum</i> (Hedw.) Schimp.		12
<i>Bryum caespitium</i> Hedw.		12
<i>Homalia trichomanoides</i> (Hedw.) Schimp.		12
<i>Thuidium philibertii</i> Limpr.		12
<i>Brachythecium albicans</i> (Hedw.) Schimp.		11
<i>Brachythecium mildeanum</i> (Schimp.) Schimp.		11
<i>Brachythecium rivulare</i> Schimp.		11
<i>Calliergonella cuspida</i> (Hedw.) Loeske		11
<i>Campylium chrysophyllum</i> (Brid.) J. Lange		11
<i>Didymodon fallax</i> (Hedw.) R.H. Zander		11

Table 2: Estimation of the horticultural stability of bryophytes in the Botanical Garden of Tver State University



Climacium dendroides in the display “Secret Garden”

Total estimation	Species	Total score
	<i>Didymodon rigidulus</i> Hedw.	11
	<i>Drepanocladus aduncus</i> (Hedw.) Warnst.	11
	<i>Hylocomium splendens</i> (Hedw.) Schimp.	11
	<i>Orthotrichum obtusifolium</i> Brid.	11
	<i>Plagiomnium undulatum</i> (Hedw.) T.J. Kop.	11
	<i>Racomitrium canescens</i> (Hedw.) Brid.	11
	<i>Rhytidiadelphus squarrosus</i> (Hedw.) Warnst.	11
	<i>Sphagnum girgensohnii</i> Russow	11
	<i>Sphagnum squarrosum</i> Crome	11
	<i>Barbula convoluta</i> Hedw.	10
	<i>Campyliadelphus stellatus</i> (Hedw.) Kanda	10
	<i>Cirriphyllum piliferum</i> (Hedw.) Grout	10
	<i>Fissidens taxifolius</i> Hedw.	10
	<i>Leptodictyum humile</i> (P. Beauv.) Ochyra	10
	<i>Leskeella nervosa</i> (Brid.) Loeske	10
	<i>Cratoneuron filicinum</i> (Hedw.) Spruce	8
	<i>Ditrichum flexicaule</i> (Schwaegr.) Hampe	8
	<i>Tomentypnum nitens</i> (Hedw.) Loeske	8
Species in the garden are not stable (Score 1-7)	<i>Bryum schleicheri</i> Schwaegr.	7
	<i>Helodium blandowii</i> (F. Weber & D. Mohr) Warnst.	7
	<i>Meesia triquetra</i> (L. ex Jolycl.) Aongstr.	7
	<i>Paludella squarrosa</i> (Hedw.) Brid.	7
	<i>Philonotis fontana</i> (Hedw.) Brid.	7
	<i>Pseudocalliergon trifarium</i> (F. Weber & D. Mohr) Loeske	7
	<i>Scorpidium cossonii</i> (Schimp.) Hedenaes	7
	<i>Scorpidium scorpioides</i> (Hedw.) Limpr.	7
LIVERWORTS (MARCHANTIOPHYTA)		
Species in the garden are stable	<i>Preissia quadrata</i> (Scop.) Nees	12
	<i>Plagiochila porelloides</i> (Torr. ex Nees) Shust.	9
Species in the garden are not stable	<i>Barbilophozia hatcheri</i> (A. Evans) Loeske	7
	<i>Mesoptychia badensis</i> (Gottsche) L. Söderstr. & Váňa	7
HORNWORTS (ANTHOCEROTOPHYTA)		
Species in the garden are not stable	<i>Anthoceros agrestis</i> Paton	7



Plagiomnium undulatum in the display "Secret Garden"

Bryophytes and vascular spore plants in the garden in this case could be a model object, especially because of the specific structure and functioning of these plants that requires one not only to see, but to analyze and reflect.

Conclusions

The conservation and cultivation of bryophytes allows the botanical garden to carry out the following activities at a new higher level:

1. To implement programs of *ex situ* conservation for rare species from the regional flora;
2. To conduct scientific research on biology, ecology and taxonomy;
3. To conduct school and university training in biological, environmental sciences and in landscape design using live material of all taxonomic and ecological groups of biodiversity of the region;
4. To acquaint garden visitors with the biologically and aesthetically unique originality of the region's flora, to demonstrate fully-fledged displays and to influence aesthetic taste;
5. To use investment funds for the implementation of multipurpose projects.

We would like to emphasize that, through having a living bryophyte collection in Tver Botanical Garden, we are able to combine scientific experiments on *ex situ* conservation and *in situ* studies of bryophytes with educational and outreach work. The mission of our garden is to open the world of plants for visitors and to promote harmonious relations between man and nature and this could not be carried out completely without our work on bryophytes.

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HORTICULTURE AND THE CONSERVATION OF THREATENED SPECIES

The conservation of threatened plants in *ex situ* collections is a key feature of the work of botanic gardens the world over. Such conservation work is increasingly important as the threats to species survival *in situ* increase, and is only possible thanks to the specialist skills of conservation horticulturists.

The following three case studies provide examples of how horticultural skills are being used: (i) to ensure the survival of succulent plants in botanic gardens around the world; (ii) to address threats to the native flora in Chile; and (iii) to allow the restoration of critically endangered ferns in Hawaii.

Countless similar examples exist throughout the botanic garden community – but they frequently go un-recorded and the specialist horticultural skills involved are not recognised.

A recommendation from BGCI's recent Technical Report is:

“Botanic gardens should value and measure their horticultural specialisms at the institutional level.The unique plants and plant assemblages that a garden grows define that botanic garden.”

CASE STUDY 1: SUCCULENT PLANT COLLECTIONS IN BOTANIC GARDENS SUPPORTING *EX SITU* CONSERVATION AND RESEARCH

Authors: Olwen M. Grace and Lucas C. Majure

Collections of succulent plants are a regular feature of the horticultural displays in botanic gardens. Water-storing tissues in the plant body – the defining feature of succulence – sustain metabolism under drought conditions, and are common to a variety of plants that are taxonomically distributed throughout the angiosperm tree of life, and occur throughout the world. The most diverse of these groups include the cacti (Cactaceae: 139 genera/ 1,860 species), ice plants (Aizoaceae: 125 genera/ 2,000 species) and succulent euphorbs (Euphorbioideae: 39 genera/ 2,800 species). In the botanical garden, succulent plants provide a striking feature, but even a modest display of one or two succulent plants can effectively illustrate the diversity of the plant kingdom and the adaptations of plants to desert environments.

Beyond the horticultural display, curated living collections in botanical gardens are vital for the *ex situ* conservation of succulent plants. Succulent plants are, typically, narrowly distributed with high rates of endemism and specialised habitat requirements, making them challenging horticultural subjects. Closely curated collections such as those of the Royal Botanic Gardens, Kew (e.g. 650 accessions of *Aloe*, approximately 70% from wild populations, representing about 60% of all taxa) and the Desert Botanic Garden (more than 13,000 accessions of Cactaceae, mostly from wild populations, including the largest collection of subfamily Opuntioideae 96%) are valuable for conservation and research (Hultine *et al.*, 2016), because the horticultural expertise ensures they are well curated and accessible.



Aloe polyphylla, the national flower of Lesotho, on display at RBG, Kew. The species is endangered in the wild but increasingly common in cultivation (O.M. Grace)



Succulent plant collections at the Desert Botanic Gardens, where the majority of accessions are from natural populations (L.C. Majure)

Conservation assessments (e.g. IUCN Red List) indicate grave threats to global succulent plant diversity, while trade regulations such as CITES that apply to all species in some succulent plant groups, highlight the taxonomic complexities of species-level identification. The first comprehensive assessment of the *ex situ* conservation of succulent plants (Oldfield, 1997) revealed that only a few well-documented collections in botanical gardens could be quantified, while a subsequent analysis of BGCI records for Cactaceae showed that the most endangered species were absent from botanical garden collections (Oldfield and Hunt, 2010). This implies a worrying vacuum in which very rare taxa are not adequately conserved *ex situ*. The status of succulent plant collections and an assessment of genetic diversity of those collections is now a priority, to guide botanical garden acquisition targets and plant collecting programmes that will compliment *in situ* conservation measures.

The value of living collections in botanical gardens depends upon horticultural expertise to maintain healthy, well-curated collections. Paradoxically, ornamental horticulture is also the driver of an unsustainable demand for succulent plants and seldom results in equitable benefit being shared with the people who have sovereign ownership of the plants in the wild (Grace, 2011). For example, *Aloe*

polyphylla, a species endemic to Lesotho, was once very valuable to collectors due to its rarity, but it is now commonly available, due to the development of micropropagation methods. Movement of the species is restricted by CITES Appendix 1, in recognition of the demand for material and threats to natural populations. The genetic diversity of *Aloe polyphylla* in *ex situ* collections is currently unknown.

Succulent plants are increasingly popular for water-wise gardening and landscaping in arid environments, and have been recognised for their potential as future sources of green energy. As these plants assume greater value for managing the effects of environmental change, well-curated collections in botanic gardens will become increasingly important to conserve the diversity of these exceptional drought-prone plants.

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Controlled pollination of *Aloe polyphylla* at RBG, Kew (O.M. Grace)

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CASE STUDY 2: PROJECT CHAGUAL BOTANIC GARDEN, CHALLENGES AND RESULTS IN THE DEVELOPMENT OF REPRESENTATIVE COLLECTIONS OF THE CHILEAN MEDITERRANEAN ECOREGION

Puya venusta collection at Chagual Botanic Garden, Santiago de Chile (M. Victoria Legassa)

Authors: M. Victoria Legassa, Daniela Escobar and Ángel Cabello



Lardizabala biternata, Lardizabalaceae (Daniela Escobar).

The ecosystems of the Mediterranean ecoregion in Chile (33-38°) host a large percentage of flora growing in situations of high vulnerability. In these ecosystems there are a total of 3,160 taxa, of which 52% are endemic to the country and 30% are exclusively endemic to the region (Arroyo *et al.*, 2003), making this a biodiversity hotspot of global importance. In spite of this, these plants have limited representation in the national protected areas system (SNASPE).

The most vulnerable ecosystems are those regions such as Coquimbo, El Maule and the Metropolitan area, with less than 1% of its territory under protection (Sierralta *et al.*, 2011). Until the end of the last century, such low representation was also reflected in the limited information published on phenology, types of seed dormancy and cultivation requirements for most of these species. Additionally, as can be seen from the forest plantations, parks, private gardens and public spaces of our cities, nurseries for forest and ornamental plants have not shown any interest in cultivating, introducing or making known native and endemic plants from these ecoregions.

Within this context, and in accordance with its mission to promote the development of a culture valuing the natural heritage of the Mediterranean climate area through *ex situ* conservation of its flora, Chagual Botanic Garden has undertaken several initiatives to establish practices and procedures for the genetic conservation of target species, integrating conservation and display collections. Among these collections are vulnerable endemic species and species in conservation categories, including Bromeliads; communities of sclerophyll forests - *Beilschmiedia miersii*-*Cryptocarya alba*, *Cryptocarya alba*-*Peumus boldus*, *Lithraea caustica*-*Quillaja saponaria*-*Jubaea chilensis*; deciduous trees *Nothofagus*

macrocarpa, and *N. obliqua*-*N. glauca*-*N. alessandrii*; the subandean *Kageneckia angustifolia* and *Austrocedrus chilensis*; the thorny *Acacia caven* and *Prosopis chilensis*; and shrubs from Ecuadorian slopes.

For each of the collections, different and specific places for collecting seeds were identified and guidelines and criteria were established for obtaining, handling and maintaining seeds and plants.

The search for propagation methods for native species is of vital importance for their conservation, particularly seed



Myrcianthes coquimbensis, Myrtaceae (M. Victoria Legassa).

propagation which allows the genetic variability of the specimens obtained to be preserved. Taking particular care of this genetic variability, seed collection has been carried out following the recommendations included in INIA's and Kew's manual for seed from native species (Gold *et al.*, 2004). Data on the specimens and collection sites are registered on cards which include: collection place and date, scientific name, common name, botanic family, latitude, longitude, altitude, the surrounding habitat and vegetation, and the collector's identity.

Over more than a decade, Chagual Botanic Garden has been working with all types of plants from the Mediterranean zone of Chile - some 292 species, of which 242 are endemic and 50 are native.

The seed laboratory which has been set up has allowed us to obtain information on physical parameters such as purity, number of seeds per kilogram and their viability. Germination pre-treatments have been applied to increase the speed and germination capacity of seeds, through which a significant number of specimens were obtained.

Out of the 82 species from the Mediterranean ecoregion presently classified as under some threat, the following 19 have been studied at BG Chagual's laboratory and publications have been produced: *Alstroemeria garaventae*, *A. spathulata*, *Austrocedrus chilensis*, *Austrocactus spiniflorus*, *Avellanita bustillosi*, *Beilschmiedia berteriana*, *B. miersii*, *Jubaea chilensis*, *Kageneckia angustifolia*, *Menodora linoidea*, *Myrceugenia rufa*, *Nothofagus alessandrii*, *N. glauca*, *N. macrocarpa*, *Phyllocactus curvispinus*, *Porlieria chilensis*, *Puya venusta*, *Rhodophiala tiltensis* and *Tarasa umbellata*.



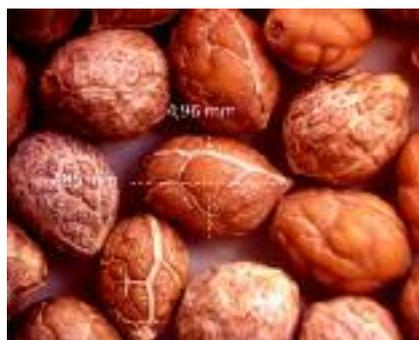
Menodora linoidea, Oleaceae (left) and *Peumus boldus*, Monimiaceae (right) (Natalia Smith).

Where the collection of seeds is challenging, be it due to massive attacks by insects, high degree of non-viable seeds, or the small number of mother plants, vegetative propagation has been tried - by bulbs (*Rhodophiala tiltensis*), by cuttings (*Avellanita bustillosi*, *Myrceugenia rufa*), or through *in vitro* culture (*Alstroemeria garaventae*, *A. spathulata*, *Avellanita bustillosi*).

97 species (85 endemic and 12 native) are maintained in the nursery, of which 29 are classified in some category of conservation; these last plants in turn come from samples taken from 39 different sites, such as: *Austrocedrus chilensis* (2), *Beilschmiedia berteriana* (2), *B. miersii* (4), *Calydorea xyphioides* (1), *Jubaea chilensis* (4), *Menodora linoidea* (1), *Monttea chilensis* (1), *Myrceugenia rufa* (2), *Myrcianthes coquimbensis* (2), *Nothofagus glauca* (1), *Pouteria splendens* (1), *Porlieria chilensis* (1), *Prosopis chilensis* (4), *Puya boliviensis* (1), *Puya venusta* (2) and *Tarasa umbellata* (1).

On the other hand, plantations have been created from collections of the sclerophyll communities *Lithraea caustica*-*Quillaja saponaria*, which include *Jubaea chilensis* from two clusters of palms, Cocalán y Ocoa and *Beilschmiedia miersii*-*Cryptocarya alba* among which specimens of *B. miersii* stand out, coming from three different places of origin.

Information gathered at collection sites and through laboratory analysis, as well as that obtained from observations on sowing, germination, cultivation and horticultural practices, are integrated with each registered accession. In addition, an inventory is being kept to allow the follow-up of these collections at the nursery as well as those plants



Calydorea xyphioides, Iridaceae (M. Victoria Legassa).

already established in the garden at places shown in the Master Plan. Results obtained from the species studied under Project BG Chagual have resulted in 19 publications in scientific outreach journals or book chapters.

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CASE STUDY 3: RESTORING CRITICALLY ENDANGERED FERN SPECIES

Author: Ruth Agurauja

Introduction

As a result of long-term research at Tallinn Botanic Garden (TBG), Estonia (R. Agurauja, since 1999), *ex situ* propagated plants of three globally critically endangered endemic fern species *Asplenium dielpallidum* N. Snow, *Asplenium dielmannii* Viane and *Asplenium diellaciniatum* Viane have been propagated and returned to their country of origin – Kauai island in Hawaii in 2015. All three federally listed species (Endangered Species Act) are extremely endangered (less than 50 extant mature individuals) due to their very small populations and very local distribution. Their natural habitats are heavily disturbed and natural recruitment is very slow in these conditions, the extinction rate of individuals of *A. dielpallidum* being about three times higher than establishment of new individuals (Agurauja, unpublished data).



Gametophyte cultures being soaked in distilled water for few minutes before replanting into new trays

Propagation at Tallinn Botanic Garden

Germination tests at Tallinn Botanic Garden (TBG) were initiated in 2011. There was no preliminary evidence about any other type of sporophyte production than sexual for this group of ferns (Wagner 1952). Single individual gametophyte cultures never showed any sporophyte formation, which indicated that these species were obligatory out-crossers.

Spores were collected from all currently known populations of the study species. The number of reproductive individuals was smallest for *A. dielpallidum*, therefore the spores from different individuals from different locations were mixed for cultures. For *A. dielmannii* only a single population is currently known, the spores of its different individuals were combined per sowings. More numerous but morphologically variable *A. diellaciniatum* was handled as consisting of three local (sub-) populations, and these were kept separate during germination tests.

The spores were sown on moist neutral soil substrate in covered phytatrays (SIGMA CellCulture P 1662). The cultures were grown under fluorescent light (OSRAM L 30W/77) on a 16-h light, 8-h dark cycle at 22–24 C. The germination and gametophyte growth were examined weekly by dissecting microscope (Leica S4E).

Left above: Ferns re-potted at NTB
Left: Un-packing ferns after successful arrival at NTB

Average germination rates varied from 30 to 35 days. The growth and development of the gametophytes was much slower. Full maturity of gametophytes was reached 3.5 to 4 months after the sowing. As the gametophyte growth extended over the months and years, the trays became densely filled and the gametophytes were replanted repeatedly. Thus an *ex situ* collection of gametophyte cultures was established at TBG.

Replanting of gametophytes was a delicate task conducted with the help of stereomicroscopes using dissecting needles and tweezers. The gametophytes were soaked in distilled water for a few minutes before replanting into new trays. Fern gametophytes produce motile sperm and for sexual reproduction they are totally dependent on the availability of free water. Soaking them, in addition to the misting of the trays helped to speed up the formation of sporelings.

Tests demonstrated that older gametophytes remained capable of vegetative and regenerative growth. Gametophyte cultures could therefore serve well for preserving the gene pool for *ex situ* research and propagation for restoration, particularly for species which have short and non-branching rhizomes with a single apical meristem.

The full cycle from the spore to mature spore-producing individuals took 4–5 years in cultivation.





Gametophyte culture of Asplenium dielpallidum at TBG

Translocation from TBG in Estonia to NTBG in Hawaii, United States of America

The route of the ferns propagated in Estonia was as follows: Tallinn Botanic Garden Estonia → National Tropical Botanical Garden (NTBG), Kauai → Kauai Mesic Elevation Nursery in Kokee → natural habitat within their natural distribution area.

As there was no guarantee that the ferns would survive long travel flights across the world, it was decided to send out the plants in all different life stages – gametophytes, young sporophytes and mature individuals. Full documentation of the plant material was conducted, including collecting DNA and spore samples and mounting voucher specimens for TBG and NTBG.

All living plant material had a phytosanitary check upon departure from Estonia and also on entering the country of origin. As the ferns were grown on soil substrate, the soil had to be replaced with certified substrate. The soil was removed by washing the roots in a flow of purified water. Cleaned roots were covered with a mix of hydrogel and vermiculate, wrapped in thin shade cloth. For protecting the rhizome and fronds from occasional damage during transport, the plants were placed in Tetra Pak cartons and packed tightly into sealed thermoboxes.

The first three thermoboxes with plants were carried as checked luggage with Hawaii State Botanist Dr. Margaret Sprock-Koehler, because this was the quickest way to get them back to Kauai. The condition of the plants was unexpectedly good upon arrival. The rest of the ferns travelled to Kauai as airfreight deliveries by Fedex.

Altogether 13 thermoboxes with 1,790 specimens reached Kauai (*Asplenium dielpallidum* – 848 specimens, *Asplenium dielmannii* – 465 specimens, *Asplenium diellaciniatum* – 477 specimens) together with 90 units of gametophyte cultures.

The ferns were replanted into pots at NTBG and later relocated to Kauai Mesic Elevation Nursery in Kokee for further acclimatization to the local climate.

Planting out and first-year survival rates

Planting in the natural habitat began in 2016 and continued in 2017. Altogether 276 individuals have so far been planted in natural habitats in four locations within fenced enclosures:

Asplenium dielpallidum – 143 individuals in two locations in Kuia Natural Area Reserve, survival 91.6% after the first year in the habitat.



Dr. Margaret Sprock-Koehler (Statewide Botanist of Hawaii) with the first fern delivery



Leena Horma weeding out contaminating mosses from gametophyte cultures.

Asplenium dielmannii – 114 individuals in one location, in Na Pali Kona Reserve, 96.5 % alive after the first year in the habitat.

Asplenium diellaciniatum – 19 individuals in one location, in Na Pali Kona Reserve, all alive after the first year in new location.

Partners

The return of the ferns to Kauai was made possible thanks to international cooperation and the joint efforts of several institutions - Tallinn Botanic Garden, National Tropical Botanical Garden (NTBG), Plant Extinction Prevention Program (PEPP), University of Hawaii Department of Botany, Division of Forestry and Wildlife Department of Land and Natural Resources (DOFAW-DLNR) State of Hawaii, United States Fish and Wildlife Service (USFWS).

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CAREER LADDER FOR HORTICULTURISTS IN THE SOUTH AFRICAN NATIONAL BIODIVERSITY INSTITUTE (SANBI) “HORT LADDER”



Anthony Hitchcock inspecting *Erica verticillata* restored to Rondevlei (Adam Harrower)

The career ladder for horticulturists follows a multi-dimensional approach and is aimed at recognizing, attracting, retaining and developing horticulture and horticulturists in botanical gardens, to fulfil SANBI’s mandate.

Introduction

In the South African National Biodiversity Institute’s (SANBI) nationwide network of national botanical gardens, horticulturists, and the work they do, are varied. They can be highly specialised in a particular area, but most often, they are multi-disciplinarians. SANBI’s horticulturists are unique in their work, with a mandate

specialising in indigenous plants. Key broad focus areas for their work are horticultural research and development, conservation, garden management and public information management. As in other professional fields, they also manage resources and human capital.

Horticulturists in SANBI are qualified professionals responsible primarily for the development, maintenance and

curation of living plant collections to support or drive research, education and conservation, generating knowledge and disseminating it in various ways, including public talks, and publishing in popular and/or peer-reviewed journals. To be eligible for consideration under the ‘Hort Ladder’ a horticulturist must perform a minimum of 60% of their duties in horticultural pursuits.

A horticultural pursuit concerns itself with plants or landscape management associated with botanic garden management and development, including such activities as:

- living collections curation;
- *ex situ* and *in situ* conservation;
- taxonomy;
- developing/utilising techniques and protocols to grow a diverse range of plant species;
- education and communication on the importance of conserving plants and how to grow or use them reaching a diverse audience;
- landscaping to achieve public displays;



Mashudu Nndanduleni hand pollinating *Serruria florida* in the motherstock for threatened species (Vuyani Nqumla)

- sustainable development of plants linked to people's well-being;
- conserving indigenous or local knowledge, research and development.

Although horticulture in SANBI's national botanical gardens is a specialized and core profession, its growth and development has been limited by a lack of a career pathing and development. To address this, a career ladder for horticulturists was launched by SANBI in 2015/16 to recognise, attract, retain and develop horticulture and horticulturists.

The Career ladder

Objectives

- To develop a clear progression and career path for horticulturists within SANBI.
- To standardize performance and management tools for horticulturists.
- To advance horticultural science to benefit SANBI's mandate.
- To encourage, recognize and reward specialization in horticulture within SANBI.
- To encourage academic advancement in horticulture.
- To attract, develop and retain horticultural skills in the Institute.

The career ladder applies to both permanent and fixed-term contract horticultural staff.

Rungs and requirements

The career ladder for horticulturists in SANBI has eight rungs. The rungs are:

Rung 1: Candidate Horticulturist – works under close supervision.

Rung 2: Horticulturist 1 – works under some supervision but shows ability to become more independent.

Rung 3: Horticulturist 2 – works independently and starting to develop their record of accomplishments hereafter referred to as track record.

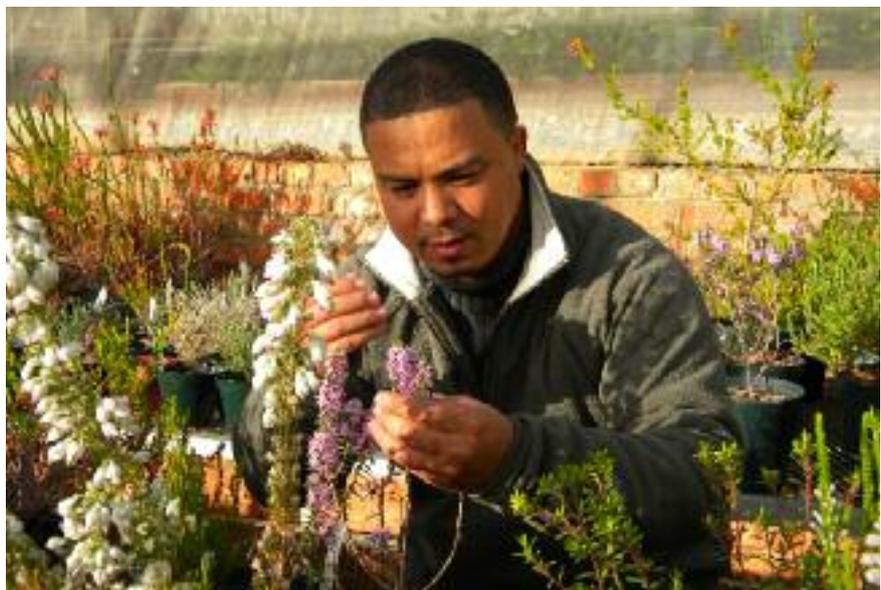
Rung 4: Senior Horticulturist 1 – starting to establish their track record locally.

Rung 5: Senior Horticulturist 2 – locally established, and starting to establish their track record regionally.

Rung 6: Principal Horticulturist 1 – regionally established track record with considerable and increasing recognition as a leader, leads projects in SANBI with a team of national collaborators.



*Dineo Dibakwane collecting *Athanasia grandiceps* seeds in the Drakensberg (Sthembile Zondi)*



Roger Oliver inspecting buchu at Kirstenbosch (SANBI collection)

Rung 7: Principal Horticulturist 2 – nationally established track record with considerable and increasing recognition as a leader, leads projects in SANBI with a team of national collaborators.

Rung 8: Chief Horticulturist – highly recognised at national and international level. Leads teams of collaborating horticulturists or professionals, inside and outside the Institute, which includes internationally based members.

Career ladder criteria

The career ladder is based on a series of inputs and outputs that describe and measure the skills and experience required to fulfil different rungs on the

career ladder. Inputs can loosely be defined as what an individual brings to the job, in terms of their learnt skills and experience. Outputs are the measurable deliverables of the job and for which evidence of achievement can be provided.

- **Input:** quantifiable measure of capability based on qualification, experience and leadership
- **Output:** quantifiable measure of productivity identified as relevant to a specific profession

Capability indicators have been defined to help in the measurement of individuals' suitability to a specific rung.



*Mashudu Nndanduleni monitoring and doing inventory of *Leucadendron argenteum* (Silver tree) at Cecilia Forest (Chamell Plum)*



Bathabile Ndlovu plant collection Midlands (Dineo Dibakwane)



*Bathabile Ndlovu pruning *Plectranthus saccatus* (Philisiwe Sibiyi)*

Each input and output is weighted and contributes to an overall score. A horticulturist's position on the ladder is established by determining the weighted sum of levels of competency regarding Inputs and Outputs. Expectations are cumulative, and at each rung, additional achievements are added to those of the rung immediately below.

The inputs for evaluation are:

- **Input 1: Required qualifications**
This Input refers to appropriate academic or professional qualifications needed to perform horticultural duties to achieve the required levels of acceptance by peers, stakeholders and clients nationally and internationally at different levels of a horticulturist career ladder.

- **Input 2: Relevant working experience**

The appropriate working experience will specifically be related to botanical garden management and horticulture needed to successfully perform horticultural duties e.g. garden maintenance operations, garden development, the support of human capital development, curation of living collections and specialised botanical garden services to the Institute.

- **Input 3: Strategic horticultural leadership**

Strategic horticultural leadership refers to skilled-based leadership complemented by the proven ability to develop and implement horticultural strategies in horticultural subject areas and/or areas of competency. Strategic horticultural leadership has an impact at a local, regional, national and international level.

The outputs for evaluation are:

- **Output 1: Horticultural research and development**

Horticultural research and any conservation research and restoration must be guided and undertaken according to scientific research methodology principles and policy. Knowledge dissemination involves reporting on the results of research in a number of different ways. It includes publication of peer-reviewed papers in scientific journals, books, popular

articles, web-based articles, public or institutional lectures, debates and panels, and information leaflets. These are used to engage not only with the scientific community, but also with users of research outputs, including a range of end-users and policy-makers and ultimately interested members of the public. The emphasis should be on recent achievements, and for this purpose, the incumbent's track record over the past seven (7) years is used when determining appropriate levels. Requirements for this output include the ability to undertake scientific horticultural research and the ability to communicate research results and outcomes.

- **Output 2: Human capital development**

Human capital development is the ongoing development of self, staff, work-integrated learning (WIL) students, post-graduate students and interns through coaching (skills development), mentoring, work assignments, structured training and appropriate supervision in order to maximise human potential, in line with the needs of the Institute.

Requirements for this output include: the ability to transfer skills and knowledge, the drive for self-development, the ability to be an affective mentor, and to deliver formal and informal training.



Monique McQuillan restoring Erica verticillata, extinct in the wild, to Kenilworth Racecourse Conservation Area (Anthony Hitchcock)

• Output 3: Curation of living collections

Living collections require dedicated, skilled staff to develop and grow them into useful assets of the Institute and the country. Competent individuals are crucial to the success of any living collection. Requirements for this output include skills related to ensuring the viability and genetic integrity of the collection, to managing a range of species, to ensuring accuracy of complex data recording, to conducting field collecting and to identify and set living collection norms and standards.

• Output 4: Horticultural maintenance and development

Horticultural maintenance includes all aspects of daily operational processes and development of botanical gardens, associated nurseries, and the need for planning to meet the mandate of SANBI. Requirements for this output include the ability to develop and implement horticultural maintenance processes, the ability to plan long and short term targets for horticultural development, and the ability to align strategic Garden Development Plans to meet expectations and align them to the botanical garden's vision.

• Output 5: Plant conservation and collaboration

Collaboration through engaging stakeholders or partners internally or externally is an integral part of SANBI's mandate in fulfilling its mission and reaching its objectives. Collaborations may entail a simple project with two or three role players or a complex project with multiple stakeholder organisations and

individuals entailing several and more involved facets. Collaborations and partnerships should first benefit the particular garden where the incumbent is based, but may later lead to national, network-wide and international benefits for all stakeholders. Requirements for this output include the ability to harness unique expertise or capabilities for mutual benefit, establishing or strengthening co-operative linkages and thereby increasing productivity, avoiding "re-inventing the wheel" to reach inter-related goals quicker, and gaining support and mitigating risks.

Applying the Hort Ladder

Horticulturists are assessed according to the level of competence displayed for each of the three inputs and five outputs. Value points are assigned for the appropriate level of competence in each area and then added to give an overall score, which is then used to determine the appropriate placement on the career ladder. It is important to note that horticulturists can be assessed as being at different levels for different inputs or outputs (e.g. a horticulturist can be at level 3 for Output 1, but level 5 for Output 5).

An illustration of the application of the Hort Ladder is provided for a horticulturist submitting a 'portfolio of evidence' as follows:

Input 1 – Required qualifications: Completed NQF (National Qualification Framework) level 7 qualification in relevant discipline. (e.g. BTech or Advanced Diploma, or any qualification deemed to be equivalent by the South African Qualifications Authority, SAQA). Equates to level 4 = 40 points.

Input 2 – Relevant working experience: 5-6 years working experience in horticultural field. Equates to level 5 = 80 points.

Input 3 – Strategic horticultural leadership: Provides strategic horticultural leadership within subject areas locally. Equates to level 4 = 40 points.

Capability indicator:

- Evidence of independent development of components of strategy in subject areas within a garden. May include composition of sections of written strategy, review or analysis of past trends or current situation (1 over 7 years).

Output 1: Horticultural research and development
Conducts horticultural research and writes popular articles independently. Equates to level 4 = 40 points.

Capability indicators:

- Takes responsibility for designing and completing horticultural experiments.



South Africa's Millennium Seed Bank Partnership team harvesting seed from the threatened succulent Frithia humilis (Mesembryanthemaceae) at a coal mining site in Mpumalanga, South Africa (Erich Van Wyk)



Sthembile Zondi experimenting with Protea seeds (Dineo Dibakwane)

- Evidence of acceptance for publication of 2 popular articles per year (14 over 7 years).
- Presents research findings, done under supervision at local conferences or professional forums; 2 over 7 years worked (either poster or oral presentation).
- Evidence of acceptance for publication of 1 co-authored peer-reviewed publication over 7 years.

Output 2: Human capital development

Focuses on developing own skills and shows ability toward the coaching and mentoring of ground staff and students. Equates to level 3 = 20 points.

Capability indicators:

- Evidence of self-development by means of an achieved career development plan.
- Evidence of 2 ground staff and 3 WIL students development over 7 years worked.

Output 3: Curation of living collections

Curates basic living collection(s) independently (a basic collection requires less specialist understanding and may have limited taxonomical challenges, be easier to propagate, cultivate and or acquire than a complex collection). Equates to level 4 = 40 points.

Capability indicators:

- Annual work plan reflects independent curation of basic living plant collection(s).

- The submitted and reviewed curation plan/continuance plan accurately reflects the collections, which is evident in the Garden State of the Collections review every three years.
- Fieldwork conducted introduces new appropriate accessions, independently.
- Accurate collection records are inventoried and submitted to the garden Plant Recording offices every 1-3 years.

Output 4: Horticultural maintenance and development

Independently develops and implements complex maintenance and basic development plans. Contributes to the NBG Garden Development Plan and implements section development. Equates to level 5 = 80 points.

Capability indicators:

- Evidence of independently developed and reviewed complex maintenance plans and submitted annually.
- Evidence of horticultural norms and standards developed and are included in maintenance plans.
- Evidence of contributions to individual Garden Development Plan.
- Evidence of section development plans and can provide long term (greater than 5 years) plans.

Output 5: Plant conservation and collaboration

Runs multiple complex plant conservation projects through internal and external collaborative engagements and provides input into the development of SANBI's regional conservation plans. Equates to level 6 = 120 points.

Capability indicators:

- Evidence of successfully leading and coordinating, multiple, concurrent complex projects that engaged multiple stakeholders.
- A record of at least 2 regionally completed complex projects over a period of 7 years worked.
- Produces quarterly progress reports on current regional collaborative initiatives (e.g. the implementation of a number of regional plant conservation/restoration programmes).

In the above example, the overall score for both inputs (160) and outputs (300) combined = 460 points, which would indicate the incumbent should be placed

on Rung 4 of the Career ladder and would equate to Salary level 9: Senior Horticulturist 1.

Evaluation process

At regular intervals (the standard being every three years), horticulturists are required to submit a portfolio of evidence, based on the three inputs and all five outputs, using evidence from the previous seven-year period only. This portfolio is assessed by a SANBI-appointed Moderation Panel. Horticulturists are required to show consistent satisfactory performance in order to progress to the next rung of the ladder.

Career Development Plans

These are developed to outline the milestones required for horticulturists to progress to the next rung of the ladder and cover a 3-5 year period. Career Development Plans are translated on an annual basis into the work plan of the horticulturists and also link with their Personal Development Plans.

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The MSBP staff targeting endemic Watsonia umtamvunense for seed collecting at Umtamvuna Nature Reserve in Pondoland

From Idea to Realisation

BGCI's Manual on Planning, Developing and Managing Botanic Gardens

4 Parts - 8 Chapters

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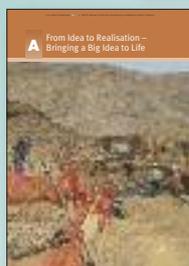
Botanic Gardens Conservation International



The manual is intended for botanic gardens and arboreta as ever-evolving institutions that respond to environmental and societal needs, changes and challenges.

It is not meant to be prescriptive but to offer guidance and ideas with case studies from around the world. As a comprehensive resource, the guidance provided aims at newly developing institutions with limited experience as well as at established botanic gardens that may seek advice or information for instance as part of a re-development or an organisational review.

The manual is organised in 4 main parts and 8 chapters.



Part A: From Idea to Realisation – Bringing a Big Idea to Life

This section is primarily aimed at stakeholders who wish to create a new botanic garden or substantially modify an existing garden. It covers the process involved in transforming the idea of a botanic garden into reality with all of the planning, building and development in between.

Chapter 1: Planning and Implementing Botanic Garden Design Projects



Part B: Organisational and Operational Essentials

This section sets out the governance models, processes, human resources and financial mechanisms required to operate a botanic garden.

Chapter 2: Governance Models, Human and Financial Resources Development



Part C: The Plant Collection – Linchpin of the Botanic Garden

This section discusses the plant collection that the botanic garden is built around. Topics include the development of a collection policy; collection record management systems; horticultural management; and uses of the collection.

Chapter 3: No Plant Collection without a Strategy or Policy

Chapter 4: The Plant Collection in the International Policy Context

Chapter 5: Collection Record Management Systems

Chapter 6: Horticultural Management

Chapter 7: Using the Plant Collection – Research, Conservation, Education, Public Engagement, Recreation and Tourism

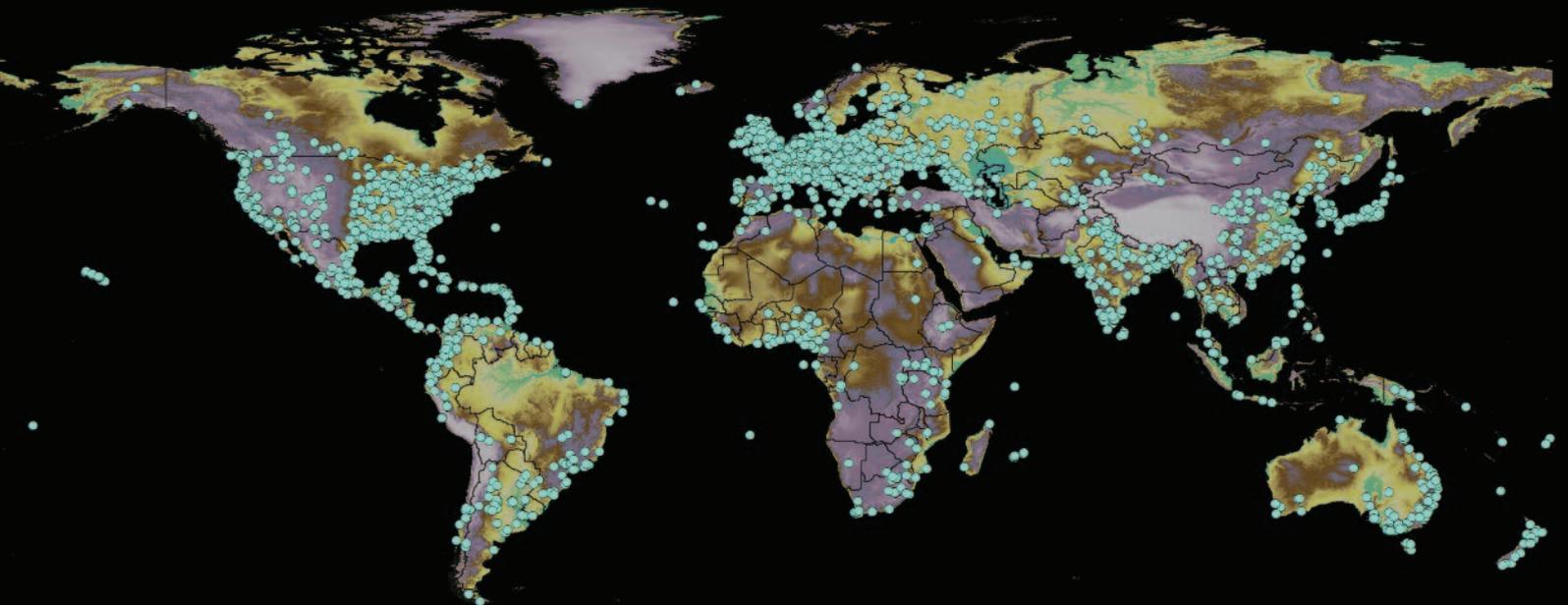


Part D: Botanic Gardens as Models of Environmental Sustainability

This section sets out how botanic gardens around the world are addressing sustainability challenges such as energy, water and recycling.

Chapter 8: Managing Environmental Sustainability

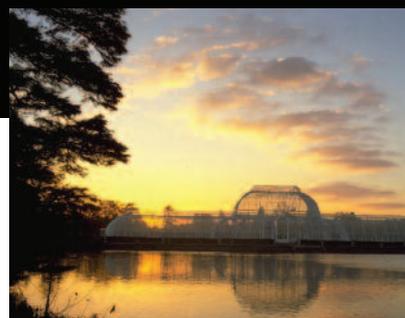
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BGCI's directory of botanic gardens, GardenSearch, lists 2,500 botanic gardens that conserve a third of known plant diversity and attract 500 million visitors a year.

BGCI is a leadership and catalyst organisation that works to promote botanic gardens as a professional community, share knowledge and skills and mobilise funding for plant conservation.



Membership benefits include

- BGCI's publications, including our journals, BGjournal and Roots
- Botanic garden technical support and advisory services
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Plants for the Planet

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