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Botanic gardens and their contribution to Sustainable Development Goal 15 - Life on Land

BOTANIC GARDENS CONSERVATION INTERNATIONAL

Cover Photo: Franklinia alatamaha *is extinct in the wild but successfully grown in botanic gardens and arboreta (Arboretum Wespelaar)*

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United Nations Decade on Biodiversity 2011-2020

IN THIS ISSUE...

EDITORIAL:
BOTANIC GARDENS AND SUSTAINABLE DEVELOPMENT GOAL 15

Sustainable Development Goal 15 (SDG 15) is in many ways the SDG most relevant to the work of botanic gardens. With its focus on 'Life on Land', it provides an important entry point for botanic gardens into the global development framework, linking their conservation work to internationally agreed goals and targets. In this edition of BGjournal we explore a number of different activities carried out by botanic gardens that deliver SDG 15 targets, including threat assessments, *ex situ* conservation, *in situ* conservation, ecological restoration and sustainable development.

On the Coromandel coast of India (pp. 16-18), Auroville Botanical Gardens are conserving Tropical Dry Evergreen Forest, the most threatened and reduced habitat in India, which is now largely confined to sacred groves and cultural sites. The Garden raises awareness about the importance of the conservation of these sites but is also actively restoring this and other vegetation types, working closely with some of India's largest commercial companies.

Crossing the Indian Ocean into Africa, the Royal Botanic Gardens, Kew is working with the Food and Agriculture Organisation of the United Nations (FAO) and Forestry departments in Burkina Faso, Mali and Niger on the African Union's Great Green Wall project (pp. 19-22) which aims to restore Sahelian vegetation affected by climate change and desertification. In collaboration with local communities, seeds of 55 useful woody and herbaceous species have been planted to restore 2,235 ha of degraded land and create sustainable income-generating opportunities for up to 32,000 people. Over 1,000,000 seedlings of selected species have been planted in around 200 experimental plots and additional techniques have been tested such as assisted natural regeneration of native species, all the methodologies and results being rigorously measured to better inform large scale efforts.

Equally impacted by climate change are the fragile alpine habitats of North America. On pages 23-27, Betty Ford and Denver Botanic Gardens describe the work they are doing to raise awareness of and conserve the alpine habitats and species of the Rocky Mountains. Their emerging strategy includes the use of botanic gardens in alpine zones to educate the public and active programmes monitoring, conserving and restoring alpine habitats and rare and threatened species.

As well as becoming increasingly involved in *in situ* conservation efforts, botanic gardens are stepping up their more traditional activities in assessing the conservation status of plant taxa and carrying out *ex situ* conservation activities. On pages 28-31, Suzanne Sharrock and colleagues from BGCI give a useful summary of the contributions that the global botanic garden community is making to red listing and seed banking.

Botanic gardens are particularly well placed to work at the species conservation level, preventing critically endangered plant species from becoming extinct. An example of this is given by BGCI's Head of Tree Conservation and Ecological Restoration, Kirsty Shaw (pages 32-35), who describes an integrated conservation project focusing on Malawi's national tree, the Mulanje Cedar. This critically endangered species is nearly extinct in the wild, and species recovery efforts combine restoration with livelihoods benefits for local people.

Species recovery and habitat restoration programmes are not just about planting native species. In many cases, natural habitats and native species are in decline because of pests, diseases and invasive alien species that outcompete them. Botanic gardens today are very much involved in identifying potentially invasive species and implementing suitable controls. The work of German gardens in identifying species with actual and potential invasiveness is presented on pages 36-39, and is a model that national botanic garden associations can follow elsewhere.

Our featured gardens this issue are the 10 National Botanic Gardens of the South African National Biodiversity Institute (SANBI). SANBI's gardens are involved in all aspects of SDG 15, carrying out activities ranging from in situ conservation of native habitats to ecological restoration, sustainable development and public engagement (pp. 9-11). Our plant-hunting story (pp.6-8) also comes from South Africa and is an inspiring example of how a small garden can achieve significant impact.

Finally, I would like to welcome Noelia Alvarez to BGCI. Noelia is featured in our 'Talking Plants' section (p 12), and has a passion for plants, botanic gardens and conservation. With nearly 20 years of experience as a conservation horticulturist, she brings an important new dimension to the BGCI team as well as Spanish language skills, which will help us support botanic gardens in Latin America.

I hope that you enjoy this edition of BGjournal. If you have any comments you would like to make, I encourage you to email us at info@bgci.org. We would also like to hear from you with suggestions and ideas about future editions of the journal.

Dr Paul Smith
BGCI Secretary General

Ian Harvey-Brown

FEATURES

NEWS FROM BGCI

PLANT HUNTING TALES:
SEED COLLECTING IN THE WESTERN CAPE OF SOUTH AFRICA

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NEWS FROM BGCI

SEED CONSERVATION DIRECTORY OF EXPERTISE

BGCI has recently launched a Directory of Expertise on seed conservation. The Directory contains information on individuals, facilities and expertise around the world related to seed conservation, with a focus on plant species of wild origin.

The Directory includes information from over 400 experts and can be searched geographically (by country, region or multiples of countries), by expertise related to various aspects of seed conservation, by facilities and by habitat type.

This tool will benefit the global plant conservation community through expanding seed conservation networks, facilitating exchange of information and ideas, and enable better seed conservation stewardship by supporting connections, collaborations and exchange.

The Directory is accessible at: www.bgci.org/plant-conservation/seedexpertise/

BGCI LAUNCHES BOTANIC GARDEN ACCREDITATION SCHEME

BGCI has launched an accreditation scheme which aims to distinguish botanic gardens from other types of gardens and parks and recognises achievements in plant conservation. The scheme includes three different accreditations:

- **Botanic Garden Accreditation** is aimed at botanical institutions wishing to establish their credentials as botanic gardens.
- **Conservation Practitioner** recognises botanic gardens with a conservation-oriented approach.
- **Advanced Conservation Practitioner** is for botanic gardens that have significant conservation impact and focuses on conservation actions that support local, national or global conservation goals.

The first to achieve BGCI Botanic Garden Accreditation

Gullele Botanic Garden, Ethiopia;
Huntington Library, Art Collections and Botanical Gardens, USA;
Jardín Botánico Universitario – BUAP, Puebla, Mexico;
National Botanic Garden of Wales, United Kingdom;
Pha Tad Ke Botanical Garden, Laos;
Stellenbosch University Botanical Gardens, South Africa;
University Botanic Gardens Ljubljana, Slovenia;
Wollongong Botanic Garden, Australia.

Botanic gardens that achieve any of the three accreditations will be recognised by BGCI in later issues of BGjournal.
Find out more at: www.bgci.org/accreditation

GROWING TREES ON THE IUCN RED LIST

The latest update to the IUCN Red List of Threatened Species (2018-1) included new assessments for 699 tree species. These assessments will make an important contribution to the Global Tree Assessment. Some assessments are for trees that have never been on the red list before while others are reassessments of trees that previously featured on the list.

The update includes assessments for agarwoods - in the genus *Aquiliaria*. These species are highly threatened by overexploitation for the fragranced wood they produce known as Agarwood. *Aquilaria malaccensis*, is one of the most prized agarwoods, and has been reassessed as Critically Endangered, due to the increased threat from overharvesting and habitat conversion over the last decades.

Following a successful red list training course hosted by BGCI and Cayes Botanic Garden in Haiti in October 2017, the first assessments of Haiti's endemic trees can now be found on the IUCN Red List. Over fifty species are assessed including eight species of *Miconia*.

More assessments for *Fraxinus* and *Tovomita* can now also be found online and all species of the family Theaceae now have published assessments on the IUCN Red List.

NEW BGCI TRAINING RESOURCES

BGCI has produced a series of training materials useful for those working in botanic gardens and plant conservation. Newly released resources focus on forest restoration, seed conservation and red listing for trees:

- **Forest restoration e-learning modules:** A suite of modules providing guidance on restoring forests. There are three modules in the series, which explore planning forest restoration and how to select and source appropriate native species for restoration.
- **Red listing e-learning modules:** A series of four modules on red list assessments of trees. Together these offer an introduction to tree red listing for anyone interested in getting involved with red listing of tree species.
- **Seed conservation video library:** A series of videos from around the world showcasing seed conservation initiative and demonstrating a range of techniques used in seed collecting and conservation.

To find out more, visit the resources section of the BGCI website. www.bgci.org/resources

THE GLOBAL STRATEGY FOR PLANT CONSERVATION – WHAT FUTURE?

The follow-up to the Global Strategy for Plant Conservation 2011-2020 will be considered in 2020 as part of the development of a post-2020 global biodiversity framework.

In order to gather views on the nature and content of a Global Strategy for Plant Conservation beyond 2020 and how it might be integrated into the post-2020 global biodiversity framework, the CBD Secretariat has launched a survey – available in English and French. The results of the survey will be considered at the forthcoming Conference of the Global Partnership for Plant Conservation and the sixth meeting of the Liaison Group on the Global Strategy for Plant Conservation (Cape Town, South Africa 28-31 August 2018).

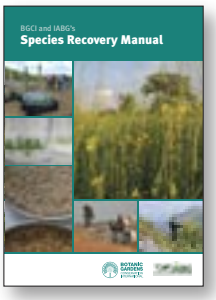
To find out more and complete the survey, visit: www.bgci.org/news-and-events/news/1496/

ECOLOGICAL RESTORATION ALLIANCE – PUBLIC SYMPOSIUM

The next public symposium of the Ecological Restoration Alliance of Botanic Gardens will be held at the Royal Botanical Gardens (Ontario, Canada), on 3rd October 2018. The public symposium "Restoration in Urban Areas" will bring together restoration practitioners and researchers, from across the world to discuss how to deliver effective innovative ecological restoration, particularly in the urban context. A tour of ecological restoration sites within the 1,000 ha of nature sanctuaries owned by Royal Botanical Gardens as well as nearby projects in other protected areas will also be organised for ERA members. The tour will include wetland, prairie-savannah and other restoration themes, as well as a visit to a reclaimed quarry that now hosts a vibrant wetland.

SPECIES RECOVERY MANUAL

BGCI and the International Association of Botanic Gardens (IABG) have published a manual to guide species recovery projects. Species recovery involves many different disciplines and actors, and responsibility for it at a national level is often unclear, given that it cuts across different ministries and agencies. This new manual clarifies the aims and purpose of species recovery, set out the various steps involved, and indicates good practice. This manual is aimed specifically at conservation practitioners but also includes comprehensive bibliographic references, which enable more in depth reading on the topics covered in this publication. The manual includes chapters and case studies from members of the Ecological Restoration Alliance of Botanic Gardens.



Download a copy of the manual from the resources section of the BGCI website.

BIG PICNIC

As well as in depth research into public opinion on food security issues, BigPicnic is seeking to carry out a large-scale survey to look at what motivates people across Europe and beyond to choose the food they eat. This will help us to develop recommendations to shape the future of research and innovation in areas related to food and food security.

Find out more and complete the survey at www.bigpicnic.net

PLANT CONSERVATION AND BIODIVERSITY BENCHMARKING

BGCI-US and The American Public Gardens Association are proud to announce the launch of their Plant Conservation and Biodiversity Benchmarking site. This provides the most comprehensive look at current plant conservation capacity for all public gardens throughout North America. The tool allows you to access, analyse, and download reports relevant to your garden and conservation goals – and see how your activities align with international plant conservation strategies.

Find out more at www.publicgardens.org

Authors: Robbie Blackhall-Miles and Ben Ram

PLANT HUNTING TALES
SEED COLLECTING IN THE WESTERN CAPE OF SOUTH AFRICA

Ben with Protea rupicola *at near 2000m asl*

Created to tell the story of land plant evolution, Fossil Plants is a back-garden in North Wales that is home to a collection of over 1,000 plant species and is bolstered by a small nursery facility used for horticultural research. We (Robbie Blackhall-Miles and Ben Ram) wanted to expand knowledge and understanding of these plants and aid their conversation, so in 2014 the garden joined BGCI as an institutional member. At only 115m², it may well be the smallest botanic garden in the world.

One of the greatest stories of plant evolution and diversification is that of the *Proteaceae*. Colloquially known as proteas, this plant family includes the iconic *Protea* and *Banksia* amongst its 83 genera. We have focussed much of our efforts on understanding the horticulture of proteas, particularly ones that live in a temperate climate similar to our own. Many of the proteas regularly available in European horticulture are not suited to growing in our often cool and damp climate, preferring a more Mediterranean one. In the wild, however, many proteas that grow in the higher altitudes of Chile, South Africa and Australia do experience similar conditions to our own. We have compared weather data from our own weather station and historic data from nearby long running weather stations to find that they are similar to one at 1000m above sea level, on a mountain called Dwarsberg in the Western Cape of South Africa.

Mimetes argenteus

Leucospermum winteri

Protea rupicola

This knowledge encouraged us to start planning a seed collecting expedition to the highest peaks of the Western Cape of South Africa. With the support of Cherise Viljoen, Production Nursery Manager at Kirstenbosch National Botanic Garden, and Rupert Koopman, Cape Nature Botanist, we identified appropriate permits necessary to undertake such a proposition and with the collaboration of Stellenbosch University Botanical Garden, were permitted to collect seed of these higher altitude plants in September 2015 and again in December 2017. On each occasion the planning process took almost a year but allowed us to be confident of achieving our aims. Although initially motivated by adventurous botanical exploration, we soon realised that there was a real need to obtain a better horticultural understanding of South Africa's high altitude Proteaceae, as they are little understood from a restoration point of view. Germination is not the end of the road for restoring plants to the wild, either. It is necessary to know how to grow the plants to a size where their numbers can be increased and eventually can be returned to the wild, if needed. It was this conservation focus that was the most integral aspect of our being issued permits.

Our research and expeditions have been led by the IUCN's Technical Guidelines on the Management of *Ex situ* Populations for Conservation and the Global Strategy for Plant Conservation's Target 8. Our 2015 expedition was informed by the statement from the IUCN's Technical Guidelines:

'Ex situ *conservation should be initiated only when an understanding of the target taxon's biology and* ex situ *management and storage needs are at a level where there is a reasonable probability that successful enhancement of species conservation can be achieved; or where the development of such protocols could be achieved within the time frame of the taxon's required conservation management, ideally before the taxa becomes threatened in the wild.* Ex situ *institutions are strongly urged to develop* ex situ *protocols prior to any forthcoming* ex situ *management.*

For those threatened taxa for which husbandry and/or cultivation protocols do not exist, surrogates of closely related taxa can serve important functions, for example in research and the development of protocols, conservation biology research…'

It was with this in mind that we set out to collect both common and vulnerable species (not Endangered and Critically endangered) to create cultivation protocols for the higher altitude Proteaceae; some of which have not been successfully cultivated in the botanic gardens of South Africa due to their low altitude, and hence climate. Over a period of three weeks we visited 5 mountain ranges, each with their own flavour of the South African climate, made 115 separate observations of Proteaceae, covering 55 distinct species, of which we collected seed of 30.

The upper southern slopes of Grootberg where we found Spatalla nubicola *and* Leucadendron radiatum

Robbie and Protea grandiceps

As part of the terms of our permit we provided location data for all these observations to the Western Cape Nature Conservation Board (CapeNature) and recorded range extensions both in altitude and distribution for several species. The highlight of the 2015 expedition was our observation of *Spatalla colorata* (EN) in the Boosmansbos Wilderness Area; a species that had not been seen there for 18 years.

In 2017 we were directed more by the GSPC's Target 8. After conducting a full gap analysis of South African Proteaceae held in documented *ex situ* collections (both living and seed) we set out with targets of specific genera and species in mind. Of most concern to us were the horticulturally difficult and little-known genera *Spatalla*, *Sorocephalus*, *Mimetes* and *Vexatorella* as well as several species not held in documented *ex situ* collections from other genera: *Leucospermum winteri*, *Leucadendron rourkii* and *Protea scolopendriifolia* to name just a few.

The timing of our month-long expedition was set to coincide with seed being available of the species *Spatalla nubicola*, a near threatened protea with an area of occupancy of just 34 km² on a small number of mountain tops along a single ridge line. Potentially threatened by too frequent fire and almost certainly being pushed to its limits by climate change, this diminutive species grows in cool acid (pH 4) soils, irrigated by moisture laden clouds; a habitat so akin to North Wales. This species has never been cultivated either in South Africa or elsewhere, and seed has not been banked, so it seemed appropriate that we should try to grow it.

We found *Leucadendron rourkii*, the scruffiest species in the genus according to its namesake Dr John Rourke, in the Kammanassie mountains on the side of a narrow jeep track. This species is currently of little conservation concern but has an incredibly small area of distribution in a mountain range affected by the ever-present danger of climate change, subsequent increased fire risk and has little ornamental merit. It is thus, unlikely to be picked up by the radar of those interested in the more glamorous members of its family. This made it a good target for us to bring into cultivation and we are already observing interesting results regarding its germination and seedling mortality rates. Whilst in the Kammanassie we were also able to record observations of many Altimontane fynbos proteas found on a 2000m high ridgeline across three peaks, the results of which will help inform future red-listing and conservation efforts for this little known and threatened southern 'alpine' habitat.

During our December 2017 trip we explored 18 peaks between 1000m and 2000m in altitude, we observed and recorded 69 species *in situ* and collected seed of 43 species; many previously only held in just one *ex situ* collection worldwide, 16 being new to us and 6 being new to cultivation altogether.

We have been able to collect seed of 5 species of *Spatalla*, bring into cultivation outside of South Africa several grafted plants of *Mimetes* and plants of a single species of *Vexatorella* (*Vexatorella alpina*). Alas we were unable to find any species of *Sorocephalus*, the majority of which are threatened and not held *ex situ* (we shall have to go back). Beyond the Proteaceae we discovered an entirely new population of *Gladiolus rhodanthus*, previously only known from a single population (EOO <5 km²) occurring in an inaccessible habitat on a mountain 30km away from our new population, across the Robertson Karoo.

We are now having to come up with some novel methods for cultivating these cool growing species. Many of these methods take inspiration from having observed them in their wild habitat. In March 2018 the first cultivation protocol for a member of the Proteaceae grown at our nursery was produced and accepted for publication. In time similar protocols will be produced across the wide range of Proteaceae taxa we are cultivating at FossilPlants.

All images credited to R. Blackhall-Miles and B.Ram.

Protea scolopendriifolia

Spatalla colorata *in Boosmansbos Wilderness Area*

Critically Endangered Overberg Sandstone Fynbos

Author: Christopher K. Willis

FEATURED GARDENS

SOUTH AFRICA'S NATIONAL BOTANICAL GARDENS AND THEIR CONTRIBUTIONS TOWARDS THE CONSERVATION, RESTORATION AND SUSTAINABLE USE OF TERRESTRIAL AND INLAND FRESHWATER ECOSYSTEMS AND THEIR SERVICES

The Lowveld NBG straddles the Crocodile River and Nelspruit Cascades providing an important natural biodiversity corridor through Mbombela, Mpumalanga. (SANBI Collection)

Introduction

The South African National Biodiversity Institute (SANBI) is a parastatal organization under the national Department of Environmental Affairs (DEA). It is, amongst other biodiversity-linked responsibilities associated with the country's National Environmental Management: Biodiversity Act (NEMBA) No.10 of 2004, responsible for the management, maintenance and development of South Africa's network of national botanical gardens (NBGs).

SANBI currently manages 10 NBGs located in seven of the country's nine provinces, as well as the Thohoyandou Botanical Garden. This garden is scheduled to become the country's 11th NBG and the first in the Limpopo Province, situated in the far northeastern corner of the country. The focus of the NBGs is to grow, display and conserve South Africa's indigenous plants. The gardens conserve over 7,400 ha of natural vegetation and associated biodiversity within their boundaries, and they promote and raise environmental awareness at home and abroad. The NBGs have been supported by the Botanical Society of South Africa (a non-governmental organization established in 1913) for more than 100 years.

The gardens serve as embassies of biodiversity, culture and heritage, playing key roles in conservation, research and recreation, and through their displays, educating the general public. These gardens serve as refugia for threatened plant species, and serve an important role in climate change adaptation. The botanical gardens are centres of excellence for indigenous plants; they provide information and professional skills in horticulture (through a SANBI-developed Career Ladder for Horticulturists) and tourism. They support national, regional and international networks for the conservation, sustainable use and appreciation of the flora of South Africa, including Kew's Millennium Seed Bank Partnership.

Kirstenbosch NBG is located on the eastern slopes of Table Mountain, providing valuable protection to Afromontane forest, fynbos vegetation and their associated biodiversity (SANBI Collection)

Since becoming a 'biodiversity' (rather than a purely 'botanical') institute in 2004, SANBI's national botanical gardens have broadened their scope to focus on documenting, monitoring and showcasing the faunal components of the gardens as well as the plants.

Conservation gardens

Nine of SANBI's national botanical gardens – Free State, Harold Porter, Karoo Desert, Kirstenbosch, Lowveld, KwaZulu-Natal, Kwelera, Pretoria and Walter Sisulu National Botanical Gardens – are classified as conservation gardens, having a combination of cultivated collections and areas of natural vegetation within each garden. The Hantam NBG comprises an area of over 6,200 ha in the 'bulb capital of the world' (so-called because of its rich diversity of naturally occurring bulb species – no fewer than 2,200 species occur in the region – many endemic and threatened). The garden is located around the small town of Nieuwoudtville in the Northern Cape, and is classified as a 'natural or wild garden', conserving representative sections of the region's local indigenous flora and fauna. SANBI's vision for the Hantam NBG is for it to become a centre for long term ecological monitoring and research. Potential partners include the South African Earth Observation Network (SAEON), Gobabeb Research and Training Centre (Namibia) as well as tertiary academic institutions. It was recently discovered that a new (yet to be described) species of long-tongued fly, that has a long proboscis adapted for nectar-feeding from long tubular flowers, is considered endemic to the garden. Several other insect species new to science have been discovered by entomologists in the garden over the past few decades.

Succulent karoo and fynbos vegetation is conserved in the Karoo Desert NBG, Worcester. The garden includes pristine montane habitats accessible to visitors through a network of trails (SANBI Collection)

The national botanical gardens include natural vegetation representative of seven of South Africa's nine biome units, namely forest, fynbos (characterized by the presence of ericas, restios and proteas), Albany thicket, grassland, savanna, Nama Karoo, and Succulent Karoo. The only biomes not represented are the Desert Biome and Indian Ocean Coastal Belt Biome. Partnerships with conservation authorities in the provinces where these two biomes occur are being developed in order to establish botanical/demonstration gardens representative of each biome's unique vegetation.

As part of SANBI's Gardens Expansion Strategy: 2016–2030, SANBI aims to establish a national botanical garden in every province of South Africa by 2030. Also as part of its Strategy, SANBI has initiated in recent years a system of partnering with other existing municipal/university/private botanical gardens through signed Memoranda of Understanding (MoUs). Gardens associated with SANBI through formal MoUs need to fulfil certain criteria that are aligned with SANBI's NBGs.

Early days – restoration efforts

One of the major projects undertaken by the garden managers and their teams in at least two NBGs, (Kirstenbosch, Cape Town, established in 1913 and KwaZulu-Natal, Pietermaritzburg, established as a NBG in 1969) was to systematically remove and clear extensive areas of exotic trees and alien invasive plants (mainly eucalyptus, oak and pine plantations, as well as hakeas, poplars, brambles and invasive acacias) from the estates. Over the past 50 years or more, these areas have been transformed through both natural regeneration from adjacent forest areas and selected plantings of indigenous species. They have become important 'natural' areas and the restored habitats, with associated ecological interactions, have improved the water quality of rivers and runoff from these gardens. Removal of alien invasive plants from the natural estates remains

Brunsvigia bosmaniae *(March Lily) flowering naturally in the natural/wild Hantam NBG, Nieuwoudtville (Christopher Willis)*

Indigenous coastal dune forests are conserved in the 160 ha portion of the Kwelera NBG, East London, Eastern Cape (Christopher Willis)

an ongoing labour-intensive challenge in many of the NBG estates, particularly where the main source of seeds (through wind, animals or water dispersal) comes from land outside the gardens or along watercourses flowing through the gardens.

Conserving natural ecosystems

SANBI's NBGs serve as important natural refugia in largely urban areas. Several gardens have, over time, become like 'islands' in a 'sea' of urban development, increasing their value as green lungs of the city. Although they also have to contend with a multitude of pressures associated with neighbouring developments, most of them are still linked to adjacent natural areas, whether it be mountains, rivers, wetlands, savannah/grassland or karroid habitats. These linkages provide valuable corridors for movement of animals between the gardens and their adjacent properties.

According to NEMBA, SANBI must (a) undertake and promote research on indigenous biodiversity and its sustainable use, (b) collect, generate, process, coordinate and disseminate information about biodiversity and the sustainable use of indigenous biological resources, and establish and maintain databases in this regard. Partnerships with research institutions, universities (both national and international) and provincial and national conservation authorities, as well as SANBI's own researchers, are critical to enable research to be conducted, and to assist managers in effectively managing and conserving the natural ecosystems and associated biodiversity on their estates.

Monitoring and recording biodiversity

Since 2004, when the faunal component of biodiversity was added to the organisation's mandate through the proclamation of NEMBA, SANBI has made active efforts to record, monitor and document faunal diversity in its NBGs. Publications and field guides have been prepared and made available to visitors on the most commonly seen faunal groups (such as birds, butterflies and dragonflies), and databases prepared of animals recorded across all NBGs (including mammals, reptiles, amphibians, spiders, birds, butterflies, dragonflies and damselflies, scorpions, freshwater fishes, ants and molluscs). These databases are updated as new records become available and faunal records are shared on the gardens' web sites. In recent years, SANBI has documented the research conducted, as well as research publications produced by its various NBGs since the early part of the 20th century. It has also identified additional research and monitoring needs across its NBGs. South Africa's citizen science programmes and virtual museums (see: vmus.adu.org.za) established more than a decade ago, have also contributed significantly towards creating a greater awareness and interest amongst civil society in the monitoring and recording of species in the various NBGs.

SANBI continues to contribute towards the conservation and sustainable use of terrestrial and inland freshwater ecosystems and their associated services, in line with South Africa's obligations under international agreements, including the Sustainable Development Goals (SDGs). It continues to make active efforts to, amongst others:

- promote the conservation of mountain ecosystems and their biodiversity;
- reduce the impact of floods;
- limit the spread and reduce the impact of invasive alien species;
- reduce the degradation of natural habitats;
- conserve and prevent the extinction of endemic and threatened species;
- improve the quality of water and rivers flowing through its properties;
- promote conservation awareness and sustainable development amongst local communities.

SANBI as an organization, with ongoing support from DEA and its many partners, is committed towards leaving a better planet, and more specifically the expanding network of unique gardens under its management, for future generations. The words of the late Prof. Brian Rycroft, a former Director of the National Botanic Gardens of South Africa (1954–1983), are as true today as they were back in 1975: *"This is one institution which not only realises the importance of conserving our natural heritage but is doing something active about it"*.

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The 200 ha Harold Porter NBG in Betty's Bay forms part of the Kogelberg Biosphere Reserve, conserving valuable coastal and mountain fynbos as well as riverine and wetland habitats, extending down to the sea. (SANBI Collection)

INTERVIEW
TALKING PLANTS

In this issue of BGjournal, we talk to **Noelia Alvarez**, recently appointed as Conservation Projects Manager at BGCI. Noelia has a background in conservation horticulture and before joining BGCI, worked at the Royal Botanic Gardens, Kew.

Noelia, we know you are passionate about plants and skilled in growing them, but who or what inspired your love of plants?

I grew up in a rapidly developing city not far from Madrid in Spain. It was a very urban environment, but whenever possible my parents took me and my sister walking in the nearby mountains. This early exposure to the natural world instilled in me a love of nature and being amongst plants. I studied agronomy at university and was lucky enough to have Professor Gómez-Campo as one of my teachers. He was a pioneer in the seed conservation of wild plant species and motivated me to want to work in this area. After leaving university I decided to travel. My first stop was London, where I visited Kew Gardens as a place of respite from my otherwise busy city life. One day I decided to send my CV to Kew. To my astonishment, I was called for an interview two weeks later for a position in the horticultural team. I was offered the job and there I stayed until my recent move to BGCI.

Over the years you have worked with many different plant species, but which is your favourite – and why?

I don't have any special favourite plant. I get excited by whichever species, or plant group I am working with. During my time at Kew I worked with many different plant groups, including highly threatened island plants, the Proteaceae and Orchidaceae. All of these became my 'favourites' for a while. However, I feel that every plant is interesting in its own way. What excites me is the story behind the plant – and there is always a story!

Before joining BGCI you worked for several years at RBG Kew – what aspects of the work there did you find most stimulating and enjoyable?

I think the one word that sums up what I enjoyed most at Kew is 'diversity'. I loved the diversity of the people I met and worked with and the diversity of the amazing plant collections. I also loved the history and heritage of Kew. The glasshouses with so many cultural associations and the wonderful stories behind them. I spent several years working in the Tropical Plant Nursery – and it was amazing to see such a range of plants all growing together – plants you would never normally see in the same place at once.

Before leaving Kew, I was responsible for collecting seeds from the threatened and wild source plants in the Kew Living Collections following very strict protocols of isolation and hand pollination. The diversity of the collections certainly presented some challenges. Species that were almost unknown to science required research to understand their breeding systems and plants with very low genetic diversity often did not set seed.

The work of conservation horticulturalists is often not give the credit it deserves. How do you think we can promote horticulture as a career and encourage more young people to get involved?

I do agree that conservation horticulture – and indeed horticulture in general - is undervalued. Salary levels for horticulturists are too low and that is one reason why young people are not attracted to the sector. Conservation horticulturists generally do not get any specific training but have to learn 'on-the-job'. It takes a lot of skill to understand a diverse plant collection and know how to grow the plants within it, but too often conservation horticulturists are considered more as 'manual labour' than skilled members of a scientific team. I believe that the lack of career structure and low pay are important reasons why young people don't stay in horticulture. We need to address these issues if we want to attract more people into the sector.

You are originally from Spain. Do you think Spanish people have a different attitude to plants and gardens than the British?

It is a bit of a paradox in Britain. While horticulture and plant cultivation skills are not highly valued, people here have a real love of plants and gardening. In Spain, no-one would think of spending a day visiting a garden centre, or watching a gardening programme on TV. In Spain, growing plants is more about producing food and self-sufficiency than about beauty and enjoyment. I love the way British people value their gardens and the efforts they put into making them beautiful. I also really enjoy visiting the wide variety of gardens that are open to the public here.

You are very new to BGCI, but what aspects of your job here excite you the most and what do you hope to achieve over the next few years?

I am really excited about the opportunities BGCI provides to work with botanic gardens around the world – and the focus on conserving threatened species. If, through a project I help to set up, I can save a species from extinction, I will feel I have done something really important and worthwhile. I am also looking forward to travelling and meeting new people – and being able to share the experiences I gained from my work at Kew. The training aspect of the job is something I particularly hope I can develop. I have to say, that even in the short time I have been here, BGCI has opened my eyes to the world. It is a very small organisation with a wide range of projects and a very dynamic team. I feel I already have a lot of responsibility. This is a little scary – but also very exciting!

Barney Wilczak

ARTICLES

Author: Suzanne Sharrock

SUSTAINABLE DEVELOPMENT GOAL 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.

Sustainable Development Goal 15 (SDG 15) is in many ways the SDG most relevant to the work of botanic gardens. With its focus on 'Life on Land', it provides an important entry point for botanic gardens into the global development framework, linking their conservation work to internationally agreed goals and targets.

The table below provides a list of the targets which contribute to SDG 15 and an indication of the work of botanic gardens that contribute to each target. The articles which follow provide some case studies of these activities being carried out by botanic gardens around the world.

Goal 15.2: Forest restoration in Kenya (Barnet Wilczak)

	Target	Botanic garden activities
	**15.1:** By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	• Conservation of native habitats within the garden boundaries • Ecological restoration of degraded habitats • Identification of important plant areas for conservation
	**15.2:** By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	• Forest restoration • Forest inventories • Tree propagation and supply of plants for restoration
	**15.3:** By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	• Partner in restoration projects for degraded areas • Identify and propagate relevant plant species for such sites • Work with local communities on sustainable land management practices
	**15.4:** By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	• Identify mountain flora • Raise awareness of mountain conservation needs • Propagate and restore threatened mountain species
	**15.5:** Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	• Identify species most at risk of extinction • Take action to conserve threatened species • Reintroduce threatened species to native habitats
	**15.6:** Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	• Develop and implement appropriate access and benefit sharing policies • Share benefits with local communities from the use of local plant species • Raise awareness of ABS issues across the community
	**15.7:** Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	• Work with local communities to develop sustainable harvesting practices for local plant species • Raise awareness of the problem of the illegal trade in plant species • 'Walk the talk' in all garden retail outlets
	**15.8:** By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species	• Ensure no 'escapes' of potentially invasive species from plant collections • Carry out invasive species risk assessments • Raise awareness of invasive species issues with the public
	**15.9:** By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts	• Work with local / national policy makers, planners and developers • Offer 'biodiversity-friendly' solutions for planning and development at local level

Author: Paul Blanchflower

SDG15: TARGET 15.1
AUROVILLE BOTANICAL GARDENS – CONSERVING TROPICAL DRY EVERGREEN FOREST IN INDIA

Ashok Leyland project after 12 months

TARGET 15.1

By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

Through its essential work in conservation and restoration, Auroville Botanical Gardens celebrate the beauty and diversity of nature.

Introduction

The Auroville Botanical Gardens are situated in the South of India on the Coromandel coast, around 130 km south of Chennai, close to the town of Pondicherry. They are part of the International Township of Auroville that was founded in 1968. This intentional community, recognized by UNESCO, is based on the teachings of the Indian philosopher Sri Aurobindo to promote the ideal of Human Unity.

The Botanical Gardens, which were started in 2000, are dedicated to the conservation of the Tropical Dry Evergreen Forest - the natural vegetation of the area. Due to its narrow range and human influences over the past 10,000 years, in this densely populated coastal zone, this forest is now the most endangered of India's vegetation types. The only pristine remnants left are found in sacred groves, whose size is rarely more than one hectare. All of the other forest areas of this type, protected by the government, were cut down a number of times in pre-independence India for fuel wood and are consequently secondary growth forests – heavily dominated by thorny species and still under constant grazing pressure.

The township area of Auroville was originally a barren, windswept plateau, with many areas devoid of topsoil. When the project began in the late 1960's the area was planted with a mix of trees, both exotic and native and over the next twenty years, with constant care and protection by the early inhabitants, the area became an emerging forest. After this initial success the interest evolved and became more focused towards the native ecosystem. An extensive research program was initiated to understand the species make up of the original forest type. This led to exhaustive surveys of the sacred groves and to the identification of over 400 woody species that constituted the ecosystem components of what is now called the TDEF – Tropical Dry Evergreen Forest.

It was within this historical context that the Auroville Botanical Gardens were founded with the specific role of raising awareness about the conservation needs of the TDEF. The gardens cover around 20 hectares, which were also devoid of vegetation when the land was acquired. Now the gardens have 5 hectares of TDEF forest, an arboretum that has specimens of the trees and shrubs from the region and a number of thematic areas.

Outreach activities

Over 100 education programs are organised each year for local government schools as well as a numerous other visits from colleges, private schools and other institutions. All of which are exposed to the environmental benefits of conserving the native forests.

However this is not the limit of the gardens' work. Extensive efforts have gone towards encouraging efforts to restore and replant areas with the TDEF. Collaborations with a number of Government institutions, such as the Forest Department, are always ongoing. Additionally, in order to create a self-sustaining income stream, the team at the gardens offer consultancies and turnkey projects to commercial clients to create environmentally sound landscapes utilizing the species of the TDEF. These efforts have been ongoing for the past 10 years and there are variety of projects that have been successfully implemented.

To enable the work with indigenous species, a native tree nursery was created at the gardens. On average each year over 50,000 saplings are produced that are either planted within the Auroville forests, utilized in our own outside planting projects, or sold to other agencies engaged in planting, such as NGO's or the Forest Department.

Native tree nursery at Auroville Botanical Gardens

Shola Forest Plantation at Ooty

Industrial clients

Tamil Nadu has a number of large manufacturing industries that are run by well-established families, the TVS group is a good example. This highly successful brand was established in the southern town of Madurai in 1918 and now into its forth generation, the group has numerous subsidies and spin offs. Many branches of the family are engaged in the business and the majority of them have a passion for nature and wildlife. Auroville Botanical Gardens has worked with a number of them, for example, creating shelter-belts around their factories with pure collections of TDEF species. For this group alone we have provided over 15,000 native saplings from 120 species over the last years.

Aside from the TVS group we have also engaged with a number of other industries, most recently and very successfully with Ashok Leyland, India's leading commercial vehicle company.

At their research and development center in the north of Chennai we designed, built and planted a Wetland forest park on over 13 hectares of land. Transforming unproductive, seasonally inundated, flat land into a series of canals, ponds and forest areas. The conditions here were harsh as the ground water and soil were slightly saline. However, using over 60 native species of trees and shrubs that are adapted to these conditions such as *Salvadora persica, Thespesia populnea, Premna serratifolia, Salacia chinensis* and *Clerodendron inerme*, we were able to achieve remarkable growth rates and create a forest cover in under 18 months – The final video of this project is online at https://vimeo.com/258575105.

We have also engaged with Ramco cements, South India's second largest cement manufacturer, to establish protocols for the restoration of their worked-out limestone quarries. The potential here is extraordinary as they have land holdings of over 2,000 hectares. However the conditions for plant growth are harsh due to alkaline soils and the site being in a rain shadow. We are still in the process of trialing species, trying to find those that can withstand the tough conditions.

Education activity at Auroville Botanical Gardens

Restoration of Ramco mines

So far, we have seen good results with *Balanites roxburghii,* a number of *Ficus* species and once again *Salvadora persica*.

Tourism and recreation

Another area where there is tremendous scope for our work is in the hotel and resort industry. There are many developments in India and a number of developers have an interest to work with native species. Our first project, in 2008 was with the Mahindra group, when they developed a 12-hectare resort, 15 km south of Pondicherry. This was planted with native coastal cline species such as *Callophylum innophyllum*, *Garcinia spicata, Eugenia bracteata, Ficus microcarpa* and even the main lawns were grown with the local, salt tolerant variety of carpet grass *Cynodon dactylonium*. A more recent project is now in the completion stage on the edge of a large wetland that is connected to the sea. Here we have created a number of large ponds for the native birds and planted the entire landscape with native salt tolerant species similar to the set we have planted with Ashok Leyland.

We have also taken our ethic of working with native plants and worked in other regions and ecozones of India, most notably in the Moist Evergreen Forest of the Western Ghats. Here we worked on a resort project in the Coorg region and with Shola Forests and Native grass lands in the Nilgiris Biosphere reserve, where we have partnered with a local NGO – Upstream Ecology - to work with an Indian based architectural firm called Total Environment.

Closer to home we also have a project running with 55 of the local government schools to fence their compounds and plant shade trees along the boundaries. Here again we are using native species wherever possible, to raise awareness in the local region about the cultural heritage that is connected to these species that are basically extinct in the local context.

Challenges in restoration

All of these projects carry with them tremendous challenges, as the climatic conditions for the Dry Evergreen Forests are inherently harsh. The long dry season from January till June, followed by erratic summer rains (the Coromandel coast does not receive the SW monsoon that much of India gets in the summer months), means that survival of young saplings on open ground is next to impossible unless regular aftercare can be given, and if the project is not fenced properly then the impact of grazing herds can be disastrous. The soils are also generally impoverished so the advantage often lies with the leguminous species such as *Pongamia pinnata* or *Acacia* species. Thus it is challenging to work towards developing a truly native forest that has representation of all the genera that we know should be present such as *Agalia, Walsura, Diospyros, Memecylon, Atalantia, Pamburus, Pterospermum, Psydrax, Tricalysia, Polyalthia, Mallotus, Eugenia, Garcinia* to name some of the major contributors.

Additionally, growth rates can be slow due to the depleted soils and in the commercial world, results need to be seen. In some cases, such as our project with Ashok Leyland, the results were spectacular with some trees reaching over 3 meters at the end of the second year, as the black clay soils were full of nutrients. However, in general we need to build into the aftercare programs, not only watering, but after two years a nutritional program with vermi-compost dressings. Mulching is also very important – but a little fraught due to a very voracious termite population.

Interpretation plays a big role in our work as well, as we recognize that the scale of the projects we can accomplish at this point are still very small with respect to today's issues. Each one of our projects is in reality a symbolic statement that is issued jointly between the client and ourselves with respect to the need of society in general to take environmental restoration more seriously. To make this more effective it is important to include clear and easily understood signage materials for each location, for we hope that the visitors to each site will be the ones inspired for the next round of work. The Tropical Dry Evergreen Forests are inherently beautiful, with flowering and fruiting events throughout the year. The fact that they respond to the erratic rainfall events in the summer by pushing out new leaves, makes it all the more pleasurable to be around these species during the hot summer months. They are great friends to have beside you in the landscape, providing shade on the ground throughout the year and helping the heaviest of monsoon rains to percolate down to the precious water table below.

The environmental benefits of these forests are many. As our national economy strengthens, there will hopefully be more and more companies that are able to follow the lead of those who are already aware of their responsibilities towards the environment and be able to support this kind of restoration activity.

All photos credited to Marie Demont

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Ashok Leyland project after 12 months

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SDG 15: TARGET 15.3
REVERSING LAND DEGRADATION AND DESERTIFICATION IN AFRICA'S DRYLANDS

TARGET 15.3

By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

Agro-forestry system maintained by the women's association of vegetable producers in Dimbale, Mali (Paolo Ceci)

Introduction

In sub-Saharan Africa's drylands, increasing pressure on fragile ecosystems has resulted in continued land degradation, leading to increased poverty which, in a vicious cycle, drives further land degradation. The consequences of this desertification severely affect some of the world's poorest people, who depend on natural resources and land for rainfed agriculture and to sustain their livelihoods, while they are on the frontline of climate change (Dia & Duponnois, 2010). To address this complex challenge, the Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI) was launched in 2007 by the African Union Assembly, a partnership with the aim to restore landscapes and improve livelihoods while contributing to climate change mitigation and adaptation. This flagship land restoration programme, which consists of a mosaic of sustainable land management approaches across the breadth of Africa – from Senegal in the west to Djibouti in the east – involves more than 20 countries of the Sahara and the Sahel with impact on millions of people.

As part of this large initiative, the Royal Botanic Gardens, Kew (RBG Kew) has been coordinating the Great Green Wall Cross-Border Pilot Project in Burkina Faso, Mali and Niger since 2013. This was developed under Kew's Millennium Seed Bank Partnership in collaboration with FAO's Forestry Department. The project, funded by The Dr Mortimer and Theresa Sackler Foundation, aims to build a restoration model, to strengthen the capacity of in-country partner institutions and to engage a wide range of stakeholders to generate environmental and socio-economic benefits and relevant data.

The knowledge of plant diversity and conservation by experts at the Royal Botanic Gardens, Kew, working with in-country partners in Burkina Faso, Mali and Niger, supports land restoration and livelihoods enhancement in sub-Saharan Africa.

Project sign and country partners close to a plantation of Acacia nilotica *in Dori, Burkina Faso (CNSF-BF)*

Such data are disseminated to inform larger, regional restoration projects targeting improved ecological functioning and provision of ecosystem services (Alexander *et al*., 2016). This aims to sustain both biodiversity and human well-being, such as in the FAO-led Action Against Desertification for the restoration of agro-sylvo-pastoral systems in the Sahara and the Sahel region.

The collaborative project, led by RBG Kew, is implemented in strong partnership with national institutions in the cross-border zone between the three countries which is comprised of Bankass in Mali, Djibo and Dori in Burkina Faso and Téra in Niger. Additional field activities in Mali are carried out in Kayes. The main in-country partner institutions are: *Centre National de Semences Forestières* in Burkina Faso (CNSF-BF), *Institut d'Economie Rurale* (IER) in Mali, and *Centre National de Semences Forestières* in Niger (CNSF-Niger).

The project involves a network of stakeholders, from local community groups and environmental non-governmental organisations to government and forestry institutions. In engaging with these parties, RBG Kew has focused on the scientific and technical aspects of plant conservation and land restoration. As a science-based organisation, RBG Kew has the capacity to apply plant research to support project activities through an array of experts in plant diversity and seed conservation, working in partnership with in-country collaborators and

Supplying baobab plants to a women's association in Dori, Burkina Faso (CNSF-BF)

Bundled straw in Dimbale, Mali (IER)

international organisations such as FAO, to support *in situ* conservation and plant-related livelihoods activities.

Main outputs

The RBG Kew's Great Green Wall project is structured upon five outputs as follows: i) *ex situ* conservation of useful plant species; ii) propagation and conservation of useful species in communities; iii) support to *in situ* conservation and sustainable use; iv) use of plant species supported by the project to boost sustainable economic activities; and v) dissemination of information on project achievements.

The project method combines the reintroduction of native tree and shrub species in a restoration framework that includes the ecological and economic rehabilitation of traditional agro-forestry systems. Attention has been paid to the selection of the most useful species to propagate and the techniques that are suitable for improved and accelerated restoration (plantations, fencing, assisted natural regeneration, etc). In order to make the intervention sustainable in the long-term, local communities have been involved in the demonstration of livelihoods benefits through the establishment of community and individual plots and training in the sustainable use of plant resources. The project has allowed an understanding of what species survive and perform better in the harsh Sahel conditions and their potential for household income increase. The strong participatory approach had been previously and successfully tested by RBG Kew in the context of the MGU – Useful Plants Project (2007 – 2015), which involved local communities in plant conservation activities supported by plant research and promotion of revenue generation through the sustainable use of plants and plant products (Ulian *et al*., 2016).

Plant prioritisation, seed conservation and propagation

A participatory approach has been used to select useful plant species adapted to local conditions and important to communities' livelihoods. In 120 beneficiary village communities located in the cross-border area, with a total population of over 50,000 farmers, including 51% women, participatory diagnostic meetings have been conducted, leading to the selection of 193 plant species, most of which are mainly used for food, medicine, fodder, and fuel (Sacande & Berrahmouni, 2016). The most environmentally well-adapted and economically relevant species have been prioritised and authenticated, and seeds have been collected from the wild and used for *ex situ* conservation and propagation.

Project implementation in the three countries has contributed to long-term conservation of 84 useful woody (72) and herbaceous (12) species, which have been collected and stored to international standards both at Kew's Millennium Seed Bank and in national seed banks. Collections have been assessed through seed testing, including viability, germination, dormancy and barriers to storage, and resulting scientific information has been disseminated.

Village nursery in Te-üra, Niger (CNSF-Niger)

Research on seed biology and ecology has been carried out at RBG Kew to support the conservation and propagation of species and has led to, *inter alia*, understanding of seed germination characteristics driven by fruit and seed morphology of *Anogeissus leiocarpa*, a multipurpose tree with important economic and cultural value in West Africa (Mattana *et al*., 2018).

Support to communities for *in situ* conservation of useful species

In collaboration with local communities, seeds of 55 woody and herbaceous species have been planted to restore 2,235 ha of degraded land and create sustainable income-generating opportunities for up to 32,000 people. Over 1,000,000 seedlings of selected species have been planted in around 200 experimental plots and additional techniques have been tested, such as assisted natural regeneration of native species (e.g. *Acridocarpus monodii*) and supply of tall bare-root plants of *Adansonia digitata*. Techniques of soil preparation for planting have included digging of traditional half-moons to harvest rainwater.

Gathering key biotic data from *in situ* conservation plots, i.e. monitoring twice a year species survival rate and growth (height and diameter) rate, has allowed identification of the useful species with best retake after plantation: in Mali, 13 species have shown a survival rate higher than 50%.

A central database has been developed by CNSF-BF to store information from the three countries on species planted, plantation sites with spatial coordinates, quantity of seeds and seedlings produced, number of plants planted and replenished, growth by species and plots. These types of databases are crucially lacking for many plant reintroduction projects, particularly in Africa (Godefroid & Vanderborght, 2011).

Supporting capacity development of community members in plant propagation techniques, nursery management and *in situ* conservation is crucial to the model developed. Over 100 village technicians have been trained and supervised in seed collection and seedling production in local nurseries near the demonstration parcels.

Sustainable use of plants

The analysis of socio-economic contexts has provided insight into factors of success of initiatives promoting plant-related livelihoods: for instance, women's associations engaged in cultivating vegetables gain better revenue for child health care and schooling by preserving traditional agro-forestry systems and related biodiversity.

Through in-country partners, technical assistance and inputs have been provided to farmers' and women's associations. They have been supplied with seeds, seedlings, fencing material and planting, watering and agricultural tools. Training has been delivered in composting, bee-keeping, juice preparation from *Balanites aegyptiaca*, *Adansonia digitata*, *Tamarindus indica* and *Lannea microcarpa*, oil extraction from *Carapa procera* (which has both medicinal and pesticidal properties), gum Arabic production and *Acacia senegal* planting, which is one of the most preferred species by local people due to its multiple uses.

Multi-purpose herbaceous species have been propagated for habitat restoration and for supplying fodder, hay and material for mats and roofs. Such species include *Alysicarpus ovalifolius, Brachiaria ramosa, Andropogon gayanus, Eragrostis tremula* and *Cenchrus biflorus*.

Production and sale of juice has a valuable economic potential for increasing community wealth. In Mali, the association of environmentalists and planters of Endé can produce 100 litres of juice in a week and the retail price on local markets is 1,000 CFA francs each litre. Members of the cooperative of nurserymen of Bankass, who have received technical support from the project, are now able to produce forest and fruit tree seedlings in enough quantity to sell them not only in local markets but also to ongoing environmental development projects.

Village nursery in Te-üra, Niger (CNSF-Niger)

Assisted natural regeneration at Ende-ü, Mali (IER)

Seedlings are sold at up to 600 CFA francs each depending on the size, grafted ones at 1,000 CFA francs each, and bare-root baobab plants at up to 5,000 CFA francs each. Such activity has allowed the cooperative members to increase their annual household income by 20%.

Innovative livelihoods research is being conducted at RBG Kew to better understand the socio-economic characteristics of the targeted population that influence plant-related practices and knowledge, plant preferences and uses, and conservation.

Conclusions

Sites of RBG Kew's Great Green Wall project are located at the edge of the desert and have been selected to respond to the challenge of halting and reversing desertification. They are characterised by poor, shallow and sandy soils, low pluviometry, nine-month long dry season, extreme heat and hot wind (harmattan). Restoration actions under these conditions face severe challenges such as difficult access to water resources, inadequate labour, plant pests and animals' encroachment.

Despite constraints, the project has harvested promising results, which have been appreciated by the concerned population with regards to gradually re-established ecosystem services, soil fertility and local biodiversity.
To significantly scale up the geographic scope and the outcomes of regional actions aimed at combating desertification and improving the well-being of the population, there is a need for continued political commitment, funding and policy support, integration with other projects, stakeholders' engagement as well as research, innovation and knowledge sharing (Berrahmouni *et al*., 2014).

In this framework, RBG Kew can play an important role through carrying out science-based conservation activities and providing partners with technical expertise in seed management and germination, seed biology and ecology, and plant propagation. This is very relevant as propagation of useful species in communities to restore degraded land and their *in situ* conservation are core to the achievement of SDG 15.

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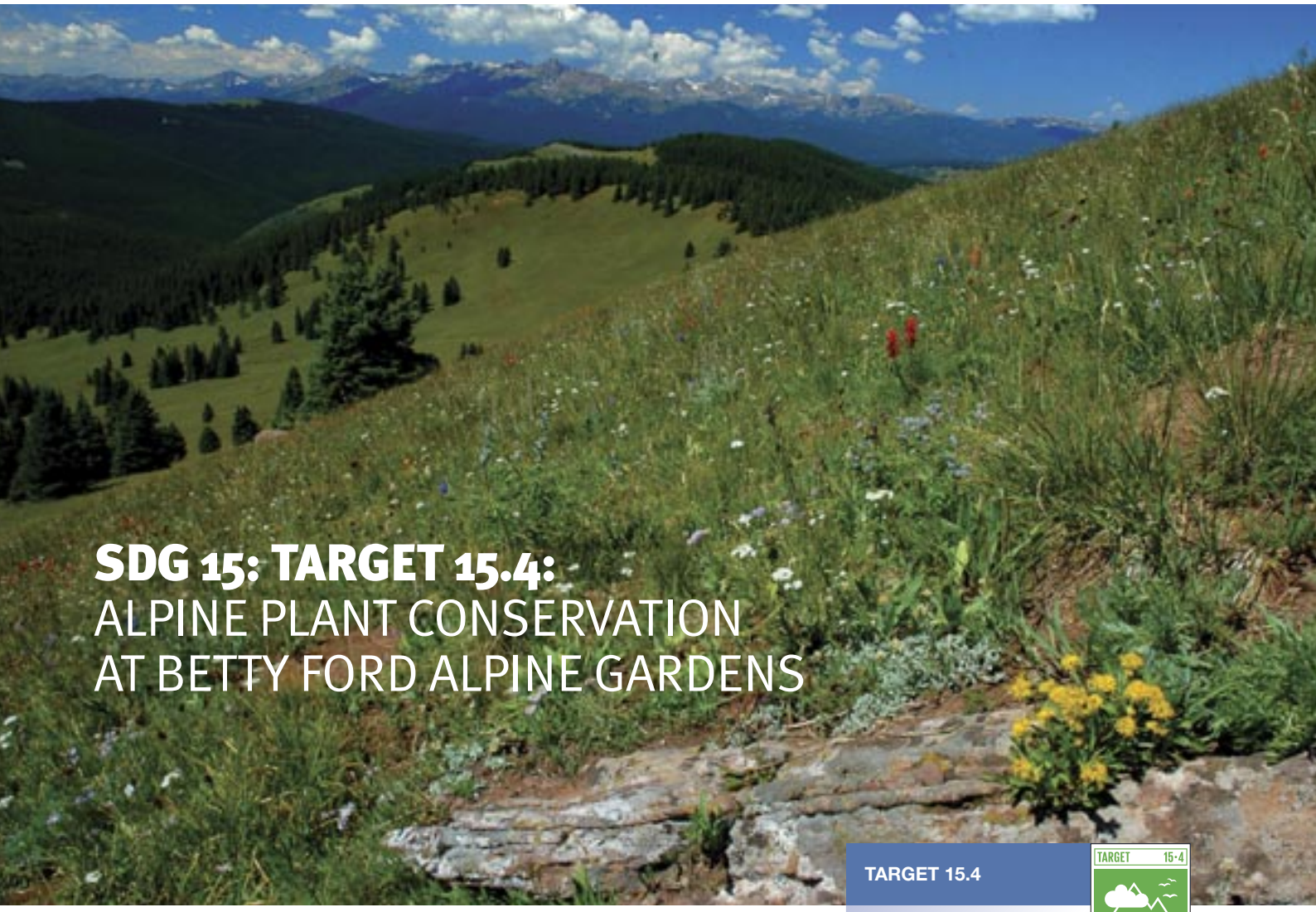
Tall baobab plant supplied by the project to a farmer in Bankass, Mali (Paolo Ceci)

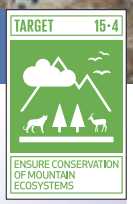
Author: Nicola Ripley



SDG 15: TARGET 15.4: ALPINE PLANT CONSERVATION AT BETTY FORD ALPINE GARDENS

Rich local alpine flora of Shrine Pass in the Gore Range

TARGET 15.4



By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development

The Betty Ford Alpine Garden is dedicated to the conservation of high elevation mountain plants and habitats. It also aims to educate the public about the vulnerability of the world's high alpine flora.

Introduction

The North American alpine ecosystem (areas above the limit of tree growth) extends from the northern sea-level tundra of Canada and Alaska, at 11,000 feet (3,350 m) and above on the peaks in Colorado and the southern Sierra Nevada, to the southern mountains of Mexico and west from the coastal volcanic Cascades to the top of Mt Washington in the East. While many regard these vast ecosystems as largely conserved because they are beyond the reach of human disturbance, they are extremely susceptible to change - and climatic change is happening on a global scale.

Betty Ford Alpine Gardens (Betty Ford) in Vail, Colorado, established in 1986, is in a unique position to lead the way for North American botanical gardens in conserving fragile alpine habitats. At 8,200 ft. (2,500 m), and in clear view of the Gore Range of the Southern Rockies, the idea to establish a garden that would specialize in alpine plants was an easy decision. Betty Ford's governing body has a vision and aspiration beyond its size, and now, thirty years later, it is comprised of roughly four cultivated acres, some natural riparian riverfront, a new Education Center and Alpine House, a well-respected education curriculum and an active conservation program.

Habitat of Penstemon debilis

The Vail ski resort helps attract large national and international visitation, and the gardens are well positioned to play a leading role in exposing visitors of all ages and nationalities to this extraordinary and fragile world above tree line. This national spotlight and a sense of urgency due to the evidence of climate change has inspired a desire to play a national role in alpine conservation and to help influence public opinion.

3 D plant display

Betty Ford was accredited with the National Collection of Colorado's alpine flora by the American Public Gardens Association (APGA) in 2010. With over 200 species represented, this is the only North American botanical garden with a collection devoted to Colorado alpine plants, mainly with wild origins. Facilitated by federal seed collecting permits issued by the United States Forest Service and Bureau of Land Management, we have made the development of this collection a top priority.

Education and outreach

With Betty Ford's mission:
"to deepen understanding of alpine plants and fragile mountain environments"
the new Education Center provides a perfect place to present information about these matters. In doing so, we support the North American Botanic Garden Strategy for Plant Conservation 2016-2020 (NASPC) objective D, "*promoting public awareness of the importance of plant diversity*" in our area. Interpretation stations include maps of the alpine areas of the world, explaining the impacts of latitude and climate on the tree line, as well as a 7x life-size diorama of alpine plants. Panels focus on reproduction in the alpine environment as well as discussing the climatic conditions. The large scale 3D

*Dwarf clover (*Trifolium nanum*)*

models demonstrate alpine plant adaptations to harsh mountain climates, such as hairy stems, extensive root systems and cushion formation. Also presented is the close relationship with native bumblebees. These robust bees can thermoregulate and therefore fly at relatively low temperatures, thus reaching the flowers of many alpine plants. Bees have adapted unique tongue lengths to reach nectaries of specific alpine species. Our research program deals in part with the difficulties of alpine plant reproduction in such seasonally harsh areas, and such material is explained in our educational and interpretive programs. We are actively expanding this information throughout our living collections.

By narrowly focusing our collection and programs, we have been able to make an important impact locally with a relatively small budget (US$1.2 million annually). Working with federal agencies Betty Ford has been active for many years collecting seed for restoration, monitoring threatened plants in nature, conducting propagation protocol studies and conducting re-introduction trials. With our new Education Center and increased staffing, we envision developing a more ambitious program over the next few years.

Achieving more through partnerships

To further the overall efforts in alpine plant conservation, the team in Vail has partnered with Denver Botanic Gardens (Denver). With its three unique locations (York Street, Chatfield Farms and Mount Goliath on Mt. Evans), and large horticulture and research staff, Denver offers a special opportunity to display and work with alpine flora. The central Denver York Street site holds the largest collection of the world's alpine plants, with almost 500 species represented.

Penstemon debilis

As such, these collections were accredited by the American Public Gardens Association in 2012; Betty Ford is the only other North American alpine garden that has been similarly accredited. Denver's satellite locations of Chatfield Farms and Mount Goliath have extensive, and expanding, collections in the suburbs and mountains of Colorado. Mount Goliath, Denver's mountain site on the Mount Evans scenic byway is a unique partnership with the US Forest Service.

Mount Goliath, the world's highest rock gardens, showcases native plants of the Mount Evans Massif, and the garden surrounding the Dos Chappell Nature Center includes only germplasm collected on-site. At 11,500 ft., it is the only maintained garden and visitor center at tree line in North America. Initiated in 1954, the partnership with the US Forest Service works effectively to educate the public on alpine environments and their native plants.

Betty Ford Alpine Gardens in early June

In addition to horticultural displays, conservation staff at Denver monitor populations of sensitive species in alpine regions of Colorado and collect seed of both common and rare species for conservation: anticipating that climate change will endanger all of them over the remainder of this century. Studies of the biology of individual species are being conducted not only in Colorado but also in similar habitats throughout North America and abroad. The studies are not only helpful in themselves, they also provide a unique perspective on North American and worldwide alpine flora.

Climate change monitoring plots with the BLM and USFS on the local Mosquito Range.

Developing a conservation strategy

Betty Ford and Denver, with strong alpine collections are now working together on a formalized protection plan for these fragile ecosystems resulting in the development of the new North American Strategy for Alpine Plant Conservation (the Strategy). Based on the original NASPC the document, still in draft form, consists of a series of targets for alpine plant conservation that will be achieved through a set of detailed action items. While still a work-in-progress, once completed the strategy will be available on various websites including both Betty Ford Alpine Gardens and Denver Botanic Gardens as well as BGCI.

Following is a first draft summary of the basic assumptions of the strategy and its targets

Monitoring Penstemon debilis

Objectives

1. Understand and document alpine plant diversity.
2. Conserve alpine plants and their habitats.
3. Promote education and awareness of alpine plant diversity.
4. Build capacity for the conservation of alpine plant diversity.

Draft targets for the above objectives

1. Creation of a widely acceptable working list of known alpine plants of the United States, Canada and Mexico.
2. Completing a working map of all North American alpine areas.
3. Carrying out a preliminary assessment of the conservation status of all known North American alpine plant species.
4. Conducting NatureServe conservation ranking (G1/T1-G3/T3) for the working list of North American alpine plants.

Box 1: Conserving rare species – the case of *Penstemon debilis*

Penstemon debilis (Parachute penstemon) is one of the nation's rarest plants. It occurs on five oil shale outcrops in Garfield County, near the town of Parachute, habitat of increased interest to the oil and gas drilling communities. With only two of its five locations on BLM land and three on land owned privately by oil and gas companies, this plant is extremely vulnerable. *Penstemon debilis* was discovered in 1986, a perennial herbaceous species, and member of the family Scrophulariaceae. It is a soboliferous plant (produces shoots from the base of the plant) with thick, succulent, glabrous gray-green leaves and white or lavender flowers. It flowers from mid-June to mid-July depending upon precipitation, on constantly shifting oil shale slopes.

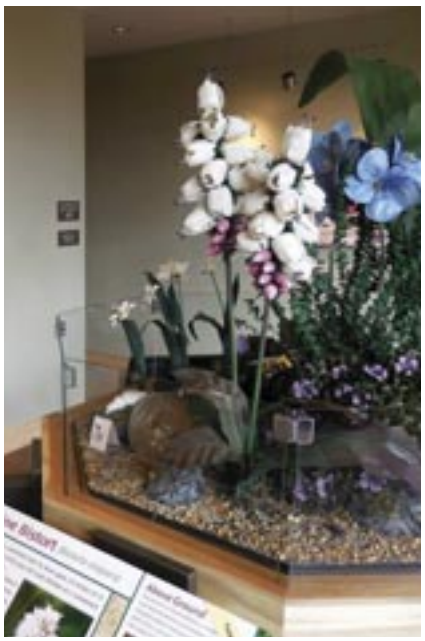
In 2011 it was federally listed as Threatened. It is classified as a G1/S1 species by the Colorado Natural Heritage Program (CNHP). G1 plants are those that are *"critically imperiled globally because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of it's biology making it especially vulnerable to extinction."* S1 plants are critically imperiled in the state.

The Gardens has been studying this plant since 2004, in conjunction with the BLM to gain a better understanding of its population biology, calculating its mortality and habitat requirements and information required to create a conservation plan for the plant.

Propagation protocols have been developed to determine germination requirements and possible future reintroduction. Plants are also held in the Gardens and used for public education purposes.

5. Developing protocols for alpine plant conservation based on research, practical experience and existing methodologies.
6. Assuring the protection of 50 percent of the most important areas for alpine plant conservation.
7. Conserving 60 percent of threatened alpine plant species *in situ*.
8. Ensuring that at least 75 percent of threatened alpine plant species are held in accessible *ex situ* collections preferably in the country of origin, and 10 percent included in recovery and restoration programs.
9. Incorporating the importance of alpine plant diversity, the threats to them, and the need for their conservation into communication, educational and public awareness programs.
10. Increasing the number of trained people working on alpine plant conservation, with appropriate facilities, according to national, regional and local needs.
11. Establishing and strengthening networks for alpine plant conservation activities at regional, national and international levels.

Attainment dates for each target will be determined as well as more detailed action items required for completion. While this particular document focuses on alpine flora, it can be used as a template to adopt similar strategies for other regional plant groups.

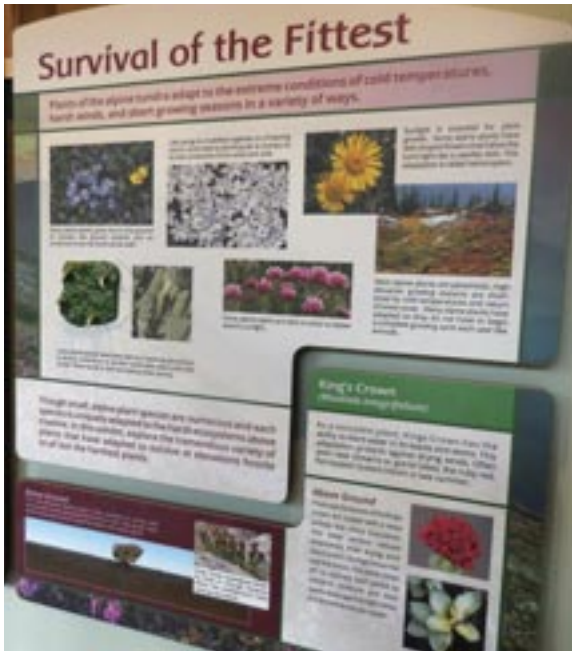


Rock Garden

Abroad, the Alpine Seed Conservation and Research Network, a consortium in the European Alps, has already made great strides in banking seeds of alpine flora. The network was established by RBG Kew *"to conserve European alpine flora and to raise awareness of its increasing vulnerability"*. Their efforts focus on seed conservation, research and public awareness with an emphasis on the alpine grassland communities of the Alps. For more information, please visit www.alpineseedconservation.eu.

What should the role of botanic gardens be?

Botanic gardens in the United States are perfectly positioned to play a unique role in alpine plant conservation. The increased public interest in conserving natural resources generally provides a much-needed opportunity to raise awareness about the effect climate change is having on alpine ecosystems. With some 140 million visitors annually, botanical gardens in the U.S. and Canada host nearly as many people as all professional sporting events combined. Gardens have an enormous opportunity to advocate on behalf of threatened ecosystems, and a substantial opportunity to influence public opinion in favor of conserving them.



Survival of the Fittest display

Nicola Ripley
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522 South Frontage Road,
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USA

Authors: Suzanne Sharrock, Malin Rivers and Katherine O'Donnell

SDG 15: TARGET 15.5: CONSERVING THREATENED PLANT SPECIES – THE ROLE OF *EX SITU* COLLECTIONS

Camellia azalea, *globally threatened Theaceae species. (Tom Hannink)*

Botanic gardens – through their living collections and increasingly, seed banks, are playing a vital role in preventing the extinction of threatened plant species.

TARGET 15.5

Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species

How many threatened plants are there?

In the face of ever-growing threats to plant diversity, conservation assessments provide an essential tool in priority setting and the planning of conservation interventions. In the past, such assessments were scattered in the literature and held in a range of different databases, making prioritisation difficult. To overcome this problem, BGCI with partners, such as the National Red List, NatureServe and the Royal Botanic Gardens, Kew – have developed a comprehensive database of plant conservation assessments - ThreatSearch[1]. This database lists global, regional and national red list assessments for plants, derived from a variety of published sources. The database presently includes over 263,000 assessments representing more than 123,000 accepted land plant species (vascular plants and bryophytes, not algae). One of the greatest challenges in developing ThreatSearch was matching the plant conservation assessments to accepted plant species names and reconciling the different assessments that might have been made for the same species.

Analysis of the data shows that about 90,000 plant species have been assessed at the global scale. This represents some 26% of known plants. Of these species at least 32,500 are threatened with extinction. The analysis has revealed wide gaps in taxonomic coverage, with some families such as Zamiaceae and Magnoliaceae being almost completely assessed, whereas other families such as Orchidaceae, Asteraceae, and Rubiaceae are under-assessed relative to the average (Bachman *et al*., 2017).

[1]www.bgci.org/threat_search.php

Filling the data gaps

It is clear that much work remains to complete threat assessments for all plant species. One initiative that addresses this is the Global Tree Assessment (GTA)[2], which aims to complete assessments for all tree species by 2020.

The Global Tree Assessment is already under way. The first step was to assemble information on the world's trees to produce a global tree checklist with country distributions. In April 2017, GlobalTreeSearch[3] was published, containing the names of 60,065 species and their distributions. This forms the backbone to GTA. The identification of widespread and common species of low conservation concern began in November 2016. A process to identify and assess these species has been designed and is now being implemented.

GTA has identified the major gaps in red listing efforts and is currently working with several groups to encourage and assist in the production of tree assessments. Table 1 provides some details of recent progress in tree red listing. The red list publications are available to download from BGCI's website.[4]

Data from the GTA shows that 34% of trees now have a conservation assessment and these are listed on ThreatSearch (including national, regional and global assessments). Around 42% of all assessed trees are threatened globally. Taking unassessed trees into account, we can say that at least 14% of all tree species are threatened with extinction globally (Figure 1).

Red List	Key facts	Date
The Red List of *Fraxinus*	53 species assessed; 11 threatened with extinction	2018
The Red List of Theaceae	254 species assessed, 85 threatened with extinction	2017
The Red List of US Oaks	91 species assessed, 16 threatened with extinction	2017
The Red List of Magnoliaceae (updated)	304 species assessed, 147 threatened with extinction	2016

Table 1: Recent progress in BGCI's tree red listing

Conservation in the living collections in botanic gardens and arboreta

Botanic gardens play an important role in the conservation of wild plant diversity, with their living collections including many of the rare and threatened species identified through the red listing process.

BGCI's PlantSearch database[5] provides a record of the combined plant collections of over 1,300 botanic gardens around the world. The database contains over 1.3 million records, relating to at least 105,000 species (approximately 30% of all known plants). A recent study comparing PlantSearch data with an early version of ThreatSearch, revealed that these collections include some 42% of known threatened plant species (Mounce *et al*., 2017). However, the study also showed that just 10% of the global network capacity is devoted to threatened species. Of the 1,330,829 records in PlantSearch at the time, 134,771 or about 10% related to threatened species, with 90% of *ex situ* collections devoted to species not yet identified to be at risk of extinction. It therefore follows that if the network can hold 42% of threatened species, with just 10% of current network capacity, there is potential to hold a greater proportion of threatened species. Furthermore, the study revealed that botanic garden collections are disproportionately temperate, with 93% of species held in the Northern Hemisphere. Consequently, an estimated 76% of species absent from living collections are tropical in origin.

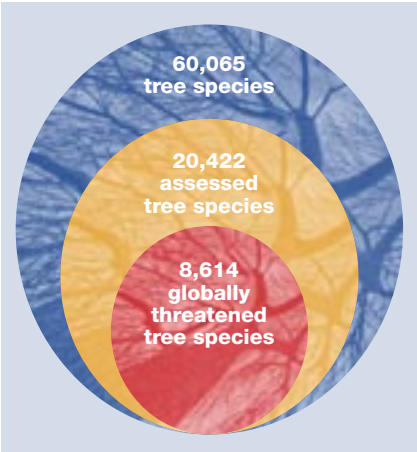

Figure 1: Number of threatened tree species

Threatened plant nursery at the Eötvös Loránd University Botanic Garden, Budapest

[2]www.globaltreeassessment.org
[3]www.bgci.org/global_tree_search.php
[4]www.bgci.org/plant-conservation/redlisting/
[5]www.bgci.org/plant_search.php

SDG 15.5 links closely to Target 8 of the Global Strategy for Plant Conservation, which calls for 75% of threatened plants to be held in *ex situ* collections by 2020. Presently, of the higher level phylogenetic lineages, only gymnosperms meet this target, with 89% of threatened species being held *ex situ*. As noted by Mounce *et al*. (2017), gymnosperms are a successful *ex situ* conservation story as: they are the least speciose of the major plant lineages, rendering the percentage-based GSPC Target 8 more feasible; there is a specific international conifer conservation programme; like most botanic gardens,

Collecting seed of Aloe suzannae in Madagascar (Paul Smith)

Plant label in Kirstenbosch National Botanic Garden, South Africa (BGCI)

they are broadly temperate; and they have horticultural value as evergreen collections. In stark contrast, the bryophytes, which have the poorest overall assessment rate of 12.2%, are similarly impoverished with respect to *ex situ* conservation, such that only 2.6% of threatened bryophytes are documented in the botanic garden network. As indicated in Table 2, representation in *ex situ* collections varies considerably across plant families, with factors such as horticultural value and ease of cultivation playing a key role.

While maintenance of species in living collections provides some level of insurance against extinction, such collections often consist of only a few individuals. These generally do not represent the genetic diversity of the species as a whole, and are vulnerable to loss. Such collections are also of limited value for the reintroduction of species into the wild or for use in restoration programmes. While multiple accessions of a species across the network might buffer against loss of the species, and could potentially provide genetic diversity for ecological restoration efforts, the *ex situ* surveys carried out by BGCI indicate that many threatened species are held in just one or a few collections[7].

Plant family /group	Percent of taxa in *ex situ* collections	Publication date
European trees	454 species, 87% in *ex situ* collections, including 81% of 136 threatened species	in press
Conifers	879 taxa, 84% in *ex situ* collections including 81% of 292 threatened taxa	2014
Betulaceae	240 taxa, 63% in *ex situ* collections including 75% of 16 threatened taxa	2015
Ebonies	806 taxa, 25% in *ex situ* collections including 25% of 101 threatened taxa	2016
Magnoliaceae	304 species, 50% in *ex situ* collections, including 45% of 147 threatened species	2016
Theaceae	253 species, 50% in *ex situ* collections, including 51% of 85 threatened species	2017
Fraxinus	53 species,85 % in *ex situ* collections, including 91% of 11 threatened species	2018

Table 2: Percentage of taxa in ex situ *collections for selected plant groups and families*[6]

Seed banking for security and use

With the increasing recognition that living collections do not include sufficient intra-specific genetic diversity for conservation and restoration purposes, there is a growing interest in seed banking amongst the botanic garden community. Seed banking offers a type of *ex situ* conservation that can, if the correct protocols are followed, maintain high genetic diversity and high longevity at a relatively low cost. A growing number of botanic gardens are now establishing seed banks – with the Millennium Seed Bank of the Royal Botanic Gardens, Kew, playing a key role in this respect. Over 370 botanical institutions in 74 countries around the world now collect and bank seed of wild species (O'Donnell and Sharrock, 2017) and BGCI has established the Global Seed Conservation Challenge[8] to promote and support seed banks in botanic gardens.

Lists of species conserved in seed banks are compiled in BGCI's PlantSearch database and analysis of this data shows that 56,987 distinct plant taxa are conserved in botanic garden seed banks. Seed bank collections within an institution range in size from 18 to over 37,000 species. If seed collections are to be of conservation value and use, the protocols used for banking must be of a high standard. While the conservation quality of the seed bank collections found in PlantSearch has not been analysed, one standard is for seed collections to be duplicated at a second, geographically separate, facility (MSBP, 2015). Therefore if one of the collections is destroyed, a back-up is available. Results from our analysis suggest that two thirds of seed bank collections are only stored in one institution, therefore not meeting this particular standard (O'Donnell and Sharrock, 2017) (Fig. 2). Further analysis is required to determine what percentage of seeds held in botanic garden seed banks meet full conservation standards.

[6]For further information, visit: www.bgci.org/plant-conservation/exsitu/

Are botanic garden seed banks conserving threatened species?

Of the species represented in botanic garden seed bank collections, 50% (28,735) have a conservation assessment either at the global or national/regional level. Of the species that have a conservation assessment, 34% (9,696 taxa) of these are threatened at some level (Fig. 3) (BGCI, 2017). If conservation assessments were available for all the species conserved in seed banks the total proportion of threatened taxa could range from 17% (if all remaining species are not threatened) to 67% (if all remaining species were threatened). In addition, 499 species held in seed banks are regionally or globally extinct in the wild.

Conclusions

Despite the fact that over one-quarter of a million plant assessments have been compiled to date, the challenge remains that the majority of plant species are still unassessed. Lack of assessments hampers prioritisation of conservation action as well as constraining the monitoring of progress towards targets.

While it is clear that botanic gardens are playing an important role in the *ex situ* conservation of threatened plant species both through their living collections and seed banks, there are still large gaps to be filled, and the majority of species in *ex situ* collections are not threatened.

The lack of threatened species in collections may be the result of information on threat status not being available, but other constraints probably also play a part. These include lack of resources for fieldwork, especially when population fruiting time is sporadic or data is unavailable and species are found in remote areas. Institutional funding may be dependent on the number of species collected rather than the conservation priority of the species. Opportunistic collection, where species may not be the priority for collection but are collected anyway as they are available, may also play a role.

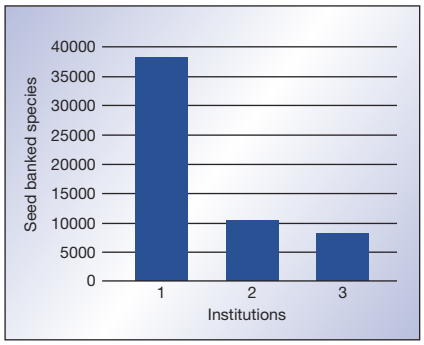

Figure 2: Number of seed banked species held at one, two and three institutions.

Selection of seeds collected during a seed conservation training course in Nepal (BGCI)

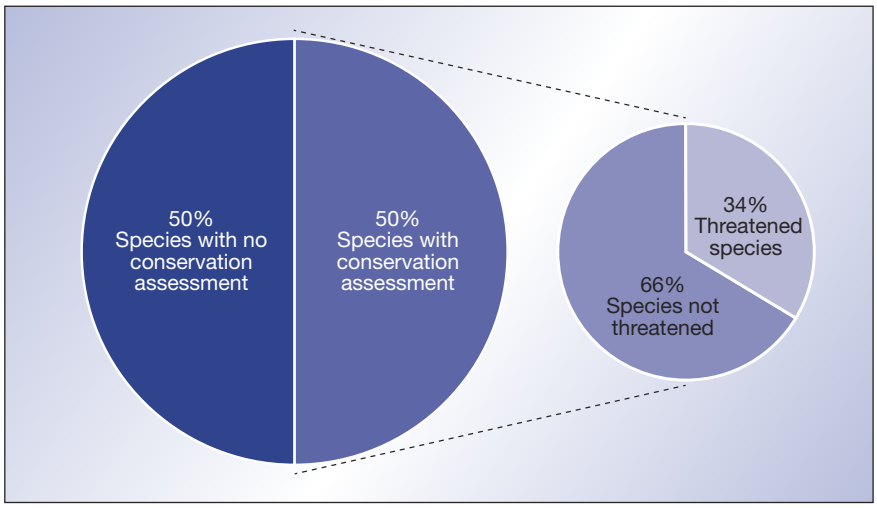

Figure 3: Status of species in seed bank collections

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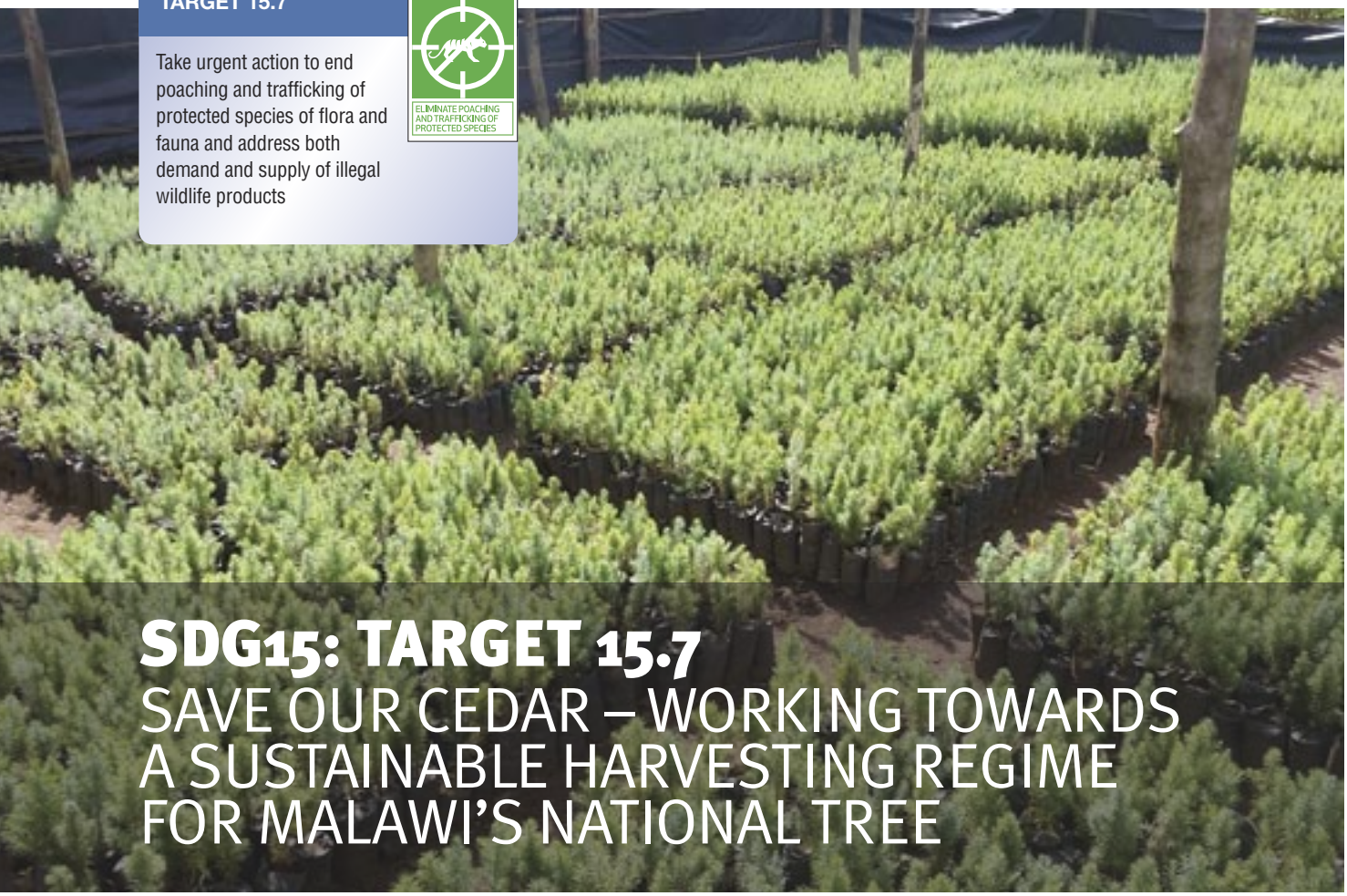
[7]http://bgci.org/plant-conservation/exsitu/
[8]www.bgci.org/plant-conservation/seedconservation/

Author: Kirsty Shaw

TARGET 15.7

Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products



SDG15: TARGET 15.7
SAVE OUR CEDAR – WORKING TOWARDS A SUSTAINABLE HARVESTING REGIME FOR MALAWI'S NATIONAL TREE

Mulanje Cedar seedlings ready for planting

Over-harvesting has had a devastating effect on the populations of Mulanje Cedar in Malawi, with very few individuals remaining in the wild. Efforts are now underway to establish a new demand and supply system to secure a future for this important species.

Introduction

For decades, Mulanje Cedar (*Widdringtonia whytei*) has been prized for its timber. Strong and termite resistant, it has been the focus of harvesting programmes in Malawi since colonial times. Excellent for carving, it has long been used for making intricate boxes, doors and frames. Mulanje Cedar is also unique as it occurs naturally only on Mulanje Mountain in South East Malawi at altitudes ranging between 1800 and 2300m. It was declared as Malawi's national tree in 1984.

Recent years have seen a crash in Mulanje Cedar populations, with harvesting taking place at an uncontrollable rate. As a result, no mature individuals remain standing on Mulanje Mountain.

This article explores the history of Mulanje Cedar harvesting, the unsustainable exploitation that has led to the extinction of this species in the wild, and introduces an initiative to establish a new demand and supply system to secure a future for this important species.

Mulanje Cedar - a history of harvesting

Alexander Whyte first publicized Mulanje Cedar. Whilst serving as Head of the Scientific Department in the British Central Africa Administration, he spent two weeks botanizing on Mulanje

Mulanje Cedar, *Widdringtonia whytei* Rendle

The genus *Widdringtonia* is named after Captain Widdrington, who published a book on European Pines in 1843. The species *whytei* is named after Alexander Whyte, who promoted this species and its potential value as a timber tree. The genus *Widdringtonia* is in the family Cuppresaceae, but was previously thought to be more closely related to cedar trees, hence the common name Mulanje Cedar. The species is also locally known as Nkunguza or Sida. There are four species in the genus *Widdringtonia*, all native to Southern Africa. *Widdringtonia whytei* is the tallest and produces the best timber.

Mountain in 1890. Whyte's report of this expedition was published the following year in Kew Bulletin (Whyte, 1891) and then in Transactions of the Linnean Society of London, alongside a botanical description of the cedar as a new species, in 1894 (Whyte and Rendle, 1894)

In efforts to safeguard what was recognized by the Administration and Protectorate Government as having potential to "*form a valuable timber supply for the country*" (Sclater, 1893), early measures were taken to protect the cedars from fires that regularly occurred on the mountain.

The first published reference to the value of Mulanje Cedar timber appeared in Kew Bulletin in 1895, when Whyte described the timber as "*equal to the finest yellow pine*" and noted that it was already in use for construction of residences in Zomba and was also in demand in Blantyre (Whyte, 1895).

Sawing operations by the Botanical and Forestry Department began on Mulanje Mountain in 1895 under the supervision of John McClounie, the then Government Forester. In his first report, he estimated the total number of cedar trees on the mountain to be 150,000 with an average of 40 cubic feet of timber per tree. Initially only dead wood was cut and projections were that "*the supply of timber yearly might be considerable*" without having to "*materially affect the forests for many years*" (McClounie, 1896).

Over the following decades, sawpits and operations expanded across the mountain. Until the 1950s, all timber was still being sawn and transported down the steep mountain slopes without machinery. It became evident that if increased timber demands were to be met, machinery would have to be used, so in 1951 a skyline timber extraction cableway was installed.

By 1965, all the accessible forest on Mulanje Mountain had been logged. In response, commercial operations scaled down. Pitsawing continued on a small scale by the Department of Forestry, but use of the skyline stopped. In the 1970s, pitsawing licences were again issued by the Department of Forestry to private operations, but rates for licenses were maintained at historic levels meaning that Mulanje Cedar timber could be obtained and sold at a price less than pine from local plantations and imported construction wood. This undermined the value of Mulanje Cedar and led to a huge expansion of cedar cutting, largely from areas previously deemed inaccessible.

Supervision of operations was no longer adequate and despite a law in place allowing only dead trees to be harvested, this was not adhered to and wastage rates were high.

Properties of Mulanje Cedar wood

- Heartwood: a uniform light brown colour;
- Scent: strongly pronounced cedar-like;
- Planed surfaces assume a satiny sheen;
- Excellent construction timber that is light to moderately heavy (38-40lbs per cubic foot air dry);
- Impervious to termites and woodborers;
- Strongly resistant to fungal attack;
- Suitable for boat building and strong roof timbers;
- Easily workable and well suited for interior finishing and furniture making;
- "Mulanje Tar", an oil distilled from sawdust and waste wood, can be used as a preservative against termites.

Cut Mulanje Cedar at Sombani on Mulanje Mountain, 2017

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

In the early 1980s, the Department of Forestry regained control. Sawyers had to pay for the actual volume of wood being harvested. Forestry staff were in charge of selecting which trees should be taken and only dead wood was allowed to be harvested. The value of Mulanje Cedar timber increased, bringing harvesting levels to a controlled rate. This change was unpopular locally, and many cedar stands were intentionally burned in protest, but enforcement was eventually accepted and Mulanje Cedar regained its position as a high value timber.

Planting practices

Mulanje Cedar is harvestable when it reaches around 50 years old. Since 1895, Mulanje Cedar has been planted in Malawi, including on other mountains, as a forestry operation for timber supply. Seeds were also transported to other countries for planting and protection.

Replanting also occurred on Mulanje Mountain. Although planting efforts were not always successful, including due to fires and attack from pests and pathogens, such efforts did help to some extent to ensure a continued supply of Mulanje Cedar to replace stocks that were being harvested.

Extinct in the wild

By the beginning of this century, harvesting had become increasingly unsustainable, including felling of planted trees from Mulanje Mountain. As a result, the Forestry Department developed a Mulanje Cedar Management Plan calling for a ban on timber harvesting for five years and for replanting efforts on Mulanje Mountain to the scale of 500,000 seedlings per year for five years (2014 – 2019).

Despite this plan and efforts to prevent extraction, the Mulanje Massif is a large and difficult mountain to police, with multiple entry points. The steep access points to the mountain and inaccessible sites where many cedars grew, was not enough to prevent harvesting.

Although there was little sign of Malunje Cedar being used locally, the extent of harvesting indicated that the timber was being used to supply national and international markets. Mulanje Mountain is very close to the border with Mozambique and, despite a lack of evidence of exports into or out of Mozambique, it was strongly suspected that this was the main international trafficking route for Mulanje Cedar timber – with operations being managed at considerable scale.

Lack of other income-generating activities meant that many local people were involved in these harvesting activities. However, with low pay rates, the exploitation of what was once envisaged as an important timber resource for the country, has in reality brought little benefit to the Malawian people. Furthermore, over-harvesting of cedar forests has had a number of other negative consequences, including flash floods due to increased run-off from the denuded mountain slopes. This has led to loss of crops, and in severe cases even loss of life.

Due to the scale of harvesting and the large numbers of people involved in this illegal activity, the mountain became an unsafe place for the Department of Forestry and other organisations to carry out conservation activities to preserve the remaining cedar stands.

A survey carried out in early 2017 reported only seven mature individuals standing on the mountain. All of these have subsequently been cut.

The extinction of this species from its natural habitat represents the loss of the largest seed stand for future planting efforts. Some of the Mulanje Cedar trees planted elsewhere by the Department of Forestry could provide a source of seed for restoration, but these stands were grown from seed selected from tall and straight mother trees, with the aim of producing the best timber. They therefore likely represent less genetic diversity than the original populations on Mulanje Mountain. This lack of diversity may impact the resilience of future restoration efforts.

Towards sustainability

In 2016, BGCI, the Mulanje Mountain Conservation Trust (MMCT) and the Forestry Research Institute of Malawi (FRIM) launched a new project, funded by the UK government's Darwin Initiative to domesticate Mulanje Cedar. The project is providing an alternative and sustainable livelihood source for communities living around the mountain who previously depended on illegal harvesting of Mulanje Cedar for income.

Mulanje Cedar Malawi's national tree being reintroduced by the Global Trees Campaign

Ten community nurseries have been set up around the base of Mulanje Mountain, with 150 people growing seedlings to restore mountain populations. Nursery groups have been trained in propagation, nursery management techniques and business skills. In the first growing season, more than 330,000 seedlings were grown and planted on Mulanje Mountain.

Optimal growing conditions for Mulanje Cedar are being identified through horticultural research carried out by Bedgebury Pinetum in the UK and research into mycorrhizal associations and pathogens is being carried out by Chicago Botanic Garden. Trials are being established in the community nurseries to test performance in the current growing season. This aims to improve growth and survival rates in the nursery, as well as identify the best areas and conditions for planting Mulanje Cedar to ensure faster growth rates.

Nursery groups are not only growing a supply of seedlings for restoration on Mulanje Mountain. The aim is to develop a national market for Mulanje Cedar; a market that demands sustainably-sourced seedlings from certified seed and nurseries. These seedlings can be planted and the timber used for personal or commercial use, without having to rely on a supply from wild sources.

Alongside cultivation in the nursery, a national public outreach campaign is highlighting:

- the current status of Mulanje Cedar;
- the responsibility the nation has to protect its national tree;
- the restoration programme on Mulanje Mountain;
- the commercial value of planting this species for future generations.

A nursery certification scheme is being developed, that will assure people that the seedlings they purchase are of good quality, from a sustainable source and that sales directly benefit community groups.

Demand and supply

Rather than reducing demand, this project represents a marketing initiative aimed to shift demand away from illegally harvested timber, and drive demand towards purchase of seedlings that can be grown for commercial gain. The supply of seedlings is not only sustainable, but is also providing local benefits, while taking the pressure off the next generation of Mulanje Cedar being planted on Mulanje Mountain.

As Mulanje Cedar is a relatively slow growing species, and Mulanje Mountain has been stripped of mature individuals, the next generation of harvestable timber will not be available for a few decades. The forced hiatus in logging activities, as unfortunate as it is, may actually assist the restoration of populations on the mountain. It is hoped that this, coupled with domestication of the species and reduced reliance on wild populations, will ensure a secure future for Mulanje Cedar.

Historic stand of Mulanje Cedar on Mulanje Mountain 1998 (Jeffrey Juwawo, MMCT)

Project launch with traditional leaders

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For more information about this project visit: http://globaltrees.org/projects/save-our-cedar-malawis-national-tree/ #SaveOurCedar

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SDG 15: TARGET 15.8
SCREENING OF BOTANIC GARDEN COLLECTIONS FOR INVASIVE SPECIES: A CASE STUDY FROM GERMANY

*A field with Goldenrod (*Solidago canadensis*). This plant is considered as highly invasive in Europe because it grows in dense monocultures.*

TARGET 15.8

By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

Botanic gardens, with their large and diverse plant collections have an important role to play in the control of invasive plant species – through their actions they can become part of the solution and not a cause of the problem.

Introduction

Botanic gardens play an important role in plant conservation, research and public outreach. Living collections of botanic gardens may also provide a source of invasive species because they harbour a high number of wild plants originating from all over the world. In European botanic gardens for example the current number of cultivated species is estimated to be c. 80,000 (Heywood and Sharrock, 2013).

In the past a number of plant species have escaped botanic garden collections and became naturalized in the wild (Hulme, 2011; 2014). In order to reduce the threats from invasive species becoming naturalized outside botanic gardens Heywood and Sharrock (2013), through the Council of Europe, published *a European Code of Conduct for Botanic Gardens on Invasive Alien Species*; this document is not legally binding but suggests voluntary measures. Among them it proposes to "*undertake an audit of the existing collections in the botanic garden for invasion risk*". Reichard (2011) recommends that all botanic gardens should implement such Codes of Conduct to reduce the spread of invasive species.

Here we present an evaluation of the invasiveness of plant species grown outdoors in 20 German botanic gardens and two in neighbouring countries.

*Kudzu (*Pueraria montana*), an invasive species that easily could become established in Germany (Forest & Kim Starr)*

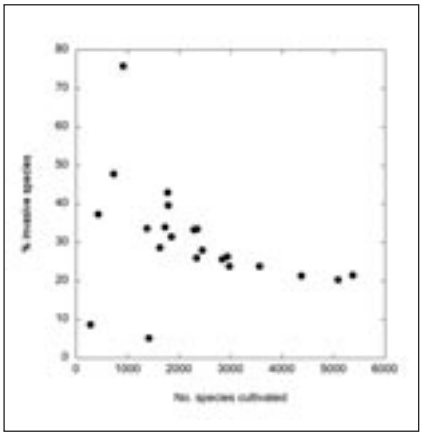

Figure 1: Relationship between number of cultivated species (outdoor) from 22 botanic gardens in Germany and adjacent countries and the proportion of invasive species as listed in the Global Compendium of Weeds.

The aim was to (i) identify those species that are known as invasive in whatever region of the world, and (ii) to identify amongst these, species that do not grow wild in Germany but which have a climatic match between their native ranges and Germany, thus are likely to be able to spread into suitable habitats. These can be considered as species potentially invasive to Germany and requiring special attention.

The screening

Lists of plant species grown outdoors were obtained from 22 botanic gardens (20 in Germany, 1 in Switzerland, 1 in Poland). These lists were kindly provided by the custodians of the respective botanic gardens. Plant names were first checked for correctness according to The Plant List (2013). Hybrid taxa and cultivars were excluded. All revised lists were merged to a single species by garden table and subjected to further analyses.

In total 14,076 species were recorded, of which 73% are not present as natives or established aliens in the German flora. The number of cultivated species among gardens ranged from 277 to 5,377.

Invasive species

We first identifyed species that are listed in the Global Compendium of Weeds (GCW 2018). This database contains more than 28,000 taxa that are weedy or invasive somewhere. We considered a species invasive if it has the attribute *"agricultural weed"*, *"noxious weed"* or *"environmental weed"* in the GCW.

The proportion of invasive species among gardens varied considerably (Figure 1), ranging from 5.2% to 75.9%. Overall, gardens had 2,550 invasive species corresponding to a proportion of 18%.

Not all of the invasive species identified so far would be able to establish in Germany and spread, as there were species on the lists which originate in warm temperate and subtropical climates. Therefore, secondly we examined the species further and subjected them to a risk analysis to identify species that could establish in Germany based on their hardiness zones and for which information on ecological impacts exist. This was based on original research articles, books on invasive plant species and online reources giving detailed information on the ecology of the species. Besides research articles, the major sources were GISD (2018), Invasive Species Compendium (2018), NOBANIS (2018), Weber (2016) and references therein, and Weeds of Australia (2018). This step was necessary as listing in the GCW is not sufficient to demonstrate negative ecological impacts of a given species.

This step yielded 30 species that could be considered potentially invasive to Germany (Table 1). Among them are well known and troublesome invaders such as the lianas Japanese honeysuckle (*Lonicera japonica*) and kudzu (*Pueraria montana* var. *lobata*). Both species are

*Japanese honeysuckle (*Lonicera japonica*) - a potentially invasive species in Germany (Forest & Kim Starr)*

established and spreading in other European countries. Among forbs, Nootka lupin (*Lupinus nootkatensis*) is of particular concern because it has a similar ecology as the already established *Lupinus polyphyllus* and is able to build dense monocultures.

During the course of the study, information on invasive species in collections was fed back to the participating gardens and a list of potentially invasive plants in collections has been made available on the website of the Botanical Garden of Potsdam (www.uni-potsdam.de/botanischer-garten/ueber-uns/naturschutz/botanische-gaerten-und-invasive-pflanzenarten).

*Mandarin rose (*Rosa moyesii*) does not appear on any list of invasive plants or weeds and can be cultivated without risks. (Ewald Weber)*

At the present time, few gardens in Germany are taking active steps to prevent the unintentional spread of invasive species; exceptions being the Botanical Garden of Potsdam which highlights such species on seed lists and Bonn and Tübingen Botanic Garden which do not distribute such species at all. This study represent the first attempt to identify the scale of the issue and focus attention on invasive species in German botanic gardens.

Conclusions

Screening procedures to identify invasive species are important steps towards developing best practice policies and guidelines to prevent the spread of such species. As Heywood (2011) pointed out, botanic gardens will continue to introduce new plant species and evaluating the risks is essential. Changing environmental conditions in the landscape due to land use changes and global warming will increase the likelihood of plant species becoming naturalized and eventually invasive. Therefore botanic gardens need to develop proper biosecurity management, which ideally all botanic gardens follow. Among the measures that have been proposed are information sharing, increasing awareness, educating the public and taking care that invasive plants in the garden collections do not naturalize (Heywood and Sharrock, 2013; European Botanic Gardens Consortium, 2018).

The species listed in Table 1 require special attention because they include widespread and well known invasive species. Our study showed that screening the collections in botanic gardens is feasible and worth conducting in order to help reduce the threats by invasive plant species. Such an approach also helps to highlight that the majority of cultivated species do not have the risk of becoming invasive.

Acknowledgements

We thank all custodians who provided species lists, and Conrad Blanck and Steffen Wolff for technical assistance in the data management. This project was funded by the Deutsche Bundesstiftung Umwelt DBU (German Federal Environmental Foundation).

Above: Impatiens parviflora *has become widespread in Central Europe and invades disturbed forests*
*Top: Goldenrod (*Solidago canadensis*)*

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Species	Native range	Invasive range	Habitats where invasive
Akebia quinata (Houtt.) Decne.	Asia	New Zealand, USA	Forests, forest edges
Alstroemeria aurea Graham	South America	Australia, New Zealand	Forests, shrubland, riparian habitats
Ampelopsis glandulosa (Wall.) Momiy.	Asia	Northeastern America	Forest edges, river banks
Baccharis halimifoliai L.	North- and Central America	Southern Europe, Australia	Coastal swamps, forests, woodland, pastures
Berberis darwinii Hook.	South America	Australia, New Zealand	Forests, woodland, pastures
Carex kobomugi Ohwi	Asia	Northeastern America	Coastal beaches, sand dunes, coastal flats
Clematis terniflora DC.	Asia	Northeastern America	Forests, woodland, forest edges
Cortaderia selloana (Schult. & Schult.f.) Asch. & Graebn.	South America	Southern Europe, western North America, Australia, New Zealand	Grassland, heath- and shrubland, woodland, riparian habitats, coastal dunes
Cotoneaster pannosus Franch.	Asia	Australia, California, South Africa	Grassland, coastal beaches, coastal scrub
Elaeagnus pungens Thunb.	Asia	British Isles, New Zealand, USA	Forests, riparian habitats
Fuchsia magellanica Lam.	South America	Australia, New Zealand	Forests, forest edges, scrub, woodland, riparian habitats
Juncus acutus L.	Southern and western Europe	Australia, New Zealand	Grassland, riparian habitats, edges of salt marshes, pastures
Lespedeza juncea (L.f.) Pers.	Asia	Northeastern America	Forest edges, grassland, wetland edges
Leycesteria formosai Wall.	Asia	Australia, New Zealand	Forests, forest edges, woodland, riparian habitats, moist gullies
Ligustrum lucidumi W.T.Aiton	Asia	Australia, New Zealand	Grassland, woodland, forests, forest edges, riparian habitats
Ligustrum sinense Lour.	Asia	Australia, New Zealand, southeastern USA	Forests, forest edges, woodland, riparian habitats, edges of wetlands
Lonicera japonica Thunb.	Asia	Europe, Australia, New Zealand, North America	Forests, forest edges, riparian habitats
Lupinus nootkatensis Sims	North America	Iceland, Norway	Sandy beaches, heathland, riparian habitats, grassland
Nymphaea odorata Aiton	North America	North America	Ponds, slow rivers
Paederia foetida L.	Asia	Southeastern USA	Forests, forest edges, tropical hammocks, woodland
Passiflora caerulea L.	South America	Australia, New Zealand	Forests, forest edges, coastal scrub
Pennisetum macrourum Trin.	South Africa	Australia, New Zealand	Grassland, woodland, pastures, riparian habitats, disturbed sites
Pinus banksiana Lamb.	North America	New Zealand	Grassland, heathland, woodland, forest edges
Pinus contorta Douglas ex Loudon	North America	Australia, New Zealand	Grassland, woodland, forest edges
Polygonum perfoliatum L.	Asia	Southeastern USA	Forest edges, woodland, riparian habitats, pastures
Pueraria montana var. *lobata* (Willd.) Sanjappa & Pradeep	Asia	USA, Southern Europe, South Africa	Forests and forest edges, woodland, riparian habitats
Rubus cuneifolius Pursh	North America	Australia, South Africa	Grassland, heathland, woodland, riparian habitats
Tamarix ramosissima Ledeb.	Russia, Asia	Australia, North America, South Africa	Salt marshes, riparian habitats, woodland
Wisteria sinensis (Sims) Sweet	Asia	Eastern USA	Forest edges, woodland
Zizania latifolia (Griseb.) Turcz. ex Stapf	Asia	New Zealand	Freshwater wetlands, wet meadows, riparian habitats

Table 1 Plant taxa that are not established in the wild in Germany and that are invasive in other parts of the world. These taxa are being cultivated in German botanic gardens and are potentially invasive if they become naturalized. Many of these species are also being sold in the horticultural trade.

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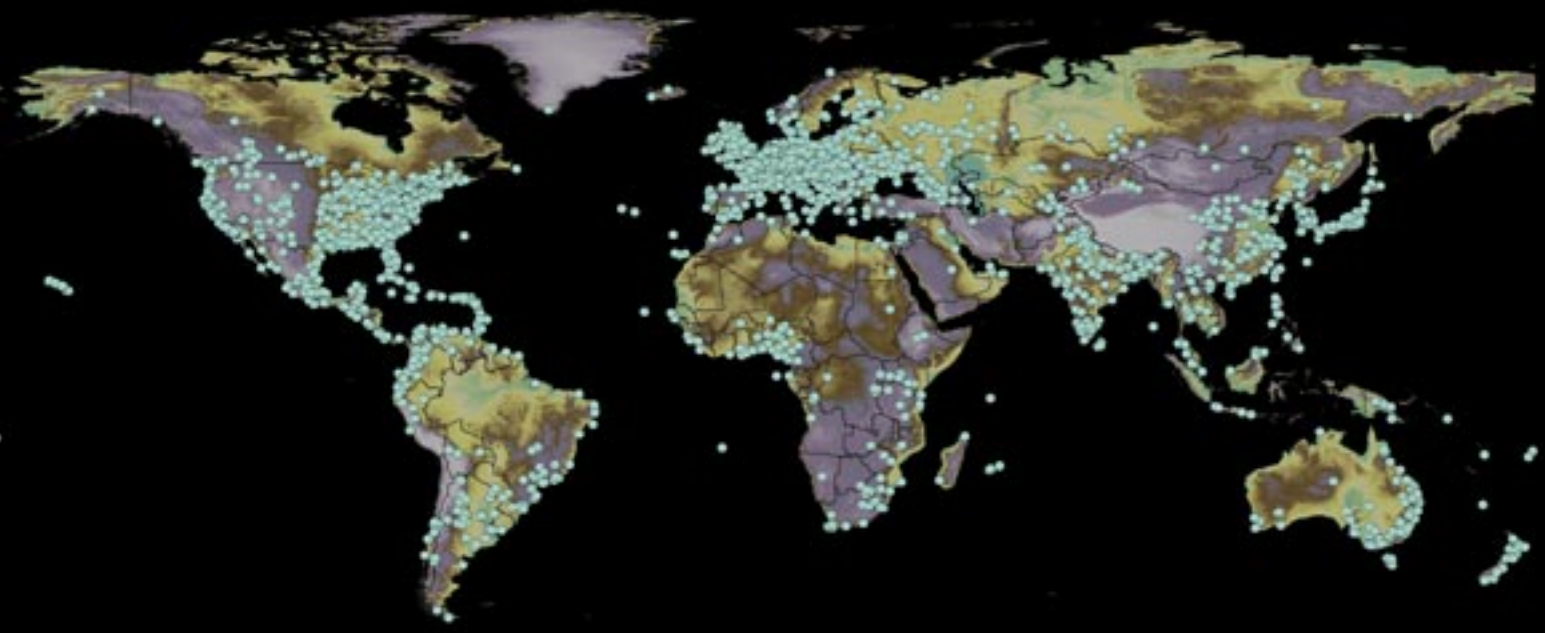

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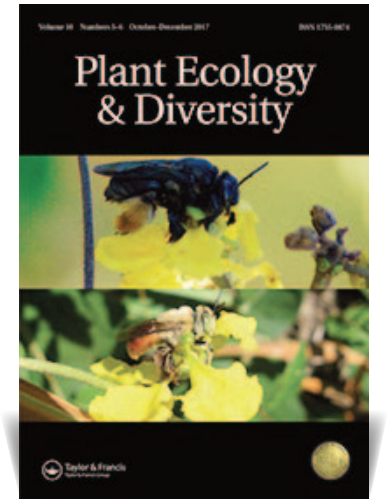

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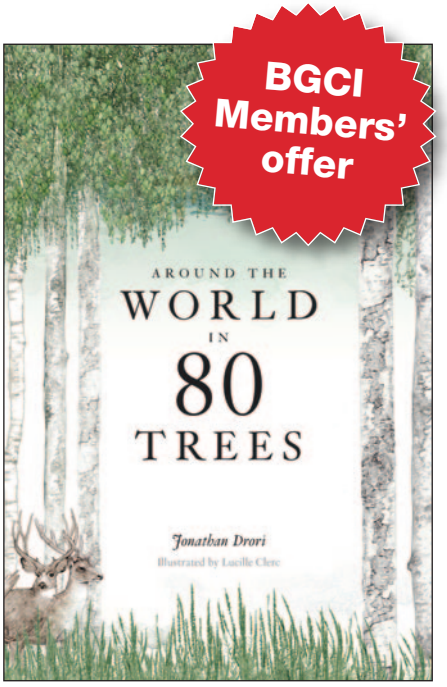

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