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

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

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CHAPTER 7: USING THE PLANT COLLECTION – RESEARCH, CONSERVATION, PUBLIC ENGAGEMENT, RECREATION AND TOURISM

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7.1 RESEARCH AND CONSERVATION

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7.1.0 Definitions

Conservation assessment: The process to determine which species are at greatest risk of extinction. Conservation assessments are used to prioritise the most threatened species for conservation action, publicise their plight and provide information needed to plan the action needed to save them. Assessment of conservation status can also be referred to as 'red list assessments' based on the IUCN Red List of Threatened Species – the most widespread system used to evaluate the conservation status of species.

Cryopreservation: An *ex situ* conservation method for long-term storage using liquid nitrogen at -196°C. This technique may be used in particular for recalcitrant seeds which cannot be stored via standard seed banking (see definition) methods.

DNA bank: An *ex situ* conservation facility for long-term storage of genetic resources – e.g. plant genomic DNA conserved at -80°C.

Ecological restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. Ecological restoration seeks to 'assist recovery' of a natural or semi-natural ecosystem rather than impose a new direction or form upon it.

***Ex situ* conservation:** Conservation of components of biological diversity outside their natural habitats. This off-site storage of genetically representative samples of natural populations serves as a backup in the event of species extinction in the wild (see also *in situ* conservation).

Field gene bank: An *ex situ* conservation collection of 'live plants'. Field gene banks, often generally referred to as 'living collections' are especially important for long-lived perennials that reach sexual, reproductive maturity only after protracted periods of time, or for species with short-lived, desiccation-sensitive (recalcitrant) seeds, as well as for plants that only reproduce vegetatively in the wild.

Herbarium: An *ex situ* plant collection of dried voucher specimens mounted on paper along with collection information to act as a preserved and lasting record.

***In situ* conservation:** Conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in the wild.

***In vitro*, tissue culture:** A collection of techniques using test tubes, culture dishes, etc. to maintain or grow plant cells, tissues or organs under sterile conditions on a nutrient culture medium. Plant tissue culture is widely used to produce clones of a plant through a process referred to as micropropagation.

Pollen bank: An *ex situ* conservation facility for long-term storage of desiccation tolerant pollen following freeze- and vacuum drying.

Population introduction: The intentional movement and establishment of an individual or a group of individuals outside their natural range. The aim is to prevent extinction of populations of the target species by establishing new populations in suitable habitats with favourable environmental conditions in areas where they have not been recorded from in recent geological history.

Population reinforcement: Measures to assist the recovery of declining or degraded populations of species and enhance their viability, that without intervention would not regenerate in the wild. The aim is to enlarge the effective size of remaining populations by increasing genetic diversity or representation of specific demographic groups or stages and, where possible, re-establish their original connectivity in the wider landscape.

Population reintroduction: The intentional establishment of an individual or a group of individuals in their natural area of distribution from where they have disappeared. The aim is to re-establish a viable population of the target species in its original range. This can either concern the reintroduction of a particular population that is no longer present where it formerly occurred, or of the species at large if all of its populations have entirely ceased to exist in the wild.

Seed bank: An *ex situ* conservation facility to store seeds. Seed banking describes the entire process from seed collection in the wild to long-term storage at -20°C ± 3°C in the seed bank. This has many advantages such as ease of storage, economy of space to represent genetic diversity, relatively low labour demands and consequently, the capacity to maintain large samples at an economically viable cost.

Spore bank: An *ex situ* conservation facility for long-term storage of desiccation tolerant spores following freeze- and vacuum drying.

7.1.1 Introduction

As multidisciplinary institutions at the interface between people and plants, botanic gardens are prime centres for botanical research and plant conservation. With plant diversity continuing to decline worldwide, *ex situ* conservation at botanic gardens presents a major insurance policy for the safeguard of rare and threatened species. Plant material held in *ex situ* collections can be used in efforts to reinforce dwindling and degraded plant populations in the wild, let alone to reintroduce species and populations where they have entirely disappeared. Botanic gardens are also becoming increasingly visible as influential stakeholders and versed actors in the area of restoration ecology and practice. What is more, in times of unprecedented global transformations, climate change and changing ecosystems, botanic gardens may hold plants and genetic diversity relevant for the development and management of emerging ecosystems with new species assemblages.

KEY MESSAGE

Ex situ conservation of plant germplasm provides a vital backup in the event of species extinction in the wild.

Given the multiple facets of *ex situ* conservation, this section aims to provide guidance on selected key research and conservation undertaken by botanic gardens. This includes methods and standards for different types of *ex situ* conservation collections – living and non-living – and their relevance to and integration with *in situ* conservation endeavours (Figure 7.1.1). While the research component as presented in this section primarily considers efforts supporting practical conservation (Case study 7.1.1), it should not be overlooked that botanic gardens are, as a matter of course, major scientific institutions for the numerous study areas of botany, including plant taxonomy and classification, nomenclature, phylogeny, vegetation ecology, study of flora, horticultural research, physiology, phytopathology, phenology, economic botany, etc. Equally, botanic gardens are also centres of excellence to develop plant-based solutions to pressing global challenges such as food security, poverty, health and sustainable water and energy provision, thereby contributing to the Sustainable Development Goals (SDGs) and Aichi Biodiversity Targets (Chapter 4, Section 4.2). As institutions maintaining *ex situ* collections, botanic gardens are also the prime agents working towards achieving Target 8 of the Global Strategy for Plant Conservation (Chapter 4, Section 4.4.3) aimed at integrated *ex* and *in situ* conservation action of species at risk of extinction.

Figure 7.1.1 Overview of *ex situ* plant conservation strategies and links to *in situ* conservation

***EX SITU* CONSERVATION**							
***'Hortus vivus'* – Living collection**						***'Hortus siccus'* – Non-living* collection**	
Collection category	'Live plants'	Germplasm / propagules				Dried, spirit-preserved, etc.	Derived, secondary resources
Collection type	Field gene bank	Seed bank	Tissue culture / cryopreservation	Pollen / spore bank	DNA bank	Herbarium and other collections incl. fruit, wood, fossil, etc.	Illustrations, images, plant data records, books, etc.
***IN SITU* CONSERVATION**							
Species recovery	Population reinforcement						
	Population reintroduction						
Ecosystem recovery	Ecological restoration						
Ecosystem design	Population introduction						
	Emerging, novel ecosystem conception and/or management						

**Non-living collections may still contain viable plant material, such as seed or intact DNA.*

CASE STUDY 7.1.1

Research programmes at botanic gardens supporting practical plant conservation – three examples from Denver Botanic Gardens, Colorado, United States

Jennifer Ramp Neale, Sarada Krishnan and Rebecca Hufft, Denver Botanic Gardens

- **Phenology monitoring**

Phenology examines biological phenomena such as timing of germination, blooming in the spring or leaf colour changes in the fall. Understanding the timing of such events and their relationship to climate is critical to planning seasonal work like plant population monitoring and seed collection.

Since the 1950s, dedicated volunteers across the country have tracked the phenology of lilacs. Partnering with the USA National Phenology Network (USA-NPN), Denver Botanic Gardens (DBG) has been monitoring the phenology of *Syringa vulgaris* individuals, including 25 *S. vulgaris* varieties. Monitoring all of the varieties in one location provides the opportunity to determine how phenology varies among the varieties. In 2013, DBG also planted two cloned lilacs (*Syringa x chinensis* 'Red Rothomagnesis') received from USA-NPN. Data collected from these and other cloned lilacs allow phenological comparisons across the country without genetic variation contributing to differences in timing. The observations have been invaluable in documenting plant responses to changing spring conditions. This information has been used along with historical weather data across the country to capture the timing of spring indices, such as leaf-out and flowering that primarily vary with temperature.

Monitoring lilac phenology at Denver Botanic Gardens. (Image: Denver Botanic Gardens)

- **Long-term research into the life-history and demography of *Astragalus microcymbus* – a rare species endemic to Gunnison County, Colorado**

Since the mid-1990s, Denver Botanic Gardens has been partnering with the US Bureau of Land Management (Colorado State Office) to monitor population demographics of the rare skiff milkvetch, *Astragalus microcymbus* (Fabaceae). The study was initiated to learn about the species' life-history, determine population trends and examine management actions that will best support long-term survival. DBG has tracked thousands of individuals at six sites within a drainage outside of Gunnison, Colorado. The first nine years of research documented a statistically significant population decline in all monitoring plots, prolonged dormancy, episodic fruit production and herbivory. More recent results indicate that while *A. microcymbus* is stable in overall population size it is following a large time-scale cyclical pattern of growth and decline. The findings of this research conducted over a period of 25 years have contributed to formal assessments of the species by the US Fish and Wildlife Service, listing it as a candidate for protection under the Endangered Species Act.

Surveying Astragalus microcymbus (Fabaceae). (Images: Denver Botanic Gardens)

CASE STUDY 7.1.1 (CONT.)

- **Conservation management recommendations based on studies of population genetics for federally protected *Sclerocactus* species in the arid west of Colorado**

In collaboration with the US Fish and Wildlife Service and the US Bureau of Land Management, Denver Botanic Gardens has collected genetic data on three federally protected members of *Sclerocactus*. The Colorado hookless cactus (*Sclerocactus glaucus*) has a limited distribution in Western Colorado. It has been listed as Threatened under the Endangered Species Act (ESA) since 1979. Populations have been monitored throughout their range to better understand life-history traits of the species. Partnering with the University of Northern Colorado, DBG has conducted a population genetic study to identify diversity within and among populations as well as any populations showing hybridization with the widespread small flower fishhook cactus (*Sclerocactus parviflorus*).

Utilizing microsatellite markers, the genetic diversity in more than 800 individuals throughout the species' range was studied. Two genetically distinct regions of the Colorado hookless cactus were identified: a northern range occupying the Colorado River drainage and a southern distribution in the Gunnison River drainage. Few hybrid individuals were found during the study. As morphological traits used to identify species and potential hybrid populations did not correlate with genetic identity, it is recommended to manage populations in the future based on geography rather than morphological criteria.

Similar management recommendations were made for two other species of *Sclerocactus* found in Utah and protected under the ESA, the Pariette cactus (*Sclerocactus brevispinus*) and the Uinta Basin hookless cactus (*Sclerocactus wetlandicus*). Analyses of nearly 600 individuals across the species' ranges identified two genetic clusters which do not entirely correlate with the species as defined by morphological traits.

Sclerocactus glaucus in the wild. (Image: US Fish and Wildlife Service)

7.1.2 Conservation Prioritisation

While *ex situ* collections are established to serve many purposes, such as to represent species for their geographic, phylogenetic and ecological significance and/or cultural uses, securing threatened taxa of urgent conservation concern has become a major focus for botanic gardens in the last few decades. Determining the conservation status of plants is an important first step to identify species that are at risk of extinction in the near future. Species conservation assessments are essential to prioritise *ex* and *in situ* conservation action and make informed conservation decisions. The most widespread system used for conservation assessments is the IUCN Red List of Threatened Species (Box 7.1.1). Therefore the process of assessing the extinction risk of species is also referred to as 'red listing'.

Box 7.1.1 IUCN Red List Categories and Criteria

The IUCN Red List of Threatened Species has nine different categories:

Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE).

EX means a species has gone extinct, whereas species that are EW are extinct in the wild, but do persist *ex situ* (such as in botanic garden collections). CR, EN and VU are the three threatened categories used for species that face a high risk of extinction in the wild. Species that do not qualify for a threatened category, but are close to or likely to qualify for a threatened category in the near future, can be assigned to the category NT. LC is used for species that are assessed but are not considered threatened. The use of the category DD may be assigned to poorly known taxa. Species not yet evaluated are classified as NE.

To assign a species to a red list category different criteria are used to measure symptoms of extinction risk. Species are evaluated in relation to five criteria, based on a set of quantitative thresholds and several subcriteria, in order to assess whether a species qualifies for a threatened category (CR, EN, VU). The five criteria are: A) Population reduction; B) Geographic range; c) Small population size and decline; D) Very small or restricted population; and E) Quantitative analysis.

Botanic gardens play a vital role in red listing. They help analysing the impact of different threats on plant diversity and, in such a way, informing species level conservation assessments. Botanic gardens are ideally placed to support red listing as they have a wealth of expertise, information and experience for plant red listing. Botanic gardens are often centres for taxonomic expertise; and taxonomic experts not only tell us which species we should red list but they often have a wealth of relevant information on particular species groups. Botanic garden staff will have information on habitat requirements, propagation techniques, threats in the wild, etc. All this information is useful when red listing plants. In addition to scientific knowledge and expertise of the botanic garden staff, valuable information on distribution, population structure, habitat and ecology, threats and current conservation action may also be found in herbaria, libraries, living collection databases and other information sources housed at botanic gardens.

Both, existing and new information, are collated and a species is then listed to be of conservation concern (i.e. threatened) or not, based on a set of categories and criteria. Conservation assessments can be made on global, regional and national scales. BGCI's ThreatSearch database lists all known plant conservation assessments, including global and non-global assessments. It contains over 242,000 assessments which represent over 150,000 different taxa (Box 7.1.2). Although a threatened conservation status itself does not warrant conservation action, this information is useful to prioritise conservation action and make effective and informed conservation decisions.

Box 7.1.2 ThreatSearch database

ThreatSearch is the world's most comprehensive database of conservation assessments for plant species, including global, national and regional assessments. The database allows to search over 242,000 conservation assessments, representing over 150,000 taxa.

Together with BGCI's two main collaborators – the National Red List and the Royal Botanic Gardens, Kew – currently available conservation assessments have been assembled into a single list of conservation assessments for plants. New conservation assessments as well as older, non-digital sources are continuously being added.

It is possible to search for species of interest, and also filter on scope, threatened status and year of the assessments. Species names have been matched to The Plant List wherever possible. The source of the assessment is indicated, and, when available, a URL link will refer to the original source of the information.

ThreatSearch is directly relevant to conservationists, educators, horticulturists, collection managers, researchers, policy makers and many others who are working to save and understand plant diversity. ThreatSearch can be used to measure progress toward several targets of the Global Strategy for Plant Conservation.

Many botanic gardens are involved in national or regional red listing initiatives (Case study 7.1.2). They play a vital role in contributing information towards conservation assessments for plants. These evaluations will help the botanical community to prioritise *in situ* as well as *ex situ* conservation action.

CASE STUDY 7.1.2

Species conservation prioritisation – Red Listing at Jardim Botânico do Rio de Janeiro, Brazil

Malin Rivers, Botanic Gardens Conservation International, and Eline Martins, Centro Nacional de Conservação da Flora committee

An example of a botanic garden actively involved in producing national level conservation assessments (i.e. Red Lists) of plants is Jardim Botânico do Rio de Janeiro (Rio de Janeiro Botanic Garden) in Brazil. The botanic garden hosts the Centro Nacional de Conservação da Flora (CNCFlora) at their research institute.

Brazil's flora consists of over 46,000 species, and red lists (conservation assessments) are an important tool for prioritizing the limited resources in the conservation of species. CNCFlora is responsible, at the national level, for assessing the conservation status of the Brazilian flora, by the year 2020. CNCFlora adopts the standards and procedures recommended by the International Union for the Conservation of Nature (IUCN). The red listing of the Brazilian flora is performed by the CNCFlora Red List team, in collaboration with a network of experts from across botanic gardens in Brazil and the scientific community. This network helps to validate the information collated by the red list team and contribute to the consistency of the conservation assessments.

The workflow adopted by the team has an online information system developed specifically for the process of assessment of extinction risk and has three main steps:

1. The first step is data analysis, which is the compilation of data online to create a species profile. The information collated includes: population structure, ecology and distribution of each species, as well as information on threats and conservation actions.

2. The second step is validation. During this stage the data are passed on to the network of collaborating specialists who access and review the information entered.

3. With the knowledge generated and passed by the expert, the third step begins: the process of extinction risk assessment, following the IUCN categories and criteria (version 3.1). During this step, the species are categorized into one of the extinction risk categories.

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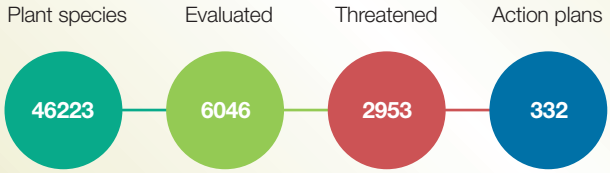
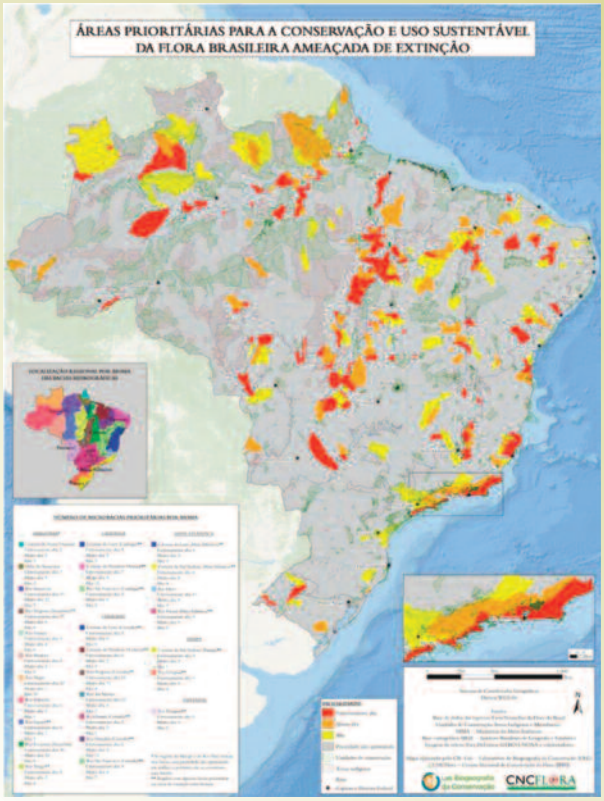
CASE STUDY 7.1.2 (CONT.)

When the assessments are complete they are available again to be reviewed by experts who can send comments and suggestions regarding the assessments. Subsequently, the ratings are published in the CNCFlora portal and sent to the Ministry of Environment (MMA), responsible for drafting the Official List of Threatened Plants in Brazil. In December 2014, the first results were officially recognized by the MMA. This allowed the publication of the updated official list of threatened flora in Brazil, an important tool for public policy and law enforcement for the conservation of threatened flora (MMA, 443/2014*).

Since 2010, CNCFlora has assessed the extinction risk of 6,046 species of the Brazilian flora (13,2% of the national flora), and nearly half of these are of species considered at risk of extinction (i.e. threatened). CNCFlora also works to develop recovery and action plans for many of the most threatened species and habitats.



*Ministry of Environment (MMA), 2014. Portaria no 443, de 17 de Dezembro de 2014. Diário Of. da União 110-121.



Priority conservation and sustainable use areas based on red listing. (Image: Centro Nacional de Conservação da Flora committee)

Orthophytum humile (Bromeliaceae), endemic to Brazil, assessed as Critically Endangered. (Image: Rafael Louzada)

7.1.3 From Species Prioritisation and Collection Policy to Plant Collection

Ultimately, our choices of which species and populations to collect and how well we can store them for long periods of time may well mean that some plants survive into the next century that otherwise would not. Guerrant *et al.* (2014)

The focus and types of research and conservation programmes carried out as well as related facilities and equipment required by botanic gardens, are determined by the vision and mission of the institution (Chapter 1, Section 1.2.4) and, more specifically, its collection policy (Chapter 3). These fundamental frameworks will inform or define the species selection, sampling strategy and collection types the botanic garden is aiming at (Box 7.1.3).

Achieving genetically diverse collections representative of the wild populations is a key endeavour of *ex situ* conservation. The enormous diversity in reproductive systems in the plant kingdom that has a bearing on the amount and structuring of genetic variation within and among populations, makes the provision of general guidance on sampling strategies towards genetically representative *ex situ* living conservation collections a challenging task. Building on guidelines produced by the Center for Plant Conservation (1991) and Guerrant *et al*. (2004), Guerrant *et al*. (2014) provide one of the most comprehensive reviews. While they highlight that there is no single correct sampling strategy or protocol, a number of key questions (Box 7.1.3) will help plan and schedule collection over time.

KEY MESSAGE

No one-size-fits-all – each plan for establishing *ex situ* conservation collections should be based on the individual and specific purpose of the plant holdings, the size of and potential damage to the wild populations to be collected from, as well as the ability of the botanic garden to maintain the collections over time.

Ultimately, each situation should be evaluated in the context of the particular purposes and uses for which the collection is made. This will include the nature of the target taxa, the manner in which the samples will be stored and maintained, the period of time they will be stored, and whether wild-collected samples are to be used directly or whether their numbers will be increased by horticultural growouts (Guerrant *et al*., 2004). In conclusion, the 1) purpose of collecting plant material, the 2) potential damage to wild populations from over-collection, as well as the 3) ability to maintain the samples in good condition, should always carefully be considered by any *ex situ* collection strategy.

7.1.4 *Ex Situ* Living Collections

Ex situ conservation strategies for living plant material as pursued by botanic gardens comprise a range of collection types, including field gene banks, seed banks, *in vitro* tissue culture and cryopreservation, pollen and spore banks as well as DNA banks. While the conservation value of *ex situ* plant holdings is determined by the level of their genetic representativeness of wild populations, the various types of collections present different advantages, challenges and management approaches towards achieving this principle.

KEY MESSAGE

Whatever strategy of *ex situ* conservation employed, the conservation value of the plant holdings is ultimately determined by the extent of their genetic representativeness of wild populations.

- **Field gene banks**

Field gene banks or 'live plant' collections are a key *ex situ* conservation means especially for long-lived perennials that reach propagation maturity only after protracted periods of time, or for plants that generate short-lived, desiccation-sensitive seeds that are not suitable for storage in seed banks. In some circumstances, they may be the only viable option for *ex situ* conservation of recalcitrant germplasm. Live plant collections may also be required for species that generally reproduce vegetatively in the wild.

Box 7.1.3 Integrated sampling strategy – key questions

***Ex situ* collection policy:**	• Which plant groups and taxa to collect?
***In situ* sampling strategy:**	• For each taxon – from how many and which populations to collect? • Within each population – how many and which individuals to collect? • For each individual – how many and what kind of propagules to collect? • What is the maximum sample size the population can bear without damage?
***Ex situ* collection type:**	• What collection types are serving best its purpose? Field gene bank; seed bank; tissue culture; cryopreservation; pollen-, spore- and/or DNA bank?

The breadfruit collections of the National Tropical Botanical Garden's (NTBG) Kahanu Garden, Maui, and the McBryde Garden, Kauai, are among the world's largest live plant holdings in this taxonomic group. (Image: National Tropical Botanical Garden)

Especially within the global crop community, this form of reproduction may also be intentional to conserve gene combinations that would be lost when changing to seed propagation. For species from remote locations, field gene banks may prove more practical for various research purposes given their immediate accessibility and availability of living plant material.

A genetically diverse collection representative of the wild population is vital to maintain its fitness and avoid inbreeding, a risk in particular for outcrossing species – plants that are not self-pollinating. Controlled pollination for seed production may be required to reduce the risk of outbreeding depression, i.e. to avoid the mixing of genetically distant individuals or populations within the collection that potentially could lead to lower fitness of the next generation. A fluctuating population size, for instance as a result of changing horticultural care and mortality rates, can also affect the field gene bank's genetic structure. Depending on the extent of the genetic diversity of wild populations, space requirements may present a key limitation of live plant collections, in addition to the challenge to protect them from natural disasters. Plants held in field gene banks may also be prone to hybridisation with closely related species. What is more, live plant collections may also be susceptible to spreading invasive species as well as pests and pathogens. They therefore should include a rigorous risk assessment for all taxa to be grown in the collections. Examples of comprehensive risk evaluation frameworks from global to national levels include the Invasive Plant Species Voluntary Codes of Conduct for Botanic Gardens and Arboreta, the European Code of Conduct for Botanic Gardens on Invasive Alien Species, or the Weed Risk Assessment of the National Institute of Water and Atmospheric Research Ltd (NIWA) in New Zealand. In conclusion, field gene banks should:

- Represent the full genetic diversity of the natural populations;
- Be established in close collaboration among the various institutions holding live plant collections to coordinate population priorities and avoid risks of cross-breeding;
- Ensure that collections of closely related species are not established in proximity to each other to prevent potential hybridisation;
- Undertake, prior to their establishment, a thorough risk assessment pertaining to the species' potential of becoming invasive and being the carrier of pests and pathogens;
- Monitor periodically the genetic condition of populations to enable the identification of potential problems related to erosion of genetic diversity over time.

Despite these challenges, live plant collections provide a vital complementary *ex situ* conservation strategy. This is supported by a growing number of molecular studies demonstrating that field gene bank collections can be representative of wild populations if established sampling methods are applied thoroughly (Case study 7.1.3).

CASE STUDY 7.1.3

Zamia decumbens – research on a model species to demonstrate that a botanic garden collection can capture the genetic diversity in a wild population

Patrick Griffith *et al., Montgomery Botanical Center, Florida**

Cycads are an imperiled group of plants, and *ex situ* collections present an important part of conservation planning for this group, given seed recalcitrance, difficulties with tissue culture, and ongoing *in situ* threats. The majority of the 331 extant species are recorded on the IUCN Red List of Threatened Species, and more than 75% are threatened with extinction. Given their long history – cycads represent a lineage that is Paleozoic in origin – living cycads are often used in teaching collections at botanic gardens and universities.

This study sought to illuminate how well an *ex situ* collection of a cycad can capture the diversity in a wild population, thereby establishing also the conservation value of the collection.

Methodology

A model species, *Zamia decumbens*, was chosen on the basis of geographic isolation and detailed census knowledge, which allowed near-total sampling of *in situ* plants. The Critically Endangered *Z. decumbens* is known from a limited area of the Maya Mountains in southern Belize. At the time of its description (Calonje *et al.*, 2009), the species was known from two main populations of 234 and 183 plants, restricted to two limestone sinkholes separated by 7 km, and a few scattered hilltop populations of no more than 12 plants each. The remote, isolated locations preclude any potential introgression of other *Zamia* spp. from horticulture or *in situ* plants. Via 10 microsatellite markers, 375 *in situ* plants were compared to 205 *ex situ* plants grown from seed collected in the wild in 2010.

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CASE STUDY 7.1.3 (CONT.)

Summary of results

Genetic-distance analysis demonstrated high fidelity of the *ex situ* collections to their *in situ* source populations as well as clustering of *ex situ* progeny by accession and strong identity with their respective mother plants. Structured resampling of allele capture from the *in situ* populations by the *ex situ* collections showed that allele capture increases as number of *ex situ* plants maintained increases, but with a diminishing rate of increase.

Conclusion

The data obtained demonstrate that botanic garden collections can better conserve the genetic diversity of *in situ* cycad populations if four recommendations are followed: 1) use the species biology to inform the collecting strategy; 2) manage each population separately; 3) collect and maintain multiple accessions; and 4) collect over multiple years.

While genetic information has great potential to inform *ex situ* conservation collections management, caution against overstating the utility of genetics for plant conservation needs to be prompted. The assay of the type described here must be considered in the context of specific biology (Guerrant *et al*., 2014). And finally, while conservation genetics study certainly provides much greater insight into *ex situ* collections management, it cannot replace the basic work of the botanist, curator, propagator, or horticulturist – it remains essential to integrate conservation genetics with other data and with tangible effort.

*Griffith, M.P., Calonje, M., Meerow, A.W., Tut, F., Kramer, A.T., Hird, A., Magellan, T.M. and Husby, C.E. (2015). Can a Botanic Garden Cycad Collection Capture the Genetic Diversity in a Wild Population? International Journal of Plant Sciences 176(1).

Zamia decumbens in its sinkhole habitat, Toledo, Belize. (Image: Michael Calonje)

• Seed banks

Increasingly, botanic gardens around the world have set up seed banks as part of their plant conservation programmes. The storage of orthodox seeds for long-term conservation is an effective *ex situ* insurance strategy to complement *in situ* conservation of plants, guaranteeing the survival of individual species. Many thousands of seeds may be stored for a particular species, each one representing a potential new plant. Seed banking provides an efficient and cost-effective means of preserving the diversity of plant species: each collection occupies a relatively small space and requires little attention over time. Skills, knowledge and data built up through the conservation of these collections will support wider plant conservation activities (Box 7.1.4).

Box 7.1.4 The Global Seed Conservation Challenge (GSCC)

BGCI's Global Seed Conservation Challenge (GSCC) aims to increase the contribution of botanic gardens towards Target 8 of the Global Strategy for Plant Conservation. This target calls for 'At least 75% of threatened plant species in *ex situ* collections, preferably in the country of origin and at least 20% available for recovery and restoration programmes by 2020'.

The GSCC has five aims:

- Engage more botanic gardens to become involved in seed banking, working 'outside the garden walls' to bring into *ex situ* collections threatened species that are not already conserved;
- Highlight and celebrate success for seed conservation including awarding prizes to gardens that excel;
- Strengthen networks to help botanic gardens share experiences and resources in seed banking;
- Establish a seed collecting 'hub' at BGCI which will provide a 'one-stop-shop' for seed banking information and training resources;
- Provide training and build capacity to support seed collecting and raise seed banking standards.

Seed collections are carefully dried and processed before being placed under storage at -20°C. These conditions allow the potential longevity of the seeds to be maintained. The viability of the seed collections is monitored periodically by germination testing. Banked seed collections are available for germination and propagation, for use in research and human livelihoods, and for the potential recovery and restoration of threatened species and ecosystems (Case study 7.1.4 and Section 7.1.6).

CASE STUDY 7.1.4

Using seed collections for *in situ* conservation

Marian Chau, Honolulu, Hawai'i

Threatened species held in the seed bank are an essential tool for preservation of genetic diversity, reintroduction, and research on germination, dormancy, and favourable growing conditions. The Seed Conservation Laboratory based at the Harold L. Lyon Arboretum in Honolulu has over 15 million seeds banked, representing more than 550 taxa of native Hawaiian plants which equates to over 40% of the flora of Hawai'i. Of the banked species over half are federally listed as endangered and/or threatened on the IUCN Red List.

The Seed Conservation Laboratory, part of the Hawaiian Rare Plant Program (HRPP), conducts crucial research into collection, preservation, and propagation of native Hawaiian plants, many of which are close to extinction. Most of the seeds collected are stored, while some are sown in the seed laboratory where they can be carefully monitored to determine their ability to germinate under different conditions and increase their chances of survival in the wild. This research is invaluable for understanding the biology of the species and aiding the reintroduction of species to natural habitats.

The endemic shrub *Cyanea grimesiana* ssp. *grimesiana* is a flowering plant native only to the island of O'ahu, which has become extinct in the wild. Re-establishment of *Cyanea grimesiana* ssp. *grimesiana* in the wild from *ex situ* tissue culture and seed collections in the HRPP has saved it from extinction.

Seeds were collected from the last individuals of this subspecies before they died and were established in the HRPP Micropropagation Laboratory. A few plants resulting from tissue culture were reintroduced to a managed outplanting site by the Hawai'i Plant Extinction Prevention Program. Reintroduced plants were hand-pollinated and produced fruits, which were deposited at the Seed Conservation Laboratory. Some of the seeds were stored for future restoration efforts, while others were germinated and grown in the growth chamber for a couple of weeks to establish before being grown up in the rare plant greenhouse. Many mature seedlings were then planted in their native habitat, re-establishing a wild population and contributing to forest restoration.

Cyanea grimesiana ssp. grimesiana propagated at the Seed Conservation Laboratory of the Harold L. Lyon Arboretum, Hawai'i. (Images: Harold L. Lyon Arboretum)

The Millennium Seed Bank Partnership (MSBP) of the Royal Botanic Gardens, Kew (RBG Kew), has established a set of Seed Conservation Standards to ensure that the partnership collections are of high quality. These standards allow collections to be recognised as a global resource and assure users of the quality of the collections stored and associated data generated through this network. Current best practice for long-term conservation of orthodox seeds is encompassed within these standards, including harvesting seeds at the optimum point of maturity, adequately representing the sampled population, and caring for collections after harvest to minimise damage and maximise potential longevity. These standards are outlined in this section:

1. Collecting

Seed collections are made from wild populations, along with representative herbarium vouchers and associated field data, according to the following guidelines:

1.1 Genetic materials, including traditional knowledge, are legally collected and conserved

Collectors must obtain permission from government and land owners/managers before seed collecting takes place. It is essential to take advice from local collaborators and national/local government offices with experience in the region.

1.2 Collection names are verified (ideally by reference to herbarium voucher specimens)

Herbarium specimens (Section 7.1.5) enable accurate identification of seed collections to a particular species. Voucher material is collected from the same population as the seeds and is linked with the seed collections and relevant field data, as well as any associated material, such as photographs. If seed is being sent out of the country, several specimens may be collected, at least one being held in the country of origin. If a field verification of the species is made, or the voucher is verified by a herbarium, data should be provided on: name of verifier, date of verification, taxonomic name and authority used.

1.3 Genetic diversity of sampled population is adequately represented

It is beneficial to rely on local knowledge and institutional priorities when establishing target species lists, so that accessible populations can be identified and seed dispersal timings can be understood. Where local botanical knowledge is not available, collecting guides may be compiled from digitised herbarium specimens, which often have information on collection locality and flowering/fruiting times. Once the target population has been accurately identified, with the help of local taxonomists, field guides and checklists, or using digitised herbarium specimens, collectors must then assess whether sufficient plants are available with mature seed to make a collection for *ex situ* conservation. A simple cut test of seeds (approximately 20 per collecting team member), gathered from plants across the population, can be used to estimate the amount of damaged, infested or empty seeds that may be collected. Assessing a Population for Seed Collection provides further information for seed collectors as to whether a population meets the minimum quality and quantity standards for seed sampling for a particular purpose or project.

In order to represent the genetic diversity of the population, seeds are collected from at least 50 individual plants, selected randomly and evenly across the population. Taking account of the future uses of the collection, including long-term viability monitoring, collectors should aim for the collection of 10,000 to 20,000 seeds per population sample. Seeds are collected using the most appropriate method according to the type of seed dispersal unit. For example, tree seeds clustered at the tips of high branches will require long-handled pruners. Shaking branches over a tarpaulin sheet spread on the ground may be more suitable for smaller, shrubby species. Collectors should avoid gathering seed from the ground as it may have been subject to ageing or insect attack since it was shed. It is also difficult to determine which parent plant the seeds have been shed from when found on the ground. Seed Collecting Techniques gives more detail on various seed collecting techniques. Seeds are collected into porous bags (i.e. cloth or unwaxed paper) and labelled with a collection number (according to the principal collector's number series).

1.4 Essential field data are recorded

Field data pertaining to the seed collection are recorded on paper forms or electronic devices. Essential data include the collectors' name(s) and institute(s), date of collection, collection number, site data (locality, latitude and longitude), habitat data (associated species), identification data (collectors' identification of the target species), sampling data (number of plants in population, number of plants sampled from, herbarium specimens taken). The field data should be transferred to the institution's seed bank database under a unique accessioning number, to which further data can be added during the processing and monitoring of the seed collection.

Training on seed collection and field data recording, Costanera Sur Ecological Reserve, Buenos Aires, Argentina. (Images: Katherine O'Donnell)

1.5 Survival of source population is not compromised

To avoid harming the plant's future survival in the wild, no more than 20% of the mature seed, available on the day of collection, should be gathered. In the case of threatened and rare species it may be more appropriate to return to the population later in the season or in subsequent years, in order to build up the collection. Collections made in subsequent years from the same population should be stored separately under a new accession number.

2. Processing

Seed collectors should aim to maintain the quality of the collection from the moment of harvest, to ensure that the viability at the point of banking the collection is as high as possible. Poor handling in the field, including holding the seeds at high humidity and temperature, will cause seed ageing. Portable hygrometers can be used to measure relative humidity of seeds and of ambient conditions, guiding the handling of seed collections (Post-Harvest Handling of Seed Collections).

Seed collections are accessioned, dried and processed according to the following guidelines:

2.1 Unique accession reference number is assigned to all incoming material

An accession number (Chapter 3, Section 3.4.3 and Chapter 5, Section 5.5.2) is allocated to each incoming seed collection so that the seeds and associated data can be tracked through their processing and storage life. Accompanying herbarium material should be given the same accession number to enable easy association with the seed collection.

2.2 Collections are placed in cool/ambient drying conditions of 15% eRH ± 3% within 4 weeks of collection

When seeds arrive at the seed bank the likely storage characteristics of the seeds can be checked, using tools such as RBG Kew's Seed Information Database. Those collections that may pose storage problems (i.e. are intermediate or recalcitrant in storage behaviour) should undergo desiccation tolerance screening (Identifying Desiccation-Sensitive Seeds).

Orthodox (i.e. desiccation tolerant) seed collections need to be dried as soon as possible after harvesting (Case study 7.1.5). This will minimise any deterioration of the seed due to aging. Any collections containing immature seeds must be ripened before drying, either under ambient conditions or in a ripening room (e.g. at 65% relative humidity and 20°C). Conditions of 15% relative humidity and 15°C are recommended for drying orthodox seeds. These conditions may be achieved in a purpose-built dry room with a sorption dryer and chilling facility, or using an incubator-dryer. Alternatively, drying can be carried out at ambient conditions using desiccants in a sealed environment. Seeds may take a few days or up to several weeks to dry, depending on the size of the seeds, the size of the collection, and other physical characteristics. Microscopic seeds (e.g. orchids) are dried for a maximum of one week. The MSB at RBG Kew has two drying rooms: one for receiving the collections on arrival prior to processing, and one located next to the cold rooms, for final drying prior to storage (Seed Bank Design: Seed Drying Rooms and Small-Scale Seed Drying Methods).

Extraction of seed of Aegle marmelos (Rutaceae), Tamil Nadu, India. (Images: Alexander Amirtham)

CASE STUDY 7.1.5

Seed banking at Cibodas Botanic Garden

Musyarofah Zuhri, Cibodas, West Java, Indonesia

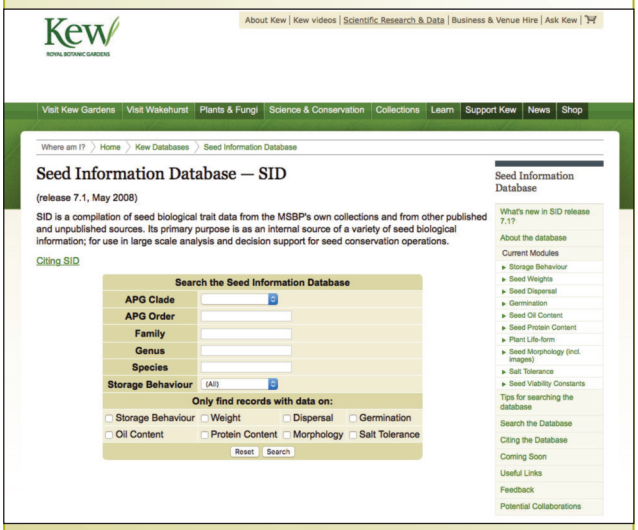
Cibodas Botanic Garden is situated in West Java, Indonesia and is a sister garden to Bogor Botanic Garden. Like many botanic gardens in tropical countries such as Indonesia there are several issues the garden needs to tackle when it comes to seed banking.

Currently the seed collecting programme is focused around seed collected from plant collections within the garden in order to fulfil the demand for seed that is required for propagation, seed exchange and material for research.

Like many other gardens that are starting seed banking programmes the future focus of the seedbank at Cibodas Botanic Garden is to collect and conserve seed of wild species. The Garden is situated next to Mt Gede Pangrango National Park, a tropical forest of Java and species within the National Park will be targeted for wild species seed collection.

Banking conservation collections requires different techniques and equipment from how Cibodas has been operating previously. The humidity in Indonesia can reach between 80-90%; these high levels mean that seed must be dried using desiccants or driers in order to bring the humidity of the seeds to levels where the seeds can be banked. Once dried the seed must be kept in hermetically sealed containers in order to keep moisture levels constant.

Another issue that affects tropical environments is that many species are recalcitrant and so cannot be dried and frozen like orthodox seed. The Seed Information Database http://data.kew.org/sid/ of the Royal Botanic Gardens, Kew has information on the storage behaviour of over 10,000 species and is a useful resource to determine which species are orthodox or likely to be based on related species.



The Seed Information Database of the Royal Botanic Gardens, Kew (data.kew.org/sid)

2.3 Collections are cleaned to remove empty, poorly-developed and insect-infested seeds and debris

Once a seed collection has been dried, it is processed in order to remove debris and reduce bulk, and to reduce the number of empty and poorly-developed seeds. The processing stage also increases the future utility of the seed collection. The seeds must be extracted from covering structures without causing damage. Much of this work is carried out by hand using sieves. An aspirator may be used for more uniform material, to winnow any debris and empty seeds from the heavier, filled seeds. The 'light fraction' is checked for the presence of good seed before it is discarded (Cleaning Seed Collections for Long-Term Conservation).

2.4 Purity is assessed by X-ray and/or cut test

X-ray analysis and/or cut tests (to look at the internal morphology of the seeds) are carried out on a small sub-sample of the main collection after seed processing. These tests provide important clues to the overall quality of the seed collections. The proportion of empty or partly-formed seeds and those that have been damaged by insects, can be determined. These seeds are recorded as 'incompetent'.

If incompetent seeds cannot be removed from the collection, the proportion of potentially healthy seeds is recorded to help interpret the results of subsequent germination tests. For example, if there are 50% incompetent seeds in a seed collection, yet 50% germinate, then 100% of the competent seeds have germinated. The number of seeds per collection must be estimated. This is done by weighing five samples of 50 seeds (or one sample of 250 for microscopic seeds) and weighing the remainder of the collection. The total quantity of seed is then calculated.

3. Storage and duplication

Seed collections are stored and duplicated according to the following guidelines:

3.1 Seed collections are banked as soon as possible after drying to equilibrium with 15% eRH ± 3% (cool/ambient temperature), and within 6 months of collection

After processing, the collections undergo a final drying stage at 15% relative humidity. When equilibrium with the dry conditions has been reached, the seed relative humidity is verified by non-destructive means, ideally using a hygrometer. Measuring Seed Moisture Status Using an Hygrometer and Low-Cost Monitors of Seed Moisture Status contain more details on determining seed moisture status using various methods. Microscopic seeds (e.g. orchids) should be banked within one week of drying.

Millennium Seed Bank of the Royal Botanic Gardens, Kew, Wakehurst, United Kingdom. (Image: Barney Wilczak)

3.2 Collections are held in air-tight (hermetic) containers
Once dried, seeds are packaged into air-tight containers of a range of sizes so that there is a minimal air space above the seeds. Containers may take the form of borosilicate glass jars with polypropylene lids or tri-laminate foil bags. Each batch of containers purchased by the seed bank should be tested for hermetic sealing properties under -20°C conditions. Silica gel indicator sachets (equilibrated to dry conditions) can be placed inside glass containers and periodically checked for colour change (indicating moisture ingress). Packaging of seed should take place under dry conditions. All collections are carefully labelled with moisture-proof labels (Selecting Containers for Long-Term Seed Storage).

It is advisable to divide collections into a 'base' collection that is infrequently accessed and an 'active' collection from which samples are taken periodically for viability testing and seed distribution. The base collections should be double packaged to reduce the risk of moisture ingress to an absolute minimum.

3.3 Collections are stored at -20°C ± 3°C
Containers are transferred to cold rooms or freezers for long-term storage at a temperature of -20°C (Seed Bank Design: Cold-Storage Rooms for Seed Storage). The longevity of the collection will depend on viability at the time of banking and on the species. Some seeds may live for only a few decades, others for centuries or millennia. As an extra precaution, small samples from collections of high conservation priority or from species expected to be short-lived may also be stored in liquid nitrogen vapour at approximately -196°C (Protocol for Comparative Seed Longevity Testing) (see also section on cryopreservation).

3.4 Collection size is monitored to ensure sufficient potentially viable seeds are available for effective management and distribution to users
When seeds are used for routine viability monitoring, for distribution and for in-house research, the seed number is re-calculated, taking account of the proportion of incompetent seeds determined during purity assessment.

3.5 Collections are duplicated at -20°C ± 3°C and 15% eRH ± 3% at a second, geographically-separate facility
It is advisable to have an agreement in place to store duplicate collections at another seed bank facility, under internationally agreed standard conditions for seed conservation. Collections sent to another facility must be accompanied by a Notification of Transfer, which provides a declaration that all material has been collected and transferred according to the terms of the duplication agreement. If the seed bank will be receiving material from across international borders, national plant health regulations must be adhered to for receipt of these collections.

4. Viability monitoring

The most reliable way to measure seed viability is through germination testing. Seed viability is monitored according to the following guidelines:

4.1 Initial viability is tested, preferably by germination test, and monitored at least every 10 years
Initial viability is assessed after at least one week of cold storage. Subsequently, collections are re-tested every ten years, or more frequently depending on their expected longevity. Seed containers for collections to be tested are removed from the cold store and allowed to equilibrate for 24 hours under dry conditions. The number of seeds used for testing depends on the range of treatments needed and the size of the seed collection. Normally 50 seeds are used per treatment, though for very small collections, as few as 20 or even 10 seeds may be used. Seeds are sown into Petri dishes containing 1% water agar and then incubated at an appropriate temperature. Information about the plant species such as its ecology and life cycle, as well as climate information, are used to predict the best conditions for germination and any pre-treatment that may be required to overcome seed dormancy.

Each germination test is checked once per week, and the germinated seeds are removed, recorded and discarded. The tests are checked in a clean air cabinet, to minimise the risk of inhalation of fungal spores produced by any mould on the seeds or agar. The test is ended when germination is no longer occurring. A cut test is used to determine whether the remaining seeds are full, empty or mouldy. Excessively mouldy but filled seeds are an indication that seed viability has declined.

4.2 Management decisions (including to regenerate or re-collect) are implemented if initial viability is below 85% and if/when collection quality drops to 85% of initial viability
The Millennium Seed Bank of the Royal Botanic Gardens, Kew has statistical tests built into the seed bank database which are used to check and re-test results when they are entered, to see if viability has declined since the last test. This information assists the management of collections by informing re-test intervals and by signalling that viability is approaching the viability standard (e.g. set at 85% of initial viability). Decisions about whether to undertake regeneration or to make a new collection are taken at this point. The presence of seed dormancy in wild species means that not all of the viable seeds will germinate in every test. A germination standard is set at a level lower than the viability standard (e.g. at 75%). Collections are awarded a 'pass' if the lower 95% binomial confidence interval on the germination percentage is above the viability standard.

Germination test results are 'accepted' if there is no statistical difference between the number of seeds that germinate and the number of germinated seeds as well as the number of fresh seeds remaining at the end of a test as determined by a 'cut test'. If the number of germinated seeds is significantly lower, further experiments are carried out to investigate dormancy, especially when the collection is rated as high priority.

See the International Rules for Seed Testing for annually updated, harmonised, uniform, seed testing methods.

5. Data management

Data are collected and collated at every stage of the seed conservation process, adding value to the collection and facilitating its use. The seed bank database should assist in collection management, meeting the needs of conservation and research programmes, and should enable data exchange with other seed banks. Statistics generated though the database will enable progress towards collecting targets to be monitored and are useful when planning future collecting expeditions.

A seed bank data management system can be organised into four main sections:

– **Donation and collection data**
This area contains information on legal agreements under which the collections have been made, the donor institute and collectors' names, site (including latitude, longitude and altitude), habitat data, plant identification and sampling data.

– **Processing data**
All results of procedures carried out on the seed collection are recorded through its processing life. The progress of a collection through the system can be tracked. Processing stages that yield key data include: X-ray analysis/cut testing, seed number determination, storage (date banked and location within bank for active and base portions), viability testing. Moisture status may also be recorded in this area. The database will include information on herbarium vouchers and glasshouse propagation data, as well as detail of duplicate collections stored at a second facility.

– **Seed distribution data**
The agreements under which seeds are held at the seed bank should be recorded in this area. A distribution policy is also included, recording what restrictions may apply to the future distribution of the seeds. Seed samples may be made available to third parties for bona fide research under a Material Supply or Material Transfer Agreement (Chapter 3, Section 3.6.1 and Chapter 4, Section 4.5.2), with the consent of the donor/landowner, and transactions are tracked through the database.

– **Taxon data**
This area includes accepted names for species and their synonyms, conservation ratings and inclusion within plant health and CITES legislation.

Although most of the seed collection data will not be accessible publicly, information on seed characteristics such as seed germination requirements and storage behaviour can be made available online.

6. Distribution

An advantage of the carefully stored, high quality seed bank collections is that samples can be distributed for use in research via an online seed list. Seed samples may be used by researchers in the sectors of food, agriculture, forestry, health and ecosystem restoration (Section 7.1.6), and in projects that will contribute to human innovation, adaptation and resilience in the face of current and future environmental challenges.

6.1 Collections are available for use [under an appropriate Material Supply Agreement], at least in-country where banked
The seed bank will establish conditions for seed sample requests that are made. Seeds may only be supplied to *bona fide* individuals that have registered on the seed list. Seed samples are sent out following receipt of a signed and legally binding Material Supply Agreement.

6.2 A distribution policy, with appropriate risk management for pests, diseases and potentially invasive species, is in place and applied
Seed samples are only supplied to individuals affiliated with organisations involved in non-commercial scientific research or conservation, as defined in the Material Supply Agreement. The agreement prohibits any commercial use of the material, progeny or derivatives. Users must avoid the spread of invasive plants and plant pests / pathogens and should check with their national authorities concerning import regulations, sending any necessary permits with their request (Chapter 6, Sections 6.4 and 6.8). Information on known invasive species that threaten biodiversity is available via the IUCN's Global Invasive Species Database. It is advisable that seed samples and the plants grown from them, are screened for diseases and kept in quarantine conditions, even where this is beyond the requirements of national authorities.

7. Seed bank risk management

The seed bank must carry out routine inspections and assessments to ensure that risks to the seed collections are adequately controlled. A purpose-built seed bank, combining good design, high build quality, robust mechanical/engineering systems managed by a building management system with associated alarms, trained staff and access control is recommended to safeguard the collections contained within.

A number of risks to the seed collections may be identified, relating to the physical destruction or integrity of the collections or may affect collection longevity (by increasing moisture or temperature). Collections are most secure when held in hermetically-sealing containers in cold storage. However, at any one time, collections may be at higher risk when present in dry rooms/containers, or in labs when being used for germination testing or research. A simple risk rating matrix can be devised to assess incidents affecting collections, according to Hazard Severity (from 'negligible impact on collections' to 'very high: majority of collections harmed') and Likelihood of Occurrence (from 'highly unlikely' to 'highly likely'). Incidents listed in a risk assessment strategy may include: fire; structural damage due to severe weather; mechanical failure to driers, chillers or alarms; power supply failure (incl. industrial unrest, bad weather); staff or contractor error; chemical leak/explosion; pest issues (rodents, insects); malicious behaviour (vandalism/terrorism); complete failure of IT infrastructure; severe weather; earthquakes. Mitigation systems and procedures then need to be established to deal with each type of incident.

For example, to mitigate against the possibility of fire incidents, a fire alarm system must be included in the building design, with regular testing and evacuation procedures in place. Seed bank managers should identify possible fire sources and arrange for regular, documented checks and servicing of all equipment that poses a risk. Duty scientists should be allocated from amongst the seed bank staff, so that any problems can be addressed as they happen (24hrs/7days) and trained fire wardens should be appointed.

• **Tissue culture and cryopreservation**

Where *ex situ* living collections or seed banks are not viable or desirable strategies, *in vitro* tissue culture and cryopreservation technologies represent alternative and complementary methods for the conservation of wild species (Panis and Lambardi, 2006). For instance, the botanic garden may not have enough land to establish a genetically representative collection, or the target species bear only short-lived, recalcitrant seeds that cannot be stored in a seed bank for their desiccation-sensitivity. Alternative *ex situ* conservation approaches may also be required for species that are sterile, and for plants that may not easily produce seeds, or produce seeds that are not readily available for collection. Such species that cannot be conserved in seed banks under standard protocols, are also often termed 'exceptional' (Pence, 2013; Wallace, 2015) (Case study 7.1.6).

CASE STUDY 7.1.6

Research and conservation of exceptional species

Sara Helm Wallace, Longwood Gardens, and Valerie Pence, Cincinnati Zoo & Botanical Garden

Exceptional species are those which are not suitable for conventional seed banking as they cannot withstand drying and/or cooling. According to preliminary results of a study led by Cincinnati Zoo & Botanical Garden focusing on threatened, exceptional species, there are over 400 tree species in the U.S.A. and Canada that are threatened, at least 80 of which have so far been identified to be exceptional.

One iconic group in this category is the genus *Quercus*, and alternative methods are being explored to accomplish the efficient *ex situ* conservation of endangered oaks. These include cryopreserving embryo axes, which can be isolated from seeds, then dried, and frozen in liquid nitrogen, or, alternatively, initiating *in vitro* cultures and cryopreserving the shoot tips or somatic embryos from those cultures.

The success of these procedures will depend on adapting them to the needs of individual oak species. Recent work with several endangered North American oaks, including *Quercus georgiana* (Endangered), and *Q. boyntonii* (Critically Endangered), has resulted in *in vitro* propagation protocols that can serve as a source of tissue for cryopreservation. Future work is needed to identify and adapt the most appropriate approaches for each endangered oak species. While these methods are more resource intensive than seed banking, they offer a viable option for the long-term *ex situ* conservation of these exceptional species.

In vitro propagation of Quercus georgiana, an endangered, exceptional species. (Image: Valerie Pence)

The tissue-cultured plants should be maintained under aseptic conditions (pathogen and pest-free), which facilitates the multiplication and distribution of plant material to other institutions. *In vitro* cultures serve also as a source of explants for the cryopreservation (see below). Removal of infected material and monitoring of the cultures is essential to avoid contamination of the *in vitro* collections.

Slow growth techniques for medium-term storage of the plant genetic resources *in vitro*, can be achieved by modifying various parameters, such as temperature, light regimen, culture medium and the gaseous environment. However, each step in the process of establishing *in vitro* cultures requires precise conditions which have to be defined for each species and type of plant material.

While the costs for the establishment of these methods are comparatively high, they may offer a needed alternative for species of urgent conservation concern. The multiplication rate of a culture, as well as the rates of rooting and acclimation, will have a major bearing on the number of transfers needed for producing plants via tissue culture; improvements in efficiency of these steps will help lower the costs. Further research into factors affecting the growth of tissues *in vitro* is required. Equally, greater coordination efforts among institutions with such facilities are needed to successfully secure highly threatened species via tissue culture and/or cryopreservation for which other viable *ex situ* conservation strategies are not available immediately.

If long-term conservation is required, cryopreservation, i.e. storage in liquid nitrogen at -196°C, is the main method currently available for vegetatively propagated plants (Sakai and Engelmann, 2007; Benson 2008). As with tissue culture, cryopreservation methods may be restrained by the initial costs, particularly to establish multiple genotypes of many species in the collection.

Cryopreservation facilities at The Huntington Botanical Gardens. (Images: Raquel Folgado Casado)

While techniques are evolving rapidly, the reaction of different culture systems when exposed to ultralow temperatures needs to be further researched to realise the full potential of cryopreservation as a tool for conservation. Therefore, sharing the resources for research among botanic gardens and other institutions working on these techniques may help to rapidly generate standard protocols for species of interest. During cryopreservation, cell division, metabolic and biochemical processes are arrested and thus the plant material can be stored without deterioration or modification (Shibli *et al*., 2004). Hence, germplasm can be kept theoretically for an indefinite time using little space. Work input is needed mainly at the start of the process when samples are prepared and cooled down, while the costs of maintaining a collection are dramatically reduced over time. Once in storage, only refilling of liquid nitrogen is needed. Other advantages are prevention of infections and genetic changes. Further, the degree of cleanliness (free of pathogens like viruses) is the highest priority for this type of *ex situ* conservation.

Appropriate tissue culture conditions are crucial in all the steps before and after the storage in liquid nitrogen (Case study 7.1.7). The acclimation of the explants used in cryopreservation (the response of some plants to abiotic contraints helps them to better respond to cryopreservation) as well as the establishment of conducive regrowth conditions are two of the most important aspects for which protocols need to be developed.

CASE STUDY 7.1.7

In vitro repository of magnolias at The Huntington Botanical Gardens

Raquel Folgado Casado, The Huntington, California

The Huntington Botanical Gardens are developing *in vitro* repositories for different groups of plants of priority conservation concern. The strategy to establish these repositories comprises all major steps, from collecting plant material in the wild through to rooting and acclimation prior to returning the plants to *ex vitro* conditions.

Tissue cultures facilitate the generation and access to sizable amounts of plant material. The *in vitro* repository is being managed under regular-growth conditions for immediate availability of plant material, and slow-growth conditions for middle term conservation. For long-term conservation, cryopreservation protocols are being developed. Key challenges for the establishment of micropropagated plants are the state and stage of the individual, environmental conditions and different levels of contamination and oxidation.

Magnoliaceae is one of the key families for which The Huntington Botanical Gardens are developing *ex situ* conservation approaches. While magnolias can generally be propagated via seed, grafting and rooting stems, these methods are not always highly efficient to obtain large amounts of disease-free plants. Besides, a number of species appear to generate recalcitrant seeds. Therefore, The Huntington Botanical Gardens are also establishing propagation protocols using tissue culture and cryopreservation.

Experiments with shoot tips from *in vitro* cultivated plants of *Magnolia macrophylla* var. *ashei* have been carried out. Dissected shot tips are cryopreserved using the droplet vitrification technique with a solution that contains a cryoprotectant. This allows the explants to tolerate the exposure to liquid nitrogen. However, the optimal length of the treatment requires further testing. After the rewarming of the shoot tips, various parameters need to be evaluated including survival rates, shoot tip regrowth and plant recovery. Based on the observations of how the explants are developing (oxidation, callus formation, hyperhydricity, etc.), the protocols can be further amended until whole plants are successfully recovered.

In vitro plants of M. macrophylla var. ashei during initiation and multiplication stages. (Images: Raquel Folgado)

Apical tip of M. macrophylla var. ashei after rewarming following cryopreservation. (Image: Raquel Folgado)

• Pollen and spore banks

Like seeds, pollen and spores can be divided into desiccation tolerant and intolerant. Pollen and spore banks may present additional means to preserve plant genetic material. In some taxa it is possible to raise entire plants as haploids from pollen grains. While pollen and spore banks require little space, long-term storage requires freeze- and vacuum drying. Both, pollen and spores may be used like explants for cryopreservation (see above) following the development of protocols to store them at low temperatures. While cytoplasmic genes may be lost in the process, pollen and spores are easier to bank than other plant tissue types, as they are more homogeneous.

• DNA banks

The creation of DNA banks allows large quantities of genetic resources – genes – to be stored quickly and in very stable conditions. For example the DNA Bank of the Royal Botanic Gardens Kew contains approximately 50,000 samples of plant genomic DNA (as of early 2015), all stored at -80°C. While DNA banks cannot replace conventional *ex situ* conservation approaches (Ebert *et al*., 2006), DNA samples present convenient experimental materials that can be shipped easily and used immediately for further molecular research, bioprospecting, phylogenetic studies, etc. Use of DNA samples in conservation is limited as whole plants cannot be reconstituted, but the genetic material can be introduced to other genotypes for plant breeding purposes.

DNA banking facility and molecular lab at The Huntington Botanical Gardens. (Images: Brian Dorsey)

7.1.5 *Ex Situ* Non-Living Collections

- **Herbaria**

A large variety of resources are available which deal with the set-up, arrangement and management of a herbarium. The Herbarium Handbook (Bridson and Forman, 2004) is the most comprehensive reference available for anyone wishing to create and maintain a herbarium. This section aims at providing an overview of the key aspects of herbaria and highlights their value of integration with other botanic garden collections.

KEY MESSAGE

Herbaria are vital repositories of plant information and should be integrated with other *ex situ* collections towards a comprehensive understanding of the species' biology and conservation needs.

1. Definition and purpose of a herbarium

A herbarium (plural: herbaria) is a collection of dried voucher specimens which are mounted on paper along with collection information to act as a preserved and lasting record. Vouchers can be created from wild plants or living collection accessions.

A herbarium is better than any illustration; every botanist should make one. Carolus Linnaeus (1751)

Herbarium specimens and their associated collection data (Chapter 3, Section 3.5) provide a wealth of knowledge on plant species and the environment that they inhabit. This information is mainly used for identification, research and teaching. Uses of herbarium specimens include the following:

Taxonomist at the Herbarium of the Royal Botanic Gardens, Kew. (Image: Board of Trustees of the Royal Botanic Gardens, Kew)

- Herbarium vouchers act as a reference library of taxa to be used for identification purposes.
- The specimen acts as a voucher for seed or living plant collections and will allow for accurate identification and naming.
- Specimens are essential for systematic research e.g. specific families (Fabaceae, Rubiaceae and Sapotaceae) or floristic work (Flora of China, Flora of Tropical East Africa and Flora Europaea).
- If a species has not yet been described reference to herbarium specimens allows a taxonomist to confirm species new to science.
- Collection information provides useful information on flowering and fruiting time which can be useful for phenological studies or to time seed collection activities (Haggerty *et al*., 2012).
- Collection information provides habitat and distribution data for each species.
- Herbarium specimens can be used to determine the conservation status of a species (Rivers *et al*., 2011).
- Extraction of DNA for use in DNA barcoding to help identify species and in conservation genetics (Särkinen *et al*., 2012).

A list of additional uses of herbarium specimens can be found in 100 Uses for an Herbarium (Well at least 72). Funk, V. (2003).

2. Setting up a new herbarium

Before starting a new herbarium it is important to determine the infrastructure, equipment and supplies that will be needed. It is essential to think about the long-term use of the buildings and the collection over time. The herbarium at the Royal Botanic Gardens, Kew has to constantly expand and adds a new wing every 40 years or so to keep up with the growing collection. Herbarium Essentials by Victor *et al*. (2004) provides a very useful section on 'Starting a new Herbarium' which covers these points in detail.

– Herbarium types

Herbaria can be categorised as global, national or regional depending on the geographic representation of the specimens they house:

Global: The Herbarium of the Conservatoire et Jardin botaniques Genève in Switzerland has around 6 million specimens from across the globe with a specific emphasis on collections from the Mediterranean, the Near- and Middle East, South America and Europe.

National: The Herbarium of the Institut de recherche pour le développement, Nouméa, New Caledonia, was founded in 1963. All the specimens are from the Pacific region with 90% from New Caledonia.

Regional (sub-national): Chicago Botanic Garden's Nancy Poole Rich Herbarium, United States is home to 12,000 specimens. The majority were collected in the Cook Country and the Upper Midwest.

The Index Herbariorum is a global directory of public herbaria and associated staff (Thiers, continuously updated). The directory holds information on the location, contents and the history of collections. Information is also provided on the web address, contact information and areas of specialism of staff for each institution.

– Collection types

The majority of specimens within a herbarium will be voucher specimens, however it is useful to keep a variety of other collections in herbaria including carpological, wood, fossil and spirit collections, as well as illustrations, photos and slides. Illustrations and photos are usually stored with the associated herbarium specimens as they can be kept flat. Other collections are stored separately and require specific storage requirements. Spirit collections, where plant parts are stored in an alcoholic solution to preserve their 3D structure, allow for detailed features of flowers and fruits to be preserved that would be lost during the creation of the herbarium specimen. Collections that are not stored with the main herbarium collection should be linked in some way to the main collection.

– Herbarium specimen sources

Herbarium specimen material can come from a wide variety of sources. Before collecting or accepting specimens it is important to make sure that the correct agreements and collecting permits are in place based on global policy agreements.

Collections: Collections made by staff or students within the institution, usually monographic or floristic specimens. These can be taken from wild or cultivated material.

Exchange: Several collections can be made from an individual plant or population. Duplicate specimens can then be created and exchanged between herbaria. Many herbaria do this to broaden their collection to include regions that they do not focus on for collecting trips.

Gifts and purchases: Could be a whole herbarium or a few specimens from staff at institutions with no herbarium.

Loans: Specimens of interest can be requested from other institutions. Specimens are usually requested for research purposes.

Identification service: Specimens sent to herbaria for identification are usually kept at the institution. Most botanic gardens that provide a plant identification service have a policy for dealing with identification. For instance, the South African Biodiversity Institute (SANBI) maintains a plant identification service aiming to provide clients with the necessary up-to-date information required for research and conservation of South Africa's botanical diversity.

3. Collecting, preparing and mounting herbarium specimens

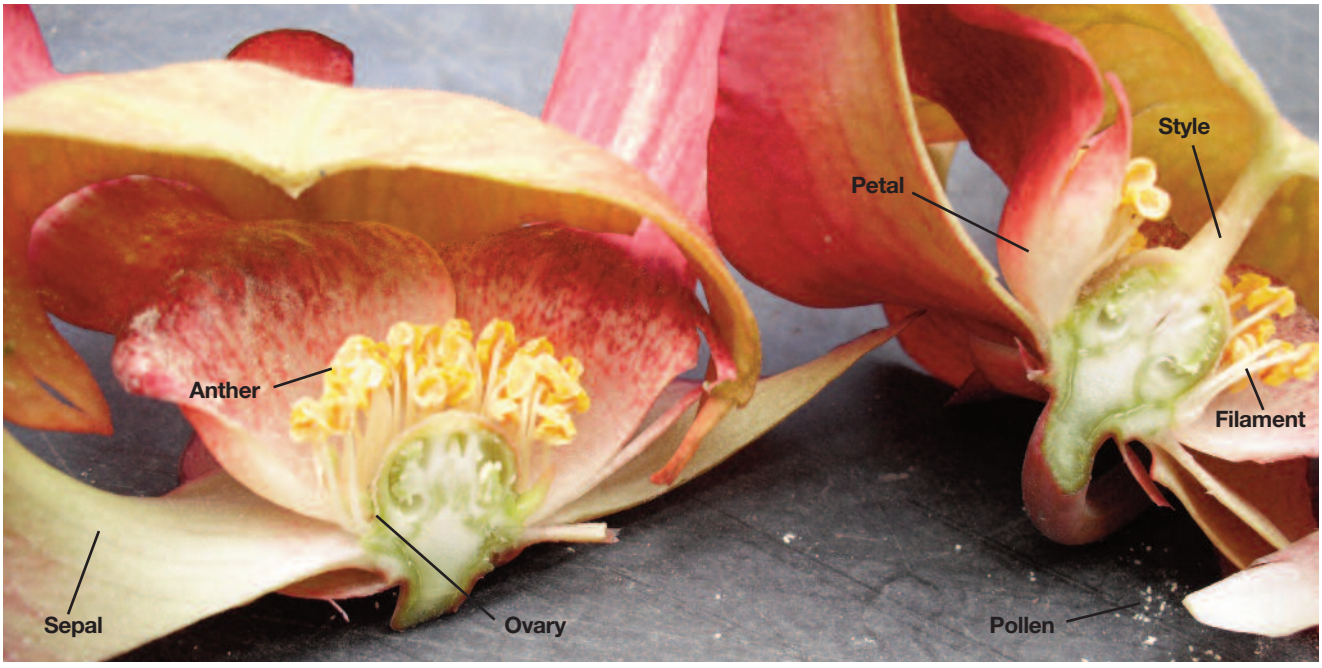
Herbarium specimens are collected in the wild or in cultivation, dried and then mounted onto sheets of paper. The sheets are then filed in folders and laid away in cabinets. The scientific value of a herbarium specimen is determined by the quality of the specimen and the associated collection data. In order to have good collections it is important to carry out the following steps to a high standard.

– Collecting

Collection information for herbarium specimens, as with living collections field data, is essential if the specimen is to represent any scientific value. This collection information must be linked with the herbarium specimen throughout the processing of the specimen so that passport information can be related to the specimen.

It is important when making herbarium specimens that attention is paid to capturing the diagnostic features which are representative of the taxa such as fruit, flowers, stems, leaves, roots and tubers. This will allow for easier identification of the specimen and provide a useful reference material for verification of other specimens. Different families have different diagnostic features and so require different plant parts to be collected. The family Apiaceae for example requires presence of ripe fruits in order to distinguish between genera and species. Ranunculaceae requires underground parts and fruits to be collected whereas for Eriocaulaceae different stages of inflorescence should be sampled. The Herbarium Handbook has an extensive list of families of flowering plants with a short note on the features which are important for identification and should be referred to when collecting.

It is recommended that when possible, identification of the specimen should take place in the field in order to determine what parts are essential for identification. It is useful to take several examples of key features such as flowers in order to be able to show both internal and external structures.



Capturing diagnostic features in the field. (Image: Garance Wood-Moulin)

In order to capture the phenotypic diversity of a species it is useful to make several specimens for a single taxon at each of the different stages of life history. This is one of the main advantages of holding herbarium specimens of living collections as taking multiple collections at different life stages is relatively easy to do.

– Preparing

A plant press should be used to dry herbarium specimens as soon as possible after collection in the field. Specimens should be laid flat and attention should be paid to making sure that all diagnostic features will be represented in the dried specimen, including the underside of leaves. Specimens should be placed inside absorbent paper such as newspaper and cardboard (with corrugated aluminium sheets), and pressed. If a press is not available heavy objects such as books should work. Drying can be achieved by leaving the plant press in the sun or by placing it in a dry room or oven.

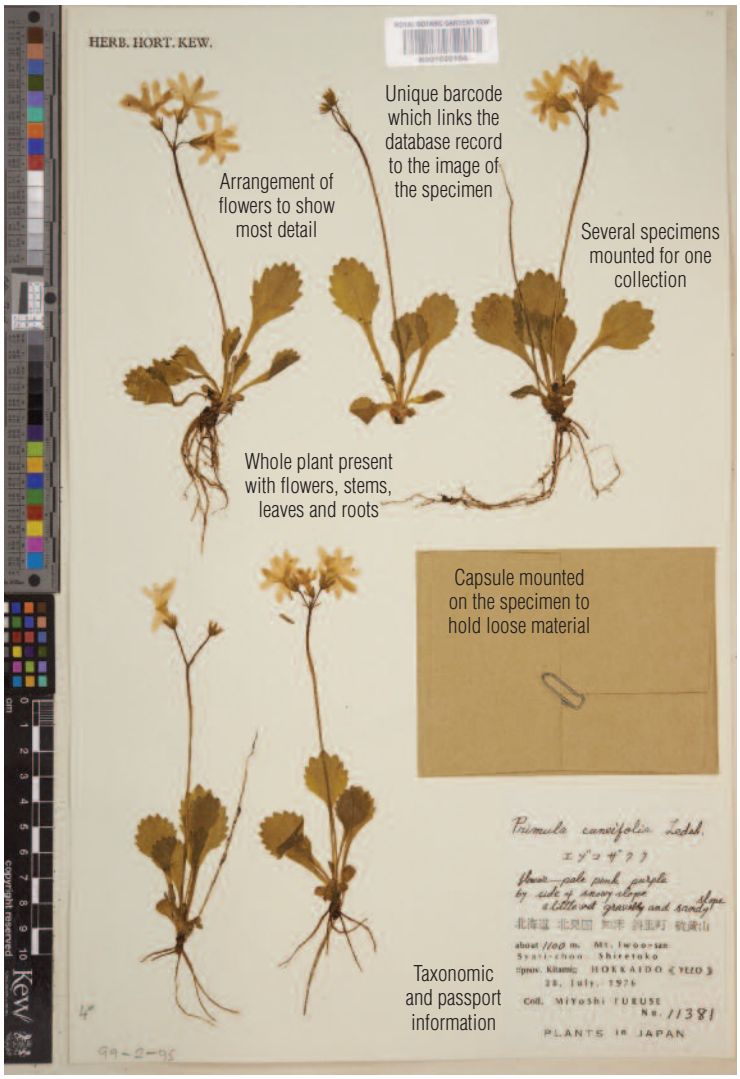
Herbarium preparation. (Images: Missouri Botanical Garden, top; Zhou Yuan, above)

Dried specimens lose a lot of the characteristics of the living plant. It is worth making notes of features such as flower colour, smell and waxes which are present in the living plant and will be lost on drying. This information along with all other passport data of the specimen should be associated with the plant material in some way. This can be done by giving the collection a unique collection number. This collection number can be attached to the specimen using jeweller's tags and should be associated with the passport data. The specimen and passport data can then be reunited when mounting the specimen.

– Mounting

Once the specimen is dried it is glued to archive paper or sewn if more bulky. The information from the passport data form (Chapter 3, Section 3.5) is used to make a label for the herbarium specimen; this is then glued to the specimen sheet.

It is important to think about the longevity of the collection when mounting. Archival quality paper (acid free) and pH neutral glue should be used for mounting specimens to ensure that the collections last. Loose material such as fruits or seed should be placed in a capsule which can then also be glued to the sheet. Any loose leaf material should be placed in this capsule to make it available for DNA extraction.



Information components on mounted herbarium specimen. (Image: The Board of Trustees of the RBG, Kew)

– 'Difficult' species

Certain specimens are difficult to collect, press or mount. In order to avoid having collections that are bias towards taxa which are easy to collect and preserve, it is important to be aware of the problem plant groups and to know how to deal with these. Specialist equipment and knowledge is required for collection of these groups:

Collecting: Trees are more difficult to collect from than small herbaceous species. For collecting specimens from trees it is useful to have a hard hat, tree loppers, ladder and binoculars. The family of Urticaceae has stinging hairs and *Mucuna* (a genus in the family Fabaceae) has irritant hairs. Gloves should be worn when collecting from these species.

Pressing: Succulents are too wet to dry using standard methods. For Aloes and Agaves the flesh should be sliced and the gel removed before drying. Cacti can be sliced thinly as this will aid drying, but the internal succulent tissues need to be largely removed using a scalpel.

Mounting: Bulky specimens such as palms are usually mounted onto oversized sheets or stored in boxes. Aquatic plants generally lose their structure when out of the water and so need to be mounted when submerged in water and then pressed.

4. Nomenclature – the importance of names

Botanical nomenclature is the system of naming plants. Names are essential for the communication of information about the taxon. The International Code of Nomenclature for algae, fungi, and plants (ICN) (McNeill *et al*., 2012) governs botanical nomenclature. The basic rules for a correct plant name are that it is legitimate and validly published.

– Identification and determination

Within herbaria taxonomists identify voucher specimens based on dichotomous keys, species descriptions or by comparison with other herbarium specimens. When a herbarium specimen has been identified a determination slip is added to the specimen with the determination date and determiner name added. Specimens can then be re-determined if the specimen is subsequently re-identified or a taxonomic revision is made.

– Nomenclatural type

When a new species is described the type specimen is the voucher or illustration associated with the species description and the taxon name. Whichever specimen was used to create the description for a new species is therefore the nomenclatural type. The specimen is a voucher for the plant name. There are various different categories of types. See the ICN for more information.

– Nomenclatural standard

A nomenclatural standard differs from the type specimen in that the specimen or illustration is the voucher for a cultivar name. The Royal Horticultural Society in the United Kingdom has an extensive collection of nomenclatural standards within their herbarium as they specialise in plants of garden value.

5. Curation of specimens

It is important to determine the arrangement of the specimens within the herbarium. The arrangement of the herbarium will depend on the type of collections and their expected use. Irrespective of the arrangement chosen, the specimens should be easy to find and lay away. The three main types of herbarium specimen arrangement are systematic, alphabetic and geographic. Most herbaria use a combination of systems to curate their collections (Case study 7.1.8). The advantages and disadvantages of these systems are discussed in detail in The Herbarium Handbook (Bridson and Forman, 2004).

– Systematic

There is a variety of systematic arrangements which are used to curate herbarium specimens. This involves the ordering of plants based on their relationship. Within the last few years many herbaria have arranged or rearranged their herbaria to follow the evolutionary classification of the Angiosperm Phylogeny Group (APG) system which was published in 2009. This results in genetically related families being grouped together so that for instance Fabaceae is next to Rosaceae and Dicksoniaceae is far away from Caprifoliaceae. Systematic arrangement at the genus, species and infraspecific level will depend on availability of APG revisions (presently APG IV, 2016).

– Alphabetic

Arranging the herbarium alphabetically involves arrangement of families, genera, and then species. For example:

Family	Acanthaceae Juss.
Genus	*Acanthopale* C.B.Clarke
Species	*Acanthopale aethiogermanica* Ensermu
	Acanthopale albosetulosa C.B.Clarke
	Acanthopale azaleoides C.B.Clarke
through to	Zygophyllaceae R.Br.

With collections that are ordered alphabetically it may be beneficial to keep major plant groups such as monocots and eudicots in separate collections.

– Geographic

Herbaria generally incorporate a level of geographic arrangement to their collections. This arrangement will depend on the areas of the world the collection is from. In global herbaria, the globe is often split into regions related to where the bulk of specimens are from. It is unlikely that specimens within national or regional herbaria will benefit from this type of curation.

– Cultivated

Cultivated and wild collected specimens are usually kept separately (Chapter 3, Section 3.5.5).

CASE STUDY 7.1.8

Herbarium arrangement at the Natural History Museum, London, United Kingdom

Jacek Wajer, Natural History Museum, London, United Kingdom

The Natural History Museum (NHM) in London has one of the largest herbarium collections in the world, containing over 5.2 million specimens. The collection is divided into four major curatorial units based on the phylogenetic position, geography and historical significance of stored material. These four sections are known as the Cryptogamic, Seed Plants, British and Historical herbaria. Arrangement of the specimens within each collection is either systematic or alphabetical depending on their intended use and available literature.

Seed plant collections

The Seed Plants Herbarium is arranged according to the latest Angiosperm Phylogeny Group (APG) system of flowering plants classification. The families recognised in this system have been given numbers 1-413 and are organized accordingly. Some 100 additional families which are not accepted by APG but represented in the herbarium are filed adjacent to the family to which all, or the majority, of genera would eventually belong. An index of the families and the genera recognized in this system is available in the herbarium to aid the location of relevant specimens. The genera within most families are arranged systematically in a sequence based on the latest available monographic treatment, with any new genera being added in alphabetical order at the end of this arrangement. In some families (e.g. Solanaceae) all of the genera are arranged in alphabetical order only. Within each genus, specimens are divided first into geographical regions, based on their collecting locality, and then sorted into species within each region. The herbarium is divided in 26 geographical regions, with cultivated specimens stored at the beginning of the sequence. Maps explaining this arrangement are available throughout the collection. Species are usually arranged systematically within each geographical region and there is often an additional alphabetical run of new species at the end of the systematic sequence. An index to the species is usually found in the first folder of each genus, unless each geographical region has its own arrangement in which case the index will be located in the first folder of each geographical section.

Cryptogamic collections

The cryptogamic collections contains the Fern, Algae, Bryophytes, Lichens and Diatoms. The Fern Collection is split geographically between British collections and the rest of the world. The British collections are arranged following a sequence of genera and species compiled in 1980 by Clive Jermy, and in vice-county order within each species. The non-British specimens are arranged according to *A new generic sequence for the pteridophyte herbarium* published in 1975 by J.A. Crabbe, A.C. Jermy and J.T. Mickel (Fern Gazette 11: 141-162). Each genus is arranged geographically, and species are curated either systematically or alphabetically.

Historic collections

Specimens of historical importance dating back to the mid-17th century, like those collected or owned by the founder of the museum's collection Sir Hans Sloane are stored separately for conservation and security reasons. They are arranged thematically rather than systematically in 265 bound volumes. Each volume contains a mix of specimens collected either by a particular botanist (e.g. Sloane, Kaempfer, Petiver, etc.) or from a specific place (e.g. Europe or Chelsea Physic Garden, etc.). A guide to this collection was published in 1956 and can be consulted to find most of the specimens.

Examining specimens in the herbarium of the botanic garden of Curitiba, Brazil. (Image: Michael Willian)

6. Cataloguing collections

The herbarium catalogue is a directory of the filed-under names of specimens within a collection. Cataloguing allows for a summary of what is in the collection to be easily accessible and queried without the need to refer to the collection itself. In addition a catalogue represents a backup which is useful when collections are misplaced or go missing.

Collections can be either catalogued electronically or on paper. Paper indexes are usually stored in the collection, for example an index to the Brazilian species in the genus *Bauhinia* is likely to be stored with the specimens and can be referred to in order to allow users to easily determine whether taxa of interest are present and if so where to find them.

Electronically cataloguing the specimens within the herbarium allows for a register of collections to be available and easily searchable. One advantage of electronic cataloguing is indexes such as the one above can be produced easily by querying the database. Additional information such as presence of a spirit collection can be linked to the specimen within the electronic catalogue.

– Integration of herbarium collections with other collections

As previously highlighted recording and managing botanical data are important in order for collections to be effectively managed as well as to ensure that they provide education, research or conservation value. Herbarium specimens can act as vouchers for other collections within a botanic garden including living, seed, DNA or spirit collections (Case study 7.1.9). When the name of the voucher specimen is changed, either when re-determined or if a new combination is created, it is important for the linked collections information to reflect this. If this does not happen then management of the collections is impossible as there will be two names associated with a single taxon. Integrating separate collections is an issue for many existing herbaria, while new ones should implement an integrated approach from the outset.

CASE STUDY 7.1.9

Linking living collections to herbarium specimens

Alison Foster, University of Oxford Botanic Garden

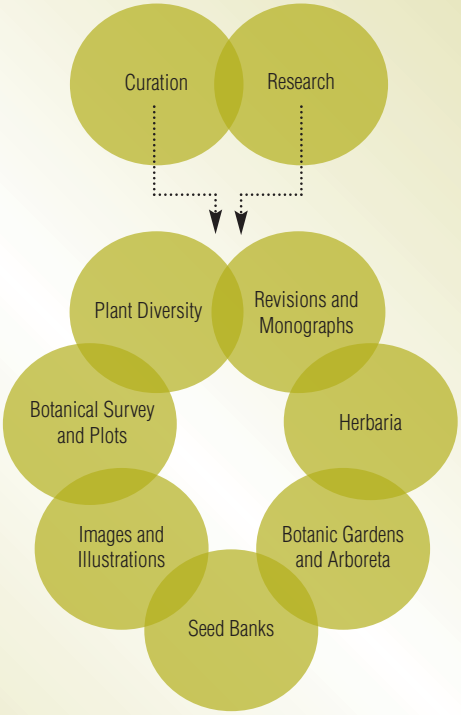
Like other botanic gardens and arboreta, the University of Oxford Botanic Garden and Harcourt Arboretum maintain detailed records about all their plants. It is vital that these records are kept up-to-date and easily accessible to those looking after the collection. The Botanic Garden at Oxford has kept records in some form or another since it began, including a catalogue listing all plants at the Garden, published in 1648.

As computers became common in the workplace, the record-keeping system moved to an electronic format. The first such system, in 1986, used a simple database filing system. In the mid-1990s, the records were moved to BG-BASE, software developed at the Royal Botanic Garden Edinburgh.

Over the past few years, as Oxford Botanic Garden has worked ever more closely with the Oxford University Herbaria (FHO and OXF), it seemed sensible to investigate whether the Garden and the Oxford Herbaria could use compatible data-management systems, allowing much closer integration of herbaria and living collection data; a key part of our future strategy. The Oxford University Herbaria use BRAHMS (Botanical Research and Herbarium Management System) to document their collections. The developer of this database (Denis Filer) is based in Plant Sciences in Oxford and had been working with Gerda van Uffelen at Leiden Botanic Garden to develop a new Living Collections module for BRAHMS, so it seemed a natural choice to make the move to BRAHMS to facilitate this integration. In early 2011, they began to transfer data from BG-BASE to the BRAHMS Living Collections module; by mid-2011, BRAHMS was up and running at Oxford Botanic Garden. Since then, they have been actively using and developing the module, suggesting new functions as they go. In February 2012, they started running over terminal services and now they can access the database from different locations using both Mac and PC workstations.

This integration of the herbarium and living collections allows the gardens to work closely with the herbarium. A recent project relating to the Japan Biodiversity Hotspot aims to collect seed and document the indigenous plants of Japan. Sharing the same database set up has allowed for all the information gathered in the field (vouchers, rapid botanical survey data, seed, etc.) to be shared effectively between the Herbarium and the Garden and Arboretum.

Moreover, the gardens are working through their living collections to enrich their plant records database by adding images of their collections as well as making herbarium vouchers. By ensuring that they are using the same protocol in both departments, maximum data sharing in the longer term will be ensured.



Integration of living collections and herbaria management at the University of Oxford Botanic Garden.

Herbarium of Jawaharlal Nehru Tropical Botanic Garden and Research Institute, India. (Image: Katherine O'Donnell)

Key reasons for integration of collections' information:

- Creates a link between science and horticulture;
- Avoids duplication of effort in recording data;
- Allows for associated data to be linked to the herbarium collections;
- Allows for one central system to be updated rather than multiple systems.

Various data record systems are available which have been designed specifically to manage the different types of collection information that a botanic garden can hold (Chapter 5, Section 5.5.2). The decision on which management system to use will depend on the specific collections of the institution and their needs.

7. Virtual herbaria

Many herbaria are now involved in the digitisation of their specimens (Case study 7.1.10). This consists of creating a database record of the passport information of a specimen and linking it to a high resolution image of the specimen. Virtual herbaria can then be created online to increase the accessibility of collections. The appeal of online collections is that information that is currently stored in cupboards and therefore inaccessible to researchers, unless they make visits or request loans, is made available.

The majority of custom-built botanic garden databases use the passport information associated with a specimen to create the herbarium labels. When this information is already in the database there is no need to database the record. It is still important to link the passport information to the herbarium specimen via a unique identifier such as a barcode or accession number.

Several countries including the United States, Japan and Australia are working towards a virtual herbarium of all the specimens from each herbarium within their respective countries. These data can then be searched, mapped and analysed and provide a powerful botanical data tool for research purposes (Case study 7.1.11).

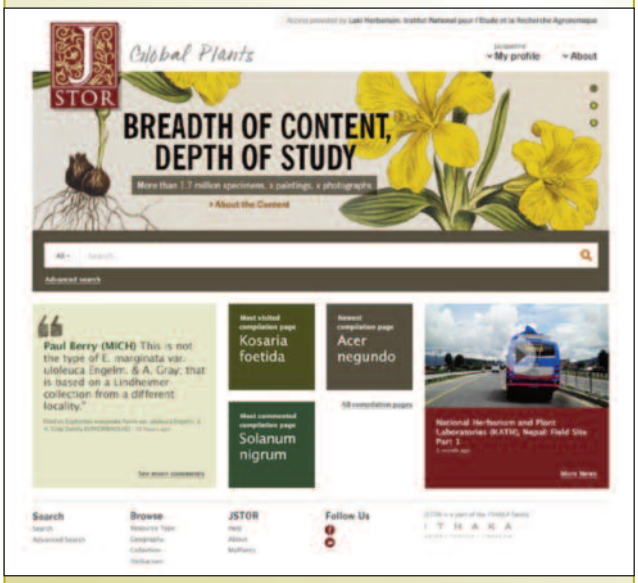
CASE STUDY 7.1.10

JSTOR Global Plants Initiative

Katherine O'Donnell, Botanic Gardens Conservation International

Funded by the Andrew W. Mellon Foundation, the JSTOR Global Plants Initiative is an international collaboration aiming to increase the accessibility of type specimens by building a comprehensive online research tool. By pulling together and linking presently scattered resources about types and other complimentary material the goal is to improve access for students, scholars, and scientists around the world. The founding partners include the Missouri Botanical Garden; Muséum National d'Histoire Naturelle, Paris; National Herbarium, Addis Ababa University; New York Botanical Garden; Royal Botanic Garden, Kew; and South African National Biodiversity Institute.

The website plants.jstor.org is a growing repository of over two million type specimens which have been made available by a community of partner herbaria around the world. Images of type specimens and their associated passport data are made available through the website. There are over 160,000 linked reference words and 20,000 drawings, paintings, photographs and other images. Features on the website include the ability to discuss and have corrected questionable determinations and specimen information. The images are high resolution to allow for detailed work online. Tools allow for specimen parts to be measured and saved. Taxonomists can update specimen determinations and carry out revision work online without having to visit the herbaria that the specimen is from.



Screenshot of the JSTOR web portal.

CASE STUDY 7.1.11

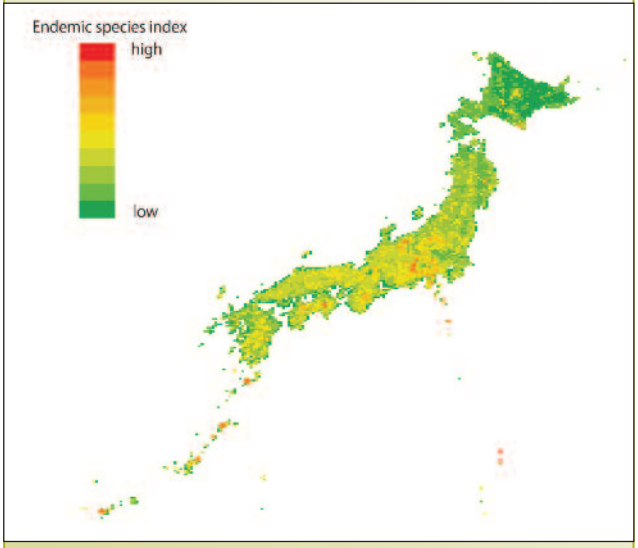
Making a map of endemic plants of Japan, using S-Net collections as well as specimens from local herbaria and museums

Tomoko Fukuda, National Museum of Nature and Science, Tokyo, Japan

While information on Japanese endemic species is available in the literature, knowledge of the occurrence and distributions of each taxon is limited. To address this gap, the National Museum of Nature and Science (NMNS) in Japan developed a map of endemic Japanese plants based on herbarium and related database records. Details of the results are provided in Kato and Ebihara (2011).

In addition to 123,061 herbarium samples deposited at the NMNS, information from other museums and institutions was collected. The S-Net (Science Museum Net) database containing specimen data from every organization in Japan was also used. This is a database of Japanese voucher specimens with associated collection and location information, including some four million data records. This information is also provided to the Global Biodiversity Information Facility. In some cases of endemic species, the herbarium materials at every museum were directly studied. As a result, 212,017 specimens of endemic plants from more than 30 organizations were used to create the map.

The *Map of Endemic plants of Japan* (Kato and Ebihara, 2011) shows the distribution of related taxa to be found concentrated in islands with mountains and in high mountains in mainland Japan. Most of these localities are already under protection as they are included in national parks, except for some that should be protected in the future. The map also highlights the most important localities for conservation of endemic plants. In conclusion, the herbarium samples and the related database records have contributed to identifying these areas.



Map of endemic plants of Japan (Kato and Ebihara, 2011).

7.1.6 *Ex Situ* Collections Serving *In Situ* Conservation

As highlighted in section 7.1.1 onwards, *ex situ* conservation provides an 'emergency ward' aimed at extinction-proofing and 'buying time' for species of urgent conservation concern. While *ex situ* collections of threatened plants therefore provide a long-term 'insurance policy' against irrecoverable loss, they are also a source of native germplasm for recovery programmes in the wild. Plant material from *ex situ* collections can be used to reinforce declining and degraded plant populations, or for reintroduction where a species or populations thereof have entirely disappeared. *Ex situ* collections of wild plants also present an essential reserve for small- to large-scale ecological restoration programmes. In the same vein, in times of rapid climate change and transforming ecosystems, botanic gardens may also hold plant material of species that likely require translocation and introduction to climatically more suitable habitats, which will lead to new species combinations that have not occurred before. These features underscore the key roles that botanic gardens play in integrated *ex* and *in situ* conservation in the twenty first century (Figure 7.1.1).

KEY MESSAGE

Botanic gardens are increasingly embracing and promoting an integrated approach to conservation. Appreciating the wide range of *in* and *ex situ* conservation measures as complementary efforts, botanic gardens are at the forefront to guide, support and implement innovative strategies aimed at securing plant diversity for future generations.

A wealth of technical resources and practical tools exist that inform and guide the development and implementation of *in situ* conservation and recovery measures as referenced in section 7.1.7. Rather than replicating these resources, this section aims to illustrate through a series of resonant case studies the vital contributions by botanic gardens to *in situ* conservation and recovery efforts. While numerous terms at various levels of complexity for different recovery approaches are in use in the conservation community, this section employs 1) population reinforcement, 2) population reintroduction, 3) ecological restoration and 4) population introduction to exemplify this work.

- **Population reinforcement**

Population reinforcement aims to assist the recovery of declining or degraded populations of species and enhance their viability that without intervention would not regenerate. For instance, this could be due to restricted seed dispersal abilities and the absence of a sufficient natural stock of seed in the soil following fragmentation of the population as a result of a natural hazard or human activity. The aim is to enlarge the effective size of remaining populations by increasing genetic diversity or representation of specific demographic groups or stages (IUCN, 2013) and, where possible, re-establish their original connectivity in the wider landscape.

Botanic gardens are uniquely placed to conduct successful population reinforcement action, especially for plants of urgent conservation concern. Based on their expertise to prioritise species, collect propagules in the wild, grow in horticultural trials and establish sizable numbers of individuals, they are equipped with the vital fundamentals to reinforce wild populations and monitor their survival over time (Case study 7.1.12).

CASE STUDY 7.1.12

Population reinforcements of critically endangered plant species in grassland habitats

Sandrine Godefroid, Sarah Le Pajolec, Fabienne Van Rossum, Botanic Garden Meise, Belgium

Nutrient-poor grassland habitats and several of their characteristic plant species have reached a critical state in many European countries. The main reasons for this situation are: habitat fragmentation, forest recolonization due to abandonment of the traditional agro-pastoral activities, and the intensification of agricultural practices leading to eutrophication. There is an urgent need to preserve, manage and restore these few remaining, often degraded, habitat patches. Part of this task includes the recovery of populations of threatened plant species that without intervention would not regenerate naturally due to restricted seed dispersal abilities and the absence of a persistent seed bank in the soil.

Field surveys and collection of Arnica montana. (Image: Sandrine Godefroid)

Southern Belgium is an important area for the conservation of semi-natural grassland types listed in the annexes of the Habitats Directive. In the framework of the European Commission LIFE project 'Herbages' (LIFE11 NAT/BE/001060), the Botanic Garden Meise, as a centre of excellence in *ex situ* conservation and plant propagation, has implemented population recovery measures in the wild for four highly threatened species: *Dianthus deltoides, Helichrysum arenarium, Arnica montana* and *Campanula glomerata*. The aim is to increase the effective size of remaining populations (reinforcement) and to restore extinct populations (reintroduction) in order to improve connectivity in the landscape.

The population recovery measures adopt a four-step approach: 1) selection and profiling of the target species; 2) source population selection and seed collection; 3) development of propagation protocols and 4) assessment of plant fitness of the populations used as seed source before planting out. For each species, a population of 500 to 700 young individuals was transplanted into three to six sites. Once *in situ* these plants (which are permanently labelled) were precisely mapped to facilitate their long-term monitoring. Each population consists of a mixture of plants from different origins arranged in order to maximise pollen exchanges between different origins.

→→→

Propagation of Arnica montana at the Botanic Garden Meise. (Image: Sandrine Godefroid)

CASE STUDY 7.1.12 (CONT.)

Planting in situ on a target area where potentially competing plants have been removed to maximise the survival rate; the saplings have been furnished with permanent labels to facilitate long-term monitoring. (Image: Franck Hidvégi)

The initial results have been very positive: the survival rate of planted individuals is over 90% while the flowering rate (>30% on average) is also remarkable, in some species just a few months after planting. Seedlings and clonal propagation have been observed indicating a potential for population expansion. Monitoring of reintroduced populations will continue for at least 10 years to gather ample data about their long-term development. A demographic survey (e.g. survival, floral production, reproductive success, and population extension by clonal propagation or seedling recruitment) is recorded yearly in the field. Germination trials are continuing to estimate the fitness of the progeny in order to test for inbreeding or outbreeding depression.

Helichrysum arenarium and Dianthus deltoides populations following reinforcement planting. (Images: Daniel Parmentier)

• Population reintroduction

Reintroduction is the intentional release of an individual or a group of individuals in their natural area of distribution from where they have disappeared. The aim is to re-establish a viable population of the target species in its original range (IUCN, 2013). This can either concern the reintroduction of a particular population that is no longer present where it formerly occurred, or the species at large, if all of its populations have entirely ceased to exist in the wild.

As repositories of wild plant material, botanic gardens par excellence play a key role in population reintroduction programmes. There are numerous instances of plant material held in *ex situ* collections from populations that no longer exist, let alone of species gone extinct in the wild such as the emblematic *Sophora toromiro* (Fabaceae) in the Easter Island or *Encephalartos woodii* (Zamiaceae) in southern Africa. Plant material of both these species however has survived in botanic gardens in Chile and Germany, and South Africa respectively, and is used in population reintroduction trials. Other examples include *Cylindrocline lorencei* (Compositae) and *Normania triphylla* (Solanaceae) – two species endemic to Mauritius and Madeira respectively (Case study 7.1.13) and *Erica verticillata* (Ericaceae) in South Africa (Case study 7.1.14).

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

CASE STUDY 7.1.13

Recommendations for successful reintroduction – experiences from recovery work of *Cylindrocline lorencei* and *Normania triphylla*, two plants endemic to Mauritius and Madeira respectively

Stéphane Buord, Conservatoire botanique national de Brest, France

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

Scientific literature is poor in studies providing analytical details of successful reintroduction of plant species (Godefroid *et al*., 2011). Several reasons explain this shortfall. First and foremost, failures are manifold, and, as a result, are not published. Often, these are due to insufficient knowledge of the reasons why the species disappeared and of the degradation of ecosystem in which the population was embedded. Without addressing these and initial ecosystem restoration efforts, reintroductions are unlikely to be successful.

Reintroduction trials with animal and plant species are being carried out for over 25 years by different conservation stakeholders in the Mauritian archipelago. In a very degraded environment resulting from deforestation and introduction of alien invasive species, the National Parks and Conservation Service (NPCS), Mauritius Forestry Service (MFS) and Mauritian Wildlife Foundation (MWF) decided to trial restoration in selected tracts of forests. Referred to as Conservation Management Areas, these one to two hectare-large areas are fenced to pre-empt any undesired interference with the restoration action. Invasive vegetation is being eradicated with remaining roots eliminated with the aid of chemical agents. While this work is carried out manually often over many years, the results are remarkable. On the site of Pétrin, NPCS was able to re-establish forest fragments on laterite; hitherto impeded by the proliferation of the introduced and highly invasive *Psidium cattleianum*, germination of seed of indigenous species having remained in the soil was observed. These preliminary efforts are quintessential prior to initiating actual reintroduction work. Following these interventions, NPCS has started to plant *Cylindrocline lorencei* (Compositae) – a species endemic to Mauritius but extinct on the island – with plantlets generated from remaining specimens in the *ex situ* conservation collection of the Conservatoire botanique national de Brest (CBNB).

Based on the same approach, MWF and MFS aim to initiate native flora recovery trials on Aigrettes island through assisted colonisation by very rare species. In situations where the indigenous flora is particularly degraded, nurseries are established on-site to produce thousands of saplings of the target species, to be able to draw on average on 4 to 12 plants/m^2, and to ensure the *ex situ* conservation of especially rare species. The sites being regularly managed and monitored in this way, reintroduction of *Dombeya mauritiana* (Malvaceae) – a species of which a single specimen was known to remain in the wild in the 90s – is another example yielding promising results to date.

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CASE STUDY 7.1.13 (CONT.)

The absence of close monitoring and evaluation following reintroduction efforts is another major obstacle to success. The return of a plant species to its restored natural environment requires to be accompanied by a well-defined monitoring method to evaluate the development of the reintroduced populations and establish best practice. Such monitoring will have to extend over often long periods, several years or even decades, in order to observe in particular the emergence of a second generation *in situ* and to quantify the evolution and dynamic of the populations. These stipulations are essential but are often not included in the funding arrangements which frequently focus solely on the initial reintroduction activities. Finding a local, institutional partner to carry on this work is therefore quintessential.

Normania triphylla, a Solanaceae endemic to Madeira, is another example of how plant material held in *ex situ* collections can be used for population reintroduction. Following an entire century during which this plant was believed to be extinct, the species was rediscovered by Padre Nobrega in the 1990s in Madeira's Laurisilva. As an insurance policy, he donated seed to the Conservatoire botanique national de Brest. A couple of years later, as the population was no longer found in the wild, a reintroduction programme was initiated by the CBNB and the Jardin botanique Rui Vieira of Funchal. Thousands of *N. triphylla* seeds were selected for germination, and saplings were subsequently planted in the wild. However, in the absence of a careful management and monitoring plan in the weeks following the reintroduction work, the intervention ended in failure.

A second trial in 2008 closely involved the Madeira National Park forest service. The new strategy adopted consisted of creating small gardens with mother plants at the homes of the forest personnel in the Park. This proximity allowed the regular maintenance of the plantlets by the Park staff. The aim was to create population nuclei of densely cultivated *Normania*, likely to generate a sufficient magnitude of seed to ensure a progressive recolonisation of the surrounding environment. The concept of 'recolonisation nurseries' *in situ* has led, several years later, to the occurrence of numerous *Normania* populations not far from the sites initially chosen for reintroduction. This method would benefit to be tested further in other species reintroduction programmes, accompanied by rigorous monitoring of the cultivated populations and of the areas that are being recolonised.

Reintroduced sapling of Cylindrocline lorencei in Plaine Champagne, Mauritius. (Image: Stéphane Buord)

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

CASE STUDY 7.1.14

Reintroduction of the Whorl Heath – *Erica verticillata* in South Africa

Anthony Hitchcock, Kirstenbosch National Botanical Garden and A. Anthony Rebelo, South African National Biodiversity Institute (SANBI), South Africa

A species gone extinct in the wild

Regarded as extinct in the wild by the second half of the 20th century, *Erica verticillata* used to grow in Cape Flats Sand Fynbos on the lowlands of the Cape Peninsula from the Black River to Zeekoevlei in South Africa. The sketchy information on herbarium sheets and in the literature suggests that this species preferred seasonally damp, acid, sandy soils near streams and wetlands. Overharvesting and agricultural and urban development that occurred as colonial Cape Town expanded resulted in the destruction of populations and its natural habitat. The last herbarium specimen collected from the wild dates back to 1908. Other records of this species in South Africa are herbarium specimens of a plant that was growing at Kirstenbosch National Botanical Garden (KNBG) in 1943 and a specimen submitted by J. E. Repton in 1961 from a cultivated plant in the Pretoria district.

Rediscovery in *ex situ* collections

Thanks to the enthusiasm and efforts of a few botanic gardens and some dedicated collectors and growers, the search for *ex situ* collections of *E. verticillata* began, becoming an exercise in detective work. With assistance from members of the British and American Heather Societies, botanic gardens, Erica growers in Europe and by searching the internet, several locations and collections were tracked including Tresco Abby Gardens on the Scilly Isles, a private Erica collection of Dr. Violet Gray via the British Heather Society, a trademarked selection from Monrovia Nursery in California called *Erica verticillata* Ruby Lace, two from a nurseryman in Germany and another collection from Royal Botanic Gardens Kew. To date, eight confirmed collections have been found three of which have been used in reintroduction efforts.

Reintroduction

The rediscovery of *E. verticillata* excited interest amongst conservationists to attempt reintroduction to its natural habitat. Following experimental planting to determine appropriate habitat conditions, Ericas of the Pretoria clone 'African Phoenix' formed the first population returned to a wild habitat in 1994. The plants attracted a number of pollinators such as the southern double collared sunbird, hawk moths and bumblebees. Despite this, they did not produce seed. A second clone, *Erica verticillata* 'Adonis', was planted in 2001 to encourage seed production. The first seed was collected from the plants at Rondevlei Nature Reserve in 2003 proved viable and seedlings were generated at the Rondevlei nursery. In 2013, fire was put through some 150 plants of the newly created population to simulate natural conditions. This was a major step in re-establishing a natural wild population and towards changing the species' conservation status from 'Extinct in the Wild' to 'Critically Endangered'. Three generations are needed to achieve this.

The first record of post fire recruitment from seed of the species was observed in 2015. However, the seedlings were overwhelmed by competing plants such as the buffalo grass, *Stenotaphrum secundatum* and the fountain bush, *Psoralea pinnata*. A pilot project started at Rondevlei in 2016 to study the role of herbivory through the reintroduction of the southern eland, *Tragelaphus oryx*, is yielding positive results as the animals are browse feeding on grass and woody vegetation, but ignoring the Ericas.

A further trial to establish this species in natural habitat was made in the Kenilworth Racecourse Conservation Area (KRCA) regarded as the best and least disturbed example of Cape Flats Sand Fynbos remaining on the southern suburbs of Cape Town. In 2004, 100 plants comprising two clones of *E. verticillata* were planted in a seasonally wet depression where another highly endangered and endemic Erica, *E. margaritacea*, grows. Introduced in mature vegetation to protect them from the summer heat and wind, the plants have survived and flower profusely every year. Seedlings have been observed in open patches near the parent plants. Cape Nature organized a control burn in an adjacent section of the KRCA in March 2005 after which further saplings grown in unigro plugs were planted in the burnt but moist area. Another planting was established on the eastern-end of the KRCA using plants in 1kg bags. This area was also burnt, but was more protected by sprouting grasses. The plants in unigro plugs all died during the hot, dry summer probably because they were too exposed to the desiccating summer winds and summer heat. Another factor may be that the unigro plants do not allow for sufficient root development to support the young plants through the first summer. The other planting from bags amongst the grasses fared better with about 30% surviving the first summer. The main lesson learnt when reintroducing nursery grown plants to a natural habitat is the value of the supporting vegetation structure as protective nurse plants. However, in a natural system after fire seedlings will germinate and being much smaller get protection from the emerging vegetation around them.

Monitoring growth of Erica verticillata plants reintroduced at Rondevlei, South Africa. (Image: Adam Harrover)

CASE STUDY 7.1.14 (CONT.)

Tokai, part of the Table Mountain National Park, is another trial site for reintroduction. Once a commercial plantation of *Pinus radiata*, the lower Tokai area, is one of the last spots in the world where the endangered vegetation type, Cape Flats Sand Plain Fynbos, survives in a large enough area for effective ecological rehabilitation. Efforts are under way to provide it with long-term protection. Most of the restoration is passive relying on plants germinating from the seed bank remaining in the soil. Only 25 local species have been actively introduced because they are of special conservation concern and have not reappeared after fire which is the natural ecological process that fynbos depends on. These include *Erica verticillata*, the Critically Endangered Rondevlei Spiderhead, *Serruria foeniculacea*, saved from the last two surviving plants at Rondevlei, resprouters which have very small seed banks such as the Wynberg Spiderhead, *Serruria cyanoides* and species with aerial seed banks (stored in fireproof cones) that do not have soil-stored seeds (e.g. Sugarbushes and Conebushes in the Proteaceae). Following initial failures, Ericas reintroduced in Tokai Park established splendidly, and have become a key feature admired by park visitors. A reintroduction experiment of 5000 plants was carried out in the Prinskasteel wetlands in 2008 using three clones planted separately and alternately in rows one meter apart, Pretoria clone 'African Phoenix', Kirstenbosch clone 'Adonis' and Vienna clone from Belvedere Palace. Each row was planted in a transect from dry to the wet area. With a 40% overall survival rate, the initial surprise was that the establishment of *E. verticillata* in the wetlands was more successful than originally anticipated. The experiment showed that despite some sedges outcompeting the species in the wettest habitat, and aliens in others, and some unfortunate management decisions that resulted in significant deaths (careless herbicide application when subcontractors controlling invasive *Rubus* spp. also sprayed some of the Ericas), the recovery was still comprehensive and extensive over the area. The variety of pollinators visiting the Ericas is astounding with far more pollinators than just birds, including wasps, carpenter bees, honeybees, hawk moths and various beetles.

Planting Erica verticillata along the Tokai Restoration Trail. (Image: Anthony Hitchcock)

Public outreach

Species recovery especially at Tokai is a sensitive process and the public are asked to keep out of the restoration areas to allow the recovery process to proceed with as little human impact as possible. Promoting awareness is however critical and necessary. To this end the South African National Parks authorities and the Friends of Tokai Park identified a dedicated area near one of the entrances where some of the threatened species are planted in display collections. The Tokai Restoration Trail includes interpretation boards explaining the restoration process and management plans for the area.

Conclusion

The restoration of *Erica verticillata* is a long process and has to survive through natural recruitment over at least three generations, i.e. three burn cycles without further restocking, replanting or reseeding before its conservation status may be reassessed based on IUCN Red List Categories and Criteria. The evaluation will depend on the numbers of plants that survive after three generations, whether these are stable, declining or increasing, how fragmented these are and the sustainability of the area that these have been restored to.

A number of lessons have been learnt through the reintroduction efforts with *Erica verticillata*. Recovery of a target species on its own is not sufficient. A cohesive management plan is required that encompasses restoration of the entire ecosystem, in this case including fire management. Reintroduction success depends upon a healthy stand of the vegetation type being in place, along with pollinators and other animals and soil fauna and flora, i.e. mycorrhizal fungi required for maintaining the system. If this is not in place steps must be taken to restore missing components. Any imbalance in this system might result in one part/component becoming a problem rather than having a beneficial influence. In particular, the role of herbivory needs to be explored further as this might be a crucial factor in success or failure.

Despite these significant efforts, conservation of the rich Cape flora remains a great challenge, especially given the increased demand for land and resources, and the effects of climate change. Many species may not be as lucky as *Erica verticillata* and could be lost forever. An example is *Erica pyramidalis*, which grew together with *Erica verticillata*, but is now extinct with no *ex situ* cultivated plants known to exist. Many species will go extinct unless the endangered vegetation type, Cape Flats Sand Fynbos, is conserved as a matter of urgency. *Erica verticillata* plays a crucial role in raising awareness of this threat as this plant has become an emblematic species symbolising the general plight of our vanishing flora that helps to create awareness that.

• Ecological restoration

Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER, 2004). A fundamental distinction between ecological restoration and other forms of ecosystem repair is that ecological restoration seeks to 'assist recovery' of a natural or semi-natural ecosystem rather than impose a new direction or form upon it. That is, the activity of restoration places an ecosystem on a trajectory of recovery so that it can persist and its species can adapt and evolve (McDonald *et al*., 2016).

Ecological restoration can and should be a fundamental component of conservation and sustainable development programmes throughout the world by virtue of its inherent capacity to provide people with the opportunity to not only repair ecological damage, but also improve the human condition. For restoration to be successful, it is essential to have understanding of the dynamics of the ecosystem being restored, and to ensure the genetic integrity of its plants by using locally propagated species.

As long-term custodians of common, rare and threatened plants, botanic gardens manage the most thoroughly documented and diverse repositories of live plants, seeds and other types of plant material from around the world. Over the centuries, they have accumulated a wealth of scientific and applied knowledge on the genetic, physiological, horticultural, ecological and other biological characteristics of plants (Hardwick *et al*., 2011). In addition, a great asset of many botanic gardens, especially in the tropics, is their maintenance of areas of primary, natural vegetation, which potentially facilitate the implementation of activities focussed on *in situ* conservation (Costa *et al*., 2016). As Case study 7.1.15 clearly illustrates, botanic gardens are therefore uniquely positioned to play an increasingly important leadership role in ecological restoration on a global scale (Box 7.1.5).

Brackenhurt Botanic Garden, Kenya – view of forest restoration site before (c. 2001) and after (2013). (Images: Barney Wilczak)

Box 7.1.5 Ecological Restoration Alliance of Botanic Gardens (ERA)

The Ecological Restoration Alliance of Botanic Gardens (ERA) is a global consortium of botanic gardens actively engaged in ecological restoration. The mission of ERA is: *To mobilize botanic gardens, arboreta and seed banks to carry out science-based ecological restoration by marshalling their expertise, networks, and resources to help achieve the restoration outcomes needed for human well-being and a sustainable future for life on Earth*. Members of the Alliance have agreed to support efforts to scale up the restoration of damaged, degraded and destroyed ecosystems around the world, contributing to the Sustainable Development Goals and the United Nations' target to restore 15 per cent of the world's degraded ecosystems by 2020. ERA member botanic gardens are carrying out ecological restoration projects in a diverse range of ecosystems. ERA is coordinated by Botanic Gardens Conservation International (BGCI).

The ERA has five goals:

1. Work with local partners to set up, maintain and document a series of long-term sustainable exemplar restoration projects in diverse biophysical, political, and cultural contexts around the globe that provide training and demonstrate the value of a carefully designed, science-driven approach to sustainable ecological restoration.
2. Improve the quality and volume of science-based ecological restoration practice by deploying scientific and horticultural skills to applied work on the ground.
3. Conduct ecological restoration research, to develop an enhanced knowledge base for restoration and identify and inform best practice.
4. Disseminate research and lessons learnt from projects.
5. Build expertise and restoration capacity through collaborations between botanic gardens, large and small, as well as with partners in local communities, professional societies, academia, industry, government, NGOs and international bodies.

Botanic gardens have launched, and maintain, successful ecological restoration projects throughout the world. Their expertise in teaching, training and outreach, and their mission for public service gives them the capacity to work with a wide variety of stakeholders, including governments, civil society, industry and local communities, providing the tools and knowledge to achieve long-term ecological restoration goals.

Screenshot of the ERA web portal.

CASE STUDY 7.1.15

Recovery of the original montane forest of Hong Kong – Ecological restoration efforts by Kadoorie Farm and Botanic Garden, Hong Kong

Gunter A. Fischer and Jinlong Zhang, Hong Kong; Yvette Harvey-Brown, Richmond, United Kingdom

With 7.2 million residents in 1,104 km^2, Hong Kong is one of the most crowded places on earth. Its primary forests were destroyed centuries ago and have not recovered since then, due to continued disturbance by humans, mainly by fire. Most of Hong Kong's natural landscapes are now covered by secondary grasslands and forests of different successional stages. In 2013, Kadoorie Farm and Botanic Garden (KFBG) established an ambitious restoration project on the upper slopes of KFBG's premises, 'Ecological restoration of the original montane forest of Hong Kong'. In order to be able to monitor the project from the first planted tree throughout the evolution of the forest, a 20 x 20 m grid was established over the total project area of 10 ha. Every planted tree and also every existing shrub and tree was identified and tagged with a unique number. Not all plots were planted as some act as monitoring plots for natural succession. Two automatic weather stations permanently monitor the climatic conditions remotely, allowing KFBG to link growth and survival rates to climatic patterns.

One of the key questions of the project is whether it is possible to shortcut natural succession and avoid the shrub and early tree stages of succession by planting climax trees at the beginning of the ecological restoration process. To address this, a series of experiments was established to overcome factors that reduce survival and growth rates of climax trees in an open grassland environment, such as strong wind, wind desiccation, strong sunshine, herbivory, competition by grasses for nutrients and water, soil erosion etc. The experiments included the use of different types of tree guards, different types of weeding mats, different types of fertilizers, soil amendments with compost and biochar and different weeding regimes. First results have been very promising and currently more than a hundred different woody species have established in the core area of the restoration site.

The experiments and strict monitoring regime in place have allowed a large amount of information to be gathered across a relatively small area and for recommendations to be made for future projects. For example, KFBG has learnt that good arboriculture is needed early on to make sure that rare climax trees grow straight, do not branch too early and are free of competition so they are not outperformed in the stem exclusion phase of succession by overly vigorous pioneer trees. Although little is still known about how plant species coexist and interact with each other in this particular ecosystem, KFBG restoration experiments enable them to compare natural succession initiated by a limited species pool caused by massive deforestation in the past with succession initiated by an artificially increased species pool. This provides a unique opportunity to test hypotheses on community assembly, species coexistence, habitat preferences, environmental filtering in a phylogenetic, functional and ecological framework. These experiments are still on-going and KFBG plan to publish a series of scientific articles in the coming years to share the knowledge gained and guide restoration projects elsewhere.

Tree planting plots with sapling guards at Kadoorie Farm and Botanic Garden. (Image: Gunter Fischer)

• Population introduction

Contrary to reintroduction, introduction is the intentional movement and establishment of an individual or a group of individuals outside their natural range (IUCN, 2013). The aim is to prevent extinction of populations of the target species by establishing new ones in suitable habitats with favourable environmental conditions in areas where they have not been recorded from in recent geological history. Population introduction may be required as climate change and global warming and/or other change agents threaten the survival of a population or the entire species in their present habitat.

A critical aspect of an intended population introduction is to undertake a rigorous risk assessment as regards the potential of the species becoming invasive in its new location. Many introduced species may not demonstrate clear signs of invasiveness only until several decades later following their establishment. Thus, introduced target species should continue to be monitored in the long run (Smith *et al*., 2013). Equally, a risk assessment should evaluate the danger posed by any pests and pathogens that the introduced plant material might be carrying, as well as the probability of hybridisation between related species. Botanic gardens in particular are well-aware of the potential threats posed by newly accessioned plant material for their existing collections as well as for wild plant populations (Chapter 3, Section 3.4.4 and Chapter 6, Section 6.8). This technical knowledge and practical knowhow coupled with the wide range of areas of expertise in plant identification, sampling, propagation and cultivation, make botanic gardens also vital stakeholders of all stages of introduction in the wild, from planning to provision of plant material over to actual introduction work and monitoring (Case study 7.1.16).

CASE STUDY 7.1.16

Securing the future of a unique Sicilian plant on the verge of extinction – population introduction of *Zelkova sicula*

Giuseppe Garfì and Salvatore Pasta, Palermo, Italy; Stéphane Buord, Brest, France; Gregor Kozlowski and Laurence Fazan, Fribourg, Switzerland; Joachim Gratzfeld, Richmond, United Kingdom

Discovered in 1991, only two small populations of the relict plant *Zelkova sicula* are known, located on the slopes of the Iblei Mts. in south-eastern Sicily (Italy). The species faces an uncertain future and has been included in the IUCN Red List of Threatened Species as Critically Endangered. Both populations are restricted to the bottom of small gullies with rivulets. Although *Z. sicula* appears to be partially adapted to the Mediterranean climate (suggested for instance by the sclerophyllous leaf traits), recurrent dieback triggered by summer-drought indicates that the populations are located in an area with suboptimal environmental conditions. Sexual reproduction in the wild has not been recorded to date, although a few dozens of plants in each population perform uneven flowering and fructification. Fertile fruits have not been found probably due to the triploidy of all individuals in both populations. The species proliferates however vegetatively, via root suckering or basal resprouting following disturbance or injury. Due to their clonal identity, the two populations have a very low adaptive potential. In addition, they are confined to the present enclaves situated within the thermo-Mediterranean belt, whilst a swift adaptation to rapidly changing, drier and warmer environmental conditions seems impossible. Population introduction may therefore represent the most effective conservation strategy, if not the last resort, to secure the survival of *Z. sicula*.

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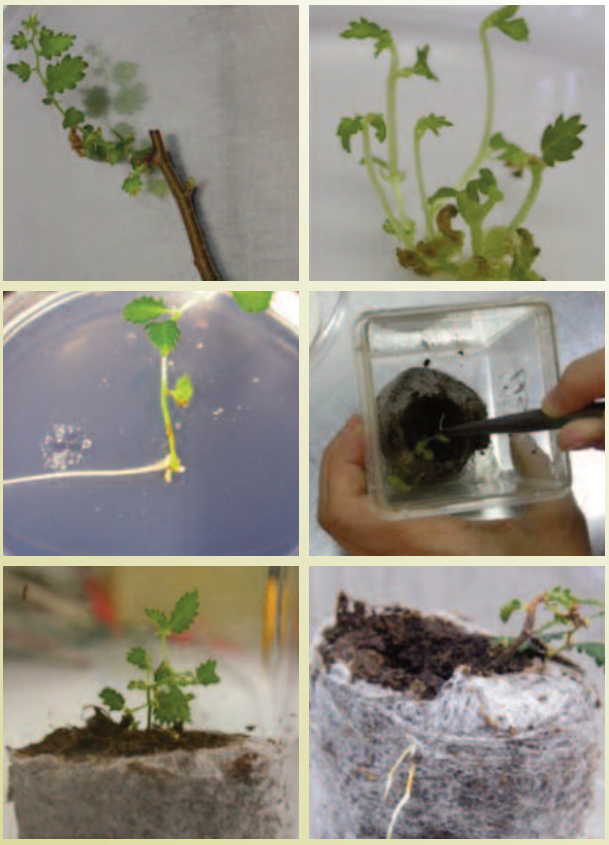
Zelkova sicula wild population (Contrada Ciranna) – habitat and habit. (Images: left: Giuseppe Garfì; right: Joachim Gratzfeld)

CASE STUDY 7.1.16 (CONT.)

Planning for long-term conservation – plant material collection and development of propagation protocols

Recognising the urgency of rapid intervention, the Institute of Biosciences and Bioresources, Unit of Palermo (IBBR-CNR), Italy, the Conservatoire Botanique National of Brest (CBNB), France, as well as the Botanic Garden of the University of Fribourg (BGF), Switzerland, joined hands to devise a conservation programme for *Z. sicula* aiming at population introduction to new habitats. Two fundamental actions preceded this endeavour: i) evaluation of the genetic diversity within the species to capture the highest genetic adaptive potential; and ii) collection of plant material and development of propagation protocols.

The molecular analyses revealed a clear difference between the two populations but identical genetic profiles within each population, confirming two different clonal lineages. To reflect occasional genetic changes arising from mutations, collection in both populations targeted material from as many mother plants as possible. Capitalising on their longstanding experience in germplasm conservation, seed germination and propagation of endangered plants, CBNB and IBBR-CNR developed vegetative propagation protocols using cuttings and *in vitro* techniques. Supported by the European Commission LIFE project 'Zelkov@azione' and BGF, propagation protocols are continuously refined, and the stock of plants is steadily growing.



In vitro propagation and explant stages of Z. sicula. (Images: Angela Carra)

Initial population introduction trials

The next step consisted in the selection of suitable sites for introduction of new populations. Data gathered on significant growth performance of a few individuals raised in *ex situ* collections suggested more humid sites in the meso- and supra-Mediterranean belt as suitable new habitats, characterized by mixed forests with summer-green, broadleaved deciduous trees. These plant communities are similar to those where the other extant West-Eurasian *Zelkova* species thrive, and match the species composition of communities with *Zelkova* spp. based on palaeoecological data. A further key requirement included the proximity to small streams as observed in the current habitat.

Three out of 17 initially identified sites were evaluated as providing the best habitat suitability and adequate site accessibility (i.e. Bosco Tassita, Nebrodi Mts.; Bosco Pomieri, Madonie Mts.; Bosco Ficuzza, Sicani Mts.). Two supplementary plots where chosen in the thermo-Mediterranean belt at Bosco Pisano, near one of the extant populations. To ensure long-term conservation and sustainability, only public land and locations within the Natura 2000 network or other protected areas were selected. However, as all sites are within protected areas, a longwinded administrative procedure was necessary to obtain permission from the managing authorities to introduce the plant into the local forests. A thorough risk assessment of the potential impact (such as invasiveness and introduction of pests) was undertaken, followed by the establishment of a detailed monitoring plan. Prior to outplanting, all saplings were transferred for acclimatization to a forestry nursery located in an area with meso-Mediterranean climate conditions, and regularly checked for eventual pests and diseases. In four of the five sites fences have been established to prevent browsing disturbance by wild and domestic ungulates.

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Wild populations of Zelkova sicula (green dots):
A: Bosco Pisano, B: Contrada Ciranna, Iblei Mts.
Introduction sites (red dots):
1: Bosco Pisano; 2: Bosco Tassita, Nebrobi Mts.;
3: Bosco Pomieri, Madonie Mts.; 4: Bosco Ficuzza, Sicani Mts.

CASE STUDY 7.1.16 (CONT.)

Letting nature take its course – yet under controlled conditions

First planting trials were carried out in June 2016 in the pilot sites of Bosco Ficuzza and Bosco Tassita using 15 plantlets per plot. They were introduced in the forest understorey at irregular intervals, prioritising streamside locations and half-shade conditions. Additional measures were taken, such as the use of hydrogel (a high water retention polyacrylate, able to prolong water supply) as well as covering the planting holes with a biodegradable mulch mat to reduce evaporation. Watering was provided right away and an irrigation plan was established for the first growing season to respond swiftly to potential drought. Planting activities continued during winter 2016 in these and two new sites (Bosco Pomieri and Bosco Pisano), raising the total number of saplings planted to over a 100 (on average some 25 per site). These efforts will be further consolidated over the coming years, including additional planting in all sites.

A truly novel approach to save a unique plant from the brink of extinction, this population introduction experiment complements ongoing efforts to secure *Z. sicula* in botanic gardens and other institutions working for plant conservation (Kozlowski and Gratzfeld, 2013). If the introduced individuals successfully establish over the coming years to form new populations, this endeavour will serve as a practical illustration of using horticultural excellence and *ex situ* conservation as an insurance policy in a future marked by rapid climate change and altering ecosystems.

Introduction of Zelkova sicula (Ulmaceae) to a new habitat, Bosco Ficuzza, Sicily. (Images: Giuseppe Garfì)

As many ecosystems and habitats are transforming into new, non-historical configurations owing to a variety of unprecedented local and global transformations including climate change, novel combinations of species are emerging that have not occurred before. Management of such 'novel ecosystems' (Hobbs *et al*., 2009) as of targeted population introductions that also represent new species assemblages, is one of the great conservation challenges in the twenty first century. Botanic gardens which are steadily embracing and promoting an integrated *in* and *ex situ* conservation approach, are once more at the forefront to guide, support and implement innovative strategies aimed at securing plant diversity for future generations.

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7.2 PUBLIC ENGAGEMENT – EDUCATION

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7.2.0 Definitions

Behaviourism, cognitivism, constructivism: Behaviourism is a learning theory that focuses on objectively observable behaviours and discounts any independent activities of the mind; cognitivism focuses on mental processes, including how people perceive, think, remember, hypothesise and solve problems; constructivism argues that students construct their own understanding and knowledge, through experiencing things and reflecting on those experiences.

Inquiry-Based Science Education (IBSE): IBSE involves a learning process in which not only facts are explained but where students are encouraged to question, hypothesise, explore different approaches to a problem, debate and discuss issues and present their findings. This learning approach includes a wide range of activities e.g. case studies, research projects, fieldwork and investigations.

Pedagogy: Pedagogy is the art or science of teaching, including the range of instructional methods.

Child protection: A child protection policy provides guidelines for organisations and their staff to create safe environments for children. It is a tool that protects both children and staff by clearly defining what action is required in order to keep children safe, ensuring consistency of behaviour so that all staff follow the same process.

Risk assessment: This is an estimate of the likelihood of adverse effects that may result from exposure to certain hazards e.g. trip or slip hazards, water hazards, poisonous plants, garden machinery, etc.

Adult education: In adult education, adults are engaged in learning beyond traditional schooling. Adult education programmes in botanic gardens are usually provided in two contexts. 1. formal – structured learning that typically has a set curriculum and is accredited or certificated; 2. non-formal – learning that is organized but non-accredited and informal and which is often related to hobbies, leisure pursuits and personal lifelong learning e.g. workshops on 'how to propagate plants', 'plant photography', etc.

Higher education: Formal education beyond the secondary level; especially education provided by a college or university.

Student teacher: Student studying to become a qualified teacher in a school.

7.2.1 Introduction

KEY MESSAGE

As public destinations that play host to an increasing diversity of visitors, we have the opportunity (and obligation) to encourage every person we encounter to learn more, care more, and do more with the plants in their lives. (Sheila Voss)

Botanic gardens offer a wealth of learning opportunities for all, irrespective of whether for adult students in further / higher education and schoolchildren (formal education) or the general visitor, community groups and families who learn through a range of interpretative materials or activities (informal education). Usually in the centre of large urban areas, botanic gardens offer green, safe and calm havens for study. Exciting living and preserved collections, and staff expertise, can be used to engage learners directly and make clear links between plants, habitats and our everyday life.

We need to foster deeper relationships with our audiences, both children and adults, to encourage them to live more sustainable lives. Education in botanic gardens, along with interpretation, is key to the delivery of this understanding and is central to the implementation of the Aichi Biodiversity Target 1 and Target 14 of the Global Strategy for Plant Conservation (GSPC) as well as supporting the Millennium Development Goals (MDG) (Millennium Project, 2006).

Education programmes offer benefits to the botanic garden including:

- Enhancing reputation;
- Supporting visitor flow around the site;
- Supporting business development;
- Bringing in new audiences;
- Contributing to the garden's corporate social responsibility.

This section discusses the pedagogical approach currently being integrated into educational programmes and also outlines a range of approaches to educational strategies. It explores the different programmes and resources to deliver these programmes such as staffing, space and funding. These elements required for the development of an educational programme are noted in Figure 7.2.1.

Figure 7.2.1: Four key elements to consider in the development of an educational offer

7.2.2 Pedagogy in Botanic Gardens

KEY MESSAGE

Botanic gardens need to develop a more professional attitude towards teaching at botanic gardens in the next decade.

To provide good learning experiences and an effective educational programme, we need to consider how, why and where learning takes place. The process of learning is complex and general philosophical theories such as behaviourism, cognitivism, or constructivism often fail to provide detailed guidance about how to organise teaching (Weibell, 2011).

Focusing on content accuracy is not enough in modern botanic garden teaching and learning. One needs to recognise the prior knowledge and experience that the learner brings to the learning process as well as their socio-cultural background, different beliefs and attitudes (see audience development in interpretation). Botanic garden educators should also be aware that their own cultural background and life experiences influence their own teaching and learning processes.

The following principles are now more visible in modern botanic garden education and serve as building blocks for the future:

1) The individual is responsible for his or her learning. Programmes need to create a 'learner centred' learning environment. Educators should discover what the learner knows and take this into consideration to adapt the programme to participant needs. Space is required for individual learning processes to occur and learners should be supported to interact with each other.

2) The learning programme has an explicit goal. Goals are set by the programme designer, however participants should also be allowed to set their own goals e.g. the Inquiry-Based Science Education (IBSE) approach. For reflections on the effectiveness of the IBSE approach see Case study 7.2.1.

3) Education programmers need to be reflective practitioners. Education staff need to reflect on how successful educational programmes are in supporting learner knowledge, skill and/or attitude development.

CASE STUDY 7.2.1

IBSE and the schools programme in Lomonosov Moscow State University Botanic Garden

Alla Andreeva, Lomonosov Moscow State University Botanic Garden

The 'Inquire' project was run by BGCI and 16 botanic garden partners across Europe, including the Moscow State University Garden, to develop the use of IBSE and reflective practice amongst educators and visiting schools (INQUIRE, 2016). Since it was first introduced in Moscow University's Botanic Garden (Aptekarskiy Ogorod), IBSE has created new opportunities for the development of education programmes and has helped to establish and expand contacts with schools, teachers, pupils and parents. It has also boosted the garden's popularity, particularly amongst teachers and families.

The botanic garden has become an experimental educational space for schools, helping to attract investment and enhance the garden's status both within Moscow University and in the eyes of the city's government. IBSE has brought with it fresh thinking on issues such as the quality of knowledge, standards of teacher training and garden resources. The garden now proactively engages university faculty, students, postgraduates and experts in the education process, including the search for new research methodologies and the application and development of existing resources.

Moscow city Education Department has given support to these IBSE-based lessons where the botanic garden hosts lessons on a contractual basis with schools. Classes visit the botanic garden monthly throughout the year, and training is devoted to specific topics, discussed in advance with the teachers. As a result, each school has its own tailor-made programme of garden-based learning. Knowledge and experience gained are often a starting point for future studies and individual project work by students, with garden experts acting as research supervisors. This collaboration has already produced important scientific results and encourages students to participate in conferences and project competitions. It also provides garden specialists with experience of project-based research.

→→→

CASE STUDY 7.2.1 (CONT.)

The new skills enhancement course for teachers has been well received by schools, with workshops run for teachers and garden educators to discuss new practices and methodologies and promote IBSE benefits. These workshops have expanded the audience of school teachers for garden-based education. Frank and open discussions of the pros and cons of new approaches include presentations by teachers of their own IBSE-based practices.

Following its adoption of IBSE, the botanic garden has devised a new programme for its Ecology School, (run on a voluntary basis every Sunday). It is mostly attended by pupils interested in scientific research, often sparked off by school lessons in the garden.

Teachers note the impact of IBSE in pupils wishing to visit the garden and interest in the lessons held there. Pupils show greater motivation in studying biology / nature, carrying out research and a willingness to express ideas, build hypotheses and argue points of view. These lessons help to develop the children's creative potential and stimulate an interest in scientific work, including independent study of plants, contemporary natural processes and links between nature and human activities. This perfectly aligns with Russia's new educational standards and ongoing educational reform.

Constructing models of flowers. (Image: Moscow State University Botanic Garden)

Recording data on plant morphology. (Image: Moscow State University Botanic Garden)

CASE STUDY 7.2.2

A strategy for Education in Missouri Botanical Garden

Sheila Voss, Missouri Botanical Garden

At Missouri Botanical Garden, our education strategy is prepared for by first establishing a solid, multi-dimensional foundation of support: 1) investment in people; 2) everyday excellence; and 3) active participation in and advancement of the field.

1) This is about staff, volunteers, interns, colleagues, and community partners who make up the teams of professionals who provide our products – the actual experiences people have in our gardens. Ensuring quality, meaningful life-shaping experiences and learning moments for our visitors happens with intent and sustained support, with a team of creative, collaborative people who are challenged, supported and equipped for success.

2): Visionary, multi-year, mission-driven strategic plans help set institutional trajectories, but it's in the everyday realm that learning moments should enthusiastically be seized – the everyday excellence. What's right under our nose is often overshadowed by the new exhibit, the future expansion, the next big thing. What basic, simple improvements, as well as new, compelling learning moments, could happen in the reception lobby or those little garden niches that families love exploring? There is undoubtedly no lack of creative ideas; however, these ideas are not acted on as often as they could be. Other priorities populate the working day: pressing deadlines, staff constraints, and budget woes.

3): There is so much to learn from each other. This happens by intentionally reaching out to, connecting with, learning from, and challenging our colleagues close to home and across time zones. What specifically do we want to learn more about, dig deeper in, and get better at? Answer this question, and, as Captain Jack Sparrow would say, "*you've got your heading*".

7.2.3 Developing an Education Strategy

There should be an overall education strategy linked to the garden's mission and direction, developed in association with the botanic garden strategy and with agreed outcomes, target audiences, implementation and evaluation plans (see interpretation strategy / master plan). Cross departmental meetings, with senior management, will ensure buy in and appropriate subject / resource allocation. Many botanic gardens such as Missouri Botanical Garden already have a strategy (Case study 7.2.2), however there are always new perspectives and improvements to explore. The Eden Project has published an essay on their philosophy / strategic approach (Blewitt, 2004).

7.2.4 Managing and Resourcing an Education Programme

There are a number of key items that you need to have when setting up and implementing an education programme.

1. Resources – staff

KEY MESSAGE

Staffing presents one of the highest investments; however, skilled staff will ensure quality programmes which have potential to raise revenue.

Dedicated staff that have the skills and expertise to develop creative programmes, administrate, teach, communicate well and evaluate are vital for managing education programmes. Providing good staff training and giving staff opportunities to share experiences across the network of botanic gardens is also important. Staffing might be considered via:

- Full or part/time employees;
- Contract teaching staff who are paid on a daily or session rate;
- Trained volunteer staff.

The Royal Botanic Gardens, Kew employed teaching staff on a contract basis for many years, which had many advantages. Staff were recruited from freelance trained teachers, who either did not work full-time due to childcare responsibilities or were older teachers, semi-retired from full time teaching. Teachers were recruited from all teaching levels and/or subject disciplines, offering good programme opportunities for Kew. The school programme cost covered hiring the teachers and programme resources. This option is possible providing you are within the legal constraints of pension provision and working time rights. The botanic garden employs full-time teachers as these provisions have now changed in the United Kingdom.

If using full-time volunteers, these should be fully vetted, trained and assessed. Volunteers require pastoral care, training and supervision and ideally a member of staff to manage them. Travel costs, uniforms and equipment need considering, so volunteers are not necessarily a cheap option. You can assess the overall value of volunteers to the organisation by working out a 'VIVA' ratio. VIVA - the Volunteer Investment and Value Audit is a measurement tool that assesses the 'outputs' of volunteer programmes (the value of volunteers' time) in relation to the 'inputs' (the resources used to support the volunteers) (Gaskin, 2011). This value is, however, just a financial one and does not take into account other valuable aspects of the volunteering process.

Volunteers are an excellent resource, however it is their right not to turn up and not to be accountable for any difficult situations that develop during an educational visit. It is better to take on volunteers in educational support roles such as 'meeters and greeters', teaching assistants, administrative support, resource management or as play facilitators. Several gardens do have a hierarchy of volunteers, with volunteers managing other volunteers; this may be necessary due to budget constraints. Careful consideration is needed in this case, so that neither volunteers nor senior management teams are put at risk regarding accountability.

Other resources you may need to fund are:

- Books, images and research resources, e.g. on-line web access;
- Staffing plus training / capacity building costs for staff / volunteers;
- Travel costs for staff attending meetings and /or volunteer travel costs;
- Artefacts to engage groups – artefacts that make links to everyday plant use, e.g. chocolate bar, toothpaste, vanilla flavouring, bead necklaces, paper, etc. Botanic garden teaching staff can use these to demonstrate items of interest during talks, tours and workshops;
- Technological support.

Education is capable of bringing in good revenue. Charges vary, so explore a number of botanic garden websites to see current costs for schools and adult education programmes in your region.

2. Resources – learning spaces

KEY MESSAGE

In botanic gardens, students are 'outside the classroom', so replicating a classroom experience on-site is pointless.

When considering educational building design, requirements include: a lot of storage; accessibility for all; adequate toilets; sturdy, correctly sized furniture; ample power points; flooring to withstand messy activities. Blackout and soundproofing may also be needed.

An educational room at the Eden Project. (Image: The Eden Project)

Although not vital to have an education building, you need to carefully consider the spaces available for education on site. Lunch space is useful for school groups and families; picnic table areas are fine, preferably covered against wet weather. Toilets and water for hand washing are important, especially if visitors are handling plant material. Have drinking water available; a water fountain or a nearby tap to refill water bottles is fine. The Case studies from Kings Park in Australia (Case study 7.2.3) and the National Botanic Garden in Nepal (Case study 7.2.4) show how staff from the respective gardens considered and developed their garden layout to maximise impact with their educational audiences.

CASE STUDY 7.2.3

Naturescape, Kings Park, Australia

Marcelle Broderick – Botanic Gardens and Parks Authority, Kings Park and Botanic Garden, Perth, Western Australia

Kings Park and Botanic Garden is in the centre of Perth, Western Australia. It is the most visited destination in the State, recording c. six million visitors a year, a remarkable figure in a city of 1.74 million people, and in a State of 2.39 million. It is 400 hectares in total, with two thirds of the land maintained as natural, managed bushland; the remaining land is developed areas, including the 17 hectare State Botanic Garden.

In October 2011, Kings Park opened its new six hectare, nature-based environmental discovery facility for children, the Rio Tinto Naturescape Kings Park. Believed to be the first of its kind in Australasia and possibly the world, this new development was a significant departure from the previous types of facilities offered to children. The opening was the culmination of more than four years of planning, consultation, design and construction and significant financial support was received from several sponsors including Rio Tinto, Water Corporation, Lotterywest through the Friends of Kings Park and the Perth Solar City programme. Since opening, Naturescape has welcomed c. 10,000 visitors a month.

Naturescape is set within a bush environment and invites children to immerse themselves in a natural Australian landscape, exploring and connecting with nature and doing what comes naturally – building cubbies, climbing high, playing hide and seek, making dams and wading in a creek.

→→→

CASE STUDY 7.2.3 (CONT.)

Paperback Creek at Naturescape. (Image: Jody D'Arcy)

The concept for Naturescape evolved in acknowledgement of the increasingly urbanised environments and the corresponding diminishing opportunities for children to experience nature first hand. Australia is one of the most urbanised countries on Earth, with approximately 85 percent of the population living in cities. Kings Park and Botanic Garden had a vision to provide a fun, educational facility that would entice children away from their computer games and electronic screens to spend more time outdoors learning about nature.

As part of the planning for the development of Naturescape, a number of formal and informal focus groups and community discussions were held. A common concern expressed was about nature based experiences of people growing up in Western Australia in the 1950s, 60s and 70s that were no longer easily available to children and grandchildren growing up between the 1980s and the present. Many people remembered, with fond nostalgia, a childhood dominated by more freedom and play outdoors.

In Kings Park and Botanic Garden, we decided to try to develop new, relevant ways to enable children to engage with nature and the natural world. Naturescape was designed to offer children the opportunity to '*escape into nature*' and explore the natural world in a fun way, to develop their sense of adventure and do the simple things that many of today's adults experienced while growing up. This nature-based experience is intended to assist children to develop an appreciation and understanding of the natural environment through unstructured activity, which in turn will hopefully encourage them to become future advocates for its ongoing protection and survival. The site also has a more formal education role, with an area dedicated to the delivery of a range of curriculum based environmental education programmes for schools, developed and delivered by Kings Park Education.

In summary, the site is based on a philosophy of '*hands*' (immersion, experiences, hands on opportunities), '*heads*' (informal and formal learning opportunities based on environmental education messages) and '*hearts*' (experiences plus understanding plus knowledge should hopefully lead to wanting to nurture the natural world and actively care for our environment). Children need nature, and nature needs children.

Kings Park has created online resources with practical advice on how to create a nature space (Botanic Gardens and Parks Authority, 2015).

Tree hide and mixing bowls in Naturescape. (Image: Jody D'Arcy)

CASE STUDY 7.2.4

Biodiversity Education Garden at the National Botanic Garden, Nepal

Kate Hughes, Royal Botanic Garden Edinburgh

A new botanic garden has been developed in Nepal with education as its principal focus. Hence the whole design of the garden was implemented with visitors and biodiversity-learning in mind. Collaboration and capacity building between staff at the National Botanic Garden, Nepal (NBG) and Royal Botanic Garden Edinburgh (RBGE) began in March 2015. Funding was awarded by the British Embassy, Nepal to enable two horticultural staff from RBGE to deliver a basic horticulture course over three weeks to 15 members of staff. The aim was to raise capacity levels in essential horticultural skills in preparation for the 9 month project to renovate an area and construct a new garden at NBG called the Biodiversity Education Garden (BEG).

The horticulture course was adapted from the Certificate of Practical Horticulture (an annual certificated RBGE course) to suit the facilities and skill levels at NBG. Staff attending the course came from different levels and departments of NBG including horticulture, botanical and administration staff. Non-horticultural staff benefitted by gaining an understanding of the work required of the horticulture team; this improved morale, communication and facilitation of horticultural activities for all involved. The BEG introduces many less common Nepalese species to visitors and is designed to provide an aesthetically pleasing, educational display of native Nepalese plants. Informative panels describe the plants and habitats represented and thousands of schoolchildren, as well as local and international visitors annually can now pick up an information leaflet on this resource or get further information through QR codes on the panels which link to a website (beg.dpr.gov.np).

From August 2015 to March 2016, RBGE staff made six trips to work alongside NBG staff to deliver the garden development stages. These included: which plants and features to preserve/remove and how to safely remove undesirable items, choosing plants/features to install, collection/sourcing and propagation of plants, care of plants, construction of infrastructure and all aspects of interpretation.

NBG staff have extensive knowledge of the climate and growing environment of their garden and are able to inform RBGE staff about their practices for the success of planned planting and where to source plants. Local contractors made the new path system using local methods in keeping with the rest of the garden. RBGE staff used their knowledge of plants from other regions of Nepal, introducing several unfamiliar plants and increasing the plant collections of NBG. RBGE staff also used their plant display experience to demonstrate RBGE practices and introduce new ideas which NBG staff can now adopt and adapt as suits.

Interpretation was another collaborative exercise with tasks split between NBG and RBGE staff. Part-produced in Scotland for availability of particular materials, the information panels are installed on a range of structures made from local products and the interpretation is in Nepalese, English and Latin. The QR codes link to the Nepalese Government Department website which is maintained and updated locally. NBG produced the general plant labels and RBGE have worked with NBG staff to ensure taxonomy and distribution information is current.

The project has environmental and educational benefits on four levels:

- Visitors will learn about the medicinal, practical and financial value of many plants in Nepal, supporting awareness for plant conservation;
- NBG staff have been introduced to more techniques for making successful garden spaces;
- NBG staff have been introduced to techniques which can help to grow and conserve plants;
- RBGE staff have learned about environments outside their experience, which will help to inform their working practices and to improve displays in Edinburgh.

The constructive exchange between NBG and RBGE strengthened as the project developed, illustrating that quantifying benefits of capacity building and collaboration takes time.

NBG staff check the interpretation panels. (Image: Royal Botanic Garden Edinburgh)

3. Marketing

KEY MESSAGE

The botanic garden website is the easiest way to promote your offer; make it easy to navigate and provide comprehensive information.

Marketing the education programme offers a wide 'reach'. Marketing tools include:

- Promotional visits to the local education authority that can cascade information through their own networks and media, saving you time and money;
- Local media – radio, TV and press;
- Regional science networks and clubs;
- Social media such as Twitter and Facebook;
- Talks and displays at 'open days' for teachers / organisations either on your own site or at educational events;
- Brochures and leaflets: These are often less effective as they are costly, soon out of date and not guaranteed to get to the right person; they often end up in the waste bin.

More information on developing botanic garden marketing strategies is in Chapter 1, Section 1.7.8.

4. School programmes

KEY MESSAGE

Delivering education programmes for schoolchildren is hard work; plan in detail, train your staff, link programmes to the curriculum and make it easy for schools to visit by getting the basics right.

Practicalities to consider for school programmes:

- Schools should pre-book for activities: Online booking (when possible) is quick and easy;
- Risk assessment / child protection policies: Ensure that activities / spaces used are covered by the Health and Safety guidelines for your area. A child protection policy (imperative in some countries) and staff training on this is useful;
- A dedicated entrance: School groups entering the botanic garden often cause queues. Consider a separate entrance or volunteer 'greeters' to welcome your school group and offer advice and support;
- The first things schools usually wish to have is access to toilets: Toilet visits take time; make sure you schedule this in;
- Assisting teachers or parent helpers: Clearly state the ratio of visiting children to adults; adults should stay with the group at all times.
- School bags: Botanic gardens are big sites. Children get tired carrying heavy bags over long distances. Consider a lockable 'bag cage' or lockers to keep bags safe;
- Have equipment for activities in the right space at the right time: Some activities require big equipment (e.g. ecological surveys). Locate your equipment ahead of time. Several gardens have tricycles with trailers or trolleys to move equipment;
- Schedule your activities: School arrivals are often delayed, so be ready to adapt activities. Visit time is often short; e.g. UK schools usually arrive at 10.30 am and leave at 2.30 pm. Don't be too ambitious! Ensure activities fit the schedule, including refreshment breaks;
- Vary your teaching style: Children learn in a variety of ways; make sure you have variety in your teaching, including Inquiry Based, hands-on and minds-on activities.

Several botanic gardens, e.g. Chicago, Sydney and Kirstenbosch offer excellent education programmes off-site for communities and schools, bringing their skills and expertise, particularly horticultural, into gardening schemes. For ideas on how to develop and run similar programmes see SANBI (2016), The Royal Botanic Garden Sydney (n.d.), and Chicago Botanic Garden (2016b).

Each botanic garden is, of course, unique including the staff and volunteers and the schools groups that visit. The education programme should relate to the particular ecological, economic, social, cultural, political and educational context of the garden. The example from Mérida (Case study 7.2.5) outlines the approach of a botanic garden in Mexico.

Before introducing a technological element into a school visit to a botanic garden, it is vital to ensure that this is adding a real benefit. A visit should be an opportunity to closely observe a rich variety of plant life. Mobile technologies used well can help to enhance this by encouraging students to look carefully and think about what they see. This can be as simple as using a camera on a phone to record specific examples or as complex as using a 'quest' application to set up a treasure hunt style activity. Attempts to create bespoke applications for use in gardens and museums have not proved lasting as yet. Although popular with students, the cost and overhead to learn a new system are not popular with teachers. More successful is to use technology teachers and learners are already familiar with and which is compatible with what they use in schools. So keeping it simple is generally more likely to succeed.

Information in the form of web content can be used to prepare for a visit. This is likely to be accessible to teachers and students prior to a visit, either at home or in school. Content they collect during a visit, in the form of photographs, short video clips or sound recordings and text can also be shared. This could be as simple as a digital slide presentation in response to a challenge set at the botanic garden, and shown to rest of the class, or a more complex presentation which is shared with the wider public via the botanic garden website. In the latter case, care would have to be taken to ensure children were not identifiable and parental permission had been obtained. The objective of producing such presentations and the prospect of an audience are both very motivating for learners.

CASE STUDY 7.2.5

Establishing a schools education programme in Mexico

Veronica Franco, Jardín Botánico Regional, Mérida, Mexico

In Mérida, formal education programmes are offered to organized groups, from a range of academic levels, who have scheduled a visit. They come with expectations related to achieving curriculum goals through the programme. The following points were considered during the development process:

1. Staff should have, or be trained in, basic teaching and learning skills. The Mexican education system has many challenges in achieving its education goals and educational approaches. Botanic gardens have good opportunities to design hands-on programmes focused on the plant displays and can plan programmes with relevant topics, goals and curriculum approaches, developing educational materials for teachers as well as for students. This requires people that know the collections and displays and the various teaching and learning approaches.

2. Programmes, whether facilitated or self guided, should link to the curriculum. Take time to analyse and become familiar with the current curriculum; this will help create relevant educational programmes. The impact of globalization on social and individual lifestyles, environmental problems, the use of new technology and changes in educational approaches amongst other issues are more and more related to the need for new paradigms in education models. Botanic gardens are well suited to develop innovative programmes that link these.

3. It is recommended to work in collaboration with the rest of your garden staff. Guided tours for groups will be enriched with the participation of all staff, not just those in education. Non-education staff may need basic training related to educational requirements, communication methodology and environmental interpretation.

4. Your education programme should be formally planned. This can include pre-visits by schoolteachers to the garden to get to know the site, exhibitions, facilities and the educational programmes. Where appropriate include follow up activities for the teacher to use back in school. This builds on the learning experience during the visit.

5. It is essential to have an evaluation strategy for your programme to help you analyse the impact that guided tours, activities, workshops, educational materials and other educational offers have on your target audiences. Evaluation strategies should be designed with visiting school staff to ensure appropriateness and effectiveness.

6. Provide essential information in your marketing. Clearly state how to arrive at the site with estimated drive times / distances and inform groups about the basic facilities on site (toilets, visitors centre, picnic areas, disabled facilities, medical services, etc.). Additional information should include activity / programme length, entrance fee / school group fee, hire costs for any kits or resources, attendance regulations and recommended behavior of schoolchildren on a visit.

Trained garden educators exploring plant growth with young students. (Image: Jardín Botánico Regional, Mérida)

7.2.5 Adult Education at Botanic Gardens

KEY MESSAGE

Botanic gardens are uniquely positioned to offer educational and enrichment opportunities for adult learners in horticultural, botanical, environmental, and related fields.

Staff and collections, and in many cases libraries and research facilities, provide the resources for the delivery of an extensive and diverse educational portfolio.

While approaches and audiences differ by type of botanic garden and their available resources, the provision of adult education programmes can fulfil mission-based and practical goals. Adult education programmes provide a context and opportunity to deliver targeted, content-specific programmes that support each garden's individual focus. Education programmes can also build or strengthen a garden's visitor and membership base by providing them with continuing opportunities for engagement, and creating a community of returning programme participants. This can result in increased public awareness and recognition of a garden in the outside community. Lastly, adult education programmes, if managed efficiently, can be a source of revenue, bringing in funds to cover staff time and contributing to the operating budget.

Audiences can be classified into three broad categories: individuals looking for personal enrichment, professionals continuing their education, and adults preparing for careers in gardening and horticulture. Adult education programmes can also be categorized into three dimensions: enrichment, professional, and career preparation. With the addition of lectures and symposia they may appeal to a variety of audiences. Casual learners often enrol in certificate programmes or professional courses, if they are looking for a greater level of expertise. The structure of courses varies from short courses (one or two class sessions of a few hours focused on a particular topic) to multi-week courses covering a topic in depth, to certificate programmes (multiple classes covering an entire domain). For example, the Chicago Botanic Garden offers short courses, multi-session courses and a certificate programme in garden design, providing opportunities targeted towards a wide variety of audiences (Chicago Botanic Garden, 2016c).

Audiences for adult education are diverse, so in developing a programme portfolio you must know your audience – who they are, their communities, their interests, and other local opportunities for learning. An audience profile can be matched to the garden's mission, resources and expertise to identify potentially successful programming opportunities. Resources might include collections, staff, infrastructure, technology, libraries, or ongoing research projects providing course content or support programme delivery. Once course content is determined, programme structure and delivery method should be identified – class size, length of each session, length of course, location, and resources needed. Content and the course format can be used to develop a business plan for implementation, ensuring that the course meets desired revenue goals. Finally, ongoing evaluation of students' experiences and revenue goals will ensure consistently successful and high quality programming. Evaluation can be used to fine tune programme offerings, and better understand changing audience preferences.

An adult education class studying gymnosperms. (Image: Chicago Botanic Garden)

Teacher and student teacher training

KEY MESSAGE

If you teach student teachers how to use the garden effectively for education, they will keep bringing their school groups back.

Several botanic gardens have experienced difficulties in supporting large numbers of school children due to staffing, space or budgetary constraints. Through teacher or student teacher training, participants trained are able to cascade the experience, skill and knowledge to their own students. The Royal Botanic Gardens Kew (Case study 7.2.6) have run a student teacher training course for many years and have developed an effective approach to course delivery.

7.2.6 Higher Education

KEY MESSAGE

Historically, botanic gardens have been used as key resources for the study of botany and biology. Today, this provision is enhanced by training students in science communication skills.

Many botanic gardens worldwide offer programmes for students in higher education as many botanic gardens are closely linked to or part of a university complex. The vital role that botanic gardens offer to students of the natural sciences as well as other disciplines are exemplified in Case study 7.2.7.

CASE STUDY 7.2.6

Student teacher training at the Royal Botanic Gardens, Kew

Gail Bromley, consultant Planting Values

The Royal Botanic Gardens Kew ran a programme developed with science tutoring staff from a leading UK teacher training institute, the Institute of Education (IOE). The four day programme was developed as an overview of how to use a botanic garden for secondary level (11-16yrs+) science teachers. The annual cohort of trainee science teachers (c80), spend day one participating in a rotation of workshops and discussion.

The workshops, which included activity hints and tips, games and other topics, focussed on current teaching / learning about:

- Plant adaptation to their habitats;
- The vital role plants play in our lives;
- Sustainability and plant conservation;
- Details of organising a class visit to the garden.

On day two, the students worked in small groups to:

- Plan topics / activities to be taught to a visiting secondary school class;
- Decide roles for each student teacher during the visit (activity deliverer, school contact person, resource management, etc.);
- Schedule and route plan the activities on site;
- Develop a Health and Safety plan;
- Agree on / produce resources needed for the activities;
- Develop a 'wet weather' plan;
- Agree on / develop an evaluation plan.

Each group discussed their plan with Kew education staff and their course supervisors to ensure they covered all aspects adequately.

Educators being trained to deliver science education. (Image: The Board of Trustees of the RBG, Kew)

Days three and four were used for the delivery and assessment of the student teacher led activities. Secondary school classes were enlisted (free) to trial the student teacher led activities. Each group delivered their activities to the school children, repeating their activities with three or four groups.

The activities were observed by Kew and IOE tutoring staff. Post-activity discussion sessions were also held with the school teacher attending with the school group. The student teachers collected evaluation data from their groups and carried out a self evaluation of their delivery / impact. Observational / evaluation notes and reflections on the process were discussed during a final plenary session.

The IOE was charged for this programme offer, bringing in good revenue. A shorter programme has also been provided to other teacher training institutes for student teachers of Geography, Mathematics and History. It can be adapted to any subject where plants can be introduced, e.g. art, technology, citizenship.

This student teacher training programme builds knowledge and confidence about the value of visiting a botanic garden and provides an excellent incentive for the later qualified teacher to visit a botanic garden with their own schools.

CASE STUDY 7.2.7

Hortus Botanicus Vindobonensis: a training and education resource for university students

Michael Kiehn, Botanical Garden of the University of Vienna, Austria

The Botanical Garden of the University of Vienna (HBV, Hortus Botanicus Vindobonensis) is a core facility of the Faculty of Life Sciences. The HBV acts in close collaboration with other departments of the Faculty of Life Sciences, especially at the Rennweg site. The garden links botanical science and conservation issues with art, politics and society for the general public (c. 200,000 visitors annually), providing school programmes, exhibitions, plant displays and events.

As a university garden, the HBV is especially engaged in higher education. Two major areas of activities can be identified: the garden provides plant material for university courses and research projects and acts as a platform for teaching botany/biology in theory and practice. The quantity and quality of plants provided for courses is remarkable: the HBV cultivates and/or organises plants for c. 30 courses annually, including general identification courses as well as special lectures or seminars on plant morphology or phylogeny. In addition, a number of research projects depend on material cultivated in the HBV. Per year, c. 8,000 whole plants and plant pieces of c. 400 species are provided for these purposes. To optimize logistics of this plant supply, the HBV has started a new database system where requests can be logged for taxa required.

The platform for teaching in theory and practice is provided through different university seminars and lectures developed by garden staff, allowing an effective use of the garden collections and expertise. These courses are offered for all types / levels of biology curricula of the University of Vienna and are relevant for both future researchers and future teachers. Courses are directly linked with garden activities and include options for the students to get directly involved in the practical work of the HBV or to continue work on subjects dealt with in the context of Master- or PhD-theses.

The garden-related courses divide roughly into two types: (a) plant-based hands-on approaches to botanical research, and (b) science teaching experiences based on botanical objects and questions. In both course types, practical botanical training and knowledge transfer, leading to applied insights into theory and practice of scientific work in botany, form the basis of all work. An example of the first type of course is the lecture 'Higher Plant Diversity and Phylogeny'. The target audience is students in the Bachelors-curriculum of biology with specialization or interests in botany. The course structure provides training in important skills including careful, theory driven observation, comparative analysis, development and testing of scientific theories and hypotheses, and critical discussion of findings. The second course type, offered each semester, is a series of science education seminars, e.g. 'Central Topics in Biology and Environmental Sciences: Environmental Protection', from which student teachers select a range for their study. Each student teacher makes a presentation based on the lecture series theme, along with their presentation development plan. Post-presentation, the student cohort discusses the scientific content and presentation skills. The seminars are also open to other biology students. This example of 'added value' incorporated in the HBV-related courses provides opportunities to connect experiences gained in these courses with later work in science-communication or research projects. A number of Master-theses on the potentials, structures, and topics of outreach activities of the HBV have additionally resulted from student involvement in garden-related courses.

In summary, the HBV higher education programme is set up to improve scientific and science-education skills of biology students, from a range of biological disciplines, by incorporating them into the practical work of the botanic garden at all levels.

Training for future teachers: students explain aspects of woodland ecology at the botanic garden to a school class. (Image: R. Hromniak)

7.2.7 Evaluating Educational Programmes

KEY MESSAGE

Evaluation provides information for communicating to a variety of stakeholders and can show the worth of programmes.

Evaluation is often seen as being synonymous with the measurement of outcomes and can be considered as both, a tool and a process. It is an important aspect of the development of all avenues of work, including education programmes, activities and interpretation. Evaluation tools also offer a mechanism for monitoring progress and therefore enable reflection amongst practitioners leading, if necessary, to changes and developments in programme structures. Opportunities for reflection can also help the programme developers identify unanticipated outcomes, or factors for success not previously recognised. Evaluation is therefore a constant process of reflection and adaptation for improvement – a cyclical process as shown in Figure 7.2.2.

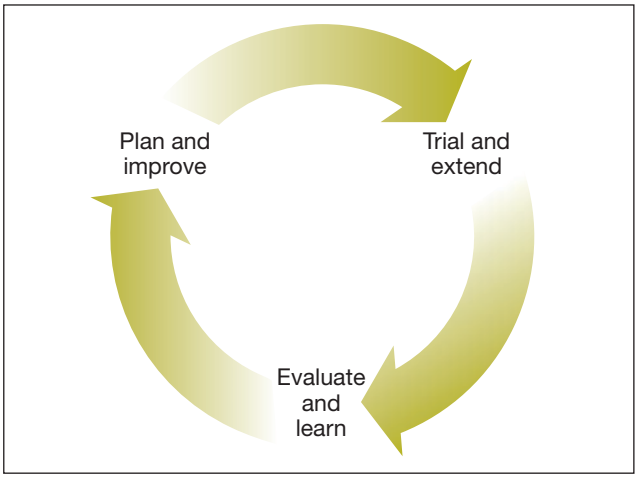
In essence, evaluation supports informed decision-making about how to spend your time and money. It does not have to be expensive or time-consuming; it is about proving what works for your visitors and what does not. There are a variety of approaches and methods for conducting evaluation and monitoring impact in informal science education settings.

1. Types of evaluation

Front-end evaluation describes the processes of determining what the target audience already knows and what they are interested in. It involves checking that proposals and ideas for events and programmes are appropriate and are likely to be well received.

Formative evaluation involves testing early versions of a programme to check whether it is going to plan (known as a process evaluation) or that it will meet its objectives or goals (progress evaluation).

Figure 7.2.2. The evaluating interpretation cycle



Summative evaluation describes the process of gauging the impact or success of the finished product, often against pre-determined performance indicators.

Remedial evaluation describes the process of conducting a final review and making amendments or remediation as necessary prior to completion of a programme or project.

Action evaluation involves identifying the aim of a programme or event before explicitly identifying the ways in which progress towards this will be monitored, including the evaluation tools to be used. At this point the design and structure of the programme can be finalised and the mechanism for monitoring the activity becomes an integral part of the activity's implementation (Stroud *et al*., 2007). It has become accepted wisdom to incorporate evaluation at the start of a project rather than just at the end.

2. Evaluation strategies

The whole process is based on social and market research methods and can include aspects such as:

Evaluation and testing: looking at the impact of your programme or activities at a specific point in time.

Monitoring: counting things, e.g. visitors and ensuring things are on track all the time.

Consultation: talking to your current or potential visitors about your plans.

Quantitative evaluation focuses on aspects of impact that can be measured numerically, such as how many people attended, and can offer a broad overview of impact. It also describes types of questionnaires or feedback forms where limited choice answers (closed questions) are used, such as yes/no or agree/disagree.

Qualitative evaluation seeks to uncover the detail of particular actions such as what did the participants or audience think about a programme. Techniques include open-ended interviews and observations.

3. Methods of evaluation

Examples of evaluation tools include traditional approaches such as recording numbers attending, or length of press columns covering the event, as well as participant observations, snap-shot/full interviews with visitors, feedback questionnaires and 'reflective journaling' – notes made by practitioners regarding the nature and structure of observed events which build upon the individual's own professional knowledge and experience as a botanic garden educator. Modern technology can also be employed, such as using a sophisticated Global Positioning System, to digitally track how visitors move around your garden. Alternatively, you can simply observe how visitors use an interpretation panel, trail or plant labels. It is worth noting that the reliance on one tool only, will limit the breadth of any analysis; overuse of qualitative tools at the end of every programme or event can result in a declining response rate, and degree of depth.

Surveys are useful for obtaining a wide range of answers from a large number of respondents.

Interviews offer an opportunity for participants to express their own opinion rather than being confined to a set of responses as in a survey. The disadvantages however, are that some respondents try to please the interviewer rather than offering genuine views and time is required to analyse the data.

Focus groups comprise groups of 6-10 people gathered to discuss particular topics, facilitated by a researcher. They allow the generation of data through group interaction, as people bounce ideas off each other, and are useful for identifying the strengths and weaknesses of a programme.

Observations of participants in a programme (including overheard comments) offer an understanding of the wider context and may help identify unanticipated problems or outcomes.

Open-ended written or drawn responses from questions such as 'describe your reactions to…' offer insights into the ways a programme is being received.

Issues to consider in conducting evaluation:

- Follow ethical guidelines regarding the collection, use and storage of data. For more information see BERA (2011).
- If appropriate, ensure that participants' responses are kept confidential.
- Consider whether questions are appropriate and culturally sensitive, also be aware of what people do and do not say and look for non-verbal responses.
- For greater reliability, obtain as large a sample size as possible.

Above all your evaluation must be tailored to what you want to know and who you are asking. Answer the questions below to help you plan your evaluation.

- What do you really want to know?
- Who can advise you on how to answer these questions?
- Which evaluation techniques can you use?
- Do you have the skills and capacity to carry out an evaluation or do you need help?
- Who will read your results and how would you like them to be used?
- How can the results help to improve future activities?
- Have you thought about any legal or ethical considerations of your evaluation?

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7.3 PUBLIC ENGAGEMENT – INTERPRETATION

Gail Bromley, Planting Values; Asimina Vergou and Liliana Derewnicka, Botanic Gardens Conservation International; Angela McFarlane, College of Teachers; Pat Griggs, Astrid Krumins and Julia Willison, Royal Botanic Gardens Kew; Kate Measures, Heritage Insider

7.3.0 Definitions

Audience development: Audience development incorporates all of what we need to do in order to build and continually nurture supportive and loyal audiences. It is occasionally used when just referring to building new audiences or engaging hard to reach audiences.

Audience research: Any communication research that is conducted on specific audience segments to gather information about their attitudes, knowledge, interests, preferences, or behaviours, so as to better design targeted interpretation or educational programmes or materials.

Co-creation: Co-creation is a process where the interpretative staff and key stakeholders actively involve their targeted audiences in the development of the interpretative concept, its design and delivery.

Demographic: The statistical characteristics of human populations (e.g. age, educational level, income) used particularly to identify markets or audiences.

Focus groups: A group of people assembled to participate in a discussion about your interpretation or education programmes, usually at concept stage and before ideas are fully developed or a group to provide feedback on a particular issue or campaign.

Public programmes: Events or educational activities to engage the visiting public, usually informal.

User group: A set of people who have similar interests, goals or concerns and who meet regularly to share their ideas.

Wayfinding: Signs, maps, and other graphic or audible methods used to convey location and directions to garden visitors.

Zoning: Interpretative zoning in the botanic garden is a process of separating out particular sections of the garden to provide certain experiences, e.g. an arrival zone where visitors feel welcomed and can plan their visit. Zoning also provides a way of ensuring that particular areas within your garden appeal to a particular audience.

7.3.1 Introduction

Botanic gardens and arboretums worldwide attract millions of visitors per year. Collectively, they are well-placed to showcase to their audiences the interrelationships among plants, animals and humans and their interdependence.

Interpretation is an essential element of a botanic garden making it different from a park. It connects the garden to its visitors, adds to the visitor experience, helps to develop new audiences, inspires people's interest in plants, makes the collections meaningful and helps gain public support.

Interpretation is not synonymous with signage. It has an educational role, acting as facilitator, enhancing audiences' experiences and enabling them to construct meanings related to botanic gardens and their plant collections. Tilden (1957), one of the first advocates of heritage interpretation summarises: *'Interpretation is an educational activity which aims to reveal meanings and relationships through the use of original objects, by first-hand experience, and by illustrative media, rather than simply to communicate factual information…'*

The development of interpretive materials should be informed by current theories about how people learn when they visit botanic gardens (physically or virtually). The nature of learning in botanic gardens, if we exempt the highly structured school visits, is in general free-choice; this means that *'the learner exercises a large degree of choice and control over the what, when and why of learning'* (Falk, 2005).

Research (Ballantyne *et al*., 2008) has found that motivations for visiting a botanic garden include the aesthetic value, spirituality, tranquility, recreation, for social interaction, and an interest in gardens, horticulture and plants. Learning does not usually come high in the usual visitor's agenda, posing a challenge for botanic gardens.

A garden is like a 500-piece puzzle and what visitors see as they move through the grounds may very well be these puzzle pieces in random order (Veverka, 2005). An interpretation master plan helps a garden to organize their main messages for visitors, making them clear during a visit; it also helps deliver the messages at key interpretive points.

This section introduces the principles underpinning interpretation in botanic gardens, how these can be adapted and extended to create highly effective learning environments.

Interpretation at the Botanic Garden Meise, Belgium. (Image: Botanic Garden Meise)

7.3.2 Characteristics and Principles of Effective Interpretation

KEY MESSAGE

Interpretation should:

Provoke (a response to an image, caption, idea)
Relate (speak to the individual or connect with their everyday life)
Reveal (the meaning, answer or result in a surprising way)
Address the Whole (through one unifying theme)

(Veverka, 2011)

Successfull interpretation:

has a theme
is organised for easy processing
is relevant to the audience
is enjoyable to process

(Ham, 2013)

There is still a great fear amongst some curators that making it easier for visitors to understand the ideas that collections represent and that exhibitions tackle will initiate a slide into poor scholarship, facile interpretation and mindless entertainment. This fear must be converted into an understanding and appreciation of the desire of a great many people to like museums and to find them both useful and enjoyable. Hooper-Greenhill (1994)

This curatorial fear also arises when interpreting botanic gardens' collections for the visitor; however by following the good principles and practice in this manual this fear can be mitigated.

Two excellent evaluation surveys of interpretation are Veverka's 'Visitor Center Evaluation Strategy' (2011b) and Masters and Carter's 'What have we got and is it any good?' (1999). Within the Masters and Carter's survey, assessing readability (the ease of reading and understanding text) can be quickly done using an online SMOG (Simplified Measure of Gobbledygook – unintelligible jargon) calculator (NIACE, 2009). A SMOG score of 10-12 (approx. ages 11-13 lower secondary level) is Masters and Carter's ideal level for interpretation to reach most people). By utilising these various tools, a good grounding is gained in understanding what makes an effective piece of interpretation and of course what does not!

7.3.3 How to Start Your Interpretative Journey: The Master Plan

KEY MESSAGE

The interpretative master plan details what messages and themes should be provided for the visitor, what outcomes are hoped for (a change in attitude or behaviour, support for the botanic garden, etc.) and how best to achieve this.

The interpretation master plan should be an integral element of the overall strategic plan for your garden. For newly established botanic gardens, or those that are re-landscaping or redesigning an area, this is an ideal time to integrate your interpretation plans (Chapter 1, Section 1.5.4).

Interpretation master plans should start with an inventory of the garden site including landscaping, key features, key equipment / techniques on public view and the plant collections available for display. Once you know what you have in the garden, it is easier to decide what can be used effectively as the stimulus for any stories you want to tell.

The interpretation master plan should be comprehensive and address the following points:

- Aims and objectives: What will be the outcome of people engaging with your interpretation? There needs to be a point to it!
- Audience development: Who are you planning to engage with this interpretation?
- What are the key messages that you want to get across, e.g. the vital importance of plants?
- What stories can you tell to get your message across?
- Types of interpretation: What is/are the most appropriate method/s to convey your message? Does that method work for the site where you are placing your interpretation?
- Themes: How can you achieve cohesion across your interpretation? Individual interpretative items should fit together to make up the 'big picture'.
- Does the interpretation match your 'brand', e.g. the tone of voice, colour considerations, style.
- Co-creation / participatory approach: Who will develop your interpretation? Is it just being managed by your in-house team, or are you going to involve any of your target audiences?
- How can you build on your interpretation? Can you reinforce the messages through other media, e.g. text on serviettes in the cafe; strap lines on literature.

Examples of interpretation master plans can be seen in Çevik (2013) and in resources from parks and recreation sites (CSP, 2016; Wells *et al.*, 2009). At the Royal Botanic Gardens Cranbourne, staff worked cross-departmentally to develop an excellent interpretative master plan for their Australian Garden (Case study 7.3.1). Wakehurst Place in Sussex, United Kingdom (Case study 7.3.2), explores how an interpretative refresh can be developed efficiently and with a limited budget.

CASE STUDY 7.3.1

Interpreting the Australian Garden at the Royal Botanic Gardens Cranbourne

Sharon Willoughby, Royal Botanic Gardens Cranbourne

The 15-hectare Australian Garden (AG) sits at the centre of the Royal Botanic Gardens Cranbourne. Sitting on the fringe of the suburbs, this significant patch of remnant bushland is an ark of biodiversity in a rapidly developing area of Cranbourne, NSW. Constructed between 2006 and 2013, the design of the AG created a revolution in thinking about the role of Australian native Botanic Gardens. The AG is striking and bold, rich with the colours and textures of the Australian landscape, a showcase of Australian native plants.

When funding became available, the Public Programs team developed and delivered the interpretation master plan, setting out what stories to tell visitors, plus where and how. A multi-disciplinary team was established to develop the interpretation master plan for the AG (Veverka, 1994). A mix of perspectives from horticulture, marketing, public programmes and plant sciences proved invaluable in understanding the AG in a number of different contexts.

Laying the draft garden designs out on a table and 'virtually walking' around them with marker pens imagining we were a number of different user groups helped us to understand the plans and the ways in which visitors might experience the garden. It allowed us to see where visitors would need seats, information signs, maps, drinking fountains and other services as well as letting us think about which senses we might activate at any given point. We also considered other ideas, e.g. photo opportunities and placement of fragrant plants (Sensory Trust, n.d.).

The typical visitor to an Australian botanic garden is over 55 years old, of Anglo-Saxon/Celtic origin, female and tertiary educated. We wanted to broaden this audience and attract new visitors. By comparing the demographic data of visitors coming to Cranbourne Gardens to the demographic profile of surrounding suburbs, the current audience gaps became evident. We prioritised young families with new houses and empty gardens, and to attract them, developed programmes of particular appeal to them.

The Scribbly Path, Cranbourne. (Image: Royal Botanic Gardens Victoria)

Working with designers, we created a set of sign types for the AG including plant labels, directional and interpretation sign-boards. This allowed us to plan more effectively as we knew sign costs, production times and word counts before starting to write anything, saving time and money.

What stories, plus where and how, to tell visitors, is more of an art that a science and having a multi-disciplinary project team helps. Appealing to hearts and minds is key; engaging visitors with cultural stories about plants, creating moments of fun and laughter and provoking curiosity through the unexpected. The AG was created to inspire visitors to use and grow Australian native plants in their home gardens. The garden also wanted to interpret the work of a modern botanic garden, highlighting conservation and plant science. Built during a decade long drought in Southern Australia, issues such as water conservation, climate change and sustainability were also important. →→→

The Red Sand Garden, Cranbourne. (Image: Royal Botanic Gardens Victoria)

CASE STUDY 7.3.1 (CONT.)

We used a thematic planning approach, linking stories or conversations that we wanted to share with our visitors in each area around an overarching theme. All the stories in the AG sit under four topics: plants, water, culture and home gardening. Colouring in a plan with these topics ensured that we had a good mix of stories across the landscape. Each topic concludes with questions about the future, enabling us to round out these ideas and keep them fresh. Working out how to deliver these stories was the next step, for instance we decided that the 'home gardening' theme was best delivered by face-to-face interpretation. This led to the establishment of a volunteer Garden Ambassador Programme. We recruited knowledgeable home gardeners to talk to visitors about gardening with Australian native plants.

Now that most of the interpretation master plan has been delivered, we are assessing what visitors take home from their visit using two strategies: a) After events we ask visitors to complete an evaluation form in return for a small prize; b) We are exploring visitor perceptions of the AG and whether we are influencing how they garden.

The Future Garden, Cranbourne. (Image: Royal Botanic Gardens Victoria)

CASE STUDY 7.3.2

From check-in to check-out – refreshing the Millennium Seed Bank visitor offer

Astrid Krumins, Royal Botanic Gardens, Kew

Kew's Millennium Seed Bank Partnership (MSB) is sited in Wakehurst Place, West Sussex, England. Wakehurst is RBG Kew's 465 acre country estate with a stunning combination of botanical gardens, mixed woodlands and Sites of Special Scientific Interest focused around an Elizabethan mansion and the MSB (RBG Kew, 2014a). The MSB is the largest *ex situ* plant conservation project in the world; saving and conserving seeds outside their native habitat. With its partner countries it also undertakes *in situ* conservation, restoring and conserving species in their native habitats. Its focus is on conserving global plant life that is a) endangered b) endemic or c) has economic value. With support from partners across 80 countries, it is on the way to bank 25% of the world's wild species by 2020 (RBG Kew, 2014b). Visitors include general visitors to Wakehurst Place as well as education groups (upper primary, secondary and university).

The interpretive displays had not been updated since the MSB opened in 2000; the interpretative focus was then on the collection and storage of seeds ('check-in'). Since 2009 the focus of the MSB has shifted to include using the seeds back in the wild for habitat restoration, agriculture, forestry and improving livelihoods ('check-out'). These stories now needed to be told.

A detailed audit of the existing interpretation was undertaken, based on Veverka's 'Visitor Center Evaluation Strategy' (2011) and Masters and Carter's 'What have we got and is it any good?' (1999). Additionally, a visitor survey on the current offer was commissioned.

A small in-house project team (project manager, head of content, head of design) was established to implement as many of the low cost, quick-win recommendations from the audit and survey as possible. A Project Board and other MSB, Wakehurst and Kew staff supported the team. The main audit and survey recommendations were: improve the readability of the text for non-specialist audiences, introduce family friendly sections, introduce colour, improve external and internal wayfinding, update images and stories, include 'check-out' stories, provide context to the seeds, make the experience feel more welcoming, provide face-to-face contact and include some hands-on activities for both adults and children. →→→

New wedge shaped panels showing 'Check in' seed processing. (Image: Anne-Catherine Sheen)

CASE STUDY 7.3.2 (CONT.)

The project constraints included a restricted budget of £20,000 to cover all external requirements i.e. print, production, installation, removal of old hardware and commissioning of visitor research. Job commitments had to be put on hold or delegated for 6 months to allow the project team to work. There could be no infrastructural changes and no additional lighting, heating or audio visual equipment. Due to lab layout, the linear journey the seeds make through the processing labs to the vaults had to be kept and a multi-purpose space, the central area needed to be kept clear for large gatherings and events.

The new interpretative approach fulfilled many of the recommended changes. In the central area of the visitor gallery, colour was added through images of banked seeds with interesting stories. A team of Volunteer Explainers were recruited and trained to engage with visitors and provide access to handling objects; this face-to-face interaction is especially important when no scientists are visible in the labs. Colour-coded headings to the labs were added, making it easier for the visitor to orientate themselves at each stage of the linear seed journey. The colours linked to the new interpretation panels which explained each stage.

The central box exhibits were removed giving increased space for events and a useable central surface. Wedge shaped panels were used in front of the MSB lab windows; tilted to make them accessible for wheelchair users. Key pieces of equipment visible in the labs were labelled to link to text and where suitable, family-friendly sections denoted by the magnifying glass symbol were added to the interpretative labels.

Interpretation in the central visitor hall area of the MSB after the renovation. (Image: Anne-Catherine Sheen)

7.3.4 Audience Research and Development

KEY MESSAGE

Knowing which audience you are targeting is critical for developing relevant and effective interpretation.

Botanic gardens are learning how to ask questions of visitors and use their learning to strengthen interpretation and education offers, formulate marketing strategies, improve visitor services and reach new audiences. Initial audience development research may include:

- The total number of visitors;
- The socio-economic background of the visitors (age, gender, etc.);
- Visit motivation (e.g. free entry, tranquillity, child friendliness, etc.;
- Visit schedule (time / day / season);
- Time spent;
- Places visited;
- Address / email.

This can be done by visitor exit surveys, visitor interviews or questionnaires, focus groups or telephone / on-line surveys if you have already have contact details captured.

The questionnaires and interviews can be supported by volunteers or intern students provided they have been trained. Focus groups are best done by external professionals.

7.3.5 Catering for Hard-to-Reach Audiences: Broadening Participation

KEY MESSAGE

Botanic gardens have a social responsibility to be accessible to all.

The audience development process will highlight a number of audiences that for one reason or another may not visit your garden. This may be due to cost (e.g. families on low incomes), lack of knowledge of the site due to language barriers or ethnicity / cultural background (e.g. refugees) or issues with physical or intellectual access. Some may have the perception that a botanic garden is just not for them (Section 7.4).

Making the botanic garden physically accessible will not only benefit those who have impairments, but often improves the visit experience for others – mothers with pushchairs or the elderly. Garden features should be easily navigated by visitors with mobility problems. Consider the positioning of interpretation. Is it too high for wheelchair users? Do you have staff trained in sign language or offer additional visual stimulation for those with audio impairment? Do you offer tactile interpretative experiences or audio interpretation for those with visual impairments? The Scottish Natural Heritage (2016), and Paths for All (n.d.) offer online resources on this matter. Each country usually has its own legislation and permissible design strategies for public spaces and exhibitions.

Prague Botanical Garden has a trail for the visually impaired using the wooden posts that line the route through the southern area of the garden and which carry their standard visitor interpretation. At the back of each post are metal panels with the same information in Braille. The garden additionally has a tactile display area where visitors can explore some of the botanical artefacts. The garden aims to enhance the trail by including acoustic guidance to make the location of each post simpler, accompanied by orientation maps specially designed for the visually impaired.

7.3.6 Botanic Garden Location and Zoning

KEY MESSAGE

Botanic gardens have a social responsibility to be accessible to all.

Signage, visitor information desks and clever layout of pathways may help 'direct' visitors to areas you want them to see, but visitors often randomly wander around the site. Multiple entry gates to the garden make it almost impossible to ensure that visitors are steered to specific displays. Finding out where visitors gather in cafes, play areas or glasshouses; and knowing which plants/landscapes (hot spots) offer the best wow factor is useful. Another consideration is how much interpretation to put out. People do not always want a sea of labels or to be confronted by a costumed interpreter; they may prefer to interpret the collections by themselves. Provide some tranquil and reflective zones in your garden where visitors can relax and just enjoy the space. Westonbirt Arboretum in the UK developed their 'zoning' strategy to ensure that the needs of their varied audiences were met (Case study 7.3.4).

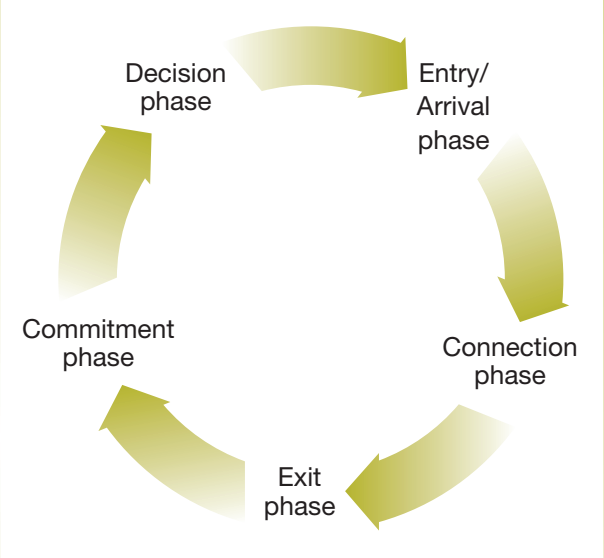
CASE STUDY 7.3.4

Get in the zone – Westonbirt, The National Arboretum, Gloucestershire

Ben Oliver, Westonbirt, The National Arboretum

Numerous studies confirm the importance of visitor motivations and expectations to the success of interpretation (Falk, 2009; Davies, 2013; McIntyre, 2013), but how do we ensure different audiences know what our gardens have to offer them? Site zoning is an effective tool for organising spaces and experiences so that visitors are able to make informed choices about where they want to go and what they want to see, so organise your site from (pre) start to (post) finish.

Experiences begin with a decision to visit. The arrival phase prepares the visitors for their day; welcoming them and setting the stage for the visit. Signage, landscaping, architecture and traffic flow, amongst other items, create a rich introduction for the experience ahead. Central to the visit is the connection phase, when visitors engage with the collections. If the decision and arrival phases are right, visitors will have made informed choices about how they want to engage with the collections and know exactly where they want to go. An organised exit experience invites people to return and get more deeply involved. The commitment phase is the follow-up; perhaps an e-newsletter or invitation.



Brochu's visitor experience model (the VEM)

In 2014, Westonbirt created a new visitor arrival zone to help orientate visitors on arrival. Entering through our Welcome Building enables visitor access to interpretative displays and trained volunteers, providing them with a clearer picture of what Westonbirt offers and, more importantly, how they can personalise this offer to their needs. The Welcome Building also acts as the defined exit point, to re-engage with visitors as they leave. →→→

CASE STUDY 7.3.4 (CONT.)

A new map subtly zones the arboretum and highlights particular features of interest. It defines areas of ornamental and native planting, helping visitors distinguish between formal and informal gardens. First time visitors are shown the key 'collection' experiences; regular users looking for a quiet walk are catered for by highlighting more secluded areas. Sites of special interest are identified with monograms, which also feature on site signage. The map is regularly updated to flag up seasonal hotspots.

The VEM should be used for individual interpretation projects. It is easy to forget the importance of a proper arrival to displays; we got engrossed in developing a new propagation viewing area but forgot to invite visitors in. As a result, evaluation showed that many people did not enter the area as they thought it was 'out of bounds'! A simple sign encouraging people to come in has rectified this.

Zoning ensures interpretation is located sensitively and where visitors are likely to engage with it. Through VEM, Westonbirt is zoned from intensive high use areas, with more interpretation, to 'wild' natural areas where visitors are seeking to escape (very limited/no interpretation). Similarly, seasonal rhythms influence visitor behaviour; seasonal zoning through trails, 'what's out' notice boards and themed guided walks cater for visitor preferences and ensure a constantly changing offer; a key requirement for a site with 70% repeat visits. Using visitor interests to zone/locate interpretation has dramatically impacted on how much they engage with our interpretation and reduced complaints about inappropriate interpretation. Visitor evaluation shows that certain tree specimens have a wow factor that makes visitors stop. Simple 'key tree' boards identifying these specimens have proved very successful.

Lastly, zoning allows the various audiences different experiences without causing conflict. An example of this is our family play trail. By positioning activities in quieter shelterbelt areas near, but not in, ornamental areas, families are able to have a bespoke hands-on experience alongside our more traditional audiences. Our play trail helps overcome parental anxiety by giving families their own space and clear rules on issues such as climbing trees, making dens or picking up natural objects.

Overview of Westonbirt site with new zoning for visitor arrival and departure. (Image: Forestry Commission)

Westonbirt map highlighting 'hotspots'. (Image: Forestry Commission)

7.3.7 Developing the Right Approach

KEY MESSAGE

Visitor's learning styles differ widely. Some visitors prefer visual stimuli, some audio and yet others learn best when they are actively encouraged to do something (kinaesthetic learners).

1. Face-to-face interpretation

Visitors enjoy 'face to face' interpretation, giving them the opportunity to ask questions, dig deeper into topics or directly handle artefacts or resources given to them by guides or interpretative staff. The personal interpretation by a guide or costumed interpreter is often cited as bringing a topic to life.

Many botanic gardens have face-to-face interpretation, using either volunteers or paid staff as guides. At the University of Oxford Botanic Garden, their (Plant) Family Days engaged audiences by focussing on a single plant family. The garden-trained, costumed actors played the part of historic plant collectors, botanists and scientists, engaging families by strolling round the plant collections talking about such subjects as how the potato first came to England or how they used medicinal plants in the 18th century. Contemporary botanic garden illustrators were also encountered in the garden, illustrating plants from the plant family being celebrated. Visitors could chat to them and have the plant characteristics explained – or try drawing themselves. These personal interactions proved hugely popular and each Family Day was richly augmented with family picnic foods made available using some of the foods or flavourings that originate from the designated plant family.

Several botanic gardens run themed tours, seminars or lectures on a range of topics such as 'Fungal Forays', 'Celtic Trees' and 'Poisonous Plants'. Many also offer 'behind the scenes' tours, showcasing rarely seen collections and the work that goes on behind closed doors. This encourages other staff, such as scientists and horticulturalists to engage visitors with personal anecdotes and amazing facts about the collections. Chicago Botanic Garden, and the National Tropical Botanical Garden (n.d.) in Hawaii are examples of gardens that run such tours. Tours for young children often prove very popular as well; Royal Botanic Garden Edinburgh (2015) and Wakehurst Place (n.d.) use their 'green fairy' tours to engage tiny tots!

2. Non-personal interpretative media

There is a large range of non-personal interpretative material, including brochures, posters, labels and panels, audio guides, trails, touch trolleys and activity stations, exhibitions and, increasingly, technological interpretation media such as smart-phone apps. Each of these applications has strengths and weaknesses which should be carefully considered before application. Considerations include ease of updating information, durability, accessibility and management, e.g. Can you mow round this panel? Can you water near this electronic interactive? Is your Wifi coverage good enough? Is this sign easy to clean?

3. Interpretation and technology

Currently, many sites are considering interpretation through technology, however screen based technologies in botanic gardens are a challenge. If outdoors, they must be able to withstand wet, cold and extreme heat, as well as general wear and tear. Screens which are not working or show out of date content are a sorry sight, so before embarking on a screen based installation it is vital that there is a maintenance budget which includes refresh of content as needed. Screens readable in daylight are now more common, but are costly. Sound can also be an issue as hearing a sound track against background noise can be difficult; headphones are an option, but again subject to weather and wear and tear.

An alternative to providing static screens is to offer content for personal mobile devices, although to work well the garden needs good mobile signal coverage. A trial of bespoke devices at RBG Kew was reasonably popular when free, but not something visitors would pay to use. An 'app' which offers free content to smart-phones proved more effective in terms of reach, although again paid for content was less popular. The advantage of such content is that it can be updated readily so is always current and can be made location relevant. As their Smartphone is with the visitor at all times, content can be called up as and when required or prompted by on site signage. The development costs are significant, and early research suggests many visitors see a trip to a botanic garden as an escape from technology, especially for their children. At the Royal Botanic Gardens, Kew, the App proved most popular with frequent visitors and took many to parts of the gardens not previously discovered (Waterson and Saunders, 2012).

4. Choose stories well

KEY MESSAGE

Telling strong stories is a wonderful way to engage the public; a simple message is most effective in communication terms so don't try to tell everyone everything.

Once you have your take home message (theme) for interpretation you need the best story to deliver your message. Interpretation should reveal the significance of your story and provide more impact than simply stating facts. Translate technical terms and concepts into language that non-scientists can engage with. Try to get your main message across quickly and then reinforce it, at the end of the panel or talk. Do not rely on words – use photos, drawings or cartoons. Ask questions, encouraging visitors to discuss your messages amongst themselves. Providing interpretation where the visitor can participate or contribute encourages critical thinking and reflection. Give specific examples rather than abstract ideas: talk about an area of rainforest equivalent to two football pitches disappearing every second. If you're describing work on the Apiaceae, mention a member of the family that your audience might know, such as coriander. Avoid 'scientific language' and jargon, make your words personal and involving, and use humour whenever possible. If someone laughs at your story, they'll probably remember it. Try to write active phrases, for example '*the plant grows*' rather than '*the plant was found growing*'. Not only is this easier to read, but it saves on

numbers of words too! Whenever possible try to ensure that you provide details of a webpage or other source of further information. Then all those people who have been inspired by your interpretation can find out more.

The Care for the Rare project (BGCI, n.d.) has developed clear messages and great conservation stories that can be adapted to any botanic garden. Choosing a catchy title for the panels, and layering the information to make it easily digestible, is good practice. In the panels, some provide information on individual iconic species while others address the importance of plants and plant conservation. Templates of these panels and the logo are available to download for use by any garden across the globe.

A recent advancement in content development for interpretation is co-creation, where the garden interpretation team works with the audiences (both existing and new) to create content together and sometimes the design and the interpretative outcomes as well. The co-creation process, which until now has been mostly adopted in museums, can be quite open, allowing the outputs to develop across the project or be produced within a framework. This process often provides interesting and relevant material with a very fresh perspective, however it is a process that needs brokering and one where the expectations of both the audience participants and the garden staff must be sensitively managed. Govier (2009) discusses co-creation benefits and issues and presents relevant case studies.

7.3.8 Managing Interpretation

KEY MESSAGE

Labels and panels need regularly checking for repairs, cleaning or replacement; time for this should be built into volunteer roles /staff job descriptions.

Interpretation needs managing and maintaining. This requires a dedicated member of staff, or a team, that works continuously to develop and enhance your interpretation. The skills for interpretation delivery include planning, evaluation, theme development, content development and text writing. Both initial and continuing training is needed for those working with face to face interpretation, e.g. guides, to ensure programmes are up-to-date with both content and communication skills.

Weather conditions, price and availability will often limit the materials you can use in the garden. For non-personal interpretation there are a number of materials available including bespoke technological / digital solutions, vinyl, enamel, glass, wood, stone, aluminium, resin and laminates as well as paper. Interpreters from a number of sites across the globe share their choices in Table 7.3.1.

Table 7.3.1 Interpretative materials for labels and panels

RECOMMENDATION	CONTRIBUTOR AND COUNTRY
Digitally printed vinyl (with artwork and printing being done in house where possible): lasting 5-7 years (RBG Sydney have used brands such as Versatec and Polycure). These can be applied to metal frames and changed as needed. For longer lasting interpretation – etched anodised aluminium signs can be used.	Janelle Hatherly, Education and Interpretation Specialist, Australia. Region with temperate climate and mild winters.
Black etched on aluminium is longest lasting If staffing time allows – regularly replaced laminated signs work well (n.b. laminated signs disintegrate after a year or two).	John Roff, South Africa. Wet temperate climate.
Large signs: laminated A3 sheets attached onto permanent supports with double-sided sticky tape. This is cheap and easy and we use the A3 printer and an A3-plus laminator on-site. Laminated properly, these last for a year, snow and low temperatures not being a problem at all, however they fade, particularly in the sun, lose gloss and become dirty, so they are changed annually. A3 and A2 format in PVC plastic has been tried outside, however these also need changing annually and are more expensive. Large banners for exhibitions and temporary navigation are made from thin and supple double-sided plastic attached to frames on eyelets. These will last through a cold winter. Permanent plant name labels are A6, printed on plastic and attached to a thin aluminium angle bar with two rivets. The upper bar end is straightened and inclined at 30 degrees, the lower is cut at a sharp angle to go easily into the soil. The bar itself is of different length depending on whether it's destined for a tree, a shrub or a herbaceous plant. These last for 3 years and longer, unless broken or scratched and are easy to wash (better with a pressurised jet than a cloth to avoid scratching). Temporary A6 labels, for example with varieties names for short-lived tulip displays, are laminated and discarded once the display is gone. A last option is two-coloured engraved plastic. These labels seem to last forever (some are 10-years old and are in good shape) but they are considerably more expensive.	Artem Parshin, Moscow. Humid continental climate, with warm humid summers and long cold winters.
Metallic labels are used which are etched or painted and these, although expensive, last a long time. Plastic / fibre is also good, as these can be moulded or embossed and given shape; they also last a long time. Laminated interpretation can be used, however these have to be regularly replaced.	Suma Tagadur, India. Warm, moist conditions.

7.3.9 Evaluation

Evaluation is one of the most powerful tools in the interpreter's kit, supporting informed decision making about how to spend time and money and moving the botanic garden's interpretation from being mediocre to accomplished. It does not have to be expensive or time-consuming, it is about proving what type of interpretation works for visitors and what does not. Guidance on how to evaluate a botanic garden's interpretation programme and facilities is in Section 7.2.7.

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7.4 PUBLIC ENGAGEMENT – A SOCIAL ROLE FOR BOTANIC GARDENS

Asimina Vergou and Liliana Derewnicka, Botanic Gardens Conservation International; Gail Bromley, Planting Values

7.4.0 Definitions

Growing a social role: Developing botanic gardens' commitment to working with their local and global communities on common issues of social and environmental importance, for the enduring benefit of those communities, the gardens themselves, and towards a sustainable future for our planet (Vergou and Willison, 2013).

Community engagement: The process of working collaboratively with community groups to address issues that impact the well-being of those groups. It includes a broad range of interactions between people.

Participation: The different mechanisms for the public to express opinions, take part and exert influence regarding political, economic, management or other social decisions and activities.

Social inclusion: The term is usually defined as the opposite of social exclusion which is 'the dynamic process of being shut out, fully or partially, from any of the social, economic, political and cultural systems which determine the social integration of a person in society' (Walker and Walker, 1997)

7.4.1 Introduction

KEY MESSAGE

Botanic gardens depend on establishing strong links with their local community. Plant conservation issues do not exist in a vacuum and are intertwined with people's lives.

From the Charco del Ingenio Botanical Garden in Mexico, supporting fair trade for the local producers through their gift shop, to Wuhan Botanical Garden in China, giving away free plants that clean the air and training the community on how to use them to reduce the impact of dust haze, botanic gardens worldwide are showcasing their social relevance. These activities indicate that botanic gardens have a social role, some within their core activities for many years and others who are starting to consider this approach.

The role of botanic gardens has been evolving since their inception, responding to social, economic and environmental changes. Their origins can be traced back to the medicinal gardens of monasteries, university gardens, and gardens that were set up to support the expansion of Empires (Sanders, 2004). More recently, because of the dramatic human impact on the environment, botanic gardens have been motivated to adjust their role to contribute to plant conservation (Heywood, 1987; Powledge, 2011). Maunder (2008) argues that, in the last 20 years, botanic gardens have found a sense of mission as providers of environmental education and science communicators, and highlights that gardens now recognize that their future depends on conveying the importance of their work and establishing strong links with their local community.

At an international level, environmental policies emphasise the need to ensure that biodiversity conservation benefits communities (e.g. Aichi Strategic Goal D, CBD 2010). Similarly, the Global Strategy for Plant Conservation (Sharrock, 2012) Target 13 calls for 'Indigenous and local knowledge innovations and practices associated with plant resources to be maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care'. Governing and funding bodies emphasise the need for the social impact of the work in botanic gardens and the wider museum sector. In recent years there has been an increasing emphasis on breaking down barriers to access and providing services for a much broader range of people. In particular, publicly funded botanic gardens and other museums are being called upon to demonstrate that their services represent good value, are responsible and relevant to the needs of their communities and are developed in partnership with them (Lang, 2001; Dodd and Jones, 2010). Further encouragement within the sector comes from either passionate professionals, eager to share their expertise for the benefits of the wider public (Black, 2005), or networks and associations that emphasise the need for change, e.g. the UK Museums Association (2013) with its visionary publication Museums Change Lives. The revised action plan from the European Botanic Gardens Consortium includes a new section on growing a social role while Objective 6 seeks to 'Develop the capacity and raise the status of botanic gardens as socially relevant organisations' (European Botanic Gardens Consortium, to be published in 2017). Since 2010 BGCI has led the Communities in Nature Programme which aims to support botanic gardens to change and become more socially relevant organisations by being part of a Community of Practice of botanic gardens who share the same vision (Case study 7.4.1).

At Westonbirt, The UK National Arboretum, participants of the Bristol Drugs Project are trained in sustainable woodland management practices. (Image: Westonbirt, The National Arboretum)

CASE STUDY 7.4.1

Communities in Nature Programme

Liliana Derewnicka, Botanic Gardens Conservation International and Alicia Fernández Rodríguez, The Linnaean Society

Communities in Nature is a BGCI strategic programme, funded by Calouste Gulbenkian Foundation, built on the results of the research report 'Redefining the role of botanic gardens: towards a new social purpose' (Dodd and Jones, 2010). This study offered a picture of the work that botanic gardens were undertaking and demonstrated how social and environmental responsibility are inextricably linked. The aim of the report was to identify the potential of botanic gardens to address their social role, by reaching all levels of society, to promote education and awareness about plant diversity and the need for its conservation. The report also identified the barriers and forces for propelling botanic gardens towards growing their social role. Based on that report, between 2011-2013, BGCI coordinated community based projects in 7 UK botanic gardens, provided training in community engagement methods and project management, ran organisational workshops in the gardens, and ensured that the projects' impact was documented through evaluation (Dodd and Jones, 2011; Vergou and Willison, 2013a). This led to the formation of a working definition of the social role of a botanic garden. Moreover, the lessons learnt and input from gardens around the world were compiled in the practical manual 'Communities in Nature: Growing the Social Role of Botanic Gardens. A Manual for Gardens' (Vergou and Willison, 2013b), a step-by-step guide for gardens on how to reach communities, create partnerships and embed a social role into the organisation's culture and practice in order to achieve long-term sustainability. This was followed by the publication of a second manual on how botanic gardens can address social issues 'Caring for your community: a manual for botanic gardens' (Derewnicka *et al*., 2015). This time a case study approach was used to inspire other botanic gardens to carry out similar projects.

Care home resident watering Calendulas as part of the Bristol Community Plant Collection - Communities in Nature project. (Image: Bristol Zoo Gardens)

The initiative is now entering its scaling-up phase, looking at how UK botanic gardens' experience of growing their social role can be combined with examples from gardens in other countries and drive international collaborations advocating for gardens' potential to achieve social impact.

This phase includes disseminating the outcomes of the initiative at conferences, writing publications in practitioners and peer-reviewed journals (Vergou and Willison, 2014a; Vergou and Willison, 2014b), offering new training opportunities and developing new large-scale projects based on this practice. In 2014, evaluation of the programme was commissioned to look at the overall impact of Communities in Nature and suggest ways of moving forward. Encouraging and supporting botanic gardens to examine their current roles in conservation, scientific research, education and recreation and to become socially relevant institutions that work towards social justice and address social exclusion is not an activity that can be achieved through one-off projects. Communities in Nature aspires to be a long-term initiative that will continue to advocate for organisational change within the botanic gardens sector as well as raise their profile as institutions that address social issues at the public, government and international policy levels.

Despite the increasing need and pressure for botanic gardens and museums to grow a social role and the evidence to indicate the impact of this work (e.g. Silverman, 2010; Urbis, 2004; Vergou and Willison, 2014b; Dodd and Jones, 2011) critics have argued that a focus of the organisations on socially relevant activities may lead them astray from their mission and distort their organisational focus. Silverman (2010) points out that some directors may rank other priorities higher, especially when resources are scarce, whilst others may question a botanic garden's capacity to engage in social work.

If saving the world's flora is considered a major priority for the work of botanic gardens it's clear that environmental issues do not exist in a vacuum and that they are intertwined with people's daily lives. It is not easy, or indeed always possible to address one without considering the other. The Village Botanists project of The Institute of Trans-disciplinary Health Sciences and Technology in India (Case study 7.4.2) illustrates how projects can satisfy an environmental goal by tackling social issues. Moreover, engaging people is considered part of the solution for conserving plants. The Aichi Biodiversity Target 1 states that: 'by 2020 all people need to become aware of the values of biodiversity and the steps they can take to conserve and use it sustainably'. Therefore it is important for botanic gardens to engage with a wider spectrum of society. This means that, according to Dodd and Jones (2010), gardens that have a demographically narrow audience of mainly white, older people with high socio-economic status, need to change. This is what O'Neil (2006) calls the 'unequal distribution of the good' of museums that can only be redressed by adopting a new view of museums which involves a theory of justice (O'Neil, 2006). David Rae (2012), former director of horticulture at the Royal Botanic Garden Edinburgh, warns that *'There's no point in preaching about environmental sustainability to only 5 percent of the population, it has to be to 100 percent, and that means everybody...So, we've got to find new ways of reaching people who don't naturally come here.'*

Social inclusion/exclusion, social justice and social impact are all terms closely related to the social role of botanic gardens. Sandell (2003) clarifies that social inclusion work in museums should not be regarded as simply a synonym for access or audience development but as work that requires the organisations to rethink their purposes and goals and to renegotiate their relationship to, and role within, society.

CASE STUDY 7.4.2

Village Botanists course, Institute of Trans-disciplinary Health Sciences and Technology, India

Deepa Srivathsa, Foundation for Revitalisation of Local Health Traditions (FRLHT), Bangalore

The Institute of Trans-disciplinary Health Sciences and Technology in India was an experienced NGO which became a university in 2003; it also houses a botanic garden. Its mission focuses on conserving medicinal plants and documenting traditional knowledge in relation to medicinal plant use. One of the ways the Institute is fulfilling this is through its 6-month training course, Village Botanists. The course aims to build the local communities' skills in identification, documentation, conservation and sustainable use of medicinal plants. It was initially funded by the Ministry of Environment and Forestry and has been running annually since 2003. Since 2010 it has been run four times a year, with 30 people trained in each course. The course is always taught in the local language and involves the basics of botany, assignments documenting medicinal plants and local knowledge in the area, field visits and comprehensive evaluation.

Originally the main focus was on conservation. The Village Botanists course builds the capacity of local communities to document their natural resources and traditional knowledge, and fulfils the requirements of India's National Biodiversity Act (aligned to the CBD). Hence the course participants (often folk healers) are recruited from areas important for the conservation of medicinal plants and these are usually villagers with low income. As the course idea developed, it became clear that by cooperating with the community, the project could link the organisation's conservation efforts to the development of these rural communities. The Institute has now established a long-term relationship with the trainees, whose contact details are included in a registry to allow continued communications. The trainees regularly monitor the populations of medicinal plants in their local areas and contribute the data to the Institute. In a conversation with Deepa Srivathsa, the course coordinator, she explains about the role of the trainees: *'Without the community help, we can't do conservation. The main vision of the organisation is conservation of medicinal plants and revitalization of local health traditions. Without community help, we can't achieve our vision. So when the community comes, they will not work for free, they will request some economic return. So this is like linking the economy with conservation'*.

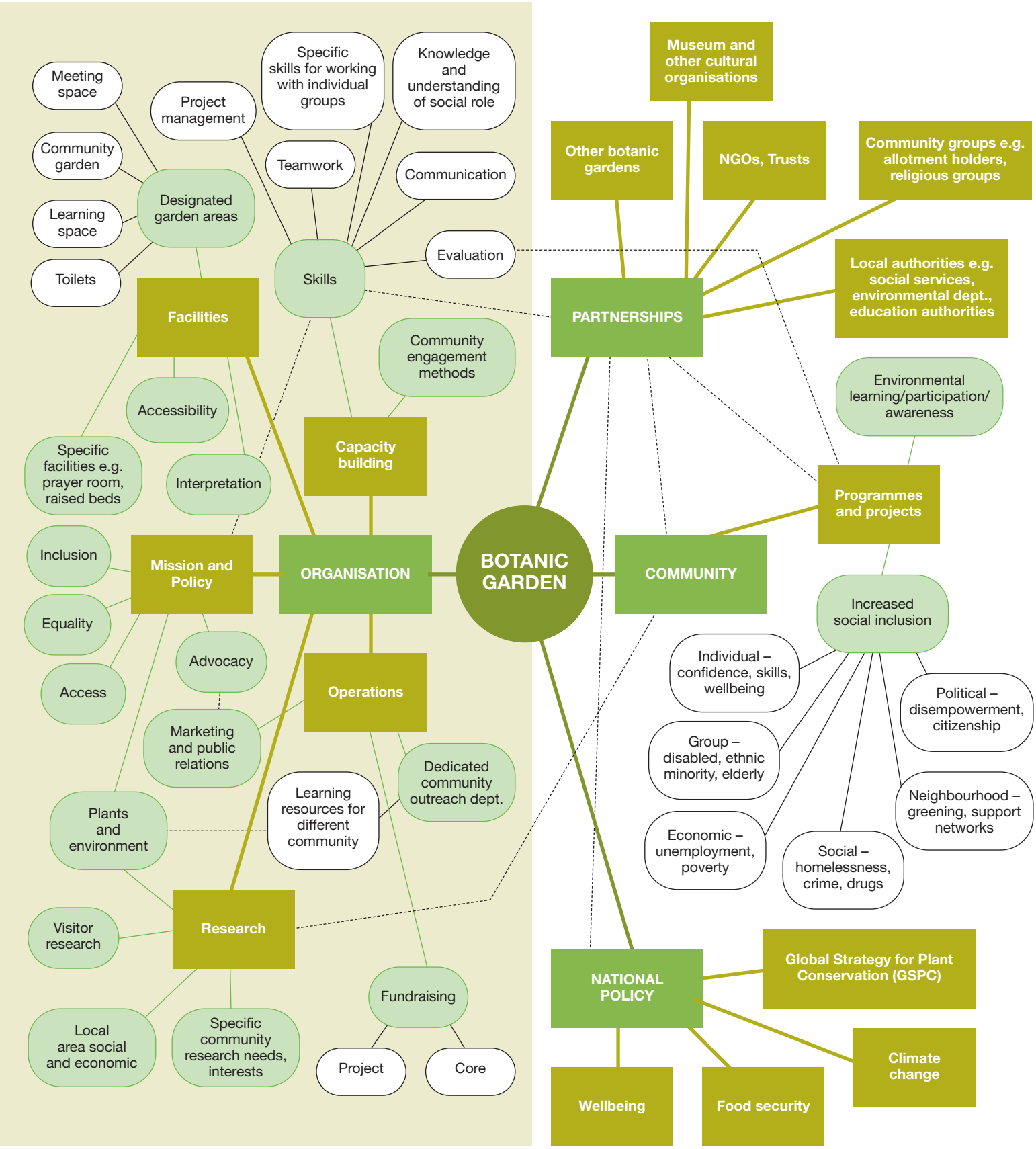
Participants on the Village Botanist training course discussing their herbarium sheets, part of the course assignments. (Image: Institute Trans-Disciplinary Health Sciences and Technology)

Thanks to the course, the trainees have found additional income by conducting surveys for the Forestry Department, becoming ecotourism guides, being involved in the People's Biodiversity Register (National system documenting biodiversity and traditional knowledge) and developing their own enterprises, e.g. selling plants grown in their own nurseries or medicines based on plants. Importantly, the course also supports women's equality by establishing women's self-help groups. Here, women learn how to improve the health of their family with the use of medicinal plants and are supported to establish community enterprises sustainably utilizing medicinal plants.

Since 2003, approximately 350 people have been trained, 75% of whom have found a job through attending this course. Although accurate data has not been collected regarding the income of the trainees, the project coordinator estimates that, on average, the annual income of the trainees who found jobs as a result of attending the course has been increased by 10%.

Growing the social role of botanic gardens is a long-term process that is influenced by many factors within and outside the organisation and at different levels, i.e. within the organisation, its partnerships with other organisations, in the community, and at policy level. Figure 7.4.1 provides an overview of all these factors and how they are interlinked. It provides a tool for holding discussions within a botanic garden and reflecting on which aspects are well developed and which need further development in order to grow a social role.

Figure 7.4.1 What it means to develop the social role of a botanic garden (Vergou and Willison, 2014a)



7.4.2 Making your Garden Accessible

KEY MESSAGE

A local 'Access Consultation Group' made up of people with different impairments can help you deliver excellent access for all. Collectively they will be aware of the problems and can offer simple recommendations for resolving them.

Growing a garden's social role requires ensuring that the garden is accessible and inclusive. Ensuring good access to all those with physical impairments is extremely important. Not only is this an essential part of any gardens corporate social responsibility (CSR) but it also supports all visitors to the gardens, in particular the elderly and parents or carers with young children. Access to interpretation in the garden is dealt with in the interpretation section (see Interpretation section on Catering for All Audiences) however the layout of your botanic garden and access strategy should also clearly address the physical access issues.

Providing physical access is not only about laying out paths suitable for wheelchairs, offering disabled car parking spaces or providing visual aids to help the partially sighted get around the garden. The cause of people's additional needs may not necessarily be visible, but should be considered when developing the garden. Making sure your catering offer includes gluten free or dairy free products, or at least clearly labelling your food products with ingredients, can help those with dietary problems decide what is safe to eat. Good positioning and a plentiful supply of seating and toilets can help those suffering from other debilitating illnesses such as cancer or heart conditions. Funds and existing building constraints may naturally influence what you are able to provide, however some issues can be dealt with cheaply and easily, e.g. the simple idea of providing a shelf in a toilet cubicle can enable those suffering from diabetes to self-inject with insulin in privacy.

An excellent way to ensure that you consider all the physical access issues in the botanic garden is to bring together, on a regular basis, a local Consultation Group made up of people with different needs. Collectively they will be aware of the problems and can often offer simple recommendations for resolving them, or put you in touch with other organisations that can help. They will additionally be excellent ambassadors for you, marketing your botanic garden to disability networks. Ensuring all your staff can recognise and support visitors with impairments will also be key to providing better access. For example, being able to recognise children with autism can stop staff from thinking a child is just being naughty and instead offer garden activity ideas that can mitigate unruly behaviour! Providing good physical access is therefore a win/win solution for all concerned.

For some top tips on museum access, that can be adapted for botanic gardens see Euan's Guide (2015) and for examples of access groups see APN (2015). Case study 7.4.3 shows how to create an accessible garden from the beginning of its development.

CASE STUDY 7.4.3

Therapeutic garden, Il Giardino SottoVico, near Florence, Italy

Stefano Battistini, Il Giardino SottoVico, Italy

Il Giardino Sottovico opened in 2009 after a group decided to build a therapeutic garden on an illegal waste disposal site. The garden seeks to tackle the social exclusion faced by people with physical disabilities or learning difficulties, whilst giving them exercise. This is accomplished by allowing them to work and mix with new groups of people. There is no dedicated project associated with this activity, rather it is integrated into the ethos of the organisation, it is part of the way the garden operates and it is aligned with its main concept: 'to involve children, families, the old and the less able-bodied in both the managing and developing of the place employing a range of skills' (garden staff). For 3 years, in partnership with the local authorities and social services, people with physical and learning disabilities have been involved in running and maintaining the garden. Four service users visit the garden each week and support its day-to-day functions i.e. germinating, collecting plants, cleaning, making labels, etc. Through this process, the garden staff have developed their skills in working with these audiences. This has not always been easy; it has taken time to learn to work well with each other. Some staff have different attitudes towards their work, for example some may prioritize the garden's appearance. One member of staff pointed out that for the garden to be therapeutic it needs to be so for the staff as well. For this reason, when conflict or different opinions emerge they try to bring them to the fore rather than 'sweeping them under the carpet'.

The garden is a non-profit organisation, with its core funding coming from donations from banks, companies and the chamber of commerce. In some cases the families of the disabled participants offer a contribution towards paying for the staff. Entrance is free and all areas are accessible to those with physical disabilities.

A crucial force behind the focus of the garden is the vision of its president whose 30 year old son has autism and was involved setting up the garden. During this process his communication skills improved and he became engaged in the tasks he was responsible for. As a consequence, the garden contacted the local authorities and social services and offered to work with people with disabilities. Nowadays, it is the local authorities and the social services that contact the garden and request spaces. Through questioning and working closely with the individuals, activities are matched to their needs. The disabilities specialist uses the *Globalità dei Linguaggi (GdL)*, a non-verbal communication method developed by Stefania Guerra Lisi.

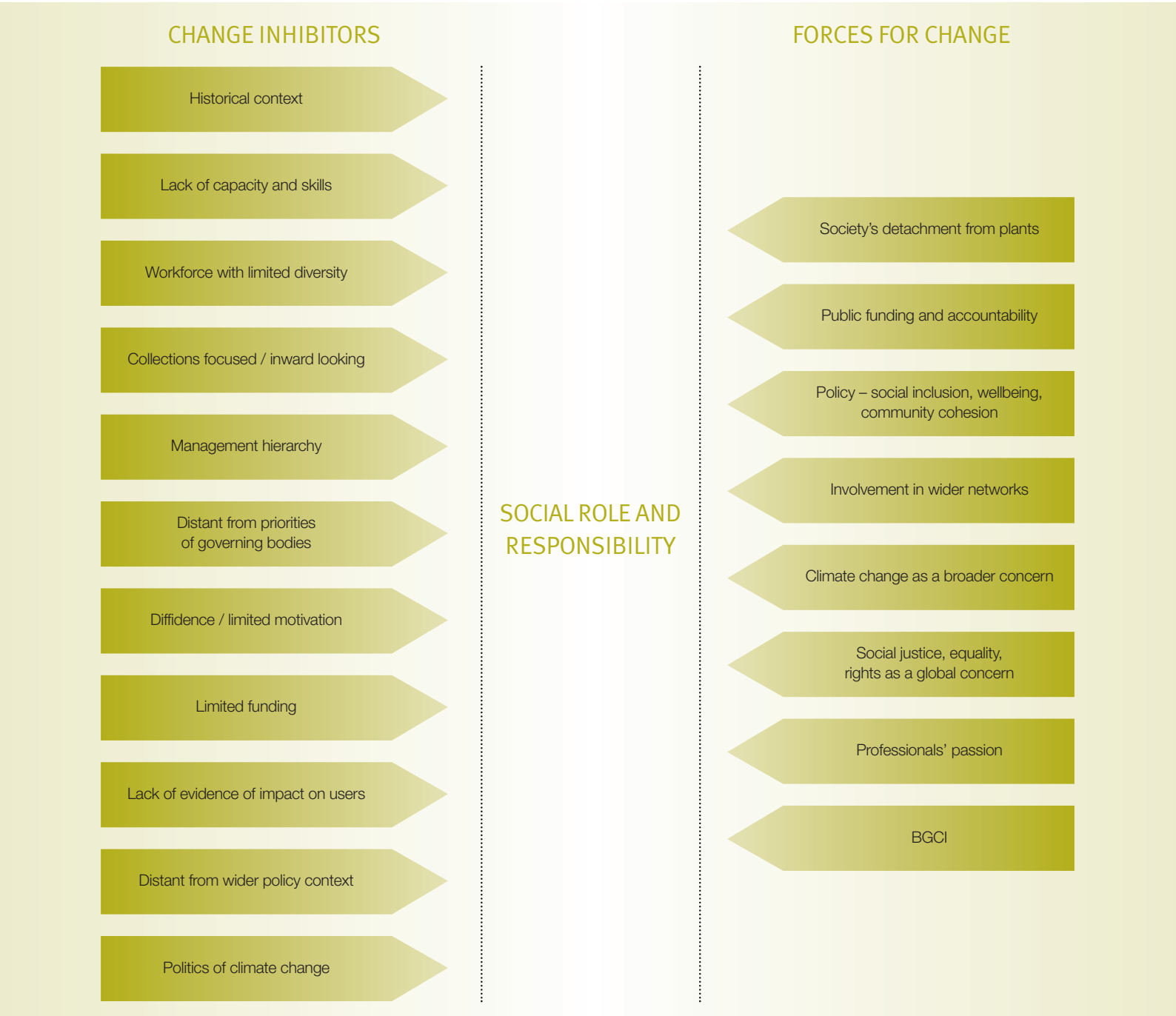
Above: As well as taking part in running the garden, Giardino SottoVico supports people with learning difficulties to take part in creative activities. (Image: Il Giardino SottoVico)

7.4.3 Key Socially Relevant Activities

Research by Dodd and Jones (2010) identified that botanic gardens already had experience in seven key areas related to their social role: broadening their audiences, enhancing relevance to communities by meeting the needs of communities, education, conducting research which has socio-economic impact locally and globally, contributing to public (and political) debates on the environment, modelling sustainable behavior and actively changing attitudes and behaviour. The research (ibid) pointed out that botanic gardens are already taking action, although there is more that could be done, and identified a number of factors that inhibit such change as well as a number of forces that can drive the change (Figure 7.4.2).

For example, small workforces, limited funding and the lack of diversity of the workforce have created hurdles for most gardens. Similarly, lack of motivation for a social purpose and a focus on collections have ensured that some gardens are content to remain as they are. On the other hand, botanic gardens may be motivated to consider their social role, especially if they are publicly funded, and they have to demonstrate their social value. Other forces include: policy developments that acknowledge the role of museums/heritage and cultural institutions in social inclusion, wellbeing and community cohesion and the involvement of botanic gardens in wider networks making them less isolated and more confident in addressing issues, like reaching a broader audience or communicating difficult issues such as climate change to their audiences.

Figure 7.4.2 Change inhibitors and forces for change towards botanic gardens having a greater social role and responsibility (Dodd and Jones, 2010)



7.4.4 'How to' Grow a Botanic Garden's Social Role

KEY MESSAGE

Participation takes time and it is important to be clear to your partners about the part they play in the process, your role and what level of participation is offered to the partners (Wilcox, 1994).

There is no single 'recipe' for growing a social role. A manual developed to support that process (Vergou and Willison, 2013b) suggests different actions that a botanic garden may undertake to become more socially relevant.

a) **Getting started:** Baseline research looking at the current and missing audiences, pressing social issues that face the local community and different audiences' needs may be a good starting point. Growing a social role is a long term process, hence many practitioners suggest starting small, e.g. by running a local community project, evaluating its impact and building slowly on the successes.

b) **Working in partnership:** Working with community groups and organisations that provide services for the community and have experience in addressing social issues and community engagement is a very effective way to develop your socially relevant work.

c) **Community engagement:** Community engagement is the process of working collaboratively with and through groups of people to address issues affecting their well-being (Fawcett et al., 1995). Growing a social role requires working for, but most importantly working with, community groups and moving away from didactic approaches. There are different ways and levels that communities can get involved in a project. Wilcox (1994) suggests a framework of participation (Figure 7.4.3) based on Arnstein's (1967) ladder of participation. Wilcox, identified different levels of community engagement and explained that different levels are appropriate for different situations and interests.

Levels of community engagement (based on Wilcox, 1994)

- Providing information (telling people what will happen);
- Consultation (offering options and receiving feedback);
- Deciding together (opportunities for ideas/joint decisions);
- Acting together (taking joint decisions forward in partnership);
- Supporting independent community interests (providing support to organisations to develop their agenda).

Case study 7.4.4 from Brooklyn Botanic Garden in the United States showcases how its Garden Bridge initiative, with its five sub-programmes, offers socially relevant activities to New York communities. The programme uses different levels of community engagement depending on the purposes of each activity ranging from providing information to supporting community interests. The case study illustrates that community engagement levels have been chosen not on the basis that the higher the level the better but based on whether they are fit for purpose.

d) **Incorporating environmental issues into a social inclusion project:** There are many environmental issues that are very relevant and can spark the interest of communities. By getting to know the community participants, their level of understanding, skills and interest you can ensure that the environmental issues are relevant to the participants' lives and can effectively engage them.

e) **Skills and qualities:** Enhancing botanic gardens' relevance to communities is an 'intensive, long term and difficult task. It requires people with specific skill sets and experience who are not always found on the staff of botanic gardens' (Dodd and Jones, 2010). These skills and qualities vary from interpersonal/communication (active listening, flexibility, respect) to more practical types of skills (project management, evaluation, teaching skills) essential for understanding the communities, meeting their needs and engaging with them in a meaningful way. These skills can be added to a botanic gardens staff team by employing new staff with experience, for example in community engagement, or by providing appropriate training to current staff. Some of the required skills may also be developed by doing socially relevant work and learning from experience.

f) **Evaluation:** Dodd and Jones (2010) have noted that one of the barriers to botanic gardens growing their social role is the lack of evidence of the impact of their work, hence, conducting evaluation of socially relevant activities should be built into project management processes. The findings of the evaluation can be used internally by the staff to drive improvement in future work (including improving project management) as well as externally to demonstrate achievements, e.g. for fundraising purposes. More information regarding different types and methods of evaluation and resources can be found in Sections 7.2.7 and 7.3.9.

g) **Sustainability:** Starting small, e.g. by running a community project, may be a pragmatic and realistic approach to growing an organisation's social role, however the process should not stop with a one-off project. To ensure the sustainability of this new role, it is important to disseminate information about socially relevant activities within the organisation, gain the support of senior management, trustees and other staff members, create new positions with distinct responsibilities for community-based work and look at the organisation's policies and operations. It is equally crucial to raise the profile of the botanic garden as an organisation that can address social issues with stakeholders outside the organisation, funders and the general public, using a variety of methods.

Figure 7.4.3 Framework of participation (Wilcox, 1994)

CASE STUDY 7.4.4

Green Bridge, Brooklyn Botanic Garden, United States

Nina Browne, Brooklyn Botanic Garden, New York

Brooklyn Botanic Garden's (BBG) Green Bridge is an integrated series of projects, focussed on urban gardening. The aim is to mobilize the local community to interact with each other and the garden and beautify their surroundings for the benefit of the environment and the individuals' health and wellbeing. The projects complement each other, involve many of the same people and work on various levels of engagement. The projects are: The Greenest Block in Brooklyn Contest, Making Brooklyn Bloom, Street Tree Stewardship initiative, Community Garden Alliance and the Brooklyn Urban Garden Training Programme (BUG).

Making Brooklyn Bloom is a free, annual, urban gardening symposium. The event entails a series of exhibitions, workshops, films and networking lunches, attended by as many as 1000 people each time. It can be seen to work on two distinct engagement levels. It can be seen as 'providing information', but, by providing an arena for interested parties to network, the symposium also supports their independent interests, thus satisfying a much deeper level of engagement. The symposium also works as a launch pad to engage people in the Greenest Block in Brooklyn Contest which sees around 200 entrants a year.

During the contest, as well as providing entrants with support through fact-sheets, BBG offer urban gardening clinics to 10 groups on a first come, first served basis. The content of these clinics is based on the results of a survey of the specific group, therefore representing the 'consultation' and 'deciding together' levels of engagement, as outlined by Wilcox. These clinics include a 'street tree 101', which also forms the basis of The Street Tree Stewardship initiative.

The Street Tree Stewardship, which includes a series of workshops on street tree care, has joined forces with the Million Trees NYC project (MTNYC) – a city-wide sustainability initiative focussing on environmental impact and green infrastructure. MTNYC aimed to plant one million trees by the end of 2015. To support the continued care for them, BBG, through workshops, engages people with the importance of the trees and how to care for them. The importance of street trees is discussed with the local people and their opinions gathered and considered. Hence, although the aim of the project is to provide information and gain support, the initiative does consider people's opinions.

Consultation is also a significant element of the Green Bridge Community Garden Alliance. To be part of this, community gardens from across Brooklyn register by completing a biannual survey about topics related to community gardening that they are interested in. The results are used to design workshops. So the information provided to the participants not only caters for their needs, but also supports their interests and enables them to develop their community gardens independently. These projects are supported by graduates of the BUG programme, which trains young people to deliver urban gardening training. As well as class time, the course includes service to community greening projects that have requested help. The trainees visit them and help the group to develop in the direction they wish to, in a way that can be sustained by the group themselves. This way of working is at the heart of 'asset based community development'. This model, employed by BBG, ensures that training offered is customized to the context. Each BUG trainee starts by finding out what a community already has to offer in order to work out how they can develop in the direction they choose. BUG graduates offer training to groups on request, as well as contributing to the other projects in Green Bridge by delivering workshops and clinics, depending on their individual skills and tastes. In this way the BUG programme not only delivers information to the trainees and the community but supports the independent and personalized development of the BUG trainees and the community groups they interact with. This project therefore manages to satisfy all the levels of engagement outlined by Wilcox (1994).

Upcycle garden created by children from East 25th Street – Greenest Block in Brooklyn 2014. (Image: Brooklyn Botanic Garden)

In 'Museums Change Lives' (2013), the Museum Association points out ten actions that will help museums improve their social impact; these could similarly be applied to botanic gardens:

- Make a clear commitment to improve the museum's social impact. Regard it as core business. Have long-term strategic goals for the impact.
- Reflect on current impacts, listen to users and non-users, involve all staff and supporters in thinking about whose needs you could serve better.
- Research what other museums are doing to have beneficial impact.
- Seek out and connect with suitable partners, e.g. local charities, social enterprises or public sector organisations.
- Devise practical proposals, working with your partners as equals. Be clear about your shared objectives.
- Allocate resources and you may need to work with your partners to fundraise.
- Review your practices and procedures so you can meet the needs of your partners and the people you aim to reach.

- Reflect on your work. Learn from and with partners and participants. Consider the benefits of evaluating and measuring your impacts.
- Encourage wider participation in all aspects of your work: bring more voices into interpretation and devolve power. Encourage people to contribute to decision making about what to do, what to display and what issues to address.
- Strive for long-term, sustained change based on lasting relationships with partners and long-term engagement with participants, maintained beyond time-limited work and one-off projects (Museums Association, 2013).

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7.5 TOURISM AND RECREATION

Richard Benfield, Central Connecticut State University

7.5.0 Definition

Tourism: 'Tourism is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/ professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents) and tourism has to do with their activities, some of which involve tourism expenditure.' World Tourism Organization (2010)

7.5.1 Introduction

KEY MESSAGE

An estimated 500 million people visit botanic gardens every year – presenting an invaluable potential to raise the profile plant conservation, and offering a vital opportunity for recreation, relaxation and contemplation.

Tourism is probably the world's fourth largest industry after fuels, chemicals and food (Lew et al., 2014) contributing 9% of the global GNP, one in 11 jobs worldwide and accounting for USD 1.4 trillion or 6% of all the world's exports. In 2013 international tourism arrivals reached 1,087 million after surpassing the billion mark in 2012. With an estimated 7.15 billion people living on the Earth, this means that over 15% of the global population is travelling internationally for tourism purposes every year. This figure does not take into account domestic tourism which in some countries (e.g. the United States) may be as much as 95% of all tourism travel. Furthermore these percentages are expected to rise as leisure time increases, emerging economies steadily contribute to global tourism numbers and as per capita incomes grow. Tourism will be a major economic force in the twenty first century.

Botanic gardens worldwide are a major, if often still unappreciated, destination for tourists. Based on extrapolated records from BGCI's GardenSearch database, it is estimated that some 500 million people visit botanic gardens every year. Individual botanic gardens also post some impressive numbers when compared with other tourist attractions worldwide. Singapore Botanic Gardens regularly exceeds four million visitors, Beijing Botanical Garden over 2 million and all of the botanic gardens in Australia's major cities exceed 6 million visitors yearly. When aggregated together, visitation numbers of the more than 800 botanic gardens in the United States amount to over 80 million in one year – more than those of Disneyland and Disneyworld combined and more than those of Orlando or Las Vegas, America's two most popular tourist destinations. Thus, botanic gardens are now significant tourist destinations. Their impressive visitor numbers make the tourist an integral part of botanic gardens' mission fulfilment and their economic viability.

7.5.2 Assessing Tourist Demographics

KEY MESSAGE

Botanic gardens cannot know to whom they are attractive without understanding their current and potential future visitor.

In 1954, the marketing leader Peter Drucker said '*If we want to know what a business is we have to start with its purpose. … There is only one valid definition of business purpose: to create a customer.*' It is the customer who determines what a business is. For it is the customer, and he alone, who through being willing to pay for a good or service, converts economic resources into wealth, things into goods. What a business thinks it produces is not of the first importance – especially not to the future of the business and to its success. What the customer thinks he or she is buying, what he or she considers 'values', is decisive. Because it is its purpose to create a customer, any business enterprise has two – and only these two – basic functions: marketing and innovation (Drucker, 1954).

Botanic gardens fulfil a wide range of functions and roles including research, conservation, education, pleasure provision and/or entertainment, thus creating a customer as indeed the 'one valid' definition of purpose. Botanic gardens have historically been the locus of public events, usually horticultural in nature, that attract customers to the venue. In recent years, these programmes have become more varied – art and concerts in the garden, displays, exhibits and museiculture that have what has been called a 'wow' factor. In the future, it might be expected that there will be growing innovation which will provide the motivation for greater visitation. However, this will not materialize without making the visitor aware of either of the traditional or innovative programmes that botanic gardens are offering, and marketing to visitors will become very important. Furthermore, botanic gardens cannot know to whom they are attractive without understanding their current and potential visitor.

- **Approaches to knowing your visitor**

In attempting to assess its tourism or visitor potential, the botanic garden can address the following research areas:

1. Membership;
2. Source of knowledge of the garden including media used;
3. Media habits in general (reading, watching, technological use of media);
4. What was the specific motivation or reason a visitor came to the botanic garden today – if there was one;
5. Satisfaction with the botanic garden and its constituent parts (displays, gift store, café);
6. Age of visitors;
7. Income;
8. Educational level;
9. Number in party and relationship of visitors;
10. Origin of the visitor (postal or zip code).

While these data generally are readily collected, it is becoming increasingly apparent that the botanic garden visitor is a complex individual that possesses specific opinions, values and lifestyle traits and habits. Furthermore, these personality traits are expressed in the need for relationships with other individuals and products that cater to those needs and wants. This realization has been addressed by those botanic gardens developing and promoting a particular institutional brand (Case study 7.5.1) and appears to have clear links with other botanic gardens enjoying success through new social media (Section 7.5.3). These types of data that explore the visitor psyche have been termed 'psychographics' and yet there are few botanic garden studies that probe this area of visitation. One landmark study of botanic garden tourist psychographics found that 69% of visitors had '*always been interested in gardens*' (Connell, 2004). Of the 30% who had not always been interested, ages 25-40, with a mean of 32.97, were the years in which they generally became interested, probably as a result of home ownership. Connell indicates only 10% became interested in gardening in their teen years. MINTEL Ltd. (2005) states however, that gardening interest reaches its apogee upon retirement and botanic garden visitation probably follows a similar pattern. Significantly, Connell notes that interest in botanic gardens seems to be cyclical, holding a greater appeal for those whose formative years were pre-World War Two, but has been growing steadily now amongst younger age groups. Connell goes on to indicate that motivations for visiting botanic gardens are often a mixture of reasons, and probably more complex, best summed up as '*to enjoy the peace and quiet along with the natural environment*'.

CASE STUDY 7.5.1

Atlanta Botanical Garden – 'Ten Years of Success'

Richard Benfield, New Britain, Connecticut

The Atlanta Botanical Garden (ABG), Georgia, United States, is one of a number of American botanic gardens that arose in the late sixties and seventies (Chicago, Memphis, Denver) as part of urban development to make cities and especially downtown areas more liveable. Thus, a botanic garden was first proposed for Atlanta in 1973. Like most botanic gardens, the collections and infrastructure were slow in developing and perhaps the first 'full' year of the development in 1983 saw 50,000 visitors come to the site.

The latter part of the twentieth century saw the construction of a conservatory (opened 1989), the development of different show gardens, the initiation of education, horticultural and science programmes (in 1995 ABG became a founding member of the Georgia Plant Conservation Alliance), as well as the early stages of a dedicated tourism function with the hosting of concerts, Venus Fly Trap exhibits and the attraction of a Titan arum bloom that generated significant publicity and visitation for the fledgling institution.

Thus the stage was set for what has been dubbed the '*Ten Years of Success'* that has driven visitation of 110,000 in 2002 to over 525,000 in 2014. It appears that there were a number of sequential steps and paradigm shifts that created the success the botanic garden enjoys today:

– In 2002, the botanic garden was clearly at a level that begged the question whether it should remain a stable, static, unassuming minor attraction in the City of Atlanta or go to another level of development. This question was posed and answered by the securing for 2004 of the most prestigious exhibit in the institution's history: 'Chihuly in the Garden'. An exhibition of 50 original glass sculptures by internationally renowned glass artist Dale Chihuly that were on display from May to October, with an extended run through December. The nine-month blockbuster exhibition brought the botanic garden to the forefront of cultural tourism in the southeast of the United States. It drew some 350,000 visitors to the botanic garden and created an economic impact of USD 50 million or more.

– Rather than allowing Chihuly to define future visitation, the botanic garden followed Chihuly with an 'Orchid Days' and a 'Locomotion in the Garden' show (2005).

→→→

Tree canopy walk. (Image: Atlanta Botanical Garden)

CASE STUDY 7.5.1 (CONT.)

– From 2005 to 2009 the botanic garden featured different but equally impactful shows ('Bugs and Killer Plants', 'Sculpture in Motion', Henry Moore sculptures) to maintain the momentum that had been created.

– In 2011, two major initiatives were undertaken to develop reasons for visitation in the shoulder months of spring and winter. Accordingly, in spring 2011 'Atlanta Blooms' was introduced as a display of bulbs which in its first year attracted 60,215 visitors at a time when previously visitation had been poor. The following winter 2011-12, 'Holiday Lights', with over 1 million LED bulbs, created a festival of lights that attracted 165,000 visitors in 2014.

To suggest that for the botanic garden to go from 50,000 visitors in 1983 to 500,000 in thirty years, was solely a result of the provision of blockbuster attractions would be misleading. Behind the visitation was a philosophy, based on a mission statement, and delivered by marketing and sales, that was specifically directed at the long-term responsibility and viability of the botanic garden: '*The mission of the Atlanta Botanical Garden as a non-profit is to develop and maintain plant collections for display, education, research, conservation and enjoyment*.' To create that enjoyment, the botanic garden developed its own distinctive brand with the following marketing actions:

- Convert interest into action and inject urgency into messaging;
- Market the botanic garden as lifestyle brand;
- Change 'not enough time' perception to 'can't afford emotionally not to go';
- Inform and motivate prospects;
- Market continuously, as this is now a botanic garden for all seasons;
- Encourage viral marketing;
- Market (family) benefits aggressively, specifically to adults 45-59, women with children 35-45 and young adults 25-34;
- Leverage 'something's always in bloom' to smooth seasonal skews;
- Ask for the 'membership order' (i.e. what people want);
- Seed environmental messaging as part of the experience, but don't lead with it to drive visitation.

• Methods to assess tourist demographics

In assessing tourist/visitor demographics, patterns of movement, influencers, motivations and impacts, there are a number of basic but effective techniques available:

– A visitor survey conducted amongst the population at large – the potential market (by phone, mail or in-person – the last being the most effective) probing awareness of the garden;
– A visitor survey administered either at the gate upon entry/exit probing the types of questions suggested above;
– Focus groups, in which a selected group of respondents are asked questions or proffer opinions on a botanic garden's status in the marketplace;
– The 'Delphi Technique' in which the botanic garden invites recognised experts in the field of garden tourism to assess patterns, trends and postulate future influences on the botanic garden's internal and external environment;
– Economic impact studies probing the spending habits of both the botanic garden and the visitor for use in assessing economic importance of the institution to a municipality, region or country;
– Motivation studies, probing the psychographics of the visitor in which opinions and preferences are often explored by means of a graduated Likert-type scale.

The statistical outcome of these studies can take a number of forms:

– Simple frequency (percentage analysis);
– Correlation tables in which correlations between variables are charted;
– Simple mean (average), median (50% division of all cases) and mode (highest category) are stated.

These analyses are easily run, and the results obtained by use of basic statistical programmes such as IBM SPSS or SAS. They may also be used in advanced data analyses which might include:

– Simple regression (comparing one dependant variable with an independent variable for essentially prediction purposes);
– Multiple regression using a number of independent variables;
– Cluster analysis;
– Factor analysis (using multiple variables to derive underlying factors);
– Zip code or postal code mapping (the use of GIS programs to map zip/post code locations); GIS software is required and is usually only available from GIS firms or university geography departments;
– Econometric analysis of economic information to give empirical findings of these data.

• Visitor segmentation

Most botanic gardens appear to segment their market into:

Primary markets

1. An elderly demographic (often loosely referred to as the Baby Boomers);
2. Often or predominantly female;
3. Higher (disposable) incomes and education;
4. All age groups with an interest in gardens and gardening;
5. Usually house owners;
6. Educational groups; K-12/ kindergarten to sixth-form;
7. Tourists, both domestic and international, and day visitors.

Secondary or emerging markets

1. Millennials (those born between 1980 and 2005);
2. Propensity to visit botanic gardens as sedentary leisure-time outdoor activity;
3. New house owners usually 25 years of age and older;
4. Generation X born between 1964 and 1980. A smaller demographic, often with a garden and in need of upgrading landscape.

Historically, the application of the research showing a botanic garden's major visitor markets has been applied in the form of paid and unpaid advertising (news and press releases). However, paid advertising has only been the prerogative of larger, wealthier botanic gardens. A significant number of smaller, often not-for-profit botanic gardens or institutions governed by a Trust (Chapter 2, Section 2.2.2), are unable to dedicate large sums to paid advertising. When this is aimed at, placement in gardening and lifestyle magazines seem to provide the best return on investment. This choice is invariably borne out by consumer research. In the case of smaller botanic gardens, local community advertising may be used but more often the institution uses a steady diet of press and news releases to impart their information. Furthermore a key presence in advertising campaigns, often coordinated by the local, regional or national tourist offices, has been a major source of awareness and marketing. This has been rapidly changing with the advent and undoubted success of social media.

7.5.3 Social Media

KEY MESSAGE

Social media, without a doubt, have become botanic gardens' major public outreach conduit in the twenty first century, both as an online information exchange tool and stimulus to visit on-site.

The introduction and explosion of social media applications has also significantly changed marketing approaches by botanic gardens to tourism development. The use of social media in general and certainly for botanic gardens is now vital to enhance their visitation – there is so much 'noise' out there that social media allow individual institutions to get noticed instantly.

Firstly, social media level the playing field – if a botanic garden has great content, it can compete with the likes of top brands to rise above the marketing noise. For instance, the use of social media has been proven successful for botanic gardens participating in USA TODAY's yearly contests which ask the public to vote for their favourite botanic gardens. Those institutions making extensive use of social media are among those most highly voted for.

Secondly, social media are the first means available to botanic gardens to connect to hundreds of thousands of people in real time unlike standard print or electronic advertising. Social media have the potential to be a major force in botanic garden visitation in the twenty first century, given that close, immediate personal links are desired by all people, and furthermore that personal values, attitudes and lifestyles define visitors and their motivation to visit botanic gardens.

Thirdly, social media lend themselves particularly well to botanic garden tourism and vice versa:

a) They do not require a huge investment, and numerous botanic gardens do not have significant funding for marketing.
b) Botanic gardens are visual and as many social media platforms, including Tumblr and Instagram, two of the fastest growing social platforms with highest rates of engagement, are predominately visual.
c) Social media are about telling a story, through the use of great content, and botanic gardens are replete with stories and anyone can use a smartphone to take a photo or video and publish it immediately.
d) With social media, botanic gardens can 'brand listen' using free social media tools like Hootsuite[1], and follow hashtags[2] to 'hear' what the public is saying about their botanic garden. Botanic gardens are even using social media to decide on which images to use in their calendars that will be sold in the gift shops.

The application and efficacy of social media in botanic gardens has yet to be fully defined and appreciated. It is clear that botanic gardens make use of various types of social media channels for different purposes.

Different types of social media lend themselves well to visual content in a way that is difficult to achieve through traditional promotional tools. Another attraction of social media is the immediacy of the information going out to followers; real-time updates on conditions at the botanic garden or events happening can be made available instantly. Further reasons to employ social media include the ease of use, cost effectiveness, ability to schedule and/or archival value.

Social media have the ability to share content with other tourist and business organizations in a collaborative fashion for post exposure to a wider potential market. The image or post may tell little about the specific botanic garden. However, as Case study 7.5.2 points out, because visitors on average stay for less than two hours on site, they can find the details they are looking for about the region where the botanic garden is located, whilst they may also gain the sort of ancillary but pertinent information about the botanic garden of interest. Social media are very much a reciprocal business – formally called 'building social capital' in the social media world. However, while many social media users gauge success on the number of likes or followers, it should be noted that this does not equate to return on investment.

Not only can botanic gardens reply to people's comments, they can do so at any time and they are notified, allowing a conversation to begin. Others might join in too. People enjoy personalised responses, especially from brands (see also Case study 7.5.1 regarding the importance of branding botanic gardens), and it makes them much more likely to have that brand at the top of mind when considering a botanic garden as a tourism and recreation option.

[1] HootSuite is a social media management tool that allows users to schedule and post updates to any pages or profiles for Facebook, Twitter, Instagram, etc. – the HootSuite dashboard. Upon signing up, a dashboard with tabs organizing all the social profiles connected to HootSuite are being provided. It also allows users to follow and respond to conversations about the botanic garden across social media platforms.

[2] A hashtag is a word or an unspaced phrase prefixed with the hash character (or number sign) – # – to form a label. It is a type of metadata tag. Words or phrases in messages on microblogging and social networking services such as Facebook, Google+, Instagram, Twitter, etc. may be tagged by entering # before them, either as they appear in a sentence, e.g. 'New artists announced for #SXSW2014 Music Festival' or appended to it. The term hashtag can also refer to the hash symbol itself when used in the context of a hashtag. A hashtag allows grouping of similarly tagged messages, and also allows an electronic search to return all messages that contain it.

CASE STUDY 7.5.2

Tourism at Royal Botanic Garden Edinburgh, Scotland

Richard Benfield, New Britain, Connecticut

The Royal Botanic Garden Edinburgh (RBGE) has a long and distinguished history. Established in 1670 as a 'Garden of Signatures' for medicinal purposes, in the following centuries it would become a repository for some of the most important plants discovered by plant hunters for commerce, research and exhibition. Additional sites were acquired and run by the RBGE starting in 1929 such that today there are three regional gardens administered by RBGE at Benmore, Logan and Dawyk. In 1858, the tallest conservatory in Britain was opened for palm display and today all eleven glass houses are linked as a complete visitor package. In 2013, 679,756 visitors came to RBGE making it one of the top three tourist destinations in Edinburgh. Of those 679,000 visitors, approximately 80% are Scottish residents (66% Edinburgh residents, 33% outside Greater Edinburgh), 10% English and 10% international visitors. The desire was to significantly increase the latter two market segments.

At the basis of a new marketing strategy was the need to know the customer. The Insight Department of VisitScotland, Scotland's National Tourist Organization, researched the overseas market to gauge the propensity of holiday visitors coming to the gardens. Botanic garden visiting of all overseas residents to the United Kingdom is third in popularity, 56%, after 'Castles' and 'Famous monuments'.

Much like RBGE, 44% of all Scottish botanic garden visitors are locals, 26% Scottish, 25% other United Kingdom (mostly England) and 6% overseas. For United Kingdom visitors in particular over 40% have never been to Scotland and get their information on Scotland from online travel sites (53%), guidebooks and brochures (43%), the national tourism website (42%) and other travel websites and blogs (34%). Thus it appears that the English tourist is heavily influenced by computer-based information. This is borne out by data that finds 43% of English visitors spend over 20 hours a week on the internet and that 69% are active on Facebook, 29% Twitter and 25% Instagram. At least 70% go on Facebook daily and 50% to Twitter. Finally, of the English botanic garden visitors, they are predominantly male (59%), usually without children (66%) and highly educated. Perhaps most surprisingly, of those English visitors, aged 25-34, 37% say the botanic garden is the main purpose of their visit (as opposed to 17% of all tourists), suggesting that garden visitation is not just for elderly females. Similarly for those aged 55 and older, 22% say visiting a botanic garden is the main purpose of their trip, again higher than the percentage for total British tourism.

From an understanding of the demographic characteristics of the visitor, the botanic garden can now segment the market they wish to address. VisitScotland had undertaken a segmentation study of the English market: *'Traditional tools often define consumers purely by demographic or life stage variables that assumes everyone in one age group acts in a similar way. Segmentation offers the chance to research … the wants and needs of consumers as well as their specific behaviours, alongside demographic and life stage information … VisitScotland's segmentation model is based on a behavioural approach based on … motivations, and behaviours, attitudes toward Scotland … and their use of media channels'.*

From this research, five tourist segments presented themselves and the RBGE has seized on two, 'Engaged Sightseers' and 'Natural Advocates', to address in their marketing. The study indicates their level and type of social media participation (generally 'followers' rather than innovators), the major print media they use (usually gardening magazines) and the challenges and obstacles to greater garden visitation (potentially due to issues of signage, distance or information dissemination). This research of potential visitors can be compared with survey studies undertaken in and by the botanic garden to compare and contrast its current visitation. In RBGE, visitors are predominantly female (60%), over 50% were over 45, and 10% identified themselves as being disabled. Again, while the national data showed 42% of English visitors had never been to Scotland, only 20% of RBGE visitors were first-time visitors suggesting a new potential market of first-time visitors to Scotland and thus the botanic garden. Finally, tourists spend on average some two hours in the botanic garden, and thus by extension after that leave and visit another location. The fact that RBGE is a founding member of a new national collaborative group called 'Discover Scottish Gardens' set up in 2015 to raise the profile of Scotland's gardens and its outstanding horticultural offering suggests a wise development in Scottish garden marketing with around 300 garden institutions in Scotland being open to the public; as members of a new network, they will also create a collective voice for botanic garden tourism in Scotland.

Logan Botanic Garden, United Kingdom. (Image: BGCI)

Selected social media platforms

Social media have been experiencing an unprecedented speed of development in recent years. While the types selected below were among the most commonly used in 2016, the list is by no means comprehensive.

- **Facebook**

Facebook is one of the most popular social media platforms, with 1.86 billion monthly active users in 2016. It is widely used across most age demographics and cultures, especially in the major tourism markets of Canada, United States, United Kingdom, Japan and Australia. It allows for paid targeting of users – geographically, demographically and by interest. However, it is a 'closed garden' – a term used on the internet to label content that is not universally accessible or searchable. For members of the public who do not have a Facebook account, not all content is available to them.

Most botanic gardens use Facebook to broadcast events, photos and videos – mostly to great acclaim. In turn, they obtain valuable feedback in terms of likes, shares and comments from around the world in real time. Similarly, the botanic garden can engage followers in real time and in the follower's own language as there is a translation function embedded. An institution can test ideas and photos for traditional marketing on Facebook to get feedback and ask those most interested in the garden experience what they think about ideas or plans that are being considered. This can be a very valuable feedback mechanism. However, the average Facebook post has a lifespan of three hours before the internet forgets about it – it is still there, but few will be engaging with it.

As an example of the power of Facebook, The Butchart Gardens in Victoria, British Columbia, Canada, created a post in 2013 that went viral unexpectedly. Initially, people and then radio and TV stations were asking for photos of a rare snowfall that had fallen on December 5, 2013. The garden subsequently posted a photo of snow in the garden. The reach of this single photo was 75,000 people, with ~7,000 likes, comments and shares and 6,500 actual post clicks. To give perspective, the largest local paper in Victoria has a circulation of 58,000. A myriad of conversations came out of this single post, keeping the Gardens top of mind for the day and the weeks after. It is apparent that in rare instances, a fledgling brand, can rise up above the 'noise and chatter' on social media. The Butchart Gardens make extensive use of hashtags, both to index posts and to get noticed by people outside their social media channels. They use three 'branded' tags: #butchartgardens, #butchartchristmas and #butcharttraffic (to give real-time traffic updates to people waiting in line for special events and on high volume days) among many others. This approach gets like-minded individuals together into a conversation, so, in the same vein in the gardening world, #gardens, #gardening and #gardenchat are very popular hashtags.

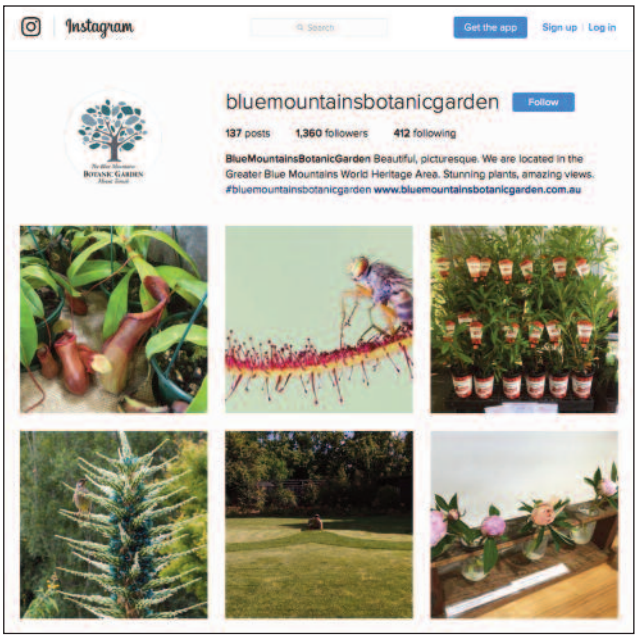
- **Twitter**

There are over 317 million monthly active Twitter users. Botanic gardens make use of Twitter mainly for broadcasting information regarding an event, a change in hours, to engage followers. Twitter messages, or tweets, have a limit of 140 characters, encouraging concise messaging.

The average Tweet has a lifespan of a few minutes unless it gets retweeted a lot or unless it is pinned (only one allowed) to the top of the page.

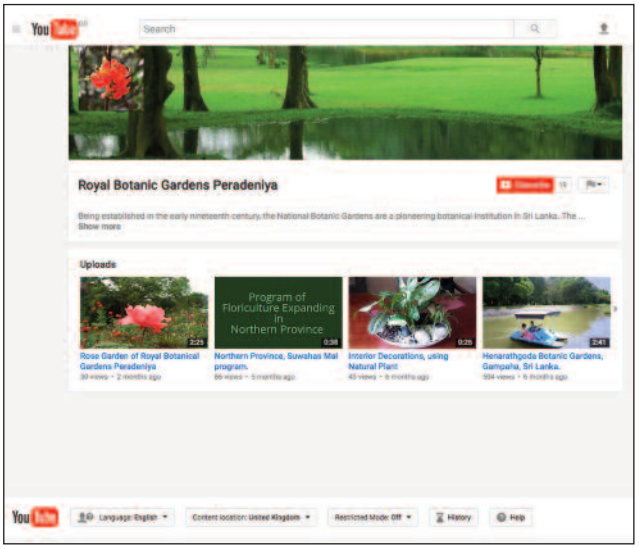
- **Instagram**

Instagram is one of the fastest growing social media platforms. By its very nature as a photo-sharing app, this highly visual social media platform is also of great relevance to botanic gardens. The majority of the users of Instagram are young people. The use of hashtags # with keywords is also an important element of this platform. The average post has a lifespan of several hours, mostly because of hashtag searches which are popular on Instagram.



- **YouTube**

While YouTube has not been used extensively by botanic gardens to date, the scope for use is tremendous, as botanic gardens and their activities are uniquely suited to video. Most videos are shot by traditional media and then can be uploaded onto a botanic garden's YouTube channel and then shared through other social networks as a conversation starter. Demographics widely vary however clearly they are very subject dependent.



- **Pinterest**

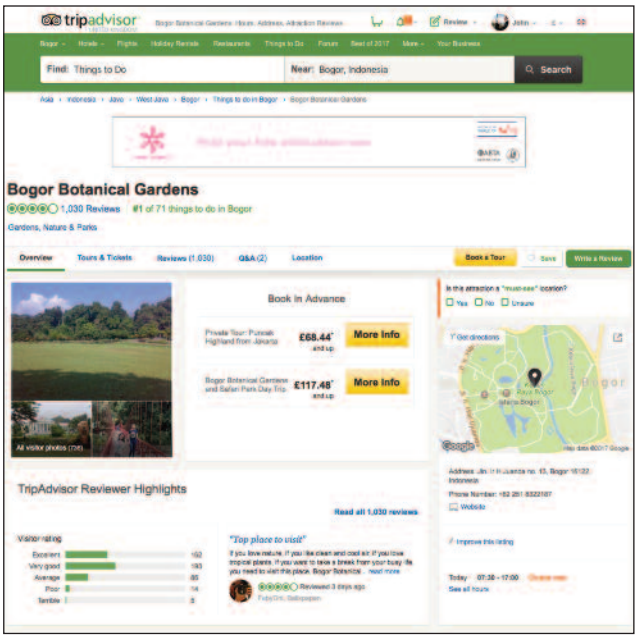
Pinterest is used to highlight important branded accounts or regionally significant accounts. As with Instagram, Pinterest is highly visual and offers a great outreach platform for botanic gardens. They can use it to drive web traffic while highlighting blooms, nature, weddings, travel and more, and can also feature other botanic gardens and sites.

- **Blogs**

Blogs offer long-form text posts but can also incorporate photos and videos. The lifespan of blogs is much longer than the social media mentioned above, and allows for archiving of content. Blogs are a useful channel for botanic gardens to provide updates and news or to go into more detail about their work.

- **TripAdvisor**

Not a social media as such, TripAdvisor is a consumer review site that is integral to the marketing of many botanic gardens. People may often view the site to study previous visitor reviews and to ask questions before deciding on a potential visit. Regular reviews from visitors can encourage footfall to the botanic garden. In order to capitalize on this, botanic gardens should interact with Tripadvisor users.



7.5.4 Conclusion

Tourism to botanic gardens for many years was rather unappreciated and unnoticed. This began to change around the turn of the century as botanic gardens became more relevant probably owing to the desire of the public for conservation, sustainability and a realisation of the socio-cultural value of gardens and gardening. More recently the academic world, governments and the tourism industry have begun to investigate botanic gardens visiting and gardening as actual and potential tourist attractions. It might be concluded that botanic garden visitation is on the threshold of becoming a major component of twenty first century tourism, and that much of this growth may be enabled by the linkage of social media and botanic gardens. Decisions have to be made on how botanic gardens might go to the next level of development to fully and sustainably capitalise on their potential as tourist destinations.

7.5.5 Bibliography and References

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