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**Botanic gardens -  
science, innovation and  
pushing boundaries**



**BGCI**

*Plants for the Planet*



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# EDITORIAL

## CELEBRATING INNOVATION IN BOTANIC GARDENS

The study and cultivation of plant diversity by botanic gardens is firmly rooted in the past but innovative new approaches look to the future. Advances in science and technology are providing new opportunities to understand plant diversity and develop solutions to current environmental problems. This issue of BGjournal celebrates innovation in botanic gardens – pushing the boundaries of scientific knowledge and its practical application. It also considers the engagement of gardens with their visitors to share the science and make environmental knowledge more accessible and relevant to wider audiences.

Scientific research has been an important component of the work in botanic gardens for over 500 years. Documented plant collections continue to provide living laboratories and models of ecological interactions. From observation of whole plants to genetic and DNA analysis new techniques are enabling deeper understanding of the plants in collections that have important implications for management of diversity in the wild. The application of new techniques for identifying plant species is described by de Vere; for documenting their conservation status by Bachman and Moat, for conserving *in vitro* by Valerie Pence and communicating with the public by Matthew Jebb.

The *ex situ* collections of plant material and expertise within botanic gardens are increasingly being used to support species reintroduction and ecological restoration programmes. BGCI is currently involved in the development of the Ecological Restoration Alliance of

botanic gardens that will be launched in May this year with an ambitious action plan to restore 100 priority sites around the world. This scheme is a response to the urgent need to prevent the further loss of ecosystem services and to support international biodiversity policy objective. Availability of appropriate plant material is one of the prerequisites for meeting this objective. Botanic gardens collectively hold around one third of all plant species and thus provide a vital store for restoration. The Australian Seed Bank Partnership described by Sutherland is an exciting new approach strengthening Australia's capacity to restore and connect landscapes and ecosystems through seed-based restoration. The paper by Samain and Cires provides an example of how material in collections can be evaluated to show its appropriateness for restoration in the wild. The authors remind us that to be of conservation value, living collections must be genetically representative and they describe the first comprehensive study of three plant groups sampled in the wild and in living collections.

Restoration needs to take into account changing climatic conditions and the somewhat controversial question of assisted migration is tackled by Hallfors, Vaara and Lehvavirta in their article that highlights the responsibility, skills and opportunities that botanic gardens have in this emerging field.

The creation of new botanic gardens allows the opportunity for research to be fully integrated with garden design, management of living collections, education and training from the outset. Exciting progress is the development of the Oman Botanic Garden that aims to



grow all the native species of Oman is described by Oliver, Al-Farsi, Al-Hosni, Al-Makmari and Kneebone.

I hope you enjoy the richness of ideas presented in this issue of BGjournal! BGCI will strive to share the best of botanic garden innovations, and at times provocative, ideas. Please let us know your thoughts and ideas for future debate as we collectively secure planet diversity for people and the planet.

**Sara Oldfield**  
Secretary General, BGCI



# PLANTS FOR THE FUTURE – A FUTURE FOR OUR PLANET

## TOWARDS A PROTOCOL FOR GENETIC MANAGEMENT OF *EX SITU* LIVING PLANT COLLECTIONS

There is an urgent need for worldwide assessment of genetic diversity of *ex situ* living plant collections and comparison with wild populations, especially for threatened species. The Botanical Garden of Ghent University, Belgium is addressing this need.



Esteban Martínez climbing a tree to collect a newly discovered *Hydrangea* species on the volcano Tacaná in Chiapas state in southeast Mexico near the border with Guatemala. Stems with leaves of this species are visible on all the trunks (Marie-Stéphanie Samain).

### Introduction

It is estimated that one third of all plant species are threatened with extinction and yet plants continue to be underrepresented in conservation debates and policies. However, global initiatives, such as the Global Strategy for Plant Conservation (GSPC) are aiming to bring a significant change. As stated in Target 8 of the GSPC, at least 75% of threatened plant species should be present in *ex situ* collections. Botanical gardens play a key role in conservation of plant diversity, but only about 30% of globally threatened plant species are currently held in their living collections (Oldfield, 2010). To be of conservation value, living collections must be genetically representative. Although information on genetic diversity in *ex situ* collections is scarce, it is thought that diversity is low in collections of numerous species. Moreover, besides the many studies and initiatives for specific taxa, our knowledge about the genetic diversity of threatened plant species in general is quite limited. This lack of insight into genetic diversity of threatened wild plant species contrasts with the broad knowledge about crops and their wild relatives. This fact is also reflected by GSPC Target 9, which specifically states that 70% of the genetic diversity of crops, including their wild relatives and other socio-economically valuable plant species, should be conserved. We still have a long way to go to understanding genetic diversity in threatened plants, conserving an important part of this diversity in *ex situ* collections, defining which percentage of genetic diversity might be feasible and/or desirable to aim for, and finally making this available for conservation and restoration projects.



A happy team of botanists and local children after discovering a new *Hydrangea* species on the volcano Tacaná in Chiapas state in southeast Mexico near the border with Guatemala (Paco Najarro).

### Setting the stage

The GSPC 2011-2020 states that:

**“ Without plants there is no life. The functioning of the planet, and our survival, depends upon plants. ”**

Achieving Target 8 of the GSPC depends on the existence of genetically representative collections, and these are essential for recovery and restoration work. Our focus should therefore be on assessing and ensuring the conservation value of *ex situ* collections (Sharrock *et al.*, 2010).

Assessments of a representative sample of plant species will provide a basis for an initial estimation of a baseline, and to monitor progress towards this target. Therefore, toolkits under this target need to include protocols for genetic management of *ex situ* collections and consequent reintroductions.

One of the suggested milestones to serve as a step towards the 2020 target is that *ex situ* collections of all critically endangered species should be genetically representative of the species (SBSTTA, 2010). However, preliminary observations and data suggest that this currently is not the case in many collections, as the genetic diversity from wild population to *ex situ* collections ‘gradually’ decreases (= genetic bottleneck) as a consequence of 1)

habitat destruction narrowing genetic diversity and subsequent evolution (= genetic erosion), 2) collection bias (‘easy’ localities, selection of morphological variation which is not necessarily reflected by genetic variation), 3) cultivation bottleneck (accessions dying because of unsuitable conditions). Hence, the establishment of a protocol guiding genetic management during the different steps (wild population – *ex situ* collection – reintroduction) is essential for implementation of Target 8 of the GSPC and, ultimately, for safeguarding the future of our planet.

### Towards an assessment for flagship groups: *Hydrangea*, *Magnolia* and *Cactaceae*

The Botanical Garden and the Research Group Spermatophytes of Ghent University (Belgium) are increasingly involved in conservation of the plant groups which are housed in their living collections and studied in ongoing projects, such as *Peperomia* (Samain *et al.*, 2010), *Hydrangea* (Red List project in cooperation with BGCI, including a specific conservation project in Mexico), and *Aristolochia* (Rivera Hernández & Samain, 2011). Our strategy, to combine fundamental botanical research with conservational efforts, has also led to the establishment of a project, initiated in 2011, which will be continued and accelerated thanks to the support of the Fondation Franklinia. Within this project we aim to compare genetic diversity between wild populations and *ex situ* collections of three unrelated

Angiosperm groups with different life histories and growth forms. A range of genomic tools will be applied to wild and *ex situ* individuals of selected species of the flagship groups *Hydrangea*, *Magnolia* and *Cactaceae* to enable rapid characterization of genetic variation, providing 1) support for specific conservation actions, and 2) general guidelines and a protocol on genetic management for acquiring accessions for *ex situ* collections, in order to be used by collectors and botanical gardens worldwide in the framework of the achievement of Target 8 of the GSPC.

### Sampling and lab work

The three plant groups being studied are considered as priority groups for BGCI, the IUCN/SSC Global Trees Specialist Group and the International Organization for Succulent Plant Study (IOS), with whom we cooperate. These groups are rather well-studied taxonomically and are also very important in the horticultural trade, with especially *Cactaceae* also suffering from illegal harvest and trade. Despite the fact that these groups are a priority for conservation, the genetic diversity within *ex situ* collections is almost entirely unknown, and has not been compared with wild populations. There is clearly an urgent need for this research.



Collecting *Hydrangea aspera* with local botany students on mountain Taiping Shan, Taiwan (Eduardo Cires).



Characteristic	RFLP	Microsatellite	AFLP	ISSR	PCR sequencing
Genomic abundance	High	Medium	Very high	Medium	Very high
Part of genome surveyed	Low copy coding regions	Whole genome	Whole genome	Whole genome	Whole genome
Amount of DNA required	High	Low	Medium	Low	Low
Type of polymorphism	Single base changes, insertion, deletion	Changes in length of repeats	Single base changes, insertion, deletion	Single base changes, insertion, deletion	Single base changes, insertion, deletion
Level of polymorphism	Medium	High	Very high	High	Very high
Inheritance	Codominant	Codominant	Dominant	Dominant	–
Ease of use	Labour intensive	Easy	Difficult initially	Easy	Easy
Automation possible	Low	High	Medium	Medium	High
Cost of automation	High	High	High	Medium	High
Development costs	Medium	High	Low	Low	High
Reproducibility (reliability)	High	High	High	Medium to high	High
Level of training required	Low	Low/Medium	Medium	Low	High
Cloning and/or sequencing	Yes	Yes	No	No	Yes
Radioactive detection	Yes/No	Yes/No	Yes/No	No	Yes/No
Proprietary rights status	No	No (some licensed)	Licensed	Licensed	No (some licensed)

Table 1. Comparative assessment of some of the salient characteristics of different molecular genetic screening techniques: RFLP (or Restriction fragment length polymorphism), Microsatellites or simple sequence repeats (SSRs), AFLP (or Amplified fragment length polymorphism), ISSR (or Inter Simple Sequence Repeat) and PCR sequencing.

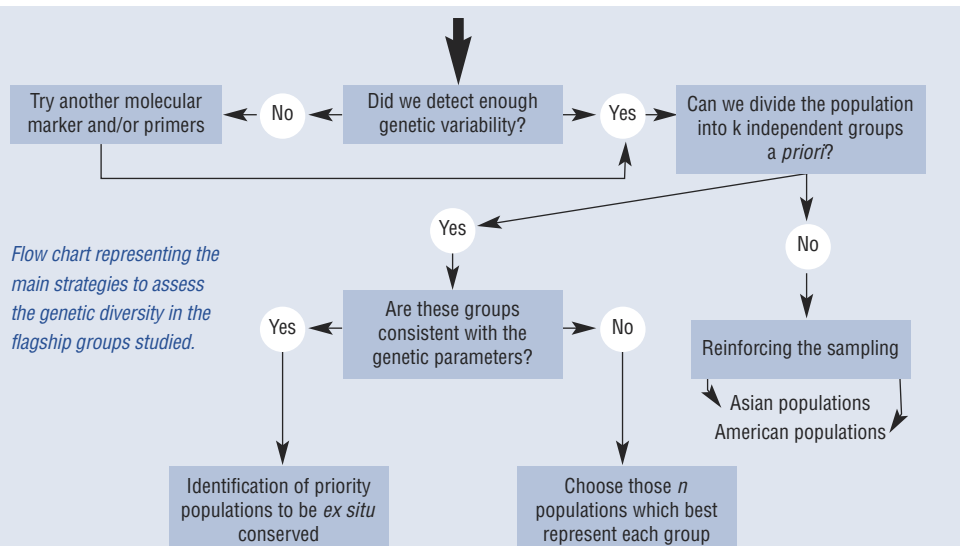
**“ Around one-third of the globally threatened species that are found in botanic garden collections are recorded in only one collection. ”**

Global and/or local Red Lists are available for each group (*Magnolia*: Cicuzza *et al.*, 2007; Cactaceae: e.g. IUCN, 2011) or are being prepared (*Hydrangea s.l.*). These groups represent different unrelated families of Angiosperms, with different habitat preferences and a range of life history traits. Within each group, taxa are selected based on: 1) presence in a representative number of public and accessible private *ex situ* collections (botanical gardens, arboreta, etc.), 2) well-documented origin of the accessions, and 3) availability of material verified by specialists. Because of the second criterion, the quantity of useful accessions available for the research is

much reduced, but we believe it is not useful to include samples without documented origin, as their value, for example in reintroduction projects, is highly doubtful. Additionally, *Magnolia* and *Hydrangea* individuals are plants with life spans of several hundred years, predating fragmentation events, so we will obtain reliable genetic information that may help genetic restoration projects (e.g. López *et al.*, 2008).

Availability in botanical garden collections has been checked via the PlantSearch module on the BGCI website ([http://www.bgci.org/plant\\_search.php](http://www.bgci.org/plant_search.php)) or via direct and ongoing communication with gardens. A final selection criterion is that most of the species are ‘Vulnerable’, ‘Endangered’ or ‘Critically Endangered’ according to IUCN Red List categories and criteria, hence they are priority species for conservation and for use in recovery and restoration work. Furthermore, the genetic diversity of these rare species will be compared with some more common or widespread species.

Field work has already been or will be performed in countries and areas where the Research Group has extensive field experience and local cooperation partners (Latin America and East Asia). Within the wild populations, a representative sample of individuals will be collected, meanwhile in the *ex situ* collections we aim to include an equal number of accessions from as many gardens as possible. In addition, our work on *Hydrangea* will also help to build new living collections, e.g. in Mexico, supported by the Mohamed Bin Zayed Species Conservation Fund. Molecular tools provide valuable data on diversity through their ability to detect variation at the DNA level. Identification is of fundamental importance in diversity studies in a variety of different ways. For evaluation of species diversity, it is essential that individuals can be classified accurately. The identification of taxonomic units and endangered species, whose genetic constitution is distinct from their more abundant relatives, is important in the development of appropriate conservation strategies. Taking advantage of current molecular techniques, relatively quick assessments of genetic diversity in plants can be performed using well-sampled material and ready-made protocols, as long as the most limiting factor, funding, is available. For each flagship species, different molecular techniques (e.g. RFLP, microsatellites, AFLP, ISSR, PCR sequencing) are currently being tested and/or developed, with comparisons of cost versus data yielded, ease of use, and applicability for conservation



Flow chart representing the main strategies to assess the genetic diversity in the flagship groups studied.

research (Table 1). For the elaboration of these techniques, either in-house experience has been developed or collaboration with experienced research groups has been set up.

### Outlook – Connecting the dots

To our knowledge, this is the first comprehensive study of this kind, with a constant evaluation of the different techniques, in order to assess the progress of the project (see Figure 1). The expected results can be subdivided in two levels: i) specific results for each group: they will provide insight into genetic diversity and history, providing a basis for further conservation work; ii) comparison of different unrelated groups with different life histories and growth forms: this approach will lead to a general overview of the genetic diversity available in wild populations and *ex situ* collections, as well as of the specific problems involved with decreasing genetic diversity from the wild to the collection, information which will be extremely useful for implementation of Target 8 of the GSPC.

Some important specific outcomes are listed here: 1) assessment of percentage of genetic diversity present in *ex situ* collections worldwide for the three plant groups under study, 2) identification of priority populations for *ex situ* conservation, 3) definition of a genetically representative collection (compared to Target 9 of the GSPC stating that 70% of the genetic diversity of crops and other socio-economical valuable plant species should be

conserved), 4) indication of the number of samples that needs to be collected in the wild to obtain a genetically representative collection, 5) testing the hypothesis that endangered species with narrow distribution are genetically limited, 6) conservation of flagship species, and finally, 7) reports and publications in cooperation with e.g. BGCI, the IUCN/SSC Global Trees Specialist Group and the IOS. Last but not least, it has already become clear during this pilot year 2011 that this study will lead to further international cooperation with many interested gardens and researchers.

**“ We expect to form a scientific network studying genetic diversity in plants for conservation purposes under the auspices of BGCI. ”**

Please feel free to contact us if you would like to cooperate, exchange experiences, or if you have comments or questions.

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Marie-Stéphanie Samain preparing herbarium specimens of a new *Hydrangea* species of Los Tuxtlas, state of Veracruz, Mexico (Esteban Martínez).

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Mountain Wawu Shan, Sichuan, China, location of several *Hydrangea* specimens (Eduardo Cires).



# BARCODE WALES:

## DNA BARCODING THE NATION'S NATIVE FLOWERING PLANTS AND CONIFERS

DNA-based identification systems can help to identify and monitor species and provide a platform for a wide range of applications where accurate species identification is required.



*DNA-barcoding at the NBGW laboratory.*

The ability to identify plant species is fundamental to our understanding of the world around us. To conserve plants, their habitats and ecosystems we need to be able to identify and monitor species.

**“ Objective 1 of the Global Strategy for Plant Conservation is that: “plant diversity is well understood, documented and recognized. ”**

Correct identification is also vital in order for us to use plants for food, medicine or materials. Identification of plants often relies on morphological examination, but around the world there is a shortage of taxonomic experts able to identify species. Beyond this, it is often desirable to be able to identify species from material where morphological approaches are difficult or impossible to use; for example, from pollen, roots, seeds, or fragments of tissue. In these situations DNA-based identification systems can be used and in 2003 Paul Hebert coined the term ‘DNA barcoding’ (Hebert *et al.*, 2003).

DNA barcoding uses short sections of DNA to act as a unique identifier for species. The aim of DNA barcoding is to have global agreement on the regions of DNA and protocols used for different groups of living things in order to create an international resource for species identification. To begin with, reference DNA databases are developed using species identified by a taxonomic expert; unknown DNA sequences can then be compared to these to make an identification. Open Science is key, DNA barcodes, their associated information and protocols for their development should be available to everyone, from researchers, regulatory authorities to the general public.





*Tephrosia integrifolia ssp. maritima.*

There are now initiatives throughout the world for DNA barcoding species from all of the kingdoms of life, such as the International Barcode of Life initiative (IBOL), which works across 25 countries and aims to DNA barcode 5 million specimens from 500,000 species within five years. The Consortium of the Barcode of Life (CBOL) is devoted to promoting DNA barcoding as a global standard for DNA-based species identification and the Barcode of Life Data System (BOLD) provides a key repository for DNA barcodes and their associated data (Ratnasingham and Hebert, 2007). In 2009, the Plant Working Group of CBOL proposed two sections of genes within the chloroplast genome, *rbcL* and *matK*, for plant DNA barcoding, with the suggestion that more markers may be required (CBOL Plant Working Group, 2009). In December 2011 the nuclear gene ITS was announced as the official barcode for fungi during the 4th International Barcode of Life Conference in Adelaide, Australia.

Projects are now underway to DNA barcode the world's plant species. For example, the New York Botanic Garden is DNA barcoding the world's trees, whilst the Universities of Adelaide and British Columbia are working on grasses. Some projects are concentrating on floristic regions: Korea University is working on the flora of Korea, the University of Johannesburg on the flora of the Kruger National Park, the Smithsonian Institute on tropical forestry plots and institutions throughout China are working together to DNA barcode their flora. The Royal Botanic Garden Edinburgh is DNA barcoding British

bryophytes and at the National Botanic Garden of Wales, we are DNA barcoding the native flowering plants and conifers of Wales, with our partners at the National Museum Wales (Hollingsworth *et al.*, 2011).

**“ Botanic gardens are increasingly using DNA barcoding as an identification tool for plants in their collections. ”**

#### Barcode Wales

Wales has 1,143 native and archaeophyte (species introduced before 1500 AD) flowering plants and conifers, found within 455 genera, 95 families and 34 orders. In order to create a reference database of DNA barcodes for these, it is vital to start with correctly identified source material. Taxonomist, Dr Tim Rich, from the National Museum Wales is responsible for checking every species that we DNA barcode. We have concentrated on using herbarium specimens for DNA barcoding. The herbaria of the world provide an incredibly valuable resource of plant species that have been collected and identified by expert taxonomists. We have developed special protocols for extracting DNA from herbarium specimens to make full use of this resource.

For the resulting DNA barcodes to be of most use, it is very important that along with the DNA sequence there is a full record of when, where and by whom the plant was collected. All users of the DNA

barcodes need to have access to this information, along with a scan of the herbarium voucher. Where fresh material is collected for DNA barcoding an associated herbarium voucher must always be made. The only exception to this is for endangered species where creating a voucher is not possible on conservation grounds; in this case a photograph is used instead. We also need to DNA barcode more than one specimen for each species to allow for errors and any variation between individuals within the species. The level of variation within the species should be low however, as the idea behind DNA barcoding is to use regions of DNA that differ between species but which are the same within a species. For our Barcode Wales project we aim to DNA barcode at least three samples for each species using the DNA barcode markers *rbcL* and *matK*.

Over the last three years we have sampled 4,272 plant specimens, 3,637 from the National Museum Wales herbarium (NMW) and 635 freshly collected from throughout Wales. We have 5,723 DNA barcodes, 3,304 for *rbcL* and 2,419 for *matK*. Of the 1,143 species of Wales we have DNA barcoded 98% using *rbcL* and 90% with *rbcL* and *matK*. Our first scientific publication describing our results and protocols will be available soon (de Vere *et al.*, in press) and all of our DNA barcodes, along with their associated collection information and scans of their herbarium vouchers will be accessible shortly on the Barcode of Life Data System in the Plants of Wales project.



*The herbarium at the National Museum of Wales.*

The Barcode Wales project provides a valuable resource for researchers wanting to identify species using DNA-based approaches. Our DNA barcodes for Wales also provide a stock of barcodes that can be incorporated into other projects. The 1,143 species of Wales represents 77% of the native flowering plants of the UK. We have just begun DNA barcoding the rest of the UK flora, working with the Royal Botanic Garden Edinburgh.

“ Once the native flora of the UK is complete we will begin on the non-native species. ”

### Applications

The range of applications using plant DNA barcoding is as broad as our imaginations, with some great applications already being developed. Ecological applications include understanding below-ground biodiversity by DNA barcoding roots (Kesanakurti *et al.*, 2011), reconstructing past landscapes using plant remains (Sonstebo *et al.*, 2010) and identifying invasive species (Bleeker *et al.*, 2008). DNA barcoding has been used to verify the contents of plant products including medicinal plants (Chen *et al.*, 2010), berries (Jaakola *et al.*, 2010), olive oil (Kumar *et al.*, 2011), tea (Stoeckle *et al.*, 2011) and kitchen spices (De Mattia *et*

*al.*, 2011). DNA sequences obtained for DNA barcoding have also been used to create phylogenetic trees for phylogenetic community ecology research (Kress *et al.*, 2009).

At the National Botanic Garden of Wales we have started to develop applications that use our DNA barcodes for Wales in collaboration with partners around the world. We have worked with Dr Sandra Ronca (Aberystwyth University) and Prof. Mike Wilkinson (University of Adelaide) to track the movements of pollinators in threatened habitats by DNA barcoding pollen found on their bodies. We are working with Dr Joel Allainguillaume (University of the West of England) to use DNA barcoding to carry out ecological surveys and Dr Neil Loader (Swansea University) on reconstructing landscapes from plant remains in peat cores. We are also using our DNA barcodes for human health in a project with Jenny Hawkins and Prof. Les Baillie of the Welsh School of Pharmacy (Cardiff University). For her PhD research, Jenny is collecting honey samples from throughout the UK and testing their ability to fight the hospital infections MRSA and *Clostridium difficile*. She will then DNA barcode the honey to find out what plant species the bees visited to make it. We hope to use this to pinpoint active phytochemicals donated by the plant species that contribute to the honey's anti-microbial properties.

Many of our applications use 'next generation' DNA sequencing as this allows us to analyse samples containing mixtures of plant species. Our PhD student, Hannah Garbett, co-supervised by Dr Tatiana Tatarinova (Glamorgan University) is developing bioinformatic tools that will help to analyse these large and complicated datasets. As well as using our DNA barcodes for species identification we are working with Prof. Pete Hollingsworth (Royal Botanic Garden Edinburgh) to create the first complete national phylogeny of the flowering plants of the UK.

### Public engagement

DNA barcoding is not only a resource for scientists; it is also an excellent way to engage people with their native flora and plant sciences research. At the National Botanic Garden of Wales we are particularly interested in projects that link arts and science. We have worked with botanical artist, Emma Tuck, on a contemporary art exhibition and community artist, Pod Clare, on a Barcode Wales mosaic created by community groups from throughout Wales. We are currently working with Prof. Andrea Liggins (Swansea University) on a photographic exhibition to be shown in botanic gardens and universities throughout China on native Welsh plants and their DNA barcodes.



Collecting specimens for DNA barcoding.



Barcode Wales is also a mechanism for training the next generation of plant scientists. The workforce assembling the DNA barcodes for the Barcode Wales and Barcode UK projects are undergraduate students who spend a year at the Garden as part of their degree. Their work is supplemented with work experience students from A-level to postgraduate who spend from two weeks to a few months at the Garden.

The Barcode Wales project provides the most complete coverage of DNA barcodes of any national flora, offering a platform for a wide range of applications where accurate species identification is required. It also provides a hub for multi-disciplinary research across the arts, sciences and social sciences and a vehicle for training plant science students and volunteers. The DNA barcodes and their associated information are Open Access to make a resource available to everyone.

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 Consortium for the Barcode of Life <http://www.barcodinglife.org/>  
 International Barcode of Life Initiative <http://ibol.org/>  
 Barcode of Life Data System <http://www.boldsystems.org>  
 4th International Barcode of Life Conference <http://www.dnabarcodes2011.org>

# GeoCAT -

## AN OPEN SOURCE TOOL FOR RAPID RED LIST ASSESSMENTS

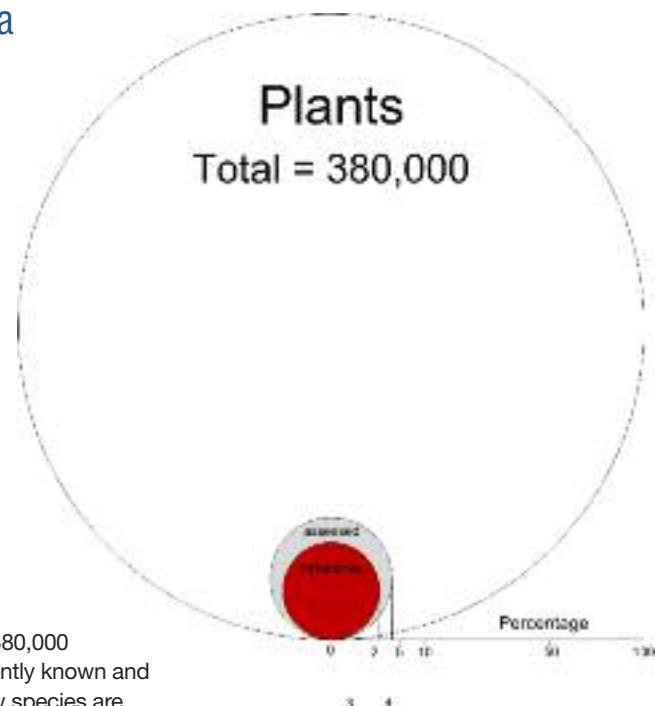
The combination of botanical collection data and the latest web mapping technology is providing better tools to support the work of conservation scientists. The Royal Botanic Gardens, Kew have developed GeoCAT – the Geospatial Conservation Assessment Tool - to help ease and speed up the process of Red List assessment for plants.

### Plants and the Red List

The IUCN Red List is well known to many as the most authoritative source of information on extinction risk for the world's organisms. The annual release highlights the familiar creatures: the polar bear, the orang-utan, the rhino, the gorilla - the celebrity species of the conservation world. And each year we are reminded again that many species are slipping toward extinction, usually as a result of pressures from human activities. But when was the last time you remember a species of plant being mentioned? All too often plants fall under the radar when it comes to the Red List, although they are being assessed and they are as threatened as the 'better known' groups such as mammals (see the Sampled Red List Index – *Plants Under Pressure a global assessment 2010*). So why is there such a shortfall? The sheer number of species, in comparison to the number of available scientists, is the main problem.

There are as many as 380,000 species of plants presently known and around a thousand new species are described as new to science every year<sup>1</sup>. There are more species in a single family of plants such as grasses (Poaceae) than there are all known mammals (5,488). With that in mind it is no wonder that so far only around 4% of the world's flora have been assigned a category of threat on the global Red List. Although significant activity on Red Listing for plants is taking place around the world, often in botanic gardens, the sheer scale of the task is daunting.

Despite attempts from the botanical community to accelerate the production of Red List assessments, such as the ambitious Target 2 of the Global Strategy for Plant Conservation<sup>2</sup> 'an assessment of conservation status of all known plant species' we are still falling short. The implications of this are very significant. How can we even begin to focus our



**“ Only around 4% of the world's plants have been assessed for their conservation status at the global level. ”**

resources into practical conservation effort if we don't know where or what to focus on? The good news is that progress is being made. Not only is raw information on plants becoming increasingly available through data sharing platforms such as the Global Biodiversity Information Facility (GBIF), but automated and semi-automated tools are now available to allow scientists and experts to harness that data to answer important questions like – how endangered is my species?



With these powerful analytic tools we can more rapidly assess species and more effectively prioritise conservation action. With the development of tools such as GeoCAT, the target of assessing all species may just become more achievable.

## Introducing GeoCAT

The Royal Botanic Gardens, Kew has long been associated with the Red List process, being key players in the development of the original Red Data books of endangered plants and continuing with major contributions of plant assessments to the present day Red List. The Geographical Information Systems (GIS) Unit at Kew has a more specific interest in the application of GIS techniques for Red List assessment, in particular the geographic components of an assessment. Innovations within the field of GIS over the last few decades have allowed for the first time the production of tools to aid Red List assessment such as the CAT (Conservation Assessment Tools) project<sup>3</sup>. Released in 2007, CAT is an extension to the ArcView GIS software system and allows automatic calculation of measures used in Red List assessment. With the recent explosion of web mapping innovations such as Google Earth and Google Maps it was clear that these conservation tools needed to be brought into this new era, which led to the development of GeoCAT.



Screenshot from GeoCAT – illustrating multiple data sources, and the metadata window allowing you to view the underlying data for each point.

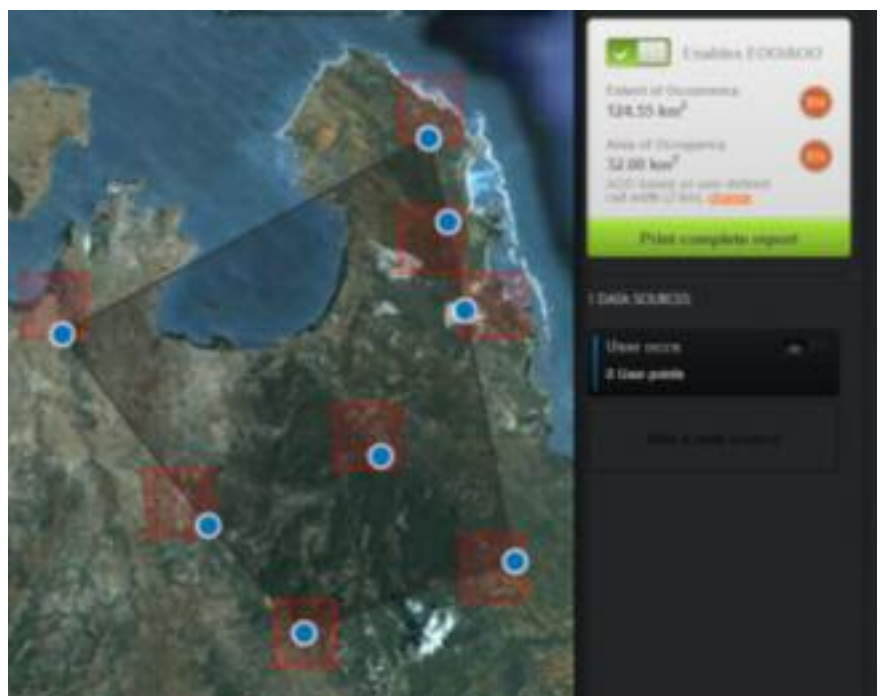
GeoCAT is a rapid assessment tool that utilises primary plant occurrence data to produce measurements relating to the geographic range of a species. These are then compared with the IUCN Red List categories and criteria and provide evidence to support a full Red List assessment. It is important to note that it is an expert driven system i.e. it is assumed that the user of the tool has good knowledge of the species being assessed as well as a thorough understanding of the Red List categories and criteria (IUCN 2001).

## Geographic range measures used in the Red List

One aspect of Red Listing that has been particularly challenging so far is the calculation of geospatial measurements included in the criteria – in other words criteria related to the geography of a species. Geospatial aspects of the Red List criteria mostly relate to Criterion B - Geographic Range, but also appear as elements throughout the other categories A – D. Two different measures of geographic range: extent of



GeoCAT (accessible at this URL: <http://geocat.kew.org/>) is a web based tool developed through a collaboration of the Royal Botanic Gardens, Kew, IUCN and ViBRANT that supports the Red Listing process. If you want a quick way to find out more you can watch the video here: <http://vimeo.com/22739331>. The GeoCAT home page - <http://geocat.kew.org/>.



Screenshot of extent of occurrence (EOO) and area of occupancy (AOO) analysis. When the analysis is enabled the results are displayed showing area in km<sup>2</sup> and corresponding Red List category.

occurrence (EOO) and area of occupancy (AOO) are used in the Red List criteria. Extent of occurrence (EOO) is a measure of the geographic range size of a species. IUCN guidelines suggest a minimum convex polygon (MCP) can be used to calculate this value. A MCP is defined as the smallest polygon in which no internal angle exceeds 180° and contains all sites of occurrence. This value represents the spread of risk for a species such that species with a large extent will be more robust to threatening processes. An alternative approach for depicting a species range is to show the area where a species occurs or area of occupancy (AOO). A simple way to measure this value is to overlay the distribution with a grid and sum the area of square grid cells the species occupies

### How it works - calculating geographic range of species for Red List assessments

GeoCAT is driven by primary occurrence data. For hundreds of years botanists have been travelling to the ends of the earth to take cuttings from plants as scientific specimens. Herbarium specimens are verifiable records that show where and when a particular species was collected. By combining these records at the species level we immediately have an indication of the geographic range of a species and it is this data that GeoCAT analyses to determine the two measures of extent of occurrence (EOO) and area of occupancy (AOO). A benefit of GeoCAT is that as well as data being provided by the user e.g. from a database of their own specimens, it can also be imported from existing online sources such as GBIF and Flickr. The images in Flickr need to be labelled with the species name and 'geotagged' or 'georeferenced' i.e. assigned a latitude and longitude co-ordinate so we know where it was taken.

The data can be entered in three ways:

- Import from online sources - existing sources of primary data can be queried. By adding a search term e.g. a scientific name or a common name you can query two sources of online data: GBIF and Flickr. Any matching record that has been georeferenced can be added directly to the map editor.

- Upload your own data - where occurrence data has already been gathered, for example, in a specimen database or spreadsheet, it is possible to import this data directly to the map editor. Data simply needs to be converted to comma separated values format following a standard structure.
- Manual add - you may have specific knowledge regarding the distribution of a species. The user can add points directly to the map with a single click.

With data on the map the user can then edit by adjusting points, removing them and by examining the original data e.g. inspecting a Flickr image to see if it really is the species it is labelled as. From here, at the click of a button the analysis can be enabled. Based on the points on the map, the extent of occurrence (EOO) and area of occupancy (AOO) values are instantly calculated and the values are compared with the thresholds set in the IUCN Criteria. For example if the extent is less than 5,000 km<sup>2</sup> then it meets the threshold for the Endangered (EN) category. From here a simple report can be generated and the data can be saved or exported to other formats such as KML for visualisation in other packages such as Google Earth. As mentioned previously it should be noted that this does not represent a full Red List assessment, it provides evidence that fulfils part of the criteria.

### Impact and benefits

GeoCAT is a good example of the innovative work presently being carried out in botanic gardens, in this case to directly support plant conservation. Specifically GeoCAT provides the potential to speed up the Red Listing process for plants and offers hope that global targets such as the Global Strategy for Plant Conservation may be reached. By utilising existing data it is an evidence based approach that can be used immediately as much occurrence data is already available. The tool is open and free to use so there are no restrictions in terms of accessibility aside from a connection to the internet. It provides a platform that can be built on in the future to make other aspects of the Red List criteria automated. In short, it could be the first step towards a fully automated data driven Red List

assessment. Perhaps then we will see plants in the spotlight for the next edition of the Red List.

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# FROM FREEZING TO THE FIELD— IN VITRO METHODS ASSISTING PLANT CONSERVATION

When seeds are few and cuttings difficult, tissue culture can provide an alternative conservation pathway



Above: The rockhouse habitat that is home to the Cumberland sandwort experimental population (Valerie Pence)  
Left: A storage tank in CREW's CryoBioBank (CREW).

## Introduction

Off the main public path of the Cincinnati Zoo & Botanical Garden, in the corner of the park, one can find the Carl H. Lindner Family Center for Conservation and Research of Endangered Wildlife (CREW). From this small, two-story building, plant and animal research is being conducted that is impacting rare species across the country, and beyond. CREW's Plant Research Division (PRD)'s particular focus is using *in vitro* (tissue culture) methods for propagating and preserving endangered plants. The work is directed

primarily at species for which traditional approaches are not adequate. Thus, when seeds are few and cuttings are not workable, tissue culture can provide an alternative method for propagation. When seeds are lacking or are "recalcitrant" (sensitive to the drying necessary for traditional seed-banking), freezing tissues from *in vitro* cultures can be an additional tool for banking valuable genetic material from rare taxa. The PRD has developed protocols for the *in vitro* propagation and/or preservation of over 50 rare species, providing materials for restoration projects and tissues for long-term storage in liquid nitrogen in CREW's CryoBioBank.

## Propagation for restoration

Propagation is a key element in providing plants for recovery projects. For many endangered species, traditional propagation by seed or cuttings can meet propagation needs, but for species with few or no seeds or few individuals, plant tissue culture can be used to supplement these methods

(Sarasan, *et al.*, 2006). The PRD collaborates with a number of other institutions, including botanical gardens in the Center for Plant Conservation network (Center for Plant Conservation 2012), government agencies, NGOs, and research stations. These institutions often identify plants for which *in vitro* approaches could be useful and then provide the starting material (seeds or shoot tips) to CREW for propagation.

**“ Over 100 botanic gardens around the world have tissue culture and micropropagation facilities. ”**

(BGCI GardenSearch database, 2012)

The Autumn buttercup (*Ranunculus aestivalis*) is one such species, known from one site in south central Utah in the Sevier River Valley. When it became obvious that the population was declining, The Nature Conservancy bought the property in order to protect





*Todsens pennyroyal growing at White Sands Missile Base (Doug Winget).*

and northern Tennessee. Like the Autumn buttercup, CREW initiated several genetically different tissue culture lines from seeds that had been collected by researchers at the Missouri Botanical Garden. Shoots were produced, rooted, and plants transferred back to soil.

In order to demonstrate the feasibility of using tissue culture propagated plants for the recovery of this species, an experimental out-planting was made at a rockhouse site in southern Kentucky in collaboration with the U.S. Forest Service. Plants were planted in different areas of the rockhouse, in order to evaluate the microhabitats within the rockhouse, which differed in light and moisture levels. Over the course of six years, plants at several of the microsites have grown and reproduced well, indicating the viability of these methods, should they be needed to help preserve the species in the future. A genetic study is also underway to analyze the genetic diversity of this new, experimental population.

By combining the laboratory strengths of CREW with the field expertise of collaborators in botanical gardens, governmental agencies, and non-profit organizations, the work at CREW is being integrated into conservation efforts for species recovery and demonstrating that tissue culture propagation can be an important tool for conservation and restoration.



*Cumberland sandwort flowering in culture (Valerie Pence).*

were initiated from each seedling. As with most tissue culture systems, the shoots can be maintained and multiplied in culture by dividing and sub-culturing the shoots onto fresh medium every 6-8 weeks. By changing the components of the medium, the shoots can be stimulated to form roots, and once rooted, the shoots are then ready to be moved back into soil. This is a clonal method of propagation, but each genetic line initiated from a separate seed is maintained separately, creating a collection of genetically distinct lines in tissue culture.

When the plants were rooted, they were sent to the Arboretum at Flagstaff, where they were carefully removed from their culture tubes and acclimatized to soil and to real-life conditions in a greenhouse. At that point they were ready to face life out in the wild. In 2007, a group of buttercups, originally propagated at CREW, was planted back out at the Sevier Preserve, and, while none of the plants from the original population have been seen in recent years, a group of the CREW-propagated plants are surviving and flowering.

Another such species is the Cumberland sandwort (*Minuartia cumberlandensis*), a small plant that grows only in sandstone rockhouse habitats in the Daniel Boone National Forest of southern Kentucky



*The Autumn buttercup (Valerie Pence).*

the plant. Over the past decade, five organizations, including CREW, The Arboretum at Flagstaff, The Nature Conservancy, U.S. Fish & Wildlife Service, and Utah State University, have come together in a partnership to work on studying and restoring this species (Pence *et al.*, 2008). A small number of seeds were collected at the site and sent to CREW where they were germinated *in vitro*, and shoot propagating cultures



## Resources for the Future

In a similar fashion, the PRD is utilizing *in vitro* methods to provide tissues for long-term liquid nitrogen storage, when seed banking is not a workable option for a species (Engelmann, 2004). This work centers on the CryoBioBank (CBB), CREW's liquid nitrogen storage facility. The plant collections, or "Frozen Garden" within the CryoBioBank include seeds, spores, and tissues of about 150 plant species in four distinct collections, all stored at -196°C (-320°F).

Seeds and spores are prepared for freezing by simple drying, but tissues, such as shoot tips and embryos, require more elaborate procedures. Concentrated solutions of sugar and other chemicals, known as cryoprotectants, remove water from the tissues and protect the cells from damage during the freezing and thawing processes. The extremely low temperatures of liquid nitrogen provide stability for the tissues, maintaining them in a state of suspended animation for decades.

The CryoBioBanks's Frozen Garden is made up of four distinct collections. The Regional Seed Bank includes seeds

of state and federally endangered species from Kentucky, Indiana, and Ohio, including such species as Short's goldenrod (*Solidago shortii*) and Running buffalo clover (*Trifolium stoloniferum*). Because not all endangered plants are seed plants, there is a Pteridophyte (Fern) Bank and a Bryophyte (Moss) Bank, which contain spores, as well as tissues of gametophytes and sporophytes. The Endangered Plant Tissue Bank contains samples of tissues from *in vitro* cultures of endangered plants that are grown at CREW. Material is continually added to the collection, and some samples are over 20 years old. Recently, samples of pollen from the American chestnut (*Castanea dentata*) were shown to be viable after 15 years of storage in liquid nitrogen, while shoot tips of the Cumberland sandwort were recovered after 10 years in liquid nitrogen.

Perhaps one of the most important uses of the CryoBioBank is to preserve tissues from endangered species that fall into the category of "exceptional" species. These are plants that either produce few or no seeds, or their seeds are sensitive to drying and cannot be put through the rigors of normal seed-

banking (Pence, 2011). For these plants, banking tissues from *in vitro* cultures in liquid nitrogen can provide an alternative method for long-term germplasm storage. At CREW, multiple genotypes of several species are being collected, put into culture, and then cryopreserved, in order to maintain a back-up to the genetic diversity of these species, should they decline or be lost in the wild. These include three endangered pawpaws endemic to Florida, the Four-petal pawpaw (*Asimina tetramera*),

*The small Cumberland sandwort flower*  
(Brian Jorg).



A second planting of CREW propagated Autumn buttercups took place in 2010 in Utah (Valerie Pence).

Beautiful pawpaw (*Deeringothamnus pulchellus*), and Rugel's pawpaw (*Deeringothamnus rugelii*), all with desiccation-sensitive seeds (Pence, 2006). Samples from a species from the mountains of New Mexico, Todsens pennyroyal (*Hedeoma todsenii*), which produces no seeds, are being collected, cryopreserved, and also analyzed genetically at CREW to document the diversity of the population (Pence *et al.*, 2009). There appears to be some diversity, even though no seed production has been documented in this species, suggesting that reproductive deficiency is a recent development in this species. Todsens pennyroyal is found on the grounds of White Sands Missile Base, and this work has been funded, in part, by a grant from the U.S. Army. Again, partnerships with those working in the field have been an important part of this work.

Tissue banking of exceptional species, as well as the *in vitro* propagation of plants for reintroduction, supports Target 8 of the Global Strategy for Plant Conservation (Botanic Gardens Conservation International, 2011), which sets goals for *ex situ* conservation and restoration. While these methods are more labor intensive and, thus, more expensive than traditional methods, they do provide tools for dealing with exceptional endangered species, and for maintaining precious plant diversity into the future.

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# EXCITING HORTICULTURAL CHALLENGES AT THE OMAN BOTANIC GARDEN

The Oman Botanic Garden aims to house all 1,200 native, as well as the traditionally cultivated Omani plant species within its collections



Team members from the Oman Botanic Garden on a field trip in the Dhofar region of southern Oman (Ian Oliver).

The Oman Botanic Garden, focusing on Oman's native flora, is the first of its kind in the Middle East region. The Garden which is 420ha in extent is not far from Muscat the capital of Oman. It aims for excellence in botanical research, education and interpretation, cultivation and display of the unique flora of Oman. A project of this magnitude obviously has its challenges, but the Living Collections Department faces more tests than usual. There are a total of 26 dedicated persons working in the living collections department – of this, 9 are University graduates.

The garden aims to house all 1,200 native, as well as the traditionally cultivated Omani plant species within its collections, with the vast majority housed in the living collections. Prior to the formation of Oman Botanic Garden in 2006, only very few of these native species had ever been propagated, and grown *ex situ*. Eventually all the native flora will be grown in specially constructed habitats that resemble the wild area the plants came from. While the habitats are constructed, the plants are cultivated in the nursery, ready to be planted out once the hard landscaped construction has been completed.

All relevant information about cultivating the plants is collected in the field so when the plant material is back in the garden the plants can be successfully



Salim Al Makhmari harvesting potential cutting material of a native tree *Lannea malifolia* in the southern Oman coastal zone in Dhofar (Ian Oliver).

propagated. This includes local climatic conditions, watering requirements, soil types, sun or shade conditions, with success and failures recorded from the beginning of this project.

Field data helps to determine growing conditions for plants. Research and field work is a core function of the botanic garden, with over 200 field trips having been undertaken in the last 6 years to explore the landscapes of Oman and collect seeds and data on plant distribution, vegetation ecology, environmental conditions, and conservation status. Oman Botanic Garden uses BGBASE to enter data on a



Salim Al Hinai, horticultural assistant, moving a recently large potted container plant -150 litre air pot in the nursery (Ian Oliver).

field computer during trips, to ensure that data is accurately recorded. Each new species collected in the field is awarded its own unique accession number which remains with that plant throughout its lifetime. Seeds are dried, cleaned and counted in preparation for propagation, while cuttings and plants are processed as soon as possible by the horticultural team. All propagation data is also entered into BGBASE so that cultivation methods can be analysed for success and repeated.

**“ Cultivation protocols are developed based on detailed field observations. ”**

The nursery has state-of-the-art facilities including shade houses (9000 m<sup>2</sup>), outside hardening-off areas (3000 m<sup>2</sup>), 4 polytunnels (4000 m<sup>2</sup>), 2 glasshouses (2600 m<sup>2</sup>), a propagation house (700 m<sup>2</sup>), nursery offices, staff canteen and a meeting room.

The nursery uses a number of technical aids to lessen its impact on the environment. For example, a sophisticated computerized control system manages the whole nursery operation, by continuously monitoring outside conditions and adapting the water efficient cooling systems within the polytunnels and glasshouses to ensure a growing environment that is beneficial to the plants. Oman is primarily an arid country so efficient water use is vital. A combination of automated irrigation

drippers, ebb and flow matting and manual watering systems ensures irrigation is targeted exactly where it is needed. To reduce water usage even more, the team has tested a range of water-holding soil additive products. Sprinkling the water-holding soil additive products on the surface of some medium sized potted trees (*Prosopis cineraria*) has reduced their dependence on water by as much as 40% during the hot summer months.

**“ Oman’s plants have attracted healers, crafts people, explorers and botanists for over 2,000 years. The country is home to over 1,200 species of plants, with 80 species found nowhere else in the world. ”**



Young baobabs (*Adansonia digitata*) standing on wooden pallets that vary from 6 and 4 years that were grown from seed in air pots housed in the nursery (Ian Oliver).

The botanic garden’s focus is on sustainable development, and therefore basic principles of sustainability are implemented to minimise damage to the environment and depletion of natural resources.

In order to reduce the carbon footprint, the use of peat, a non-renewable horticultural product, is to be radically reduced. Since the start of the project, as more data about plant requirements has been established, the dependence on imported peats has been reduced by 50%; the peat has been replaced with local soils, sharp sand and gravel. At present there are very few peat alternatives available in Oman. In the future, however, compost will be locally sourced using biodegradable green waste.

New cutting media have been developed that suit the soil conditions in the areas from where these plants originate.

Plant health is important in the fight against pests and diseases. Chemical use is minimised and is based on low-toxicity. The use of strong organo-phosphates is not permitted on the site. Instead more environmentally friendly pesticides, like Indian neem cakes (*Azadirachta indica*) and lemon and chilli grass extracts, are used. In the future it is hoped that biological control agents will be used to effectively combat all pests and diseases.

Integrated pest management helps reduce pesticide use. Good hygiene is of paramount importance to good plant health. Infestation levels are continuously monitored. Different coloured insect sticky traps help to monitor and remove pests.



Air pots have had a positive impact on growth rates and longer term survival of large trees and shrubs. This innovative product comes in perforated pre-moulded sheets of recycled polyvinyl, ready for assembly on-site. The perforations allow for air-pruning so protruding roots are effectively dried out when they come into contact with the outside environment. The air flow also allows the roots to stay cooler, which is vital when temperatures in the nursery can exceed 49°C during the summer. Sizes used are 45 litres, 150 litres, 600 litres and 1000 litres. The young baobabs (*Adansonia digitata*), are cultivated in air pots containing several hundred litres of specially prepared growing mixtures. Baobabs in Oman can eventually reach a height of 15 meters. In the Middle East Baobabs are unique to southern Oman and a few areas just across the border in Yemen. Many translocated trees are potted up in air pots holding 1000 – 1500 litres of growing medium.

**“ Over 20% of Oman’s plants are threatened through environmental issues such as over-grazing, development and habitat destruction. ”**

Translocation and rescue of mature trees from degraded or disturbed sites is ongoing. The team works in conjunction with the Ministry of Transport and visits



*A large rescued Olea europaea being loaded into a pick-up ready for transportation back to the Oman Botanic Garden (Abdullah Al-Hosni).*

road construction projects, water pipeline sites etc. to identify large trees for rescuing. Large trucks and construction machinery are used to excavate mature specimens that would otherwise be destroyed. The survival rate is about 60%. As much care as possible is taken when transporting these large tree specimens, for example by wrapping the roots in geotextile cloth during transportation back to the nursery in Muscat where they are immediately planted into large air pots. Some of the

largest trees are 5m tall, for example one *Juniperus excelsa* which is several hundred years old, and two *Olea europaea*. A large desert rose, *Adenium obesum* measuring over 3m in height, has also been rescued.

It is essential that climate controlled shade houses are provided for the plants as without them they would be stunted or die. Plants respond best to 50% shade. Some of the plants will eventually have to be hardened off so that they can be planted outside in the harsh desert conditions.

Through the use of new products and experimental horticultural techniques, the nursery now houses 100,000 plants and approximately 360 species and is the largest documented collection of Arabian plants in the world.

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*Khalid Al-Farsi, nursery production supervisor, standing next to a baobab in the Dhofar province of Oman. The tree will be translocated to the garden in the near future (Ian Oliver).*



# THE ASSISTED MIGRATION DEBATE – BOTANIC GARDENS TO THE RESCUE?

Conservation actors are being forced to re-evaluate the suitability and effectiveness of their conservation approaches in the face of climate change. With the rapidly emerging need for a better understanding of assisted migration, botanic gardens now have an opportunity to provide society with unique expertise.



*Setting up the trial in Oulu BG (Maria Hällfors).*

## Introduction

Climate change is having a considerable impact on wild plant species, with declines in populations and distributions shifts towards the poles and higher elevations being reported by scientists. One of the most alarming estimates paints a grim picture of more than half of the European

flora becoming endangered by the year 2080 due to climate change (Thuiller *et al.*, 2005). However, it is not only biodiversity that is experiencing the pressures brought about by such changes. Conservation actors, including botanic gardens, are being forced to re-evaluate the suitability and effectiveness of their conservation approaches and may need to consider novel strategies.

With the combined effects of climate change and habitat degradation taking its toll on biodiversity, it seems that we can no longer focus on trying to reverse the trends. Instead, we need to start working to mitigate the negative effects. In Europe, for example, the progression of climate change will mean that more than half of the species in existing protected areas will be subject to



unfavourable conditions (Araujo *et al.*, 2011). Thus, we need to become more proactive in species conservation. Perhaps the most controversial proposal thus far is moving species beyond their historic natural ranges, a strategy often called assisted migration, assisted colonization or managed relocation. Botanic gardens, with their expertise and resources, could play an important role in investigating the possibilities of carrying out assisted migration in a sustainable way.

In this article, we aim to highlight the responsibility, skills and opportunities that BGs have in this emerging field. We will briefly review the basic ideas behind assisted migration and describe a multi-disciplinary research project that was initiated at the Botany Unit of the Finnish Museum of Natural History in 2011.

### **Assisted migration challenges the traditional conservation view**

When the environment changes a species has two options. It can adapt or it can move to more favourable areas. Species that do not manage to do either will go extinct. We may not be able to help species adapt to new habitat requirements nor can we entirely rely on conventional conservation methods like *in situ* conservation in protected areas to accommodate species in a changing

world. However, we could adapt our thinking and conservation strategies to find new ways to save biodiversity. *Ex situ* conservation offers a valuable tool for preserving threatened species (Pritchard & Harrop, 2010). Although on its own it is not a sustainable solution for conservation, it does provide an essential step in the process of introducing species back into the wild. This could include introducing species into habitats outside their natural range, if their original habitat is no longer climatically suitable – assisted migration.

Active discussions on assisted migration have been taking place since around 2005. Moving species to novel areas raises not only ecological, but also judicial, ethical and economical challenges. Which species should we move and when? How can we ensure that the species do not become invasive? How much should we interfere with nature, and is it even legal? And finally, how much would this cost? It is essential to develop joint research programmes that include ecological, legal, and ethical perspectives in the investigation of assisted migration.

### **Plant conservation prohibited by law**

Currently there are few laws that unambiguously regulate assisted migration as a conservation strategy.

There are, however, many legal restrictions on the movement of species in both domestic and international laws. Some of these laws restrict the intentional movement of the species itself, while others are designated to protect the areas to which species may be transferred. In an era of climate change, when assisted migration may need to be considered, these regulations may actually hinder the conservation of the world's biodiversity, although their original intent was to enable it.



*Individuals of Siberian primrose ready to be planted in the trial plots (Marko Hyvärinen).*



*Svanhovd BG in northern Norway, where part of the Siberian primrose trial was set up (Marko Hyvärinen).*

The majority of current international nature conservation treaties (e.g., Convention on Biological Diversity, Convention on International Trade in Endangered Species) were developed before a broad understanding of the impacts of climate change on species conservation had been reached. Therefore, research findings and new methods developed concerning assisted migration may require a re-consideration of current conservation legislation. Indeed, completely new comprehensive regulation mechanisms may need to be developed. This would help to ensure

that each assisted migration intervention and trial is duly coordinated and safely implemented. However, it must also be recognised that ecological circumstances, such as climatic conditions and the level of habitat fragmentation, vary between nations. Hence, species conservation regulations which suit one nation, may not be suitable for another.



*A translocation trial of the Siberian primrose being set up at Svanhovd BG in northern Norway (Marko Hyvärinen).*

Besides the need to inform the scientific and conservation communities, professionally produced educational materials and expert advice for the public and local decision-makers are important. Already at least one case of assisted migration, uncontrolled by the authorities, has been initiated, as the “Torreya Guardians” continue to move the threatened *Torreya taxifolia* further north in the USA.

### **Botanic gardens have invaluable expertise and experience**

Botanic gardens have a long tradition of growing plants in locations beyond their natural distribution. Thus they have ample experience to investigate the effect of macroclimatic factors on species. Translocation trials conducted



*“The Flood – wet to the skin” was one of the six environmental art works exhibited in Kumpula BG during the summer of 2009. They were produced in collaborating of students of art and science during an environmental art course called “Growing season”. In 2012 a similar course, “Reclaimed territories”, will be organized focusing on, e.g., assisted migration and BGs (Mikko Heikkinen).*

under controlled conditions can offer valuable information on the possibilities of moving species to new locations.

Botanic gardens are also lead players in the field of *ex situ* conservation and species reintroduction. While living collections provide experience of species requirements, all kinds of *ex situ* collections may offer an important source of knowledge and plant material for both the research and practical actions required for assisted migration projects. This is especially true for species that are extinct or extremely rare.

Moreover, being highly involved in invasive species management, botanic gardens also hold knowledge and share information on invasion biology, a key question to be addressed when considering moving species to novel areas. Furthermore, apart from offering valuable information for evaluating species’ current and future climatic ranges, herbarium records along with species distribution databases can also be used to predict invasion risks (Aikio *et al.*, 2009).

### **New openings for botanic garden conservation - the Helsinki example**

The Assisted Migration research project at the Botany Unit of the Finnish Museum of Natural History started in 2011 with an analysis of the legal and

ecological aspects. To begin with, a conceptual analysis is necessary, as the debate and the terminology are still evolving. The first translocation trial between botanic gardens has been started and an assessment of the need for assisted migration in the conservation of Finnish species is underway.

The key question in the analysis of the regulations that concern assisted migration is whether we need new guidelines to enable its execution. The regulations should be compatible with nature conservation legislation at large, but also fair and just within society. Through comparing the results of the legislative analysis with current ecological knowledge, we will recognise the best model for regulation of assisted migration and present it for introduction into the Finnish legal order.

The invasive species problem and ethical questions are next in line, and in the near future we hope to be looking into aspects of population genetics, economics, and the social acceptability of using assisted migration as a conservation strategy. The uniqueness of the project lies in the multi-disciplinary approach that allows a wide-angled examination of the problem. We will also cooperate with other institutions involved in conservation in order to include the knowledge held by these organisations.





Even though the winters in Helsinki can be quite cold, plants from more northern locations can be tested for their reaction to a warmer climate with shorter winters in Kumpula BG (Mikko Paartola).

### Translocation trial of Siberian primrose

The most southern variety of the threatened Siberian primrose (*Primula nutans* var. *jokelae*) grows on the shores of the Bothnian Bay. Climate change may threaten this species and the next more northern suitable habitat for this variety may be by the shores of the Arctic Sea, 500 km north of its current range. Thus, the variety may need to be assisted in its migration when climate changes.

In a translocation experiment we are studying the success of the species at three climatically different sites: the University of Oulu Botanic Garden, Finland; University of Helsinki Botanic Garden, Finland; and Svanhovd Botanic Garden, Norway. Through the trial we can compare the effect that climate in these three areas has on the Siberian primrose and find out whether macroclimatic factors are decisive for the viability of the species. From this we can extrapolate whether the southern variety could already grow on the shores of the Arctic Sea and whether a warmer climate affects it negatively. The experiment, conducted with the help of the botanic garden network will thus give us insights into the need and possibilities for assisting the Siberian primrose in its migration under a changing climate.

### Multiple roles for botanic gardens in the development of assisted migration

With the rapidly emerging need for a better understanding of assisted migration, botanic gardens now have an opportunity to provide society with

unique expertise. Botanic gardens can, for example, collect and disseminate information about the criteria and best practices concerning assisted migration; give expert advice concerning the ecological requirements of focal species; provide plant material and develop seed and *ex situ* collections to support the study and application of assisted migration; offer testing grounds for species' reactions to different climatic conditions; and evaluate risks of invasiveness. Furthermore, the international network of botanic gardens can prove essential, as future (assisted) migration routes do not necessarily respect national borders. Hence, international assisted migration research initiatives would provide a strong platform for external funding.

Botanic gardens also routinely communicate information through their networks and public education programmes and the idea of assisted migration could be disseminated in various ways. As an example, the University of Helsinki participates in the Helsinki World Design Capital Year 2012 and the assisted migration research project is part of the University's contribution to designing the future through scientific innovation. Together with other research initiatives concerned with climate change, we will unite recent research results with art to create discussion within both the scientific and the public community. One attempt is a science and environmental art workshop for university students, called Reclaimed Territories that will be organised in Kumpula Botanic Garden in spring 2012. The course culminates in an art exhibition that will be displayed during the summer.

As botanic gardens are institutions connecting research, conservation, and education they are well suited for innovative research openings bringing together stakeholders, knowledge producers, and end-users from various disciplines as well as society at large. In this role of linking different sectors, they can play an important role in enhancing the debate on controversial subjects, such as assisted migration, and push the boundaries of their traditional fields of expertise.

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*The Siberian primrose (Primula nutans var. jokelae) may need to be assisted in its migration as climate changes (Marko Hyvärinen).*



# Dreaming of **Sheep-eating** plants

## Modern digital media can enhance the botanic garden visitor experience

**W**hen I tell teenage visitors to Ireland's National Botanic Gardens (Glasnevin) that we have a living plant that can catch, kill and eat a sheep they are usually left speechless trying to decide if I am telling the truth. Perhaps even readers of this article - who may be well-versed gardeners or garden educators will be equally suspicious of this claim? It does seem unlikely, but let me assure you it is perfectly true, and if you come to Glasnevin, and download one of our free audio tours to bring with you, you can see and hear about it at first hand.

It is my contention that to be successful, modern digital media must have two vital elements – firstly it has to be simple and preferably free, and secondly it must be intriguing, bizarre or outlandish.

**“ The world of streaming media, whether visual or audio, must seize your attention or it will be drowned by background noise ”**

An outrageous mind-boggling story or headline is vital or your message isn't going to attract attention.

Last year the National Botanic Gardens of Ireland produced a series of 30 audio clips and launched these in a number of formats – as downloadable podcasts, as a mobile phone application (app) and lastly as a souvenir 'in-hand guide'<sup>1</sup>. Mary Mulvihill, of Ingenious Ireland<sup>2</sup>, a science writer and broadcaster, conceived the audio tours idea.

Mary is a broadcaster, a writer and a storyteller, and is passionate about sharing Ireland's hidden heritage, especially its scientific brilliance and industrial archaeology. She had previously made a radio series about the



Mary Mulvihill, Matthew Jebb and Senator David Norris at the launch of the audio guides, April 2011 (National Botanic Gardens)





*The audio tours can be downloaded as podcasts, or as a mobile phone app to your Android phone. Alternatively a souvenir player can be bought at the gardens.*

work of the botanic garden's herbarium for the national radio broadcaster, Raidió Teilifís Éireann (RTE) in 2007 (*Washed, Pressed and Dried*). She therefore knew that the place was brimming with ideas and quirky stories. Together we prepared a submission to the Department of Tourism, Culture & Sport under a 'Cultural Technology Grant Scheme' that ran in October 2010. The scheme was hugely oversubscribed so we were delighted to be chosen.

The grant was for €39 000 to cover the costs of recording, editing, final production and delivery of three themed tours. A sound recordist and graphic designer were employed to ensure the final product was as professional as possible. Recordings were made both in the gardens and in a studio. The tours were to be colour-coded and self-guiding, with about 10 stops, each lasting 2-3 minutes. The points of interest would be marked with numbered disks, and a map would be needed, showing the corresponding colour-coded and numbered signs, to guide visitors along the audio trail. In as far as it was feasible, the intention was for the audio guides to be free of charge.

From the beginning we identified a number of alternative users: those with portable media player (mp3) players;

those with traditional (non-'smart') phones which had memory card slots allowing the audio files to be sold pre-loaded on a removable flash memory card (microSD); those with Smartphones who could download an application (app) comprising a guiding map, images and audio files; and lastly those with no media technology of any description.

To get the audio to the user, a range of delivery options were possible. A set of downloadable podcasts on our website, along with downloadable map-guides, was going to be the basic product. We also considered the possibility of people downloading the tours at the gardens by USB link from a dedicated computer at the visitor centre. In the end this proved too difficult to implement. Another possibility we considered was using Bluetooth wireless technology to allow visitors to load the audio files on arrival at the gardens. The costs of hardware and

the difficulties with speed of delivery, especially when multiple users were trying to download, made this impractical as well.

For visitors with older phones with neither USB nor Internet connectivity we considered selling a pre-loaded, reusable 1GB microSD media card. The customer would in effect only pay for the card, the audio files essentially being free. The memory card would allow us to "past-proof" the project: ensuring that we could still reach the significant percentage of our target audience who were using older, non-'smart', phones.

An alternative past-proofing solution was an 'In-Hand Guide' manufactured by AudioConexus<sup>3</sup>. These low-cost, credit card sized units (although somewhat thicker!) are manufactured with an hour (or two) of audio, and come complete with headphones, a folded map with instructions and batteries sufficient to give 4 to 5 plays. The full set of three tours would have required a two-hour capacity, so we opted for a selection of 16 of the 29 stories, lasting just over 45 minutes.

*The souvenir guides come in a nicely designed box with a colourful map and various images*



With the funds available, we were only able to select one of these alternatives. The difference in price per unit was more or less comparable (ca. €5). In the end we decided the memory cards were little used in general, and were just not as visually exciting as the souvenir guides. At the launch, in April 2011, presidential hopeful Senator David Norris described the souvenir players as 'cute as a button'. And they are indeed enchanting little pieces of technology. They come in a nicely designed box with a colourful map and various images. The cost of each player was just under €5, for a minimum order of 1,200 units. We also bought several hundred dual adaptors with extra headphones for €2, allowing two visitors to hear the tour together. We sell the units at cost price, or at a discount with a souvenir guide. During the summer months they sold at the rate of nearly 20 a week, but considerably fewer in the winter. To date we have sold, or given away, over 250 units and do not intend to place a fresh order. The purpose all along was for these to be a stop-gap, enabling the 'non-techie' visitor to enjoy the tours.

We had initially dismissed the idea of developing a mobile phone app as the cost of development would have been in excess of €7000. In the end a chance discussion with a company called Ziggapps presented the opportunity to develop an app at a highly competitive rate. The solution they developed meant we had a fully interactive map of the gardens with a range of images for each audio stop. In addition the identical app is available both to iPhone and android phone users. You can search on iTunes or Android Market using 'botanic' or visit the National Botanic Gardens website ([www.botanicgardens.ie](http://www.botanicgardens.ie)). With apps a decision must be made early on to launch them for free, or for a small charge, this caused some debate, but eventually we decided to keep it free.

At the end of 2005 in Ireland there were as many active mobile phone accounts as the human population in Ireland (4 million). Trends suggest that by the end of 2011, 37% of all mobile phones in the country would be smartphones .

*A listening stop on the 'Green' tour (National Botanic Gardens)*

**“ Irish mobile phone users download an average of one new app every week. ”**

Within 6 months of the launch, the app had been downloaded over 2,000 times with about an equal division between the two formats.

Every plant in our collection has a story to tell, and the audio tours have presented us with an excellent, unobtrusive way in which to bring these stories to as many visitors as possible. The stories are unashamedly wacky – A tree with no leaves, where is the soul of a plant?, the loneliest plant in the world. As for the sheep eating plant... visit [www.botanicgardens.ie/audio](http://www.botanicgardens.ie/audio) or scan the QR codes to download the app and hear all about it!



*QR code for Android Users.*



*QR code for iPhone users.*

There are three tours in the collection, each with 40 minutes of audio commentary. The Green tour explores the famous glasshouse and palm house, and is suitable for cold or wet days; the Yellow tour is an easy stroll around the gardens historic highlights; and the Red tour is an extended walk to the river, for wildlife, roses and even some philosophy. At each listening stop on the tour, there is a prominent label matching the tour colour. Each stop is only about 2 minutes or so of audio allowing the visitor a chance to hear the story and admire the plant or building. The stories were written and narrated by Matthew Jebb and Mary Mulvihill, as well as the gardens' orchid expert Brendan Sayers, and wildlife guide Glynn Anderson.

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# Growing the **social role** of botanic gardens

Are the prevailing organisational cultures and structures of UK botanic gardens fit for purpose in the 21st Century?

environmental and social challenges of the 21st Century. Fundamental to this process, argued the report, was the recognition by botanic gardens that their social role is inextricably linked to environmental issues, such as climate change and social justice.

**“ Embracing the concept of social and environmental justice is .....critical if botanic gardens are to reinvigorate their fundamental purpose. ”**

In 2011, BGCI continued to develop the themes identified in the 2010 study, working with partner gardens in the UK to help them re-evaluate their mission, philosophy, values, goals and practices within a framework of social responsibility. The project was led by BGCI in collaboration with RCMG.

## Project overview

The gardens participating in the project were asked to develop and deliver a discrete project that would address a social issue or community group relevant to their garden. The projects were aimed at engaging with non-traditional audiences on globally significant issues, such as climate change and social and environmental justice. To support the development and implementation of these projects, a series of four workshops were organised. Through these workshops, the gardens were encouraged to re-examine their social practices in relation to their potential social role. The rationale for the workshops was to develop the partner gardens as socially and environmentally



Shorefields College Year7 visit to Ness (Ness Botanic Garden)

## Introduction

In 2010, with support from the Calouste Gulbenkian Foundation, BGCI commissioned the University of Leicester's Research Centre for Museums and Galleries (RCMG) to carry out a study examining the social role and relevance of contemporary botanic gardens. The study, which was largely UK-based, but also drew on experience

from the USA and Australia, concluded that botanic gardens possess vast yet untapped potential as agents of social and environmental change. RCMG recommended that gardens should relocate their social and environmental roles within a modern framework of values, mission and vision and urged them to work together through partnerships and networking organisations like BGCI to face the

responsible organisations. They were encouraged to embrace organisational change in order to embed their social and environmental role.

### The botanic garden projects

#### **Urban Veg at Winterbourne House and Garden**

A community-based vegetable garden, *Urban Veg* involved the University of Birmingham's Winterbourne House and Garden and Birmingham's Islam Awareness Week Committee. Winterbourne had been invited to join the project on condition that it would work with the city's Muslim community, which, in 2010, amounted to around 17 per cent of its total population. For Winterbourne the project represented an opportunity to improve its visitor diversity. Typically, in line with most UK gardens, Winterbourne's visitor profile was predominantly white, middle class and relatively elderly.

Designed as a 'two-way cultural exchange and learning experience,' the project spanned the growing season of spring to autumn, from March - October 2011. The fifteen adult participants were recruited through Islam Awareness Week from a range of backgrounds among Birmingham's diverse Muslim population. Participants were responsible for every stage of the process, from deciding what to grow, maintaining the plot and harvesting the crops. Winterbourne staff led workshops on growing vegetables organically, including sowing, planting and

maintenance techniques. Environmental issues related to gardening were highlighted, including water conservation, sustainable growing media, chemical pollution, wildlife awareness, 'growing your own', reducing carbon footprints, food miles and the value of the environment in promoting healthy living.

Winterbourne staff found that the challenge of helping participants grow unfamiliar crops tested their horticultural skills and in engaging with participants from very different backgrounds, they also developed their listening and negotiating skills. As a two-way cultural learning exchange, *Urban Veg* was not a formal process of instruction but a collaborative process. Staff confidence and understanding across the organisation was developed through training, enabling them to engage with the Muslim participants in a culturally sensitive way – dealing with language difficulties, for example, and providing washing facilities and space to pray.

*Urban Veg* undoubtedly made its mark on Winterbourne, but what will its legacy be? One motivation for the project was to broaden audiences to the garden, making the garden less white and less middle-class. The visible presence of the project certainly had an impact, but how will the garden sustain the work it has done with Muslim communities? And will Muslim communities find themselves acknowledged and incorporated in Winterbourne's future programme planning and projects?



Identification of pond dipping (Ness Botanic garden)

Staff are clearly more conscious of awareness training and undoubtedly their thinking is changing. Participants came up with inspiring suggestions for the development of *Urban Veg* – extending the concept of growing vegetables into the community; seeing Winterbourne represented at festivals and melas; and using local radio stations to highlight the work of Winterbourne for Muslim listeners.

#### **Engaging Secondary Schools – Ness Botanic Garden**

The project undertaken by the University of Liverpool's Ness Botanic Garden *Engaging Secondary Schools* targeted socially disadvantaged people in its catchment area. In a joint project with Shorefields Technology College in Liverpool, a group of secondary school students took part in six day-long sessions at the botanic garden. During these sessions, they swapped their urban classroom for the garden, planting and growing potatoes and wildflowers, going on nature trails, hunting for insects and wildlife, pond dipping and learning about the life cycles of aquatic life and finding out about bees from a real beekeeper.



Discussions at Birmingham's urban vegetable festival (Winterbourne House and Garden)





*Planting out seedlings and seed sowing (Winterbourne House and Garden)*

Shorefields Technology College serves some of the most socially deprived areas of Liverpool. Thirty three first languages are spoken amongst the students at the school and levels of attainment are very low. However the school is working hard to improve the life opportunities of its students.

Working with a secondary school from the inner-city of Liverpool was a new experience for the staff at Ness. Situated in a predominantly rural and affluent area of Cheshire, Ness, like most UK botanic gardens attracts a predominantly white, middle-class, and middle-aged audience. Working with Shorefields was seen as an opportunity for Ness to 'reach out' to socially disadvantaged groups in Liverpool and Cheshire. The project challenged many staff assumptions, including the perception that secondary school students are harder to engage with than primary school children. They also harboured negative views about young people from Liverpool.

Students selected for the project were motivated and able scientists. Many wanted to go to University. Shorefields was keen to ensure that the students were not discouraged by the experience of classroom learning. For both students and teachers the collaboration with Ness proved a very positive experience. Students talked enthusiastically about the activities they had been involved in and greatly enjoyed their learning

experiences outside the classroom, especially the practical elements of the sessions. They were allowed considerable autonomy within the safe boundaries of the garden.

The students met adults from very different backgrounds, including specialists and experts with links to the University, who worked well with them. The lack of negative feedback from the students and their obvious excitement about visiting Ness were notable. Garden staff also saw the experience as very positive and enjoyable, reporting that a good relationship had developed with students and teachers.

Many of the students did not have gardens at home and most had not visited a botanic garden before. Their initial comparisons were with what was already familiar to them – parks, greenhouses and allotments. Garden staff reported that seeing the students' 'enjoyment of being outside' made the project worthwhile. Shorefields' teachers saw the visits as an opportunity for their students to compare urban with rural environments and understand the value of both.

Shorefields was clear about the project's focus on the needs of its students. It was a learning experience that took them



*Cultivating the plants in the vegetable garden (Winterbourne House and Garden)*

away from their everyday lives and brought them into contact with a range of people within a new environment. The desire to raise the aspirations of its students was a key motivator. The garden's link with the University of Liverpool was critical. Shorefields saw an opportunity to make the idea of university more accessible to their students, many of whom are from families with no experience of university, and to plant the idea of potential careers in the sciences.

For Ness, the project synchronised with the University's strategy of championing activities that involved knowledge exchange, widening participation, research and innovation. It was also linked to a 'sustainability framework' designed to 'enhance the purpose and relevance of university botanic gardens and their plant collections by utilising skilled and knowledgeable staff to benefit the community and society as a whole.' However, although staff at Ness recognised that botanic gardens do have a role to play in developing young people's learning beyond the curriculum, they lacked the means to fully communicate how to do this. Nevertheless, the project showed what Ness could do, and may provide a model for the garden to replicate with other schools, perhaps helping to broaden the view the botanic garden has of what is possible in terms of developing its social role.

### Lessons learned

The projects undertaken as part of *Growing the Social Role of Botanic Gardens* showed that botanic gardens have the potential to significantly impact on individuals, garden staff and communities. The examples of Ness and Winterbourne also demonstrated that even apparently disenfranchised communities can be willing and enthusiastic partners in joint social enterprises. Moreover the barriers to their involvement are not insuperable. However, gardens in the UK are still at an early stage in this process of engagement and there is much work to do if they are to demonstrate their real potential. Gardens need to be able to relate what they are doing to the wider policy context and see how they are part of a bigger societal picture.

The involvement of Ness and Winterbourne Botanic Gardens in *Growing the Social Role* tested their management structures and organisational practices and challenged them to reflect on and develop their social roles. Neither garden found the process straightforward but their engagement with new groups demonstrated the benefits that botanic gardens can offer marginalised communities when they embrace their social role. As a result of the project, RCMG made a series of recommendations to help botanic

gardens develop their social role. These include developing a vision for the sector, ensuring that the work of botanic gardens is rooted in the wider national policy context and understanding how they form part of a bigger societal picture. Training is essential for gardens to understand the context and barriers to participation and what it means to be excluded, as well as the dynamics of community engagement and partnership.

As the report concludes:

**“ gardens need to reach out into their neighbouring communities to establish meaningful and mutually beneficial relationships. They cannot merely see themselves as islands separate and distinct from the world around them. That way lies irrelevance. ”**

*This article is based on the report: "Growing the social role, partnerships in the community" available for download from BGCI website: [www.bgci.org/education/communitiesinnature](http://www.bgci.org/education/communitiesinnature).*



*Discussions at Birmingham's urban vegetable festival (Winterbourne House and Garden)*



# SAFEGUARDING AUSTRALIA'S FLORA THROUGH THE AUSTRALIAN SEED BANK PARTNERSHIP

The Australian Seed Bank Partnership is an ambitious long term strategy to safeguard Australia's flora in the face of changing climates and other threats to its unique plant communities and landscapes.

## Introduction

The Australian Seed Bank Partnership is governed by *The Council of Heads of Australian Botanic Gardens Incorporated* (CHABG Inc.) and brings together Australia's leading botanical institutions, seed scientists and conservation and restoration experts (Table 1) to collaborate in the collecting and banking of native seed for conservation, as well as developing enabling technologies and sharing the body of knowledge required for industry development and strengthening Australia's capacity to restore and connect landscapes and ecosystems through seed-based restoration.

The partnership is an excellent example of how the Australian Government and not-for-profit sector can work together. The Australian Government supports this conservation programme through the Director of National Parks Statutory Agency (DNP). The DNP employs a National Coordinator to develop and maintain the Australian Seed Bank Partnership programme for CHABG Inc. and provides an operational budget, facilities and services for the Secretariat through the Australian National Botanic Gardens.



*Restoration of Australian landscapes involves individuals, community groups, government agencies and non-government organisations working collaboratively and sharing their expertise and knowledge (Greening Australia).*

**Table 1: Members of the Australian Seed Bank Partnership<sup>1</sup>**

- Australian National Botanic Gardens\*
- Botanic Gardens and Parks Authority (WA)\*
- Botanic Gardens of Adelaide (SA)\*
- Brisbane Botanic Gardens Mount Coot-tha (Qld)\*
- George Brown Darwin Botanic Gardens (NT)\*
- Royal Botanic Gardens and Domain Trust (NSW)\*
- Royal Botanic Gardens Board (Vic)\*
- Royal Tasmanian Botanical Gardens (Tas)\*
- Australian Network for Plant Conservation
- Threatened Flora Seed Centre, Department of Environment and Conservation (WA)
- Greening Australia
- Griffith University
- Royal Botanic Gardens Kew
- University of Queensland

## Background

The Council of Heads of Australian Botanic Gardens was formed in the 1990s as a network of Directors from Australia's capital city botanic gardens. The original purpose of the network was to provide a forum for capital city botanic gardens to share information, develop policy and discuss and coordinate strategic initiatives for their mutual benefit and the benefit of their





*Increasing our knowledge on seed germination will help to restore understorey species and recreate resilient environments (Bindi Vanzella).*

communities. Evolving this network into a not-for-profit organisation has created an outward focused charity which supports the protection, conservation and enhancement of Australian plants and their ecosystems, as well as the provision of information and education and undertaking research about plants and plant communities. By establishing a legal body and realigning the focus, CHABG Inc. is in a position to coordinate efforts nationally to make significant contributions by botanic gardens and their partners to national conservation programmes through the scientific, research, horticultural and educational expertise within these organisations.

The Australian Seed Bank Partnership (formerly known as *Australian Seed Conservation and Research AuSCaR*) builds on the legacy of work and AUD\$24 million investment from 2001-2010 undertaken as part of the Millennium Seed Bank Project (now Partnership). Through this work, the Australian Partners have a proven track record in seed conservation and germination research, and to date have safeguarded over 8,000 plant species across a network of conservation seed banks throughout Australia, and improved knowledge about germination for more than 2,800 of the species that have been banked. The Australian Seed Bank Partnership is CHABG Inc.'s main plant conservation programme.

### **A far reaching impact through collaboration**

Around 92% of Australia's plant species are endemic. The loss, degradation and fragmentation of natural habitats threaten the native flora. Plants are less resilient to external pressures when the communities of which they are a part shrink, or when populations become isolated from each other. Currently, in Australia, more than 1,300 plant species and ecological communities are known to be compromised nationally and at risk of extinction. For each species listed as threatened, there are many more affected by loss of habitat and other hazards.

By evolving the AuSCaR network to the Australian Seed Bank Partnership (ASBP), under CHABG Inc., there has been a significant breakthrough in terms of bringing together expertise within





*Seed banking activities over recent years have led to the discovery of new species, the rediscovery of species thought to be extinct in the wild, as well as establishment of new populations. Mentha atrolilacina was a new discovery made by the South Australian Seed Conservation Centre (SASCC) (SASCC).*

institutions, governed under different state legislation, to tackle conservation at a national level through seed science and seed banking. ASBP programme is a commitment by CHABG Inc. to actively support the implementation of *Australia's Biodiversity Conservation Strategy 2010-2030* (Natural Resources Ministerial Council 2010:21-22) and provides a national safety net for Australia's plant species through *ex situ* conservation that will provide options for the future use of these species and provide important insurance against biodiversity loss.

Conservation seed banking efforts from members of the ASBP have also been significant in assisting the Australian Government to fulfil its major international obligations under the Convention on Biological Diversity and more specifically, the Convention's *Global Strategy for Plant Conservation* (GSPC). The ongoing work of the Partners contributes to the GSPC's objectives of understanding, documenting and recognising plant diversity and ensuring plant diversity is urgently and effectively conserved. Moreover, it contributes to the GSPC 2020 targets focusing on conservation and restoration such as Targets 4 and 8 which specify a minimum of 15% of each ecological region or vegetation type be secured through effective management and/or restoration, with at least 75% of threatened plant species in *ex situ* collections and at least 20% of

those available for recovery and restoration programmes. The Partnership also makes significant contributions to such international efforts as the Millennium Seed Bank Partnership at the Royal Botanic Gardens Kew.

The ASBP is anticipated to have ongoing far reaching effects. The work provides an insurance against the loss of plant species in the wild. Furthermore, the seed bank collections, combined with the knowledge of their germination requirements and survival strategies provide an irreplaceable resource for government, non-government organisations, landholders and community groups who are actively conserving and restoring Australia's rich and diverse landscapes.

### What are the priorities?

Members of the ASBP are combining their collecting and research efforts to create a distributed network of seed banks. These combined efforts capitalise on the nation's expertise and assist with risk management of collections, and enable a cost effective response to safeguarding Australia's flora. The efforts will aim to achieve security for Australia's wild plant diversity and increased understanding of ways to enable its sustainable use. Over the next few years, the Partnership's efforts will focus on:

### 1) A Knowledge Hub - Australia's Virtual Seed Bank

While collecting seeds and undertaking research, partners have captured large amounts of information on flowering and fruiting periods in a diversity of Australian landscapes as well as details of germination and seed storage requirements for particular plant species. The Partnership is collaborating with the *Atlas of Living Australia*<sup>2</sup> to build an accessible online seed information resource, built on national standards, so the data can be shared, retrieved and utilised as efficiently and effectively as possible. This virtual seed bank will:

- Bring together research knowledge from across the nation to enhance understanding of seed handling and storage leading to improve seed conservation and use practices;
- Support policy and planning and guide research development;
- Provide up-to-date information to restoration and conservation practitioners, and community groups, on the unique reproductive biology and ecology of native plants, to support integrated conservation and ecosystem restoration programmes;
- Encourage knowledge sharing to support economic development of native biological resources e.g. for the nursery and horticulture industry, native seed industry and Australian farmers.

### 2) National seed collection

Several of the initiatives being undertaken by the ASBP will contribute to the development of a comprehensive store of wild native plant seeds and genetic resources for conservation risk management and insurance against the loss of wild plant diversity. Through coordinated and collaborative efforts, the aim is to increase the efficiency of seed collecting and banking activities and reduce costs and unnecessary duplication.

One priority for the upcoming years is the 1,000 Species Project. This project brings together expertise from across the country; the Partners will collect and store seed from 1,000 native plant species which are valued for their endemic, endangered or economic

significance. The focus will be on species not already collected and secured in Australia's conservation seed banks.

A second priority is furthering seed science to support restoration activities through the *Restoring Diversity Project*. Understanding seed biology of Australia's diverse flora is a barrier to the success of restoring diversity in broad scale landscapes, which is an Australian Government priority. Focusing collection development on priority ecosystems and building a body of knowledge through research and development undertaken by ASBP members will make a significant contribution to overcoming barriers to effective restoration, as well as effectively building a national seed collection for conservation.

### Challenges to overcome

CHABG Inc. faces several challenges with the ASBP programme. Firstly, any national approach to conservation work in Australia is influenced by the fact that the nation is governed as a federation of six states and two territories and tensions are created by the powers being divided between the central government and individual states. Furthermore, each state and territory operates under different legislation, with varying support given to biodiversity conservation and research and development.

*Ex situ* conservation is often regarded as a 'last resort' in Australia and its role in integrated conservation management is not always recognised or highly valued. A second challenge for CHABG Inc. is to increase understanding and demonstrating the value of seed science and seed banking for the conservation and sustainable use of Australia's biodiversity, as well as broad-scale landscape restoration. This will assist the greater integration of *ex situ* conservation into *in situ* conservation and restoration activities.

Current conservation funding programmes in Australia place emphasis on practical outcomes. Seed research and development of enabling technologies for landscape conservation and restoration programmes often fail to meet the criteria for these funding programmes. CHABG Inc.'s third

challenge is to build greater support and recognition for seed banking, seed science and seed biology to facilitate greater resources for this work to be undertaken at the scale needed to make effective contributions to the conservation and restoration of Australia's biodiversity.

### Conclusion

The functional boundaries of Australian capital city botanic gardens are being pushed by the need for a suitable framework for the ASBP's conservation activities. The creation of a national botanic garden not-for-profit entity (i.e. *The Council of Heads of Australian Botanic Gardens Incorporated*) supports botanic gardens to work collaboratively for the protection, conservation and enhancement of Australian plants and their ecosystems. Furthermore, a current focus on the ASBP Programme creates an environment where staff are able to look beyond their institution and contribute to national efforts for biodiversity conservation through seed science and seed banking and the sharing of knowledge. There are great hopes, through this innovative approach, to increase resources being allocated to seed science and banking and to raise awareness and understanding of the far reaching impacts of seed science.

### Defining commonly used terms

**Restoration** – the return of a degraded habitat to its original species composition, structure and function.

**Revegetation** – to provide a habitat with vegetation; may not necessarily include original provenance or species composition.

**Source:** Offord, C.A. and Meagher, P.F. 2009. *Plant Germplasm Conservation in Australia: strategies and guidelines for developing, managing and utilising ex situ collections*. Canberra: Australian Network of Plant Conservation Incorporated.

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*The future of the threatened Mountain Swainson Pea (*Swainsona recta*) in the Australian Capital Territory is being helped by seed collection and banking and the propagation of plants for translocation to a secure site (*R. Hotchkiss*).*





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#### \*Contents of the Botanic Garden Management Resource Pack include:

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