

Journal of Botanic Gardens Conservation International

BGjournal

Volume 15 • Number 1 • January 2018

**Botanic gardens and
their contribution to
the Sustainable
Development Goals**



BGCI

Plants for the Planet

IN THIS ISSUE...

EDITORS



Suzanne Sharrock
Director of Global Programmes



Paul Smith
Secretary General

Cover Photo: *Girl planting a tree*
(Chaleow Ngamdee/Shutterstock)

Design: Seascape www.seascapedesign.co.uk

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

Further details available from:

- Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey TW9 3BW UK. Tel: +44 (0)20 8332 5953, Fax: +44 (0)20 8332 5956, E-mail: info@bgci.org, www.bgci.org
- BGCI (US) Inc, The Huntington Library, Art Collections and Botanical Gardens, 1151 Oxford Rd, San Marino, CA 91108, USA. Tel: +1 626-405-2100, E-mail: usa@bgci.org Internet: www.bgci.org/usa
- BGCI (China), South China Botanical Garden, 1190 Tian Yuan Road, Guangzhou, 510520, China. Tel: +86 20 85231992, Email: xianying.wen@bgci.org, Internet: www.bgci.org/china
- BGCI (Southeast Asia), Jean Linsky, BGCI Southeast Asia Botanic Gardens Network Coordinator, Dr. Cecilia Koo Botanic Conservation Center, No. 31, Tongsing Rd., Gaoshu Township, Pingtung County 90646, Taiwan, China. Tel: +886 8 796 0913, Mobile: +886 966484475, Email: jean.linsky@bgci.org, Internet: www.bgci.org; www.kbcc.org.tw/en
- BGCI (Africa), Kirsty Shaw, BGCI Africa Office, IUCN Eastern and Southern Africa Regional Office (ESARO), P.O. Box 68200 - 00200, Nairobi, Kenya. Tel. +254 (0)725295632 Skype: [bgci_kirsty](https://www.skype.com/user/bgci_kirsty), Email: kirsty.shaw@bgci.org, Internet: www.bgci.org
- BGCI (Russia), c/o Main Botanical Gardens, Botanicheskaya st., 4, Moscow 127276, Russia. Tel: +7 (095) 219 6160 / 5377, Fax: +7 (095) 218 0525, E-mail: seed@aha.ru, www.bgci.ru

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

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



EDITORIAL: BOTANIC GARDENS AND THE SUSTAINABLE DEVELOPMENT GOALS **02**

FEATURES

NEWS FROM BGCI **04**

PLANT HUNTING TALES: BOTANICAL SURVEYS IN JAPAN - FINDING OUT WHAT'S THERE AND WHAT'S NOT **06**

FEATURED GARDEN: BAEKDUDAEGAN NATIONAL ARBORETUM **08**

INTERVIEW: TALKING PLANTS **10**

ARTICLES

BOTANIC GARDENS AND THE 2030 SUSTAINABLE DEVELOPMENT AGENDA
Suzanne Sharrock **14**

SDG 1: NO POVERTY
BALANCING CONSERVATION AND LIVELIHOODS IN THE CHIMANIMANI FOREST BELT, MOZAMBIQUE
Alex Hudson, Jonathan Timberlake, Hercilia Chipanga and Tiziana Ulian **18**

SDG 4: QUALITY EDUCATION
BUILDING ENVIRONMENTAL AWARENESS THROUGH INFORMAL OUTREACH OPPORTUNITIES
Pamela Thompson **22**

SDG 6: CLEAN WATER AND SANITATION
TWENTY YEARS OF ECOLOGICAL RESTORATION OF WETLAND HABITATS BY THE ROYAL BOTANICAL GARDENS, ONTARIO
David Galbraith and Tjys Theÿsmeÿer **26**

SDG 11: SUSTAINABLE CITIES AND COMMUNITIES
FROM BACKYARDS TO BIOLINKS: ROYAL BOTANIC GARDENS VICTORIA'S ROLE IN URBAN GREENING
Chris Russell **31**

SDG 12: RESPONSIBLE CONSUMPTION AND PRODUCTION
BOTANIC GARDENS IN MIGRATION SETTINGS
Marie-Cakupewa Fundiko and Bartjan Bakker **34**

SDG 13: CLIMATE CHANGE
BEING LESS BAD IS NOT GOOD ENOUGH ANYMORE
Richard Piacentini **37**

EDITORIAL: BOTANIC GARDENS AND THE SUSTAINABLE DEVELOPMENT GOALS



The theme of this edition of *BGjournal* is botanic gardens supporting the Sustainable Development Goals, highlighting the intersections between plant diversity and

sustainable development – intersections which occur pretty much everywhere in terrestrial ecosystems! As always, when we try to make the case for biological diversity underpinning our life support systems, we quickly come up against the question of ‘How much biodiversity do we need?’ When he was Director of the Millennium Seed Bank, my former boss Roger Smith used to say to people who asked this question ‘Well, you tell us which plant species to ignore, and let’s see if history proves you right.’ The point he was making is that although we do not know how much diversity we need, we do know that the more plant diversity we can conserve and manage sustainably, the more options for human innovation, adaptation and resilience there will be. This point is made eloquently by Marie Haga (Executive Director of the Crop Trust) and Richard Deverell (Director of the Royal Botanic Gardens, Kew) in their conversation about plants and food security (p. 10). As Marie says, ‘we have an untapped resource: the amazing wealth of agricultural biodiversity – the thousands upon thousands of edible plants – that nature has given us. By fully tapping into this global public good, we make miracles possible; like developing plants that can stand higher temperatures, that can fight a new pest or provide higher nutritional value.’

Unfortunately, there are schools of thought that technology alone will solve all of our problems – food security, water scarcity, energy, health and climate change.

To slightly paraphrase Matt Damon in the Hollywood movie ‘The Martian’, ‘we are going to science the hell out of this’. While advances in biotechnology are undoubtedly essential if we are going to find ways to live more sustainably, the idea that we can simply research our way out of trouble, without caring for what nature has provided us with, is both naïve and dangerous. At the recent International Botanical Congress in Shenzhen – a conference at which genomics and biotechnology had a strong presence – I was asked in a public question and answer session ‘Why do we need to conserve plants when we can simply manufacture the plant species that we need?’ My answer was that (a) we can’t (yet) manufacture the plants that we need without sourcing genetic material from plants in nature and (b) if we don’t get into the habit of looking after what we already have, what hope do we have of managing anything sustainably?

With a global footfall of 500 million visitors a year, botanic gardens have the power to change attitudes. However, recent research from the zoo community suggests that simply informing people that there is a problem is not enough to change behaviour significantly¹. Education programmes have impact when they both inform and empower people to do things differently. This means venturing outside our garden walls to work with society. It is striking in Suzanne Sharrock’s article on botanic gardens and the 2030 Sustainable Development Goals (p.14) that the vast majority of botanic garden activities listed in Table 1 are doing exactly that. They are working with urban and rural communities helping them to conserve, grow and use plants sustainably. This approach is epitomised in the article on



responsible consumption and production of traditional plants in a migration setting in the Democratic Republic of Congo (p. 34) where the authors are working with rural migrants to ensure they have access to medicines and food. Similarly, the botanical knowledge of experts at the Royal Botanic Gardens Kew, combined with traditional knowledge, is being used to alleviate poverty (SDG1) in Mozambique (p. 18).

In completely different, urban, developed country settings, the Royal Botanic Gardens in Ontario is working with local authorities and nature conservation groups to clean up urban wetlands on Lake Ontario (p. 26), while the Royal Botanic Gardens Victoria collaborates with urban planners in Melbourne to incorporate wildlife corridors and green spaces into the planning process, helping both to protect native species and improve the quality of people’s lives. One of the most inspiring urban stories in this edition of *BGjournal* comes from Phipps Conservatory in Pennsylvania. Through a combination of showing how it can be done, demonstrating the cost of fossil fuel use and offering incentives to encourage visitors to change, 2,000 families have switched to renewable electricity – the equivalent of 32,000 barrels of oil not being burnt each year.

In all of these cases, botanic gardens are working outside their garden walls, helping broader society to live more sustainably. I hope you find this as inspiring as I do!

Dr Paul Smith
BGCi Secretary General

FEATURES

NEWS FROM BGCI

PLANT HUNTING TALES:
**BOTANICAL SURVEYS IN JAPAN -
FINDING OUT WHAT'S THERE AND WHAT'S NOT**

FEATURED GARDEN:
**BAEKDUDAEGAN NATIONAL ARBORETUM,
BAEKDUDAEGAN, SOUTH KOREA**

INTERVIEW:
TALKING PLANTS

Arboretum Wespelaar



NEWS FROM BGCI

HOW DID WE DO IN 2017?



BGCI has recently published its 2017 Member's Review. The review provides a synthesis of our activities over the year, and has produced some impressive statistics. For example, in 2017, BGCI trained 957 people from 310

institutions in 48 countries, while our work with the Global Trees Campaign supported the integrated conservation of 120 tree species in 17 countries, generating over 450,000 seedlings for reintroduction and reinforcement planting. During the year, BGCI disbursed funds totalling US\$ 1,048,250 to botanic gardens and other botanical institutions. As always, this figure is many times what we receive in membership subscriptions and we hope is an indication that membership of BGCI is a good investment in our community of botanic gardens.

For more information about BGCI membership, visit: www.bgci.org/joinin

WANTED! CASE STUDIES ON HOW YOUR BOTANIC GARDEN HAS CONTRIBUTED FINANCIALLY, SOCIALLY OR ENVIRONMENTALLY TO LOCAL SOCIETY

BGCI is compiling a Technical Review on how botanic gardens and arboreta represent excellent value for money and return on investment, financially, socially and environmentally. We are particularly interested in reports commissioned by botanic gardens, and carried out by third parties, that show how botanic gardens:

- Contribute financially to the local, regional or national economy;
- Deliver educational services for local authorities (e.g. schools programmes, adult education);

- Deliver social services to the local community (e.g. mental health and well-being; volunteering opportunities, act as cultural hubs etc.);
- Deliver environmental data, services or advice to government or civil society.

If you are aware of any such studies, please contact yvette.harvey-brown@bgci.org.

RAISING FUNDS FOR ISLAND TREE CONSERVATION

At the end of 2017, BGCI took part in the UK's Big Give Christmas Challenge and raised nearly £20,000 to support tree conservation on islands. The Big Give Christmas Challenge is a yearly fundraising event that sees donations doubled by matched funds.

BGCI is currently working to safeguard tree species from extinction in Fiji, Mauritius, the Seychelles and Haiti. In 2018, BGCI will extend this to include other islands where tree species run the risk of being lost forever, facing threats such as extreme weather and invasive species.

Find out more: www.bgci.org/news-and-events/news/1448/



THE WORLD'S BOTANIC GARDENS CONTAIN A THIRD OF ALL KNOWN PLANT SPECIES

In collaboration with BGCI, researchers from the University of Cambridge have carried out the most comprehensive analysis to date of diversity in *ex situ* collections. The researchers analysed the species records of a third of the world's botanic gardens, some 1,116 institutions, compiled by BGCI in its PlantSearch database, cross-referencing this with the working list of known plant species – currently sitting at 350,699.





(Baekdudaegan Arboretum)

The study found an “astonishing array” of plant diversity in the global botanic garden network, with the world’s botanic gardens containing at least 30% of all known plant species, including 41% of all those classed as ‘threatened’. However, the researchers also found a significant imbalance between tropical and temperate plants, and recommend that even more capacity should be given to conservation. The study, published in the journal *Nature Plants*, found that the global network of botanic gardens conserves living plants representing almost two-thirds of plant genera and over 90% of plant families.

To find out more and read the full paper, visit: www.bgci.org/news-and-events/news/1428/

As a result of the study, BGCI has identified 20 Angiosperm families and almost 7,000 threatened tree species that appear to be completely missing from botanic garden living collections. To see the full list of plants missing from *ex situ* collections and to help fill the gaps, visit: www.bgci.org/news-and-events/news/1432/

10TH INTERNATIONAL CONGRESS ON EDUCATION IN BOTANIC GARDENS

The call for abstracts for BGCI's 10th International Congress on Education in Botanic Gardens is now open. This event entitled "Bringing Life to the City" will take place at the University of Warsaw Botanic Garden on 9-14th September 2018. The Congress sessions will be based around the seven themes of the Congress:

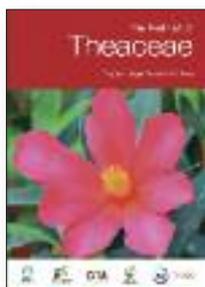
- City gardens;
- New educational tools;
- Working together;
- Supporting formal education;

- Reaching new audiences;
- Measuring impact;
- Education in Polish botanic gardens.

For further information and to submit your abstract, visit the Congress website: www.ogrod.uw.edu.pl/en/congress2018

We hope to see many of you there.

THE RED LIST OF THEACEAE



BGCI's latest Red List report was published at the beginning of 2018. The Red List of Theaceae, the tea family, reported that more than a third of the world's Theaceae

species are threatened with extinction. In preparing the report, BGCI completed assessments for 254 Theaceae species and identified 85 as threatened with extinction. Sadly, the report also identified two species as Extinct in the Wild, the Franklin tree *Franklinia alatamaha* and *Camellia amplexicaulis*, highlighting the urgent need for conservation action.

Tea itself (*Camellia sinensis*) was assessed as Data Deficient; despite its global cultivation there is a lack of available information on wild populations of the species and nearly half of all other *Camellia* species are at risk of extinction in the wild.



Franklinia alatamaha
(Arboretum Wespelaar)

An associated *ex situ* survey revealed that currently only 51% of threatened Theaceae species are present in *ex situ* collections, with the majority of Data Deficient species not being in collections. The results of the full *ex situ* survey are included in the report.

For more information and to download the report, visit: www.bgci.org/news-and-events/news/1452/

Watch out for our next Red List publication. The *Fraxinus* Red List – coming soon.....

CARE FOR THE RARE

As part of the Care for the Rare interpretation program, BGCI-US, in partnership with the United States Botanic Garden, has launched a multi-site mobile app for gardens to use to highlight the important plants in their collections. The app is currently being piloted across 10 gardens in the United States with plans to expand to a global user group in 2018.

EX SITU SURVEY OF ORCHIDS

An *ex situ* collections assessment of orchids was completed by BGCI-US in partnership with the United States Botanic Garden, using a list of 30,477 orchid species from the World Checklist of Orchids and information from 468 plant and seed collections of orchids reported in BGCI's PlantSearch database. Of 789 orchid genera, 516 (65%) are reported in *ex situ* collections. The majority (64%) of the 604 globally threatened orchid species are not yet reported in any *ex situ* collections, and 20% are reported in five or fewer collections.

CONSERVATION OF NORTH AMERICAN THREATENED SPECIES

An *ex situ* gap analysis of North American threatened species was conducted by BGCI-US in partnership with the United States Botanic Garden. Data from BGCI's PlantSearch and ThreatSearch databases identified that 3,598 (47%) of the 7,662 globally threatened species in North America are currently reported in 706 *ex situ* collections around the world. One-third (1,100) of those species are reported by only one *ex situ* collection.

Author: Jean Linsky

PLANT HUNTING TALES BOTANICAL SURVEYS IN JAPAN - FINDING OUT WHAT'S THERE AND WHAT'S NOT

Surveys for plant species in temperate Japan provide important information for conservation activities



The group collecting specimens (Ben Jones)

Plant hunting may evoke an image of an intrepid explorer struggling for weeks in hard conditions for that one target species, with thoughts of all other species forsaken. However, today, plant hunting is usually more about gathering information on plant communities and understanding the distribution of species in order to inform conservation prioritization and action. This I learned during a trip to Toyama Prefecture, Japan in July 2017 to join

botanists from the University of Oxford Botanic Garden and Harcourt Arboretum (OBGA) and the Toyama Botanic Garden to carry out surveys and gather important botanical data.

Japan is a biodiversity hotspot with approximately 7,000 native plant species. The diversity of species across the country has long been the focus of an ongoing project led by the OBGA. The project's aim is to collect and

document the flora of the country to inform conservation initiatives for threatened species. This data is gathered through botanical surveys which quickly quantify the species diversity of a given area. Plant diversity data strengthens hotspot designation and provides valuable information for a range of research and conservation activities such as species status assessments, *ex situ* conservation planning and restoration initiatives. Partnerships with botanic gardens across the country such as those with Toyama and Tsukuba botanic gardens on Honshu Island are key to collating the data from these surveys and for collecting species for *ex situ* conservation in the UK.

During my visit to Japan, I joined Ben Jones, Curator of the Harcourt Arboretum and Chris Thorogood, Director of Science and Public Engagement at OBGA



Tateyama Caldera (Jean Linsky)

to conduct botanical surveys of areas where the OBGA had surveyed and made plant collections in previous years, and to gather new data from un-surveyed locations. After meeting the local expert team at Toyama Botanic Garden, we were ready to visit our first site, the impressive Tateyama Caldera, a natural basin formed as a result of volcanic activity and erosion.

Tateyama Caldera has been a major area for research in erosion control for over 100 years and more recently a research area for natural history. Exploring the flora surrounding the disused Tateyama hot spring requires hard hats and firm footwear. This area had not been surveyed by the OBGA project previously and results of the survey work and floral observations will add direct data to verify predictions of species distributions and clarify areas containing rare species. The Tateyama Caldera area hosts some the recognizable temperate species of Japan such as those from the genera *Acer* and *Hydrangea* as well as the Honshu endemic *Salix rupifraga*, recognized as Vulnerable in Japan.

During the week, the real excitement began during the re-sampling of a site at the Nei No Sato, Toyama Outdoor Museum. This site had been previously sampled during the autumn season in October so re-sampling during the summer was expected to reveal seasonal species and build our understanding of the species diversity in the area.



Phacellanthus tubiflorus (Chris Thorogood)



Sorting species specimens (Chris Thorogood)

The team spread out across the sampling site, making collections of every species encountered. In addition to the herbaceous and shrub plants found, a canopy tree count for each sampled site was made. After the sampling, we regrouped to identify what had been collected in order to create an inventory of species for that site. Any species found more than once was deemed 'onaji', meaning 'the same' in Japanese as only a single voucher of each species is maintained as a representative of the diversity of that area. This process of identification requires local expert taxonomic botanists and we were lucky to have such expertise from the Toyama Botanic Garden. While my skills in identification of species in the Japanese flora were rough to start with, by the end of the trip, I was able to recognize some of the more common species found during our surveys. The list compiled in the Nei No Sato site will be compared by the team at OBGA to the survey made in October and provide valuable information on species distribution in Japan as well as species community-level data, which will be useful for restoration initiatives in areas with similar characteristics.

With the plant hunting on Honshu complete, the OBGA team moved on to the northern island of Hokkaido, to conduct further surveys and to strengthen *ex situ* collections of Japanese species at OBGA. One of their most interesting finds was the rare parasitic plant *Phacellanthus tubiflorus*, a species not known in cultivation. Seed of this species will be grown at OBGA to



Collecting data in the field (Jean Linsky)

contribute to the conservation of the species and to enrich their collection of rare and unusual parasitic plants – a key priority for OBGA.

The results of the botanical surveys - data and living plant collections - allow team members in the UK and Japan to advance plant conservation knowledge and action through collaboration. The conservation value of botanic garden collections is improved through field data collection, information which is sometimes missed when the blinders are on in the hunt for a single plant species. So, as the work of the Oxford Botanic Garden and Harcourt Arboretum continues, additional surveying trips will collect information from the southern, tropical areas of Japan, which means there are many more plant hunting stories to come!

Author: Min Kim



FEATURED GARDEN BAEKDUDAEGAN NATIONAL ARBORETUM

Establishing the arboretum

Founded in 2015, Baekdudaegan National Arboretum (BDNA), is a newly established arboretum in South Korea, due to officially open to the public in 2018. Located in the centre of



The Alpine House

Baekdudaegan, the largest and longest mountain range on the Korean Peninsula, BDNA plays a key role in plant conservation, addressing climate change issues, the sustainable utilization of plant resources and public education. In addition, BDNA has the extensive facilities for scientific research, including a Seed Vault and an Alpine House to conserve endangered plant species, especially those affected by climate change.

Strategic planning

Loss of biodiversity due to rapid environmental changes and rising temperatures, requires a global response. To address this, the Korea Forest Service has developed the National Arboreta Expansion Plan, which aims to develop a series of national arboreta in different climates and eco-zones for plant conservation and restoration ecology.

BDNA was founded in 2015 as part of the National Arboreta Expansion Plan. Since its establishment, BDNA has developed a Science Strategic Plan to be achieved by 2030, with the aim of fulfilling Sustainable Development Goals 13 and 15 (Climate Action and Life on Land). BDNA's science strategic plan includes the following;

- 1) Plant diversity and conservation;
- 2) Creating new value by promoting the sustainable use of ecosystems and managing forest resources;
- 3) Delivering public value and providing enjoyable and inspiring forest services.

Conservation activities

For plant diversity conservation, BDNA focuses on the banking of wild plant species, especially endangered and endemic species. BDNA has a Seed Vault facility and expertise to carry out

seed conservation research. The Seed Vault will be used to study seed physiology for the long-term storage of forest seeds.

Furthermore, in order to protect, restore and promote the sustainable use of ecosystems and manage forest resources, BDNA carries out a range of studies and activities. These include:

- biodiversity conservation in the Baekdudaegan area;
- studies of climate change impacts on forest ecosystems;
- *ex situ* conservation of alpine plants from the Asian region (BDNA Alpine House);
- ecological restoration of degraded ecosystems in Baekdudaegan;
- preservation of natural products derived from forest biodiversity.

BDNA also provides an enjoyable and inspiring service to visitors. It is continually improving its garden management systems and provides high quality education to the public in order to promote awareness of plant diversity. BDNA directly supports the Korea Forest Service in achieving their priorities for improving the forest and the environment, and we believe these outputs will have positive impacts on global environmental issues.

Seed Vault

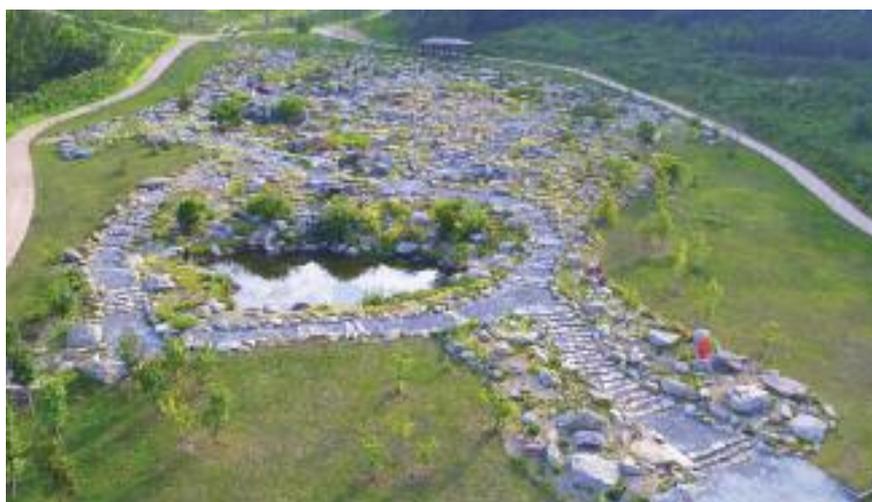
The mission of BDNA's Seed Vault is to secure plant diversity from the risks of climate change and national disasters, and to store seeds from South Korea and across the globe. It is Asia's first and largest permanent seed store, with an underground tunnel-type structure, covering an area of 4,327m² at 40m below the surface. It has the capacity to store more than 2 million seeds.

Alpine house

BDNA's Alpine House is a large-scale cool greenhouse, built to support *ex situ* conservation and to exhibit alpine plants of the world. It is designed to conserve forest resources that are threatened due to climate change. BDNA's Alpine House consists of three buildings with three different kinds of alpine environments from around the world. It has an area of 1,565m² and is arranged on 2 levels (ground floor and underground floor).

BDNA is an arboretum managed by the Korea Institute of Arboretum Management (KIAM) and is supported by the Korean government, Korea Forest Service (KFS). KIAM has been directed in the Creation and Furtherance of Arboretums and Gardens Act (Article 18-13), and supports wider Korean government objectives, through international collaboration, research and development across the globe.

BDNA has extensive facilities for scientific research, including a Seed Vault, Seed Bank, scientific laboratories and gardens with 27 different themes, such as a Rock Garden, Rhododendron Garden and Baekdudaegan Native Plants Garden.



Rock Garden

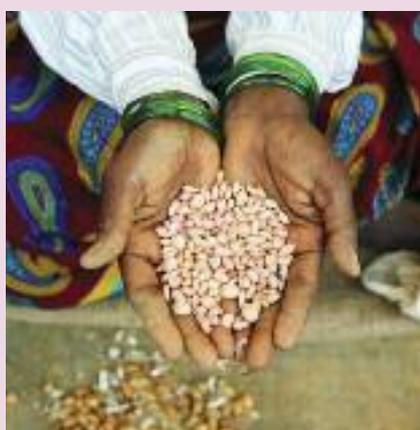


Seed Vault

INTERVIEW TALKING PLANTS



In this issue of BGjournal, our interview consists of a conversation between **Marie Haga**, Executive Director of the Crop Trust, and **Richard Deverell**, Director of the Royal Botanic Gardens Kew, UK,



Ground nuts cleaned and shelled (ICRISAT)

**FOOD
FOREVER**
Biodiversity for Resilience

Richard and Maria talk about the role botanic gardens should play in

achieving Target 2.5 of the United Nations Sustainable Development Goals. Marie and Richard are part of the **Food Forever Initiative (FFI)**, a platform that addresses Target 2.5 by raising awareness for the importance and urgency to conserve and use agricultural biodiversity for enhanced food and nutritional security.

SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture



Target 2.5:

By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels...

Marie Haga (MH): Hi Richard. Great speaking to you. Our organizations have a common goal in contributing to food and nutritional security for each one of us on the globe – today and in the future. Agriculture is facing its biggest challenges ever due to climate change, population growth and growing competition for diminishing natural resources. We are all up for trouble.

Business as usual is just not an option. We cannot rely on more water, more land, more fertilizers, and more pesticides to produce sufficient amounts of the right food. However, there is reason for hope. We have an untapped resource: the amazing wealth of agricultural biodiversity - the thousands upon thousands of edible plants – that nature has given us. By fully tapping into this global public good, we make miracles possible, like developing plants that can stand higher temperatures, that can fight a new pest or provide higher nutritional value. To make the most of

this resource, we need to safeguard it. The international community has finally acknowledged the urgency of doing so.

Under the Sustainable Development Goals, the United Nations has made a call to action for this very purpose under SDG 2, which aims to end hunger and promote more sustainable agriculture. SDG Target 2.5 states that all agrobiodiversity has to be safeguarded by 2020. How do you see botanical gardens, such as the Royal Botanic Gardens, Kew, contributing to this?

Richard Deverell (RD): Hello Marie, good to be speaking with you again. Botanic gardens have an incredibly important role in helping secure a sustainable food supply for humanity. As you say, we are currently facing some grave challenges. How will we feed 2 billion extra people on earth in the next 30 years, at a time of unprecedented climate change, while also facing what many refer to as the sixth global

extinction event? Botanic gardens have significant knowledge of plant diversity and its uses across the globe. We are a resource for scientists and agronomists who are trying to achieve food security and end hunger. But we also play an active role in educating and engaging the public about the importance of plants in helping answer that question. Plants are often forgotten, but it is our role to speak out and to excite the public about how vital plants are for all of us. We have a duty to promote the importance of plants, both in our gardens and across the communities we serve.

MH: The experiential learning botanic gardens offer is one of the best and most effective ways to deliver that message. More and more people are concerned about what they eat; where their food comes from; and the impact of our environmental footprint. I believe that botanical gardens are well situated for this conversation because they reach more than 500 million visitors a year,

from all walks of life. People can actually engage physically with the amazing sights, tempting smells and the textures of all that nature has to offer.

The work and mission of botanical gardens fits perfectly with the new trends related to the growing concern people share towards the food they eat. But even more, people need to understand and appreciate how the food we eat is directly linked to the land, the plants, and the people that nourish us. There is a huge gap that must be addressed here.

RD: At Kew Gardens, we address this by not only connecting with those who visit us personally, but also with people well beyond our garden walls through the internet and outreach programs such as Grow Wild. Botanic gardens are places where people can lose themselves in the beauty of plants. But they are places that feed the mind too. Over 80% of our visitors tell us that they learn something during their visit to Kew Gardens, and I hope that all 100,000 school children we host on educational visits come away with new knowledge and a sense of wonder about the plant kingdom. At the most basic level, everyone needs food and therefore food is a great place to start a conversation about the importance of plants to their lives.

MH: Many botanical gardens also have living plant collections, actual 'conservation-in-action' gardens. The Royal Botanic Garden, Edinburgh, comes to mind, which I know has an edible gardening project. In my view we need more of these efforts. Because the truth is that most of us are very far removed from the realities that farmers face, everyday. Many of us drink coffee every morning. Yet few people know the intricacies of the coffee tree and its extreme climate sensitivity.



Botanical gardens can help bridge the knowledge gap, allowing visitors – us, city-dwellers – to actually see how the products found in markets are grown. Can you tell us more about these living collections?

RD: I often like to remind people that much of the food we eat today isn't 'natural'. You won't find broccoli or a quintessentially English granny smith apple growing in the wild. They are the product of generations of domestication and careful breeding, just like my pet spaniel relates to a wolf. Botanic gardens' living collections are generally full of wild species, so there might be apple species that represent the ancestral type of the shiny fruit we buy today. And these wild relatives will hold different genetic material that makes them probably more robust and resilient to variable environments. It is crucially important to preserve this genetic resource to allow agronomists to breed these traits back into our domesticated varieties if and when they are needed. When we display these wild plants in Kew, we try to tell these stories. I am very keen to see more and find ways to engage our visitors to think and talk about these topics.

While many people know Kew for our beautiful gardens, at our heart we are a global scientific and conservation organization. Some of the science we do with partners around the world is incredibly inspiring. You mentioned coffee, which is the second most traded commodity around the world by value after oil. In Ethiopia it is estimated to support the livelihoods of 15 million people and it generates a quarter of the country's export earnings. Ethiopia also happens to be the evolutionary home of Arabica coffee, which is very sensitive to variability in weather patterns. Kew's scientists, led by Dr. Aaron Davis working with colleagues from Addis Ababa University, recently modeled the impacts of potential climate scenarios and generated management recommendations for the Ethiopian government on this vital and culturally important crop. Even though the models estimated that up to 60% of the current growing area would become unsuitable for coffee production by the end of the century, decisions made now would allow adaptation that would actually lead to increased coffee production.

We showcased this research in one of our cafes, and it's proving really popular with our visitors.

MH: What you say is very true, and indeed inspiring. Every time I visit Kew, the beauty and stories amaze me. In a short time, one can learn so much. But as you mentioned, Kew is much more than that. I've witnessed that through our Crop Wild Relatives (CWR) Project, wherein a global network of actors is working hard to collect, conserve and use the diversity found in the cousins of our food crops.

These wild relatives of domesticated crops are part of the untapped resources we were speaking about, which we need – and will depend on more so in the future – to help adapt our crops to new challenges brought about by climate change. These wild plants, with their thorns, colorful flowers and weird shapes, have traits often lost in the domestication process, over agriculture's 12,000-year evolution. The CWR Project is one clear example that contributes directly to the implementation of Target 2.5, and we are certainly proud and grateful to have the Millennium Seed Bank, Kew as a key partner in this ten-year global effort.

RD: In our living collections we have hundreds of species that are globally threatened, including some that we have saved from the brink of extinction. Our wild botanic garden at Wakehurst is the home of the Millennium Seed Bank, an ambitious global partnership project that aims to conserve 25% of the world's plant species in viable seed collections by 2020. We focus on endangered, endemic and economically important species in this work. As part of the economically important species, we are delighted to be working with the Crop Trust to collect and conserve the wild relatives of 29 globally important crop species. The Millennium Seed Bank is an invaluable insurance policy against extinction, and also a resource for agricultural research. As you know, under our joint project, we recently sent 70,000 seeds from 50 species related to wheat, barley and lentils to ICARDA (International Center for Agriculture Research in the Dry Areas) in Lebanon to allow them to include the materials in their collections for further distribution and research on improving crops for better climate resilience and other breeding objectives.



Luis Salazar

MH: Are there major trends in how botanical gardens are expanding their core activities to embrace current concerns?

RD: Each botanic garden is different, with some focusing more on native plants and others on exotics, or perhaps some being more active in research and others focusing more on public engagement and education. But I think all of us are acutely aware of the 21st Century challenges facing humanity, and the vast majority of us are trying to help solve them. I am strongly in favor of a plural approach, we should each be trying new things that are right for us, and learn from the experiences of one another. But on some topics, such as food security, I would like to see more collaboration to make a bigger impact. With the proximity of the targets around SDG 2.5, I would love to see botanic gardens around the world speaking with a loud voice on the importance of the protection of wild plant diversity for the benefit of food security over the coming century. It is such an important issue.

MH: What about small botanical gardens? What is their role in helping their countries achieve Target 2.5 by 2020?

RD: Every botanic garden has a role, even where their resources or capacity might be modest. Many of the people in botanic gardens we have worked with have incredible knowledge about plant diversity, its uses and conservation priorities. Many of them work with other

institutions nationally and abroad or with BGCI to combine resources to document local plant diversity, engage citizens with that knowledge and actively conserve the species they hold so dear.

MH: And the same can be said for many of the dedicated staff working in local genebanks as well. However, many people still do not understand the value of crop diversity. Wheat originated in the Fertile Crescent, in Turkey and Syria, and today it is grown across the world, even in the coldest regions of Canada and Siberia. Who would have thought this would be possible? Crop diversity provides us with the traits—like drought, heat, flood or disease-resistance that make our food crops more resilient to new climates, such as with wheat. They are amazing! But how can we expect people – from politicians and CEOs to consumers worldwide— to help safeguard the foundation of our food, if they are not aware of it? Nor the urgent need to conserve it?

This is why we launched the Food Forever Initiative, which – in support of Target 2.5 – aims at raising awareness for the importance and urgency to conserve and use this agricultural biodiversity. And I am pleased that you have decided to add your name to the notable list of Champions of the Food Forever Initiative. Why did you commit to this global effort?

RD: When I first heard about the Food Forever Initiative, it made perfect sense to me. Global food security is, in my view, one of the most important issues that botanic gardens can help solve. Knowing that humanity relies on such a narrow stream of genetic diversity – consuming around 60% of our calories globally from just three species of plant – the Initiative's aim of raising awareness of biodiversity for the benefit of food security felt like something that I had to support. Seeing the other Champions, I am rather humbled to be amongst them, but I hope that I will be able to make a contribution that makes a difference. Together, I am confident that the Champions and all the partner organizations can make a real change for the benefit of humankind.

MH: These Food Forever 'Champions' come from a range of demographic and professional backgrounds -- we have

high-level government officials, senior executives, civil society leaders, and other eminent personalities. This effort aims to reach the world's decision makers, and thankfully, many strong influencers have already joined FFI, starting with the FFI Chairperson, the President of Mauritius, Ameenah Gurib-Fakim. Other distinguished Champions include the Vice President of Peru, Mercedes Aráoz; Kees Kruythoff, President of Unilever North America; and Nikolay Dzubenko, Director of the Vavilov Research Institute of Plant Industry (VIR).

There are many more Champions; too many to list here. But together, you are right, we can make a difference. Awareness will lead to concern, which in turn will lead to action.

RD: People often feel remote from being able to make an impact on global issues such as food security. I believe that the more people know about the importance of plant diversity for food security, the more they will value plants and therefore demand action from their politicians and institutions. So, I hope that the Food Forever Initiative will be able to reach out to people around the world, through botanic gardens, but also beyond, to engage citizens in understanding and caring about this topic. I spent most of my career before joining Kew working at the BBC and saw first-hand how good, engaging and enchanting communications can make a real, positive and lasting impact.

MH: Thank you so much, Richard. It's always inspiring to talk with such committed individuals, whose efforts are helping to secure the biodiversity we all need to ensure our food, forever. Any last words?

RD: Botanic gardens can do a lot, in terms of the science we do, the collections we hold and the way that we engage with the public. But botanic gardens are only one part of the answer to the challenge of food security. I am particularly thankful that we are able to work with the Crop Trust in this shared endeavor; your leadership in this area is to be applauded.

More information about the Food Forever Initiative is available at: <https://www.food4ever.org/>

A woman wearing a yellow headscarf and a blue and white striped vest over a white shirt is sifting grain through a large, round, woven basket. She is sitting on a wooden mat on the ground. The background is a simple, outdoor setting with a dirt floor and some wooden structures.

ARTICLES

BOTANIC GARDENS AND THE 2030 SUSTAINABLE DEVELOPMENT AGENDA

SDG 1: NO POVERTY

BALANCING CONSERVATION AND LIVELIHOODS IN THE CHIMANIMANI FOREST BELT, MOZAMBIQUE

SDG 4: QUALITY EDUCATION

BUILDING ENVIRONMENTAL AWARENESS THROUGH INFORMAL OUTREACH OPPORTUNITIES

SDG 6: CLEAN WATER AND SANITATION

TWENTY YEARS OF ECOLOGICAL RESTORATION OF WETLAND HABITATS BY THE ROYAL BOTANICAL GARDENS, ONTARIO.

SDG 11: SUSTAINABLE CITIES AND COMMUNITIES

FROM BACKYARDS TO BIOLINKS: ROYAL BOTANICAL GARDENS VICTORIA'S ROLE IN URBAN GREENING

SDG 12: RESPONSIBLE CONSUMPTION AND PRODUCTION

BOTANIC GARDENS IN MIGRATION SETTINGS

SDG 13: CLIMATE CHANGE

BEING LESS BAD IS NOT GOOD ENOUGH ANYMORE

Author: Suzanne Sharrock



BOTANIC GARDENS AND THE 2030 SUSTAINABLE DEVELOPMENT AGENDA

The 2030 Sustainable Development Agenda and associated Sustainable Development Goals (SDGs) were developed to succeed the Millennium Development Goals and were adopted in 2015 by the international community through the United Nations. With 17 goals and 169 targets, the SDGs recognise the inter-relationships between human development and the environmental, economic, social and political context in which it occurs.



The SDGs call for action by all countries, poor, middle-income and rich, to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

While the SDGs are not legally binding, governments are expected to take ownership and establish national

frameworks for their achievement. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, which will require quality, accessible and timely data collection.

Biodiversity and the SDGs

Biodiversity is at the centre of many economic activities, particularly those related to agriculture, forestry and fisheries. Globally nearly half of the human population are directly dependant on natural resources for their

livelihoods, and many of the most vulnerable people depend directly on biodiversity to fulfil their daily subsistence needs. The conservation, restoration and sustainable use of ecosystems is essential for sustainable development. Biodiversity is also a key factor in the achievement of food security and improved nutrition. Genetic diversity in food crops helps to ensure the evolution of species, allowing them to adapt to changing conditions and build resilience to stress. Healthy ecosystems also underpin the delivery of water supplies and guard against water-related hazards, while wood, coal and charcoal provide energy for cooking and heating to over 3 billion people around the world. In cities, urban planning that integrates the considerations of biodiversity can contribute to more sustainable communities. For example, strategic placement of trees in urban areas can cool air between 2°C and 8°C, reducing air conditioning needs and saving energy.

Botanic gardens and the SDGs

Botanic gardens, with their focus on understanding, conserving and sustainably using plant diversity, as well as raising awareness of environmental issues, are involved in many activities that contribute to the achievement of the SDGs. Table 1 provides some examples of these activities

The SDG framework

It can be seen from Table 1 that botanic gardens are able to contribute to all 17 of the SDGs, and the SDG framework therefore provides a useful tool to link the work of botanic gardens to that of national development initiatives. While the Global Strategy for Plant Conservation (GSPC) provides a clear 'road map' for the conservation work of botanic gardens, the SDGs go beyond plant conservation, encompassing the full diversity of activities carried out by botanic gardens.

The SDGs are not a set of stand-alone goals, but should be seen as a network of goals and associated targets, in which links among goals exist through targets that address more than one goal. As an integrated system, the SDGs aim to facilitate policy integration across sectors. For example, activities carried out under SDG 12 (Sustainable consumption and production) are considered to be relevant to the achievement 14 of the 17 SDGs (Le Blanc, 2015). From a botanic garden perspective, this may provide a mechanism to help demonstrate the relevance of a garden to government departments other than the one to which it is administratively linked.

Some botanic gardens are already using the SDGs to guide their own development policies – framing their work in an agenda that links their more conventional plant documentation, research and conservation activities with targets for poverty alleviation and food security. Projects that use scientific knowledge to support livelihood development demonstrate the importance of the expertise available within the global botanic garden community. The combined knowledge of the world's plant diversity is increasingly being made available through a range of tools and resources developed within the community, and is a unique resource that policy makers and governments can draw on as they develop and implement national SDG frameworks.

References

- Le Blanc, D. 2015. Towards integration at last? The Sustainable Development Goals as a network of targets. DESA Working Paper No. 141. ST/ESA/2015/DWP/141.

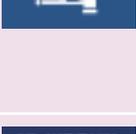
Suzanne Sharrock
BGI
199 Kew Road, Richmond,
TW9 3BW UK



Harvesting agricultural trial plots (ICARDA Terbol)

	SDG	Examples of botanic garden activities
	SDG 1: End poverty in all its forms everywhere	<ul style="list-style-type: none"> • Working with local communities to develop value-added products from local plant resources • Assisting local communities to document and safeguard traditional knowledge and practices so that they remain available to support sustainable plant use. • Creating employment locally
	SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	<ul style="list-style-type: none"> • Conservation of crop wild relatives and other plant species important for food security at the local level • Raising awareness of the importance of agro-biodiversity and its conservation needs • Supporting local food production initiatives
	SDG 3: Ensure healthy lives and promote well-being for all at all ages	<ul style="list-style-type: none"> • Documentation, conservation and research on medicinal plants • Horticultural therapy • Promoting healthy living to visitors and local communities
	SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	<ul style="list-style-type: none"> • Education and awareness raising on biodiversity and sustainability issues for all ages, both through the formal and informal education sectors
	SDG 5: Achieve gender equality and empower all women and girls	<ul style="list-style-type: none"> • Working with women's groups at local community level to empower and educate • Ensuring gender equality within the garden staff structure
	SDG 6: Ensure availability and sustainable management of water and sanitation for all	<ul style="list-style-type: none"> • Conservation and restoration of wetlands • Restoration of key watershed areas
	SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all	<ul style="list-style-type: none"> • Carrying out research on plant species suitable for use as biomass or for oil production • Demonstrating low-energy life-style choices • Waste-to-energy projects
	SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	<ul style="list-style-type: none"> • Supporting and promoting local ecotourism initiatives • Promoting the sustainable use of plant resources as a livelihood option
	SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	<ul style="list-style-type: none"> • Developing innovative solutions using plant mimicry • Demonstrating innovation in sustainable buildings

Table 1: Botanic gardens contributing to the SDGs

	SDG	Examples of botanic garden activities
	SDG 10: Reduce inequality within and among countries	<ul style="list-style-type: none"> • Building the 'social role' of the botanic garden • Working with disadvantaged groups
	SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable	<ul style="list-style-type: none"> • Conservation of urban biodiversity • Involvement in city greening initiatives • Providing open and inclusive green spaces in urban settings
	SDG 12: Ensure sustainable consumption and production patterns	<ul style="list-style-type: none"> • Research on sustainable harvesting levels for socio-economically important plant species • Demonstrating sustainability in all aspects of the gardens' operations, including retail outlets.
	SDG 13: Take urgent action to combat climate change and its impacts	<ul style="list-style-type: none"> • Research on the impacts of climate change on plant diversity; phenological studies • Education and awareness raising on climate issues • Conservation of plant species most affected by climate change
	SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	<ul style="list-style-type: none"> • Conservation and restoration of marine habitats, e.g. mangroves • Education and awareness raising of challenges facing the marine environment
	SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	<ul style="list-style-type: none"> • Identification of species most under threat and conservation of these • Ecological restoration • Conservation of important areas for plant diversity • Management of invasive species • Public engagement and raising awareness of conservation needs
	SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	<ul style="list-style-type: none"> • Working with authorities to combat illegal plant trade • Building capacity of local organisations to manage their natural resources
	SDG 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development	<ul style="list-style-type: none"> • Participating in local, national and international partnerships and collaborations

Authors: Alex Hudson, Jonathan Timberlake, Hercilia Chipanga and Tiziana Ulian



SDG 1: NO POVERTY BALANCING CONSERVATION AND LIVELIHOODS IN THE CHIMANIMANI FOREST BELT, MOZAMBIQUE

A women using the local 'peneira' (sieve) to separate maize from the maize husks after pounding (Alex Hudson)



The botanical knowledge of experts at the Royal Botanic Gardens, Kew is being used to address rural poverty in Southern Africa



Introduction

Mozambique is one of the least developed countries in the world, recently ranked 181st of 188 by the United Nations' human development index (Jahan, 2016). Much of the population live in poverty, many living in rural areas as smallholder farmers with an average of just 1.2 hectares of land (Anderson & Learch, 2016). Historic migration has been an important driver of instability for these farmers. This continues today as large economic interests, such as government or private backed farms, push farmers onto marginalised land, like that found in protected areas.

The Chimanimani Trans-Frontier Conservation Area (TFCA) is a protected area that brings together the Chimanimani National Park (Zimbabwe) with the Reserva Nacional de Chimanimani (Mozambique). This creates a cross-border protected area. It is divided into two zones: the core zone, for strict nature protection; and the buffer zone, where current communities are allowed the sustainable use of resources as long as tropical lowland rain forest and the core zone are protected (SADC, 2013).

For local TFCA communities, farming is important to their daily lives. Maize provides the main staple crop, although production is low. Communities still use

forests and natural areas to supplement their food, and to get materials and medicines. Population expansion, some of which is due to migration, has gradually increased farmland and pressure on wild harvested species (Ghiurghi *et al.*, 2010).

Under these conditions the reserve is in need of new sustainable options that provide for communities and keep natural areas safe.

Conservation in protected areas can prove to be a problem to local communities when access to resources is restricted. This is particularly damaging to those already in or close to poverty. Compromises need to be found that allow both the continued survival of people as well as protection for nature. Working with communities to decide how they use and conserve their resources, with scientific evidence and technical support, offers a way to try to tackle these issues.

Aims and Objectives/Outputs

The Royal Botanic Gardens, Kew's (RBG Kew) Darwin Initiative Project was carried out between 1st April 2014 until 31st March 2017 with communities in the Chimanimani TFCA. We aimed to provide an effective and sustainable balance between biodiversity conservation, poverty alleviation and scaled development. We worked to achieve this by combining our expertise with Mozambican partners that have different but complementary strengths to our own. Working as a team and with communities, we collected information on areas of conservation importance and plants of conservation and economic value and created new land use plans. Furthermore we supported communities

SDG1: End poverty in all its forms everywhere



Target 1.5:

Build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters....

with new livelihoods activities, such as bee keeping, and improved conservation agricultural practices and tourism.

Expertise and communities

As the leading partner, we at RBG Kew brought our global expert plant knowledge to drive conservation in the area. Our partnering lead organisation, the Micaia Foundation (Micaia), brought its experience and knowledge of working with local communities in Manica province to achieve sustainable development. The Instituto de Investigação Agrária de Moçambique (IIAM) provided its own national expertise in Mozambican biodiversity.

RBG Kew and IIAM carried out plant surveys in the community areas identifying important plants and habitats. Micaia managed all livelihoods activities and completed valuable training with



Man with a basket made from local bamboo (Alex Hudson)

community Natural Resource Management Committees, rangers and community members. They provided a link between the communities and government organisations and businesses, particularly important for new development opportunities.

The Chimanimani TFCA

Communities within the TFCA buffer zone are organised into traditional groups called *regulados*. We focussed on working with four of these *regulados* (roughly 2,281 households): Mahate, Maronga, Mpunga and Zomba (Ghiurghi *et al.*, 2010). The dominant vegetation of these areas include mixed miombo woodlands, dry montaine forest, grasslands and swamplands (Timberlake *et al.*, 2016a, Timberlake *et al.*, 2016b). Areas of moist evergreen forest are also present, known to be of conservation interest due to their dwindling area across southern Africa.

Results

Community conservation areas

Following two extensive plant surveys, we have collated valuable plant diversity information for all community areas. Important habitats and plants for conservation, as well as potentially valuable economic species, are now known and recorded (such as *Uapaca kirkiana*, *Cyperus papyrus* and *Funtumia africana*). Collating this information, we suggested to communities which areas within their land we believe would be most beneficial for conservation of plants.



Harvested sesame (*Sesamum indicum*) (Alex Hudson)



A hut roof constructed from local timber (Alex Hudson)

These areas correspond well with land selected for conservation by each *regulado*, used to create their own land use maps and strategies. These show areas which members have agreed to set aside for conservation and areas which they will continue to use in a sustainable way. Micaia helped get these zones registered with the government providing them with official protection. This has added to the protected forest reserves already found within community areas, increasing the protected area outside of the core zone to 30,375 ha.

Natural resource management and protection

Natural Resource Management Committees (NRMC) already existed in Mpunga and Zomba, but were mainly inactive and unsupported. Micaia has worked to boost these NRMCs in Mpunga and Zomba, and to set up new committees in both Mahate and Maronga. They now have the role of incorporating communities wishes into management decisions and to lead on the plans that are made.

To achieve this, members were first selected by the community members themselves. They were then trained on how to operate effectively, how to manage resources and how to deal with conflicts. Sessions were also run on the Chimanimani TFCA management plan, boosting awareness of its goals and how it is expected to be achieved.

Community beekeeping for income

Micaia trained and provided 330 households with beekeeping equipment. Many of these people have then signed contracts with the Mozambican Honey Company to supply them with honey into the future. By 2017, 4,394Kg of honey has been harvested and sold by these individuals generating over US\$3,000.

Improved agricultural practices

Micaia also involved 427 households in new conservation agriculture activities and following training, by 2017 extra incomes were generated for 408 of these. Purely from extra production, they have been able to increase their incomes from horticultural practices by between US\$8 and US\$84.

Sustainable Development Goal 1: End poverty in all its forms everywhere

Whilst we have not eradicated poverty in the TFCA completely, we have made significant progress in enabling local communities to generate more income. This is the start of a process that often takes much longer than the three years of a single project's life cycle. With Micaia continuing to work with communities, this progress is likely to carry on. Beyond immediate economic benefits, we have also helped to empower local communities and increased their resilience to environmental or economic shocks by giving them a broader array of livelihoods options.

Economic increases

For conservation agriculture and beekeeping, a smaller number of lead experts were also trained. They can expand the future influence of the project by teaching other community members these skills. It is also expected that income gains are likely to increase because training occurred towards the

end of the project. This was largely due to the need to generate interest in the activities first: once a benefit was demonstrated for early participants remaining households become more eager to get involved.

Empowering communities

Since NRMC's ability to function has improved, communities have become more involved in recording how they want their land to be managed. Knowledge and understanding of the TFCA management plan has also spread so people are aware of what it is trying to achieve and how it can be done. As a result of these actions, local communities have been empowered to be more actively involved in the decisions and management of the TFCA at many levels.

Ensuring benefits of development programmes are shared equitably between all community members is tricky. Women in particular can receive least due to local cultural norms. With 60% of beekeeping beneficiaries being women, there has been a change in attitudes on who can undertake beekeeping, and so the project has worked to improve women's place in their local society.

Livelihoods diversification

A broader array of livelihoods options makes people in poverty more resilient to environmental or economic shocks. Economic shocks come when globalised markets fail.



A local women using a bamboo basket to wash maize in the river (Alex Hudson)

During the recent financial crash prices for staple foods, including maize, went down. Sadly the poorest countries in Africa were hit worst and recovered slowest. For many smallholders already in poverty this quickly led to a struggle to survive.

Environmental shocks occur during years of extreme weather conditions or with the introduction of new pests and diseases. These often have damaging impacts on staple crop yields. Again, this impacts more upon smallholders living within poverty because they lack the economic means to get food from other sources. More options are now available to communities so they will be more insulated from some of the worst of these two problems. When a harvest of one crop fails, the others may provide the money or nutritional value that they need.

Nutritional benefits

Malnutrition can be a serious problem to those living in poverty. It can lead to medical problems and deaths, particularly for vulnerable children and the elderly. Of course this can also be compounded by shocks to farming systems.

Increasing the yields of crops improves the local food security situation for people. Using the conservation agriculture techniques, farmers will be able to provide more of the nutrition their families need from the same areas of land], even during harder years.

Future of the TFCA

Micaia will continue to work with communities in the TFCA. They have boosted their reputation nationally and internationally and have subsequently been given the responsibility to expand this work with the other five *regulados* in the buffer zone. This will help ensure the project impacts extend into more households of the TFCA long into the future.

Potential economic species also remain options for further research and development. Fruit species like *Uapaca kirkiana* and *Strychnos madagascariensis* are already important to communities and have local markets in Manica towns. Other species are used to make goods and products which people use in their daily lives and sometimes profit from. For example, mats are made from *Cyperus papyrus* and *Cyperus alternifolius* whilst the local bamboo,



Above: *Sesamum indicum* being dried behind hut in Zomba Centro and right: Basket made from the local bamboo (Alex Hudson)

Oxytenanthera abyssinica, is used to weave ornate baskets. Other species could even have broader economic value, like *Funtumia africana*, whose fine seed hairs have a potential use in the production of high quality glossy paper. These species, identified through this project, represent options for further livelihoods diversification and future sustainable development in the TFCA. Combining research with development that supports communities, to capture most of the value made, offers some exciting prospects for work to continue.

Further information:

For further information visit: <https://www.kew.org/science/projects/balancing-conservation-and-livelihoods-in-the-chimanimani-forest-belt-mozambique> Or email: t.ulian@kew.org (RBG Kew) or hercilia.chipanga@gmail.com (Micaia Foundation)

References

- Anderson, J., & Leach, C. 2016. National Survey and Segmentation of Smallholder Households in Mozambique. The Consultative Group to Assist the Poor (CGAP), Washington.
- Ghiurghi, A., Dondeyne, S., & Bannerman, J. H. 2010. Chimanimani Conservation Area Management Plan, volume 1. Report prepared by AgriConsulting for Ministry of Tourism, Maputo, Mozambique.
- Jahan, S. 2016. Human Development Report 2016. United Nations Development Programme, New York. <https://doi.org/10.1017/9789210600361>



- Timberlake, J., Darbyshire, I., Cheek, M., Banze, A., Fijamo, V., João Massunde, Chipanga, H., & Muassinar, D. 2016a. Plant Conservation in Communities on the Chimanimani footslopes, Mozambique. Unpublished report, Darwin Initiative Project "Balancing conservation and livelihoods in the Chimanimani Forest belt, Mozambique", 2014-2017 (ref: 21-006). RBG, Kew, London.
- Timberlake, J., Darbyshire, I., Wursten, B., Hadj-hammou, J., Mapaura, A., Matimele, H., & Banze, A. 2016b. Chimanimani Mountains: Botany and conservation. Unpublished report, Critical Ecosystem Partnership Fund project, 2013-2016. RBG, Kew, London.
- SADC Secretariat 2013. Southern African Development Community SADC Programme for Transfrontier Conservation Areas. SADC Secretariat, Gaborone. Available from: http://www.sadc.int/files/4614/2122/3338/SADC_TFCA_Programme_FINAL_doc_Oct_2013.pdf

Tiziana Ulian
Royal Botanic Gardens, Kew
Wakehurst Place,
West Sussex,
RH17 6TN, U.K.

Author: Pamela J. Thompson



SDG 4: QUALITY EDUCATION BUILDING ENVIRONMENTAL AWARENESS THROUGH INFORMAL OUTREACH OPPORTUNITIES

Biologist David George Haskell, author of *The Forest Unseen* and *The Songs of Trees*, implored Tree “mobsters” to use all of their senses to appreciate the natural environment. (Pamela J. Thompson)



On-site research provides the basis for the outreach programs developed by the Arnold Arboretum to encourage an interest in science and the environment amongst its visitors.

Introduction

The Arnold Arboretum is a university research institution and a public park with extensively curated historical living collections of temperate woody plants. As such it is well positioned to share its collections and communicate associated research with the general public to increase knowledge of plants. Much of our public outreach about science emerges from the wealth of ongoing on-site research. We engage our audience in the work of an arboretum and in botanical science to

encourage curiosity about plants, biodiversity, and conservation. To this end, we offer a spectrum of formal and informal engagement opportunities. As at many public gardens and arboreta, the Arnold Arboretum offers formal programs that include lectures and classes for adults, grade-school field studies, and teacher training opportunities, all requiring staffing and funding. It is our informal outreach that is perhaps most transferable to gardens and parks--of any size, with or without funding--that can be replicated and adapted to reinforce the importance of

SDG4: Ensure inclusive and quality education for all and promote lifelong learning



Target 4.7:

By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles...

natural systems to human life. Though we rarely use the word “sustainability,” our activities present foundational ideas in science and nature awareness that fuel commitment to sustainability. The following are examples of our informal opportunities that encourage a deeper appreciation for the environment (with age groups served in parentheses).

Tree Spotters (Adults) is a volunteer-run and -staffed citizen science program to observe tree species through the growing seasons at the Arnold Arboretum. Trained volunteers record observations of phenological changes in specific trees with the National Phenology Network. The program encourages people to return frequently and challenges participants to look at the parts and processes of a tree, thus acquiring observation, terminology, and species identification skills. We have found that the program affirms the scientific value of such a living collection to these volunteers and increases their awareness of climate change locally and world-wide as they contribute to society's understanding of the changing environment.

Tree Mobs® (Adults) are casual, short-notice educational presentations in the landscape with an expert. Tree Mobs bring deeper insight to the subject, expose research methodologies, and share the historic and contemporary import of our collections in a non-threatening, questions-are-encouraged manner. Each Tree Mob reveals wonders of the natural world and, directly or indirectly, the value in studying and protecting all that grows around us.

Loosely modelled after flash mobs, Tree Mobs add a social twist to science learning. We find an expert, determine a topic, and choose a date, time, and location to gather in the landscape. A few days in advance of the event, we notify constituents, and somewhat magically, individuals appear from all directions at the location and time



*A trio of Tree Spotters examine the developing flowers of *Tilia Americana*. (Suzanne Mrozak)*



*In this Tree Mob, visiting researcher Stephanie Conway explains how *Ephedra minuta* is related to conifers. (Pamela J. Thompson)*

specified. Using this simple model, we have hosted mobs with topics ranging from specific tree species to genetic selection for fruit production; from measuring the effects of climate change to changing landscape management practices based on environmental analysis; from the physics of dragonfly flight and the habits of cicada-killer wasps, to modelling the cellular structure of bamboo to inform engineering. For a botanic garden or arboretum, topic possibilities are endless and can truly reveal the complexities of life.

StoryWalk® (Families) combines literacy, movement, and community in an educational activity that is perfect for a garden setting. By sequentially posting the laminated pages of an illustrated children's book along a path in the

landscape, a family, play group, or individual can proceed along a route, "through" the story. We recently hosted a walk in which the kids exuberantly ran from sign to sign (page to page), anticipating both the content as well as the chance to read aloud. Readers of various abilities chimed in and readily took turns. In my experience, freely travelling with the story, rather than sitting restrained to a circle and being read to, felt liberating and added dimension to the narrative. Associating the story (we choose environmental themes) with the immediate natural environment grounds the topic in reality and provides extended teaching opportunities. StoryWalk® was created by Anne Ferguson of Montpelier, VT and has developed with the help of Rachel Senechal of the Kellogg-Hubbard Library. Read more at www.kellogg-hubbard.org/storywalk.



Rhododendron expert and Arboretum volunteer George Hibben explains indumentum during Collections Up Close. (Arnold Arboretum Archives)

Posts from the Collections (Adults) is a weekly-to-monthly communication from Arnold Arboretum Director William "Ned" Friedman, reporting ephemeral changes in the landscape. He observes, photographs, and writes a post that is distributed via social media, email, and on our website. Keys to successful posts are as follow:

- Make the post exciting and time-sensitive, highlighting an ephemeral phenomenon and include great images.
- Reveal the topic as a personal quest or passion, using the author's love of subject, to draw in readers.

- Unroll scientific terminology, starting simply and shifting to more complex concepts as the post continues. Once you've drawn in the reader, teach by expanding to botanical and scientific language and provide links for further learning.
- Repeat the ephemeral quality of the subject to entice people to visit immediately so that they don't miss seeing something special.

The value of Posts from the Collections extends well beyond the post itself. As a quality, frequent communication about plants from our resident plant morphologist, it is like "time with a professor." The posts expand vocabulary beyond typical daily language. They bring attention to the complexities and intricacies of plants. They entice locals to visit while also engaging constituents who are farther afield to read for a moment about a plant. The posts connect constituents with our director and affirm this arboretum's association with science. Though our posts are from a plant morphologist, such communications could be written by any staff member. Use your experts--promote the skills and knowledge of garden staff; let their curiosity and passion draw people in to the depth of your collection; and teach the value of plants, sustainability, conservation, and science.

Collections Up Close (All Ages) are free events that highlight one specific grouping of plants in the landscape. These events invite visitors of all interest levels to slow down and experience the collection in an intimate and immersive manner. A casual visitor may come upon



Education Fellow Ana Maria Caballero engages pre-service teachers in outdoor classroom techniques. (Nancy Sableski)

the event and have their eyes opened to the beauty, diversity, and intriguing story of a specific collection. Once within the collection, they can choose to have an informative conversation with our volunteer interpreters. These conversations often incite curiosity and have the potential to create increased involvement with the Arboretum. For visitors looking for a more formal learning experience, Arboretum staff members lead tours bringing to light the elements that make this particular collection so special. Involvement by intergenerational families with young children is also encouraged with activities designed to develop observational skills that share nature-based knowledge and provide safe, enticing ways to become more connected to the Arboretum and its collections. (Adults, Families)

In our **Visitor Center** (All Ages), we provide a number of casual learning opportunities. For example, an ever-evolving assortment of fresh cuttings from various plants in our living collection are identified and displayed, showing unique traits and interesting seasonal characteristics. The displays pique curiosity with visitors, staff, and program attendees, inciting all to look closely at plant parts and then to find these specific plants in the landscape. Other displays across the seasons present twig identification, leaf morphology, the rearing of moths and butterflies, and even the evolution of our plant labels, from the 1870s to the present. Our welcoming Visitor Engagement staff compose and curate these exhibits and use them daily to engage and educate visitors. Creativity and a desire to educate about the natural world spurs the development of these minimal expense displays.

Arboretum for Educators (Adults) free trainings offer opportunities for the Arnold Arboretum to influence educators, which in turn, is an effective way to exponentially reach hundreds of individuals with our message of "Plant Science IS Life Science!" Once a month for 2.5 hours, teachers of children in pre-kindergarten through middle school gather at the Arboretum to learn about seasonal topics related to plants, conduct experiments, engage in scientific discourse, and learn ways to integrate more of nature into other disciplines through observational drawing, literacy, math, and engineering activities.



In this chilly December Tree Mob, more than 30 people gathered with visiting researcher Erica Fadon to learn how buds survive through months of freezing temperatures. (Pamela J. Thompson)

Recognizing that most teachers have limited resources for science, every effort is made to highlight low- or no-cost, hands-on activities that are appropriate for children and encourage the development of important Practices of Science, in line with the Next Generation Science Standards¹ (US standards). About half the time is spent in the landscape, closely examining leaves, seedpods, flowers, bark, twigs, tree architecture, and other phenomena. Attending educators learn to feel comfortable exploring an outdoor habitat and ways to use the outdoors as a classroom or resource for study. By practicing and then modelling curiosity and close observation, participants can positively influence children's relationships with nature and provide accurate content to better prepare students for upper level science and biology courses.

Self-Guided School Trips (All Ages), listed on our website, digitally support educators with advice for conducting successful field visits and provide suggested activities that encourage students to explore trees and their relevance to all life. These suggestions, including activity sheets for pre-school through grade five and middle and high school, promote the idea that any outdoor space can be used for exploration and learning while also affirming that the Arnold Arboretum is a welcoming and curated space in which to practice these principles. The ideas behind these tips stem from our guided interactions with students, but are

amended to assume no input from Arboretum staff. We redevelop existing resources and content for expanded use in order to extend teaching opportunities beyond what we can physically staff or financially support. In this way we hope to reach many more students of all ages and their teachers to influence their relationship with the environment and develop an appreciation of all plants on this planet.

Conclusions

I share the above ideas so that others can use these as models and adapt them to their particular landscape and institutional outreach goals. There are many ways to inspire learners, so we offer multiple avenues for engagement. Repeat exposure to the natural world, to botanical concepts, and to the complexity of plants will eventually lead to an understanding of ecological function...at least that is our hope. As staff of botanic gardens, parks, and arboreta, it behooves us to use our living collections to create a wonder of nature, to build an understanding of plant lifecycles, and to provide the public with access to scientific information. We must help educators become confident in teaching about plants, ecology, and the environment with hands on experiences and replicable lessons that they can share with students. We are uniquely situated to use the plants within reach to nurture life-long interest and develop future generations of conservationists, botanists, and ecologists, whether formal or casual practitioners. We have the



Fresh cuttings in the Arnold Arboretum's Hunnewell Visitor Center introduce visitors to a variety of plants they will see in the landscape. (Pamela J. Thompson)



Moving along outdoors as the story progresses encourages freedom of movement, participatory reading, and linking the story with the surroundings. (Nancy Sableski)

knowledge within our organizations to raise the profile of plants from nice to necessity, to stress their importance in sustaining all life, and in doing so, educate for sustainability.

What we've learned

- Insert science into everything you do;
- Don't shy away from complex subjects;
- Find ways to teach in a social environment; we are social beings;
- You're never too young or too old to learn;
- Use the experts around you...if not your staff, connect with a local university;
- Make science stories personal;
- Discovery happens even with common subjects and the simplest observations;
- Plants provide endless possibilities for discovery.

Pamela J. Thompson
Manager of Adult Education
Arnold Arboretum of Harvard University
125 Arborway, Boston, Massachusetts



Educators familiarize themselves with the bark of Acer griseum (Ana Maria Caballero)

¹<https://www.nextgenscience.org/>

Authors: David Galbraith and Tÿs Theÿsmeÿer

SDG 6: Ensure availability and sustainable management of water and sanitation for all



Target 6.6:

By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

SDG 6: CLEAN WATER AND SANITATION

TWENTY YEARS OF ECOLOGICAL RESTORATION OF WETLAND HABITATS BY THE ROYAL BOTANICAL GARDENS, ONTARIO



One of several boardwalks in the capture sanctuaries at Royal Botanical Gardens carries visitors over rich wetlands.



Special reference to appropriate aquatic vegetation is crucial to successful habitat restoration of wetland environments.

Introduction

The United Nations Sustainable Development Goals (DGs) provides botanic gardens with opportunities to demonstrate their relevance to humanity in important, new ways. Sustainable Development Goal 6 is the provision of clean water, of which healthy wetlands are an important component. Royal Botanical Gardens (RBG), at the western end of Lake Ontario within Hamilton and Burlington, Ontario, Canada, was established in the 1920s and 1930s in part to protect an important natural wetland.

Since the 1950s control of invasive species and restoration of Cootes Paradise Marsh (named for an 18th Century British Army officer stationed in the area) have been important goals. This marsh, owned by Royal Botanical Gardens, is the westernmost extension of the wetlands of Lake Ontario. The importance of Cootes Paradise Marsh was recognized as early as the 1820s.

By the early 20th Century the marsh was protected as a provincial fish sanctuary and a wildlife reserve. Under stress from development in the mid-1920s, the Hamilton Board of Park Management,

along with partners like the Hamilton Bird Protection Society (now Hamilton Naturalists' Club) purchased the south shore of Cootes Paradise Marsh. This was to create Royal Botanical Gardens, establish a university, and protect the wetland from further development. In the 1940s the north shore was purchased by Royal Botanical Gardens. In the 1970s the remaining water lots of the wetland were also acquired. Since the 1950s the floristics of the wetland and surrounding natural areas has been a high priority for research at RBG.

Wetland stressors

Emergent vegetation once covered nearly the entire 270 acres of the wetland. The arrival of invasive Common Carp (*Cyprinus carpio*) in the Great Lakes in the late 19th Century resulted in ecological damage in Cootes.

During the early spring these large fish migrate upstream to spawning areas. Carp (some in excess of 20 kg) displace and stir up sediment with their bottom foraging and spawning, resulting in the uprooting of aquatic vegetation. Early carp removal efforts included netting, which proved ineffective. As of 1996 the estimated spring carp population was as high as 100,000, although few carp overwintered in the marsh (Theysmeÿer & Cairns, 1995, Theysmeÿer, 1999).

Another significant stress is managed water levels. Cootes Paradise Marsh is connected to Hamilton Harbour, which is in turn is connected to Lake Ontario. Water levels on the lake are maintained somewhat higher than historical averages (Wilcox *et al.*, 2005), although still ranging by 1.7 m as the lake cycles between wetter and dryer weather patterns. This results in areas of the marsh being submerged deeper than suitable for growth of aquatic emergent species such as Cattails (Genus *Typha*), the most common species in the marsh in recent history.

Finally, a significant stressor is the arrival of excess nutrients and other pollutants within the marsh (MOE, 1986). Several streams feed Cootes Paradise Marsh, which then drains into Hamilton Harbour.

The largest of these streams, Spencer Creek, drains a large mixed-use watershed to the west. At the western end of the marsh is also a large sewage treatment plant, which has over several decades been improved to lower phosphorus and other pollutants entering the marsh (Reddick & Theysmeÿer, 2012). However, the wastewater treatment plant is not capable of removing pharmaceuticals, which have recently been demonstrated to alter the behavior of fish exposed to the waters of the marsh (Simmons *et al.*, 2017). During dryer summers, most of the water entering the marsh is treated effluent from the sewage treatment plant.

Restoration ecology

Royal Botanical Gardens has led restoration of the wetland, as well as its other properties, for decades. The terrestrial portion of its 2,400 acre nature sanctuaries include some of the richest areas in Canada for wild plant species diversity (Galbraith *et al.*, 2011). This is an important stopping site for migratory birds, and also boasts a high insect species diversity.

As Royal Botanical Gardens' largest property, Cootes Paradise Marsh has long been the focus of many of its restoration



Pickerel Weed (Pontederia cordata) is a colourful native aquatic species found within Cootes Paradise Marsh.

efforts. It was realized long ago that keeping carp out of the wetland would be a significant step in rehabilitation and permit replanting of areas where emergent and submergent aquatic vegetation had been destroyed and plant species extirpated. A significant amount of effort therefore goes toward managing this specific invasive species.

In conjunction with an array of partners under the Great Lakes Water Quality Agreement, including the Federal Department of Fisheries and Oceans and the Province of Ontario's Ministry of Natural Resources, Royal Botanical Gardens participated in the creation of a unique system to "filter" incoming fish at the connection to Hamilton Harbour, the only outlet of the marsh. The system allows native species to pass in whichever direction they were traveling when they encountered the filter, but also to block introduced and invasive fish, specifically large Common Carp, Goldfish (*Carassius auratus*), and Carp-Goldfish hybrids. The system became operational in 1997 and is now called the Cootes Paradise Fishway. The Fishway traps fish larger than 5 cm across in large steel baskets manipulated with overhead travelling cranes. The captured fish are sorted using a system of flues and manually-controlled gates.

A different approach is taken in an adjacent marsh and stream, the lower Grindstone Creek, which is also an RBG nature sanctuary. Here similar stresses occur but a large open-ended delta presents too great a span for the single Fishway type of solution.



Royal Botanical Gardens restoration ecologists Andrea Court and Kyle Vincent planting emergent vegetation in an inner bay of Cootes Paradise Marsh.



Although it's the most common species of emergent aquatic plant within Cootes Paradise Marsh, revegetation can require planting areas with head-started individuals.

In these areas, invasive fish are kept out of about half of the creek delta through a unique application for discarded Christmas trees. Christmas trees are used to create a riverbank corridor through the delta and focal points for carp exclusion. The Christmas tree barrier system is 1.5 km in length and has been in use since 2000. It consists of berms built of discarded Christmas trees that are tied horizontally between pilings. The tree riverbanks create three separate marsh areas, complimenting two slightly upstream areas totaling 20 hectares, each outfitted with a carp exclusion/fish passage structure. The structures are kept open most of the year to allow organisms to pass, but during the Carp spawning season the gates are kept closed (May to July).

In conjunction with the operation of these invasive species control measures, Royal Botanical Gardens has been undertaking extensive programs of replanting of native aquatic vegetation, and the removal of other invasive species, notably the Eurasian Common Reed (*Phragmites australis*). In the 1990s RBG operated an aquatic plant nursery, growing its own plants to repopulate the marsh from seed or root stock from the properties themselves. While the program was relatively short-lived, it emphasized the importance of botanical knowledge and local restoration expertise. Since the 1950s our field botanists have been documenting the species composition of plant communities within the nature sanctuaries, and continue to monitor restoration progress.

Various planting schemes have been undertaken for native aquatic vegetation, with most projects focusing on Cattails (*Typha latifolia*), Southern Wild Rice (*Zizania aquatica*), and native White Water Lilies (*Nymphaea odorata*). Royal Botanical Gardens now collaborates with various native plant nurseries, providing seed from the nature sanctuary properties which the nurseries then grow up to size for planting.

Results of Wetland Restoration Projects

To measure the status and progress of the recovery work multiple monitoring programs are maintained ranging from water quality to aquatic plants to fish populations (Table 1).

Prior to 1997, upwards of 100,000 adult Carp entered Cootes Paradise Marsh every year at the height of the spawning season (Theysmeyer & Cairns, 1995). During its first year of the operation of the Fishway, 95% of the Carp were excluded, with the number changing year to year. The poorest years followed a flood that overtopped the Fishway in 2011, resulting in about 10,000 Carp in the marsh. The best year to date may have been 2013, when fewer than 300 Carp were thought to be present, following a drought and extremely low water in 2012 (RBG, unpublished data). Over the years Carp catches along 50 m-long monitoring transects have dropped from a high of 47 fish in 1995, to a recent maximum of five fish, with most sites now returning no Carp.

Category	1994-1995	2016	Monitoring Method
Water Clarity by Secchi Disk	21 cm (6-57 cm)	48 cm (22 – ~250 cm)	Index station CP2, 11 biweekly visits May- Sept
Area of Marsh Covered by Emergent Vegetation	14.9 hectares	39.8 hectares	Aerial photo interpretation
Area of Marsh with Submergent Plant Vegetation	0% cover (0-0.1%)	45% cover (2-100%)	62 quadrates, 1m x 1m
Recorded Aquatic Plant Species	2	16	62 quadrates, 1m x 1m
Abundance Index of Common Carp	2.2 (0-47 fish)	0.2 (0-9 fish)	24 electrofishing transects, each 50 m long

Table 1. Indicators of water quality and restoration progress in Cootes Paradise Marsh between 1994-1995 and 2016.



An aerial view of Cootes Paradise Marsh looking east. The city of Hamilton, Ontario lies in the distance and on the right.

Water clarity, an important measure of quality, has increased from less than 20 cm, as measured by Secchi Disk, to a most recent average of 48 cm, with highs as great as 2.5 m (0.73 NTU or nephelometric turbidity units) in 2016 (Bowman, 2017). Water clarity is highly variable and is related to weather patterns and water supply inputs, with major impairments occurring after heavy rains because of sediment and erosion upstream in the watershed, and during droughts due to algal blooms (both phytoplankton and filamentous algae). Both conditions create temporary conditions with water clarity of less than 10 cm.

Aquatic plants have expanded annually into areas formerly devoid of any vegetation. In Cootes Paradise Marsh the area covered by emergent plants has more than doubled, covering 39 hectares in recent years from 15 ha. in 1996 (Mataya *et al.*, 2017). Most expansion is through rhizomatic growth from the edges, but has been complimented with the planting of nearly 200,000 plants of various species (mostly *Typha latifolia*) which themselves then expand. The planting has also reintroduced multiple native emergent marsh species such as Softstem Bulrush (*Schoenoplectus tabernaemontani*), Hardstem Bulrush (*Schoenoplectus acutus*) and American Bulrush (*Schoenoplectus americanus*). Water lilies have expanded from two individual plants known in 1996 to several thousand as of 2016. Submerged aquatic plants, which were virtually absent at the outset of Carp exclusion, have been variable in abundance both spatially and

temporally, consistent with the variable water clarity. They have increased to a combined area of 80 hectares as of 2016 and include 16 species (Mataya, 2017). The most abundant plant is Leafy Pondweed (*Potamogeton foliosus*) as measured through quadrat surveys in late June. In the more stable water clarity conditions of sheltered inlets, Southern Wild Rice has also reestablished small populations.

In Grindstone Marsh to the east, emergent planting has been very limited, with emergent plants gradually expanding in the form of cattail (*Typha* sp.), Giant Burreed (*Sparganium*

eurycarpum) and River Bulrush (*Schoenoplectus fluviatilis*). White Waterlily now dominants in much of the Carp exclusion areas. Twelve species of submergent aquatic plants are now present in this system (Mataya, 2017).

In contrast to the success in the Carp exclusion areas in the Grindstone estuary, the 20 hectares without Carp exclusion have continued to experience decline in wetland plant populations to near total extirpation while the water clarity remains poor (less than 40 cm). As of 2016 this area is devoid of submerged and floating-leaf aquatic vegetation, with emergent vegetation consisting of a few meters of shoreline cattails.

Conclusions

Long-term projects to restore wetlands are challenging but rewarding undertakings. The restoration of Cootes Paradise Marsh in particular has seen an extensive regrowth of aquatic vegetation in targeted areas within the inlets of the marsh. This wetland is still susceptible to stressors such as highly variable water quality inputs and unpredictability in the water level. In the summer of 2017, some damage was done to the planting program when the water levels of Lake Ontario reached record levels because of massive rainfalls in April and May both locally and throughout the Lake Ontario basin.



The eastern end of Cootes Paradise Marsh terminates at the Cootes Paradise Fishway, the black structure which controls the passage of fish to and from the marsh.



Photographers and naturalists flock to the trails, wetlands, and boardwalks at Royal Botanical Gardens. Often areas of high biological diversity, such as the lower Grindstone Creek shown here, are just a short walk from major roads and urban areas.

This flooding also resulted in several trails and roads being covered with water or washed out, and interfered with but did not stop the operation of the Fishway itself.

Human wellbeing within urban areas depends on the overall quality of the surrounding ecosystem. Wetlands are not only a common feature within urban spaces: in many cases they were



The Cootes Paradise Fishway became operational in 1997. Visitors (foreground) are welcome to approach the area where staff work to sort fish, turning invasive species away from the marsh.



American Water Lilies (*Nymphaea odorata*) now cover the surface of the largest inlet along the shore of Cootes Paradise Marsh. In the 1990s the species was nearly extirpated from the wetland.

instrumental in their settlement. Ecological restoration of wetland environments by botanical gardens, with special reference to appropriate aquatic vegetation, can make a significant contribution to those urban habitats, and to UN Sustainable Development Goals such as 6 (clean water and sanitation), 11 (sustainable cities and communities), 14 (life below water), and 15 (life on land). An emphasis on appropriate aquatic vegetation in wetland restoration projects, such as those undertaken by Royal Botanical Gardens, is crucial to successful habitat recovery. As a botanic garden, RBG is also uniquely able to interpret the plant world and engage public interest in wetland plant species.

References

- Bowman, J. E. 2017. Water Quality Season Summary 2016. RBG Report No. 2017-11. Royal Botanical Gardens. Hamilton, Ontario.
- Galbraith, D. A., Iwanycki, N. E., McGoey, B. V., McGregor, J., Pringle, J. S., Rothfels, C. J., and Smith, T. W. 2011. The Evolving Role of Botanical Gardens and Natural Areas: A Floristic Case Study from Royal Botanical Gardens, Canada. *Plant Diversity and Resources* 33(1): 123-131. doi: 10.3724/SP.J.1143.2011.10235
- Mataya, K., Court, A., and Bowman, J.E. 2017. Project Paradise Season Summary 2016. RBG Report No. 2017-9. Royal Botanical Gardens. Hamilton, Ontario.
- Mataya, K. 2017. Ecological Land Classification of Cootes Paradise and Grindstone Creek Marshes. RBG Report No. 2017-13. Royal Botanical Gardens. Hamilton, Ontario.
- Ministry of the Environment (MOE). 1986. A.W. McLarty and A.G. Thachuk. Cootes Paradise Study, 1986. Water Resources Assessment, Technical Support Section, Ministry of the Environment, West Central Region.
- Reddick D. and Theysmeijer T. 2012. 20 Year Trends in Water Quality, Cootes Paradise and Grindstone Marsh. Royal Botanical Gardens. Burlington, Ontario.
- Simmons, D. B. D., McCallum, E. S., Balshine, S., Chandramouli, B., Cosgrove, J., and Sherry, J. P. 2017. Reduced anxiety is associated with the accumulation of six serotonin reuptake inhibitors in wastewater treatment effluent exposed goldfish *Carassius auratus*. *Scientific Reports*, 2017; **7** (1) DOI: 10.1038/s41598-017-15989-z
- Theysmeijer T., and Cairns V. 1995. Pre-Barrier Investigation of the Cootes Paradise Fish Community. Department of Fisheries and Oceans Technical Report.
- Theysmeijer T. 1999. The ecological relationship between the Great Lakes coastal marsh Cootes Paradise and the Fish community. M.Sc. Thesis. McMaster University. Hamilton, Ontario.
- Wilcox D. A., Ingram J. W., Kowalski K. P., Meeker J. E., Carlson M. L., Xie Y., Grabas G. P., Holmes K. L., and Patterson N. J. 2005. Evaluation of Water Level Regulation influences on Lake Ontario and Upper St. Lawrence River Coastal Wetland Plant Communities. Upper St. Lawrence - Lake Ontario Environmental Technical Working Group. International Joint Commission.

David Galbraith, Head of Science, and Tÿs Theysmeijer, Head of Natural Lands
Royal Botanical Gardens
680 Plains Road West, Burlington, Ontario, Canada L7T 4H4

All images credited to Royal Botanical Gardens

SDG 11: SUSTAINABLE CITIES AND COMMUNITIES FROM BACKYARDS TO BIOLINKS: ROYAL BOTANIC GARDENS VICTORIA'S ROLE IN URBAN GREENING



Introduction

In an increasingly urbanised world, where it is predicted that two-thirds of the world population will be living in urban areas by 2050, there is a pressing need for the application of sound urban planning approaches to create communities that can sustainably flourish in the environments they occupy. In the framework of the United Nations Sustainable Development Goals, this focus is captured in Goal 11, Sustainable Cities and Communities. While governments and planning authorities clearly play a central role in achieving better outcomes in urban development, botanic gardens also have much to offer. As scientific conservation organisations, botanic gardens are often best placed to provide authoritative advice on the



The Australian Garden follows a metaphoric journey of water from the red centre to the coast

environmental impacts of land development, certainly in terms of understanding the significance of the flora (and sometimes the fauna) in areas marked for urban development. We can also play a strong advocacy role to strive for better environmental outcomes for the benefit of the human and non-human inhabitants, as well as to positively influence the behaviour of the growing community through our educational displays and programs. The Royal Botanic Gardens Victoria's (RGBV) Cranbourne Gardens is actively contributing in these ways to residential development in our region for the benefit of our collections and natural areas and for the growing community around us.

is comprised of remnant bushland containing high quality heathy and grassy woodlands interspersed with wetlands, and an indigenous flora of 370 species. Over 30 species of plants and animals are declared as having State conservation significance, with three nationally endangered species. Scientific research and monitoring by the RGBV commenced in the 1970s and underpins the management of the natural area of the Gardens. Periodic flora and fauna surveys track the effects of management activities over time, and the influence of other factors such as visitor impacts, on-site development and land use changes in the surrounding region.

Contrasting and complementing the bushland is the 15 hectare Australian Garden, a contemporary horticultural display showcasing Australia's remarkable landscapes and plants in an artistic and architectural setting. Developed on a previously sand mined area, the Australian Garden explores the influence that our ever-changing relationship with the native plants and environments around us has on our national identity.

Cranbourne Gardens is a native plant garden located on Melbourne's urban fringe, 45 kilometres south of Melbourne's central business district. Much of the surrounding landscape beyond the garden fence has been cleared for agriculture, food production and residential development over the past one hundred years. Two-thirds of the 363 hectare Cranbourne Gardens site

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable



Target 11.7:

By 2030, provide universal access to safe, inclusive and accessible, green and public spaces...



Contemporary design interprets the nature of Australian landscapes (J Gollings)



The Melaleuca Spits in the Australian Garden – where the river meets the sea (J Gollings)

Importantly, the Australian Garden provides inspiration and advice to home gardeners to encourage the creation of sustainable home gardens using Australian plants - gardens that are well suited to flourishing in local conditions containing plants that are not weedy and are best placed to contribute to the creation of sustainable cities and communities.

Influencing change

The urban growth corridor to the south-east of Melbourne is one of the fastest developing growth corridors in the southern hemisphere. Rapid urban expansion always brings challenges for planning authorities in balancing the needs of different stakeholders—from housing densities, infrastructure needs, the allocation of public open space, to the conservation and enhancement of biodiversity values. Given that much of the land being developed is on Cranbourne Gardens' doorstep, we have a vested interest in striving to influence the development so that it occurs in a way that minimises the threats to our ecological and amenity values. Without the appropriate reservation of land beyond the boundary, Cranbourne Gardens risks becoming “land locked” by residential development and potentially isolated from surrounding biodiversity.

In assessing the risk posed by inappropriate development, it is well understood that isolation of patches of habitat restricts the dispersal of fauna and flora species, making them more vulnerable to the risk of population extinction. Retaining or recreating ecological connectivity between these patches is critical for their continued ecological viability. Habitat corridors, or biolinks, can provide a connection or land

bridge between patches and facilitate the physical movement of species as well as genetic mixing over time, contributing to more robust and resilient flora and fauna communities. Without biolinks, isolated ecological communities are more prone to the negative impacts of predation by pest animals, cats and dogs, fire and flood events, and changing habitat conditions, including those driven by climate change.

Over the past 15 years the RBGV has worked actively and collaboratively with planning authorities, government departments and developers on shaping the adjacent land developments to incorporate a larger proportion of green open space in the form of biolinks suited for local native fauna movement. The establishment of these planning controls has in large part been driven through the presence of Southern Brown Bandicoot (SBB), a small terrestrial mammal that is a threatened native species protected under Commonwealth legislation. Research by RBGV staff has been undertaken to record the presence of this species, both within the Gardens and immediately outside the predator-proof fence line of our boundary, revealing healthy numbers within Cranbourne Gardens but scattered populations outside, which are rapidly declining. Predator eradication programs coupled with habitat management has secured SBB population numbers within Cranbourne Gardens, but the long-term viability of this isolated population likely relies on genetic mixing with the

surrounding isolated populations. Establishment of secure biolinks through the new residential developments is seen as the most viable way to facilitate this. RBGV's role has been as advocate but also as scientific advisor. Part of our input to the planning process included a fully researched report that pulled together the literature available on design of habitat corridors in Australia and included a recommendation on biolink design based on a quantitative assessment of species requirements, including those of SBB. In this way the RBGV provided a robust scientific perspective towards the achievement of an ecologically sustainable outcome.

Home gardens as contributors to sustainable cities

Cities and communities rely on the essential role of ecologically functioning green spaces. The principles of ecosystem services apply here, providing the essential “sustainability” benefits related to improved air and water quality, temperature moderation, passive recreational opportunities, and social and spiritual benefits. While biolinks and public green space are important for landscape connectivity and ecological viability, the role of home gardeners in contributing to the greening of urban areas is often under-recognised. Whether the private space of residents includes a home garden, or a veranda, courtyard or balcony, plant life in these spaces all contribute to the ecosystem service benefits.



Engaging with the future - school education programs at Cranbourne Gardens

The Australian Garden at Cranbourne is a stunning contemporary showcase of Australian landscapes and plants, aiming to connect visitors with the land on many levels—artistic, intellectual, scientific, cultural, emotional, and spiritual. The design follows a metaphoric journey of water from the arid inland ‘red centre’ to the populated coastal edge, taking the visitor on a journey of discovery through a range of different garden spaces and sculptural features influenced by Australia’s diverse and spectacular landscapes. Along this journey, visitors explore and discover our relationship with Australian landscapes and plants from different perspectives – how our plants and landscapes have influenced, and continue to influence, our culture (both Indigenous and post-European settlement) through art, literature, music, science and horticulture.

The need for a garden that focusses on Australian native plants stems from a general under-appreciation of the potential of our amazing and diverse native flora. Perhaps due to the colonial origins of the majority of our population, there has been an over-reliance on exotic plants in private and public landscapes – using what was familiar to our parents and their parents has resulted in predominantly exotic displays. The trend is slowly shifting toward a greater embracing of the opportunities with Australian plants, as gardens like the Australian Garden showcase and inspire, and as the nursery trade responds to the increasing demand for more variety. The trend is not just in ornamentals as there is also growing recognition of the biodiversity benefits of using plants indigenous to the area in which they are cultivated.

In contributing to this increase in interest and use of Australian plants, the Australian Garden has a series of display



Volunteers and staff provide advice on Australian plants and garden design

gardens designed specifically with the home gardener in mind. Designed in response to a number of topical themes, the display gardens provide domestic-scaled examples of how Australian plants can be used in new and exciting ways in a range of different garden settings. Themes include low water availability, habitat creation, use of recycled materials, gardening in small spaces, productive gardens, and gardens as play spaces. Information on garden design, plant selection and cultivation, delivered both face-to-face and by interpretive signs, assists visitors to be inspired to create home gardens that will respond to their local landscape and environmental situation. In looking at how effective we are being in this space, evaluation research conducted by Willoughby, Kendal and Farrar (2013) determined that the Australian Garden displays and programs do influence people’s choice of plants and landscape designs, especially as they become more engaged with us (for example as Friends or volunteers). As new residential areas develop around us, it is increasingly important that we actively provide opportunities for closer and more meaningful engagement to maximise our educational role in creating sustainable home gardens and more connected communities.

Conclusion

Looking back at what we have achieved in influencing SDG 11 and the creation of more sustainable urban development in our region, it is clear that our scientifically robust advocacy for biolinks to connect our natural areas with the world beyond has had an impact. Open space corridors to be vegetated in indigenous plants are being incorporated into the new developments. The biolinks are not as wide as we would like, but they will



Getting them young...potting up activities engage families on the basics of growing plants

still play an important role in habitat connectivity between our stronghold of intact ecosystems and other the patches of biodiversity beyond our boundary. A State-funded RBGV outreach officer is soon to commence to continue the engagement with new home owners, school children, developers and local government in creating habitat-friendly suburbs, leveraging off the existing education programs and the displays and interpretation already provided at Cranbourne Gardens. As visitor numbers to the Australian Garden continue to increase, and as we establish more productive community partnerships, our role in connecting people with plants will result in more sustainable communities – a role that is being increasingly recognised as core business for botanic gardens worldwide.

References

- Russell, C., Willoughby, S., Burness, J. 2012. Backyards to biolinks. City Green #4
- Willoughby, S., Kendal, D., Farrar, A. 2013. Public places and private spaces. Botanic Gardens Conservation International Education Review, Roots 10 (2)

Chris Russell
Executive Director, Cranbourne Gardens
Royal Botanic Gardens Victoria
1000 Ballarto Road
Cranbourne
Victoria 3977 Australia



Display gardens provide home gardeners with ideas and inspiration to use Australian plants at home

Authors: Marie-Cakupewa Fundiko and Bartjan Bakker



Preparing the first tree nursery for the Botanic Garden Uni50Lwiro at Lwiro. This nursery includes native and exotic tree species (Marie-Cakupewa Fundiko)



In South-Kivu, one of the poorest and most violent regions of the Democratic Republic of Congo, a small team is setting up an (ethno) botanical garden to safeguard traditional botanical knowledge, endemic plant species, and wild food crops.



Pygmy women in Tshivanga

Introduction

Characterized by almost two decades of armed conflict, massive internal displacement and migration, the province of Kivu is, to put it mildly, not stable. In Lwiro district in Irhambi-Katana, families fleeing conflict and insecurity in the mountains (highland areas) find resettlement in villages close to the Kivu Lake and transitional zones.

In South-Kivu, 60% of the population has no access to land (Balagizi *et al.*, 2013). In these areas, access to land and its ownership has become a social issue and is generating great conflict between native and migrant communities.

Protected areas

To protect its mega-biodiversity, 10% of the land of the Democratic Republic of Congo (DRC) is devoted to protected areas in the form of National Parks (USAID, 2010). Unfortunately, most of the protected areas in the east of DRC are still in war and conflict zones. Since 1994, massive internal and external displacement has led to rapid urbanization in rural areas, with a huge degradation of natural habitats.

The Parc National de Kahuzi-Biega (PNKB) in South-Kivu is known for its dense forests which harbour several endemic animals, such as the Mountain

Gorilla and several threatened plant species such as the Congo balsam (*Impatiens*) of the Albertine Rift. These natural forests constitute the main source for food and medicine for about 80% of the population, especially indigenous and rural communities living around such reserves who rely on natural resources for their livelihoods. However overexploitation, combined with the impact of invasive species, now threaten the biodiversity of the forest. It is no longer allowed to remove natural resources from the PNKB.

SDG 12: Ensure sustainable consumption and production patterns



Target 12.2:
By 2030, achieve the sustainable management and efficient use of natural resources



The tree nursery for the Botanic Garden project at Lwiro, South-Kivu (Marie-Cakupewa Fundiko)

Food insecurity

Land degradation, declining soil fertility, unsustainable water use, overfishing and environment degradation are all lessening the ability of the natural resource base to supply food in the South-Kivu.

Wild food crops such as *Lebrunia bushaei*, *Ricinus communis*, *Grewia mildbraedii*, *Canarium schweinfurtii*, *Psidium guajava*, *Aframomum* spp, *Ensete ventricosum*, *Myrianthus holstii* as well as several locally cultivated food plants are becoming scarce not only on the market, but also in their natural habitats in the conflict zone.

To deal with the poverty, hunger and forest degradation, the local communities in the South-Kivu are now very much reliant on seeds of improved varieties, which are distributed by several UN agencies amongst the displaced / refugees for food security. These plants species can become invasive and constitute a real threat to the local flora, while also undermining the traditional knowledge of indigenous plants, which are more adapted to local conditions and resilient in the face of climate change. While improved varieties of introduced crops are important in addressing the food crisis in migration settings, the change in nutritional habits amongst rural communities is also leading to arrange of dietary problems, from malnutrition to diseases such as diabetes, heart disease and obesity.

Balancing priorities

It is important to protect and restore forests and their ecosystems within protected areas. This enables ecological studies and research on biodiversity conservation to be carried out, as well as encouraging ecotourism. However, the alarming rate of habitat degradation and biodiversity loss in the South-Kivu and the

importance of its protection for the world cultural heritage has to be balanced against the challenge of food security in this post-conflict zone. This requires a systemic approach and cooperation among actors operating in the chain of food production and consumption.

A component of the food supply chain can be the domestication of crop wild relatives in a botanical garden and the advocacy and promotion of sustainable consumption. Botanic gardens can also help to secure threatened plant species from the forest.

Botanical Garden Uni50 Lwiro

A new botanical garden is under development with the following objectives:

- To design and develop a reference (Ethno) Botanic Garden area as a transitional zone between the PNKB and the rural communities in Lwiro/South-Kivu;
- To contribute to further collection of the (folk) taxonomy and the domestication of crop wild relatives, to support the restoration of the forests and address food security in migration settings;
- To stimulate a systemic approach and the cooperation among local actors and stakeholders for sustainable consumption and biodiversity conservation in rural areas in South-Kivu;
- To initiate and contribute at the long-term to a Native Seed Centre Programme at Lwiro/South-Kivu for food security, sustainable production and consumption.

It is planned that the botanic garden will become an important space for research and cooperation on biodiversity conservation, to test theories on conservation and adaptation and to allow the transfer of traditional botanical knowledge about local plant species and their wild relatives in the South-Kivu.

Progress to date

A feasibility study has been completed and a pilot nursery has been created at the Université du Cinquantenaire de Lwiro (Uni50 Lwiro) in the South-Kivu. Under the supervision of M-Cakupewa Fundiko, a strong network has been established and cooperation created between several actors and stakeholders in the chain. Further steps include:

1. Delimitation of the reforestation area at Lwiro.

Between October 2016 and November 2017, the Uni50 Lwiro, under the facilitation of the DRCC foundation¹ obtained 16 ha of land from the Centre de Recherche en Sciences Naturelles de Lwiro (CRSN) to host the reforestation project and the further infrastructures of the university. The DRCC foundation has benefitted from the financial support of the Rotterdam Zoo/Botanic Garden to allow the mapping of the site, the plan and topography of the university including the pilot botanic garden and the feasibility study. For this step, an engineer in geology and topography was hired to deliver the expected results. To ensure the best design of the pilot botanic garden, the horticultural knowledge and the botanic collections at the Herbarium of the CRSN Lwiro were used, as well as several BGCI online publications (Gratzfeld, 2016).



Traditional home-made plant pockets

¹www.drccfoundation.org



The botanic garden illustrating ethnobotanical knowledge

The plans for the garden were presented at the 6th Global Botanic Garden Congress in Geneva from 25 June-30 June 2017. During this conference, the presentation “*Ethnobotany and Botanic garden in Migration settings*” was presented in the symposium on the Conservation of Useful Plants and Traditional Knowledge (BGCI, 2017)..

During this phase, M. Fundiko has also applied for diverse permits for further research and networking in the field. The permits involve a research programme on Ethnobotany of Traditional Knowledge on Food Plants in the South-Kivu. An international team at Gent University in Belgium and the Université du Cinquanteaire de Lwiro has accepted to supervise PhD research on the subject.

2. Further study on the flora including *ex situ* plant conservation was carried out using the Flora at the herbarium of the CRSN and the PNKB

3. Botanical collections of seeds for the project

Several expeditions to the forest in the PNKB and neighborhood were organized to collect seeds and seedlings of selected trees and food plants. These seeds and seedlings were further selected based on the rate of germination in the nursery. The reserve of Tshivanga in the PNKB, the Mulolo forest, and Tshibati in the PNKB were among the sites investigated. The collection thus includes seeds from both high and low altitude. The team also explored the Nyungwe National Park and the Cyamudongo forest in Rwanda on several occasions. These trips facilitated exchanges with the Botanist Prof. Dr. Fischer (Koblenz University, Germany), specialist of the Flora of Nyungwe. Further contact has been made with Prof Fischer for future collaborative

opportunities within the project. The identification and the verification of the taxonomy of species collected was carried out by experts at the CRSN Lwiro and the University du Cinquanteaire de Lwiro. Mr. Dumbo, the oldest expert taxonomist has identified most of the species collected in the wild forest.

For easy access to particular plant species, the research team also visited markets of edible and useful plants in the rural areas. The main public markets in Katana and Chabwinemwami were visited to collect seeds. For further diversification of the nursery, the project cooperates with local stakeholders and international organizations committed to forest restoration in the rural areas. These include the WWF restoration programme in the South-Kivu, the Wildlife Conservation Society, the German LHL projects and COOPERA. With their cooperation, our team has collected useful cultural keystone species such as *Moringa* and *Coffea* spp.

4. The nursery for the Uni50 Lwiro botanic garden.

Two nurseries have been managed since September 2017. Three researchers and technical staff are working daily in the nursery and the garden. The nursery is used as a place to select seeds and to grow the main traditional plant species and endemic plants. At this stage, the project team has benefited from the horticultural knowledge of B. Bakker and A. de Groot, who visited Lwiro in August 2017. The seeds and seedlings were selected based on several criteria:

- the endemism of a species and its relationship with biodiversity conservation, (fauna and flora)
- the social-cultural significance of the species in the local community, (medicinal, ritual, agricultural,)
- the degree of threat of the species in the natural habitats, (see degraded ecosystems)
- the degree of adaptation of the tree and its integration by the local community
- the availability and accessibility of the collection locality
- The germination rate of the seed

or the seedling.

Promotion of sustainable food plant production and the consumption of minor (wild) food plants is illustrated through a home ethnobotanical garden established for the traditional restaurant at the Uni50 Lwiro. For sustainability, students engaged in the project utilize traditional hand-made pockets for the germination of the seeds in our nursery. Food plants species (mainly crop wild relatives) have been collected from the wild and processed in the nursery.

Acknowledgement

We thank the management team of the Uni50 Lwiro, in particular, Prof. Dr. Mubalama Zibona and the Rotterdam Zoo/Botanic Garden for providing the space and supporting the project of the Botanic Garden of Lwiro in South-Kivu. We also thank the international network, the BGCI team in particular and the DRCC foundation for their support, advice and the cooperation. We hope they will continue to network and lobby for the funding of ongoing activities.

References

- Balagizi, I. K., Ngendakumana, H. Mushayuma, N. H., Mirindi, T. A., Muhimuzi, A. B., Bajope, B., & Mwapu, I. 2013. Perspectives de gouvernance environnementale durable dans la région de Lwiro (Sud Kivu, République Démocratique du Congo). Vertigo.
- BGCI. 2017 Abstracts of presentations at the 6th Global Botanic Gardens Congress, Geneva, Switzerland, 24-30 June, 2017. <http://www.bgci.org/files/6GBGC/Book%20of%20abstracts.pdf> (p.81).
- Gratzfeld, J. (Ed.), 2016. From Idea to Realisation – BGCI's Manual on Planning, Developing and Managing Botanic Gardens. Botanic Gardens Conservation International, Richmond, United Kingdom.
- USAID. 2010. Biodiversity Conservation and Forestry Programmes: Annual report.

**Marie-Cakupewa Fundiko
DRCC Foundation / Rotterdam Zoo
and Botanical Garden
Ammuntiehaven 743, 2511 XW,**

SDG 13: CLIMATE CHANGE

BEING LESS BAD IS NOT GOOD ENOUGH ANYMORE



Center for Sustainable Landscapes (Denmarsh Photography, Inc.)



The Phipps Conservatory and Botanical Gardens helps its constituents understand the connections between people, plants, health and the planet

Introduction

We need a major paradigm shift in the way we build and operate our gardens and live our lives. Being less bad, which is what most sustainability programs seek to achieve, is not going to help us solve major human and environmental challenges such as climate change, habitat destruction, loss of biodiversity and issues related to water, energy,

health and food security. We need to inspire our communities to embrace positive change by leading by example.

We often focus on the symptoms of problems, like climate change or cancer, and not the causes of the problems, which are related to unsustainable use of natural resources and lifestyles. Greening our buildings, programs and operations can help us inspire our constituents to change the way they

SDG13: Take urgent action to combat climate change and its impacts



Target 13.3: Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

interact with the world and address important human and environmental issues. Our progressive leadership in this area can direct us toward a regenerative world in which we respect other forms of life, share the earth's resources and live in harmony with nature. It is an opportunity in which botanical gardens are uniquely qualified to make lasting positive impacts in our communities.

Extractive	Less bad	Do good	Regenerative
About me	About us Inter-connections	About us Reciprocity	About us System
Fragments	Fragments stabilize them	Fragments Improve them	Whole

Four different paradigms for interacting with the world

In her work, Carol Sanford describes four different paradigms for interacting with the world.¹

In the *extractive* model it is all about “me”; the individual doesn’t care who or what they hurt to get what they want. The world is seen in fragments, there for the taking. This is colonialism. In the *less bad* model we see a shift in thinking from “me” to “us”; an individual in this paradigm sees the world as fragmented, but recognizes the fragments as interconnected and tries to stabilize them. This is where the environmental movement started, as exemplified by the “reduce, reuse, recycle” hierarchy and the first green building certification systems. The *do good* model is also about “us,” but recognizes reciprocity; an individual in this model sees the world as fragmented but interconnected and tries to improve it. Some later iterations of green building programs fit this model. The final paradigm is

regenerative. It is about “us,” and seeing the world as a whole interconnected system rather than separate fragments.

A regenerative world

In a regenerative world, individuals move beyond thinking about themselves in isolation and see the larger social and natural systems that we collectively need to survive. This is the paradigm we need to adopt for the long-term health of the planet. Climate change, loss of habitats and biodiversity are all symptoms of a problem that can be addressed with regenerative thinking.

It is a lifestyle issue. We routinely ignore and support activities that are bad for human and environmental health. With our use of end products, we support fossil fuels, mineral extraction, monoculture crops propped up by chemical fertilizers and pesticides and meat produced in inhumane conditions



Café Phipps (Adam Milliron)

with a diet of antibiotics and hormones, to name just a few. Nothing like this exists in nature. We are polluting the planet with millions of pounds of toxic persistent chemicals each year. By 2050, it is estimated that our disposable way of living will result in more plastic in the ocean than fish. We are presently headed toward a future where we will be remembered not for our technological or artistic achievements, but for the terrible devastation we brought upon the planet.

It doesn’t have to be this way, but it means we can no longer ignore the way we live.

Imagine what your garden would look like 10 years from now if it were regenerative. Will you reach that goal? If not, what is holding you back? Quite often the answer given is “We can’t afford it.” In the developed and rapidly developing parts of the world, that answer isn’t good enough anymore. If we cannot build a building or operate a program that contributes to making the world a better place we need to seriously consider whether we should build or do it at all. It comes down to acting on our values. If climate change and the loss of biodiversity and habitats are truly important, than everything we do contributing to that needs to be seen as a high priority.

The Phipps ‘journey’

At Phipps that line of thought sent us on a journey beginning in the late 1990s. We started with our buildings because the built environment is responsible for much of the energy and water we use



Aerial view of the Phipps Living Campus (Lofty Views)

¹Sanford, Carol, personal communication, February 25, 2017

and pollution we produce each year. Over the years since then we have built increasingly greener buildings, ultimately leading up to the Center for Sustainable Landscapes (CSL) in 2012 which is still recognized as one of the greenest buildings in the world.

A defining attribute of the CSL was the adoption the Living Building Challenge (LBC) as our design standard. The LBC is the most rigorous green building rating system in the world. It supports a regenerative way of thinking and is systems-based, which is how nature works. The LBC starts with a powerful premise to create a world that is socially just, culturally rich and ecologically restorative. It requires that projects meet net-zero energy from renewable energy produced on-site, and that buildings capture and treat all their storm and sanitary water. Materials must be non-toxic and low impact. Projects must integrate local culture, biophilia and beauty to foster community and natural connections.

Following our immersion in the LBC, we set out to make all of our programs and projects, from horticulture and facilities to food service, comply with the standard.

More recently, we have begun to align our actions with the 7 First Principles of Regeneration:²

1. **Whole:** We think in wholes rather than parts. Holistic rather than reductionist. We see our organization, staff, visitors



Center for Sustainable Landscapes - Green Roof (Paul G. Wiegman)

and ecosystem as interconnected. Nothing works in isolation. We are constantly looking for ways to demonstrate how human and ecological wellness are inextricably connected. We manifest our core values in every initiative and program. We seek to understand whole living systems and our roles as members of nature.

2. **Potential:** We initiate with potential. Rather than trying to solve problems we focus on what we want to achieve and why: We demonstrate the links between human and environmental

health at the intersection of the built and natural environments to inspire visitors to change the way they interact with the world.

3. **Reciprocity:** We recognize that we operate within living, dynamic, nested systems, and that we make reciprocal, mutually beneficial interactions with the larger and lesser systems in which we are nested. In our café, for example, we begin with responsible sourcing based on how food is produced, add healthful preparations with no junk food and follow through by composting all pre- and post-consumer waste and eliminating plastic disposables to minimize landfill waste.

4. **Essence:** We exhibit singularity, recognizing that our institution should always work from a place that recognizes our non-displaceable uniqueness. The depth of commitment to linking human and environmental health throughout all of its activities and focus on core values, mission and purpose is what makes Phipps unique.

5. **Nestedness:** We are embedded within greater and lesser systems, each playing a core role in the success of the whole and other nested wholes. We see our roles within our community, region, nation and world as opportunities to develop reciprocal, mutually beneficial relationships, particularly in areas that link human and ecological health.



Welcome Center (Paul G. Wiegman)

²Sanford, Carol (December 15, 2017). What is Regeneration? Retrieved from <https://theregenerativebusinesssummit.com/regeneration/>



Center for Sustainable Landscapes (Denmarsh Photography, Inc.)

6. Nodal: We seek interventions at the point of highest systemic return. Similar to acupuncture, where a single point or set of points can have the greatest impact. With programs like *Homegrown*, which installs vegetable gardens at homes in food deserts, or *Let's Move Pittsburgh*, which focuses on regional children's health, we move beyond the conventional botanical garden mission to amplify our impact.

7. Development: We seek to grow and develop the capacity in everyone we reach to help them make sustainability a defining component of their lives.

For Phipps it started with our own organization. The following timeline illustrates some of the key decisions that were driven by our developing value chain:

Date	Decision
2005	Adopted 100% renewable energy campus-wide
2005	Aggressive IPM and toxic pesticide reduction
2006	Eliminated plastic disposable serveware
2006	Began composting all pre- and post-consumer food waste
2009	Eliminated bottled water
2009	Switched to hormone- and antibiotic-free meat, rBST-free milk, and cage-free eggs
2010	Offset all carbon produced to heat all of our buildings
2011	Eliminated soda and junk food from our café
2011	Eliminated factory farmed meats
2015	Divested from fossil fuel investments
2017	Defined new socially responsible investment guidelines

From 2005 to 2016, we reduced the CO₂ output from our buildings by 56% per square meter, twice as much and twice as fast as the Paris Climate agreement. We continue to look at ways to improve efficiency and reduce the use of fossil fuels.

Building sustainable lifestyles

Once we had our house in order, we started to look at ways to develop the capacity in our visitors to adopt more sustainable lifestyles. In mid-January 2017 we forged an agreement with a renewable electricity provider to purchase discounted Phipps memberships that they could use as incentives for visitors to switch their home electricity to renewable energy. Because nobody knows what a ton of CO₂ looks like, we related the amount of CO₂ to barrels of oil burnt. In

June, after the U.S. announced plans to withdraw from the Paris Climate Agreement, we lined our front walkway with 16 oil barrels to demonstrate the CO₂ a typical Pennsylvania household produces to power their home each year. To eliminate procrastination, we stipulated that anyone who wanted the free membership had to switch on the spot while visiting Phipps. The result has been phenomenal. In the first 11 months, over 2,000 families have switched to renewable electricity, and those 16 barrels of oil not burnt each year are now more than 32,000.

Conclusions

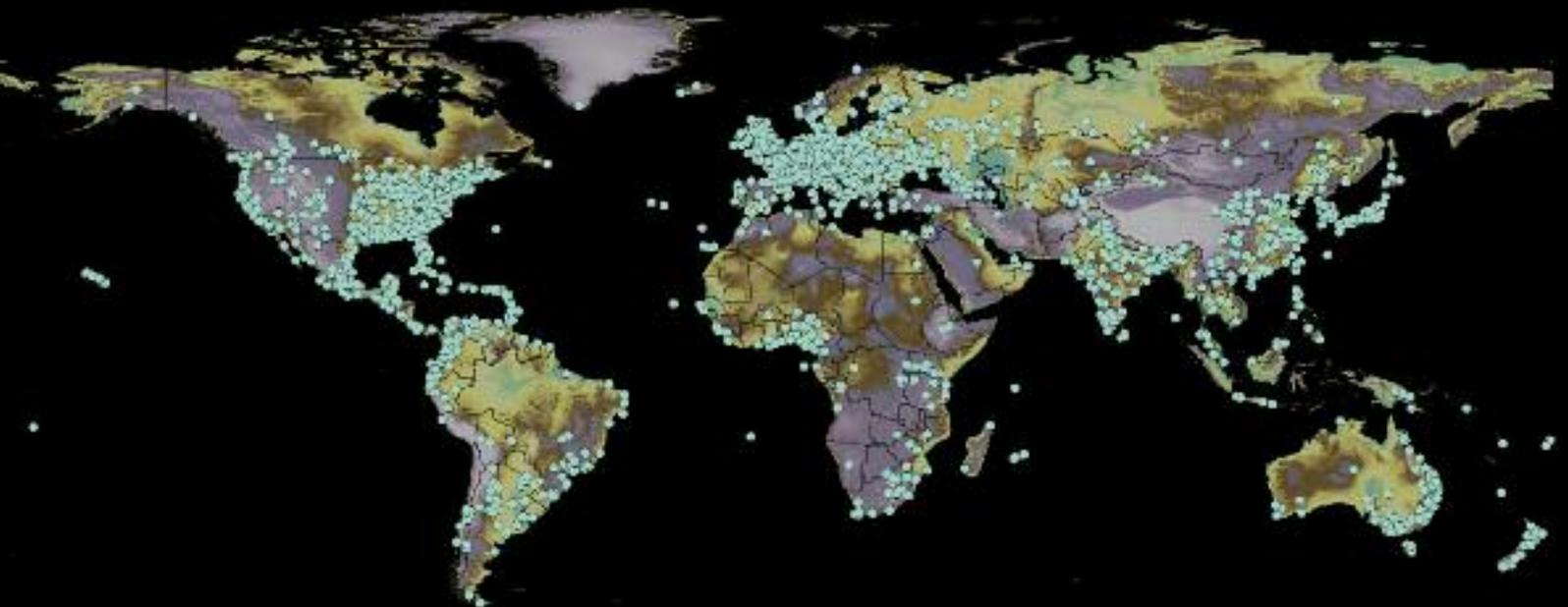
By taking a regenerative approach in the way they see and interact with the world, botanical gardens can help their constituents understand the connections between people, plants, health and the planet. We all can, and should, take short-term actions to deal with the symptoms of our lifestyles, but ultimately addressing the core problem and adopting a regenerative way of interacting with the world is the best long-term solution for our health and the health of the planet.

Richard Piacentini
Phipps Conservatory and Botanical Gardens
One Schenley Park
Pittsburgh, Pa. 15213 USA



Centre for Sustainable Landscapes environs (Annie O'Neill)

JOIN THE WORLD'S LARGEST PLANT CONSERVATION NETWORK



For 30 years Botanic Gardens Conservation International has represented the botanic garden and arboretum community.

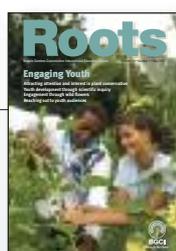
BGCI's directory of botanic gardens, GardenSearch, lists 2,500 botanic gardens that conserve a third of known plant diversity and attract 500 million visitors a year.

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

- Major discounts on registration fees for BGCI Congresses
- Tailored support and advice on request
- Preferential access to BGCI project funding
- Access to the Member's Area of BGCI's website, which includes advanced features on our databases: PlantSearch, ThreatSearch and GlobalTreeSearch
- Access to BGCI's Conservation Accreditation Scheme and Directories of Expertise in seed conservation, ecological restoration, conservation arboriculture and public engagement
- The opportunity to join BGCI's technical networks, including the Global Trees Campaign and the Ecological Restoration Alliance
- Preferential opportunities to participate in BGCI training courses in plant conservation techniques and public engagement (200 training places are available)
- Eligibility for BGCI's Botanic Garden Partnership Programme





BGCI

Plants for the Planet

**Botanic Gardens
Conservation International**

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

Tel: +44 (0)20 8332 5953
Fax: +44 (0)20 8332 5956
E-mail: info@bgci.org
Internet: www.bgci.org

ISSN 1811-8712



eurogard2018.org

EUROGARD VIII

EUROPEAN BOTANIC GARDENS, PEOPLE
AND PLANTS FOR A SUSTAINABLE WORLD

Lisboa, May 7 to 11 2018

XV Symposium de l' Asociación
Ibero-Macaronésica de Jardines Botánicos