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Botanic gardens: Using databases to support plant conservation

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EDITORS

Suzanne Sharrock
Director of Global Programmes

Sara Oldfield
Secretary General

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Design: Seascape www.seascapedesign.co.uk

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Further details available from:

- Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey TW9 3BW UK. Tel: +44 (0)20 8332 5953, Fax: +44 (0)20 8332 5956 E-mail: info@bgci.org, www.bgci.org
- BGCI-Russia, c/o Main Botanical Gardens, Botanicheskaya st., 4, Moscow 127276, Russia. Tel: +7 (095) 219 6160 / 5377, Fax: +7 (095) 218 0525, E-mail: seed@aha.ru, www.bgci.org/russia
- BGCI-Netherlands, c/o Delft University of Technology Julianalaan 67, NL-2628 BC Delft, Netherlands Tel: +31 15 278 4714 Fax: +31 15 278 2355 E-mail: l.j.w.vandenwollenberg@tudelft.nl www.botanischetuin.tudelft.nl
- BGCI-Canarias, c/o Jardín Botánico Canario Viera y Clavijo, Apartado de Correos 14, Tafira Alta 35017, Las Palmas de Gran Canaria, Gran Canaria, Spain. Tel: +34 928 21 95 80/82/83, Fax: +34 928 21 95 81, E-mail: jmlopez@grancanaria.es
- BGCI-China, 723 Xingke Rd., Guangzhou 510650 China. Tel:(86)20-37252692. email: Xiangying.Wen@bgci.org www.bgci.org/china
- BGCI-Colombia, c/o Jardín Botánico de Bogotá, Jose Celestino Mutis, Av. No. 61-13 – A.A. 59887, Santa Fe de Bogotá, D.C., Colombia. Tel: +57 630 0949, Fax: +57 630 5075, E-mail: jardin@gaitana.interred.net.co, www.humboldt.org.co/jardinesdecolombia/html/la_red.htm
- BGCI(US) Inc, c/o Chicago Botanic Garden, 1000 Lake Cook Road, Glencoe, Illinois 60022, USA. E-mail: usa@bgci.org, www.bgci.org/usa

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2011-2020 United Nations Decade on Biodiversity

EDITORIAL
BOTANIC GARDENS AND DATABASES

What is a botanic garden? This is a question that we are often asked at BGCI. The defining feature of a botanic garden is the maintenance of documented collections of plant species. Nowadays the collection records are generally computerised in database systems designed to support collection management, research, conservation and education. This issue of BGJournal focuses on the uses of databases within the botanic garden community and beyond. As noted by Ericka Witcher and Michael Calonje on p15 "*Rigorous data stewardship combined with spatial interpretations and analyses can support the spectrum of plant conservation efforts, from discovery to restoration, adding to the legacy of botanical collections handed down to us and preserving them for the future*".

From the very outset, maintaining data on the plants grown in botanic gardens, has been a core activity of BGCI. Emphasis has been placed on recording species that are rare and threatened, as far as possible in line with the IUCN Red List Categories and Criteria. *Ex situ* conservation is clearly a vital role played by botanic gardens and BGCI's PlantSearch database records global progress comparing collection data with the IUCN Red List.

Increasingly botanic gardens are becoming involved in ecological restoration. The Missouri Botanical Garden hosted an excellent public symposium on this topic on 16 July. As described by Andrew Wyatt and Rebecca Sucher of the Missouri Botanical Garden, the newly developed integrated Living Collections Management System of the Garden will ultimately evaluate the success of restoration efforts at the Shaw Nature Reserve at both the species and genetic level. Based on this, a system is proposed to support restoration efforts worldwide.

Lucy Sutherland also notes in her in her article on the Australian Seed Bank Online, that *ex situ* collections are extremely important to support diverse plantings in ecological restoration as well as safeguarding rare and threatened species. The Australian Seed Bank Online is an information sharing hub connected to the Atlas of Living Australia which is in turn a node of the Global Biodiversity Information Facility (GBIF).

With changing climatic conditions, restoration of the populations of threatened species and of species assemblages needs to take into account their climatic envelopes – areas of suitable climate where species can grow, possibly outside their traditional range. The use of botanic gardens in "chaperoned" managed relocation is described by Adam Smith, Matthew Albrecht and Abby Hird. Well maintained records of the movements of plants between gardens along a climatic gradient will be essential in this process.

The skills of botanic gardens in conservation, research, ecological restoration, invasive species control and a range of other attributes are recorded in BGCI's GardenSearch database. The online PlantSearch and GardenSearch databases are described by Suzanne Sharrock and Abby Hird on p3. BGCI is most grateful to all the botanic gardens and related institutions who provide data for these databases. We are constantly trying to improve the databases for the benefit of botanic gardens worldwide and we welcome your suggestions on other features we might consider. Please share your ideas with us!

Sara Oldfield

Sara Oldfield
Secretary General, Botanic Gardens Conservation International

Authors: Suzanne Sharrock and Abby Hird

NETWORKING BOTANIC GARDENS FOR CONSERVATION – THE ROLE OF BGCI'S DATABASES

BGCI's databases provide essential tools to support information exchange within the global botanic garden community and to promote the work of botanic gardens more widely.

Introduction

BGCI's maintains two free, online databases to support plant conservation in botanic gardens: GardenSearch and PlantSearch. GardenSearch is an on-line directory of the world's botanic gardens and related institutions while PlantSearch provides an account of the plant species held by these institutions. Information included in these databases is provided by the institutions themselves and each institution is responsible for regularly updating its own record, using an on-line log-in facility.

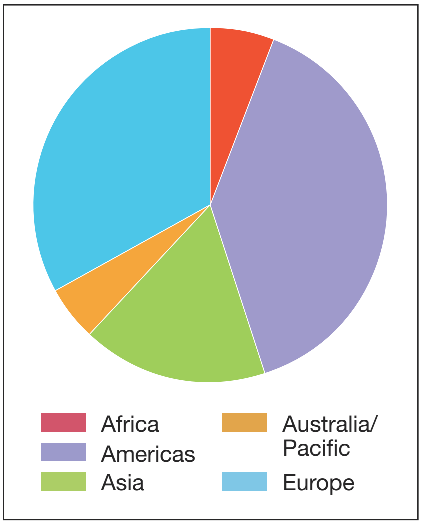

Figure 1: Regional breakdown of institutions represented in GardenSearch

Some statistics

GardenSearch:
3,200 records (institutions)
No of countries represented: 176
Breakdown of institutions per region – see Figure 1

PlantSearch:
1,255,261 collection records
413,167 taxa
1,079 institutions providing data

There has been a significant increase in the amount of data included in these databases in recent years – see Figure 2

GardenSearch

BGCI's GardenSearch database is a gateway to information about the world's botanic gardens. Each garden record provides basic information about the garden and where applicable, a link to the garden's own website. For smaller gardens that do not have their own website, GardenSearch provides a web presence they would not otherwise have. All records in GardenSearch are geo-referenced, allowing easy mapping of search results using a mapping 'applet' available via GardenSearch. As well as botanic gardens, GardenSearch also includes an increasing number of related institutions (seed / gene banks, zoos etc.), with a common interest in conservation and maintaining plant collections.

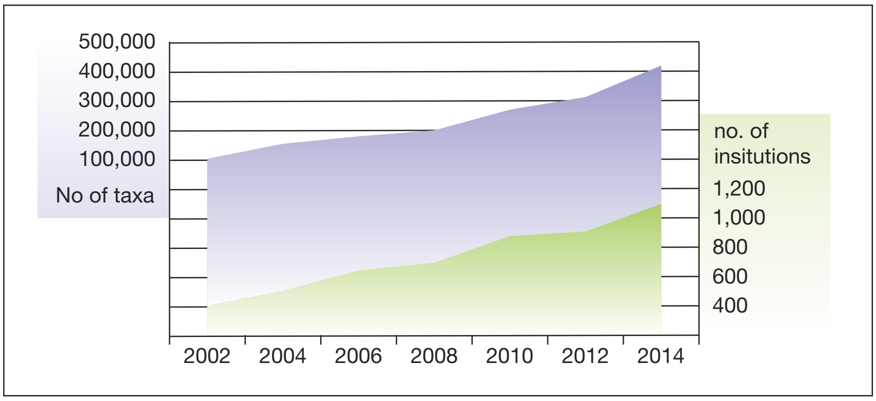

Figure 2: No of taxa and No. of insitutions providing data to BGCI PlantSearch database since 2002

GardenSearch fields are divided into three sections.

- **Section 1** allows the garden to provide basic information in a free-text format, including uploading an image. This information can be provided in the garden's local language and/ or English. This provides an opportunity for the garden to promote itself in whatever way it prefers.

- **Section 2** consists of a form to collect information on features and facilities, plant collections, and conservation, research and education programmes in a standard format. This section forms the 'backbone' of the database and the data provided is compiled into a unique, searchable global directory of skills, expertise and facilities relevant to plant conservation.

- **Section 3** allows the garden's record to be linked to related resources (journal articles, news items etc.) that appear elsewhere on the BGCI website.

Advanced Searching

In 2012, BGCI launched an Advanced Search function for GardenSearch. The Advanced Search function not only locates institutions geographically and by keyword, but also allows users to explore in more detail the conservation, research, education and public outreach facilities and expertise offered at botanic gardens around the world.

GardenSearch includes a total of 63 searchable fields related to the work of botanic gardens, each of which can be searched at the global or national level.

Some examples of the use of GardenSearch are provided below. See Figures 4, 5 and 6.

GardenSearch, as well as providing a unique tool to identify specific expertise and resources in countries around the world, also allows major gaps in botanical capacity to be identified. GardenSearch also supports studies related to plants and climate change, allowing the identification of gardens offering different climatic conditions in which to test and potentially grow plants

Figure 3: Global map of institutions recorded in GardenSearch

Figure 4: Botanic gardens with herbaria around the world – total 370.

Figure 5: Botanic gardens with seed banks in the USA: total 56

Figure 6: Botanic gardens in Asia with plant conservation programmes

in the face of changing environmental conditions. An example of this is provided by Smith *et al*., 2014, (see p. 19 of this issue).

PlantSearch

BGCI's PlantSearch database is the only global database of plant species maintained in the collections of botanic gardens and similar organizations. In addition to hundreds of living plant collections around the world, PlantSearch includes taxon-level data from gene and seed banks as well as cryopreserved and tissue culture collections.

This dynamic collections database was originally developed to measure progress towards Target 8 of the Global Strategy for Plant Conservation by tracking which threatened species are in botanical collections throughout the world. Through its online interface, PlantSearch also connects collections directly to conservationists, educators, horticulturists, researchers, policy makers and many others around the world who are working to save and understand plant diversity.

> *"GSPC 2020 Target 8: At least 75% of threatened plant species in* ex situ *collections, preferably in the country of origin, and at least 20% available for recovery and restoration programmes."*

All data included in PlantSearch are uploaded by collection holders directly to PlantSearch via an on-line facility. Uploaded taxa lists consist of seven taxonomic fields ranging from genus to cultivar name. Before being included in PlantSearch, records are screened against existing names in the database and IPNI (International Plant Names Index) to ensure that only valid names enter the database.

As of July 2014, the PlantSearch database included 1,255,261 collection records, representing 413,167 taxa, at 1,079 institutions. Each record in PlantSearch is linked to a record in GardenSearch, thus providing a geo-referenced location for each plant. Location details are however not made public, to ensure the anonymity of species in cultivation. A 'blind email' request system has been developed to allow users to request further information on species of interest.

PlantSearch has direct links to a number of other databases, most notably the IUCN Red List, but also other taxonomic databases (IPNI, Tropicos), a list of CITES species and lists of socio-economically useful plants (medicinal, crop wild relatives). Work is presently on-going to also add links to information on invasive species.

Benefits for data providers

PlantSearch provides a useful collection management tool for collection holders. By uploading a plant list, the collection holder will be notified of misspelled or unrecognised plant names in their list. Once uploaded, the list can be compared with the global database, allowing collection holders to identify how many other gardens are maintaining the same taxa. Plant lists are also automatically screened against the IUCN Red List and CITES lists, so that rare and threatened species in the collection can be easily identified. This can facilitate the establishment of conservation priorities for the collection holder and contribute to collection evaluation (Aplin, 2008; Aplin 2013).

Using PlantSearch

Ex situ surveys

PlantSearch can be used to carry out surveys of *ex situ* collections on a global, regional or national level, as well as for taxon-level surveys.

At the global level, monitoring progress towards GSPC Target 8 is constrained by lack of progress in Red Listing, with, to date, only 6% of plants having been assessed at the global level. A recent assessment by BGCI identified 29% of globally threatened species in *ex situ* collections, but the lack of information on which species are under threat means that this is probably a considerable under-estimate.

As national and regional lists of threatened species are more widely available, BGCI has also carried out a number of national/regional assessments on *ex situ* conservation progress.

In the USA, a recent review found that 39% of threatened native U.S. species are now maintained in living plant and seed bank collections. This is up from 37% in 2010[1]. This leaves more than 3,000 threatened species to add to collections by 2020 for the USA to meet the 75% *ex situ* target.

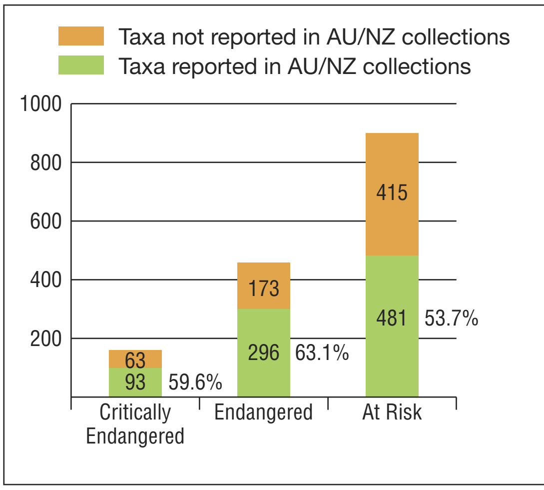

Figure 7: Results of an assessment of ex situ *collections in Australian and New Zealand botanic garden collections*

In Australia and New Zealand, 56% (854 of 1,519) of threatened species are safeguarded in living plant collections. However, although this is the best regional progress towards GSPC Target 8 found so far, there is still work to be done to reach the 75% goal by 2020. Furthermore, nearly 40% of reported threatened native species are known in only one collection, which suggests that collections contain low levels of intraspecific genetic diversity[2].

Taxon-based surveys

BGCI and its partners also use PlantSearch to carry out *ex situ* surveys of the conservation status of plant family groups. So far, these have included magnolias, oaks, rhododendrons and, most recently, conifers.

These surveys are typically carried out by BGCI following the publication of a Red List for the family or group in question, with the aim of identifying how many collections are cultivating species identified as threatened during the Red Listing process.

A summary of the results obtained to date is provided below:

- **Conifers:** The survey identified 81% of globally threatened conifer taxa in over 800 *ex situ* collections. However 134 threatened conifer taxa are known in very few or no collections. These are highlighted as priorities for establishing a more effective safety net against extinction of threatened conifers (Shaw and Hird, 2012).

- **Rhododendrons**: The survey identified 12,068 rhododendron records from 304 institutions in 42 countries. However, only 276 *ex situ* records represent just 48 of the 77 most threatened rhododendrons. This means that nearly 40% of the Critically Endangered or Endangered taxa are currently not known in cultivation[3].

- **Magnolias**: The survey included 2,274 Magnoliaceae records from 238 institutions in 47 countries. However, only 362 of these records represent 37 of the 89 most threatened Magnoliaceae. This means that more than half of the Critically Endangered or Endangered taxa not currently documented and protected in living collections[4].

- **Oaks**: The survey identified 3,796 oak records from 198 institutions in 39 countries. However, only 91 *ex situ* records representing just 13 of the 29 most threatened oaks were located. This means that more than half of the Critically Endangered or Endangered oak taxa are not currently reported by living plant and seed collections worldwide[5].

Networking projects

BGCI's databases can also be used to support projects that require a networking approach – helping to identify gardens with similar research interests, or growing specific plant species. One such example is the International Plant Sentinel Project, a new BGCI-coordinated project that aims to bring botanic gardens and arboreta together to share information on pest and disease attacks on plants in their collections[6]. The overall aim is to develop an early warning system for new and emerging pests and diseases in a globally distributed network. The knowledge of which gardens are cultivating which plant species is an essential tool in the development of this network.

Future developments

BGCI is keen to further develop its databases as a tool to support the conservation of threatened plant species and to promote and strengthen the work of botanic gardens in this area. There is clearly a high demand for information on plants in collections as evidenced by the approximately 2,000 requests passed through the PlantSearch 'blind email' request system every year. While PlantSearch does not publicly identify which gardens hold with species, many gardens are already publishing their collections data online (e.g. the catalogue of the Living Collections of the Royal Botanic Garden Edinburgh[3].

BGCI is therefore considering various options of how to make information on plants in collections more accessible to *bona fide* users, while still maintaining anonymity where this is required.

Other areas where developments are on-going are in the identification of synonyms (using information from The Plant List – see the article by Dalcin in this issue, p. 23) and better verification of cultivar names (in collaboration with the Royal Horticultural Society in the UK).

Of course, as with any database, the value of the GardenSearch and PlantSearch databases is only as good as the data they contain. BGCI is aware that the databases are incomplete and many gardens have yet to participate. However, we do believe that in our databases we have a unique and powerful tool to support plant conservation and the work of botanic gardens.

We therefore call on all gardens to join in and help us build this shared resource as a benefit to the global botanic garden network and the wider plant conservation community.

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- Shaw, K. and Hird, A. 2014. Global survey of *ex situ* conifer collections. BGCI, Richmond, UK.

- Smith, A., Albrecht, M and Hird, A. 2014. "Chaperoned" managed relocation. BGjournal 11 (2): 19-22.

For further information and to consult the databases, please visit www.bgci.org/garden_search.php and www.bgci.org/plant_search.php

Suzanne Sharrock
Botanic Gardens Conservation International
Descanso House
199 Kew Road, Richmond
Surrey TW9 3BW

Notes

[1] http://www.bgci.org/usa/naca/
[2] http://www.bgci.org/usa/bganz2013/
[3] http://www.bgci.org/ourwork/rhododendron_survey/
[4] http://www.bgci.org/ourwork/magnoliasmain/
[5] http://www.bgci.org/ourwork/2358/
[6] http://www.bgci.org/ourwork/ipsn/
[7] http://elmer.rbge.org.uk/bgbase/livcol/bgbaselivcol.php

Authors: Andrew Wyatt and Rebecca Sucher

THE EVOLUTION OF LIVING COLLECTIONS MANAGEMENT TO SUPPORT PLANT CONSERVATION

The living collections management system is an advanced tool to aid Missouri Botanical Garden in the conservation and management of almost every aspect of the living collections and horticulture activities.

The living collections at Missouri Botanical Garden (MBG), developed over 150-plus years, are at the heart of our mission and encompass over 17,500 documented taxa. From MBG's inception, plant recording was a fundamental task and began with its founder, Henry Shaw. An accomplished businessman, Shaw kept detailed handwritten ledgers of all transactions of goods imported from England and sold in St. Louis. A passionate plantsman, Shaw recorded the initial plantings at MBG with the same level of detail. In 1859, when MBG first opened to the public, these handwritten records represented the first plant recording system at MBG. The evolution of plant recording transitioned from Shaw's handwritten accession books to card systems, to the first computerized database system developed in the early 1970s. Since that time, MBG has custom designed and iteratively developed several separate but related databases to manage the living collections. These systems each served a narrow purpose and were not coupled or integrated. Over time, the inadequacies of the databases began to impact collections care and progress towards strategic goals. In recent years, increasing threats to plants and habitats worldwide have made the documentation of our various living collections management practices more

Figure 1: iPad inventory screen

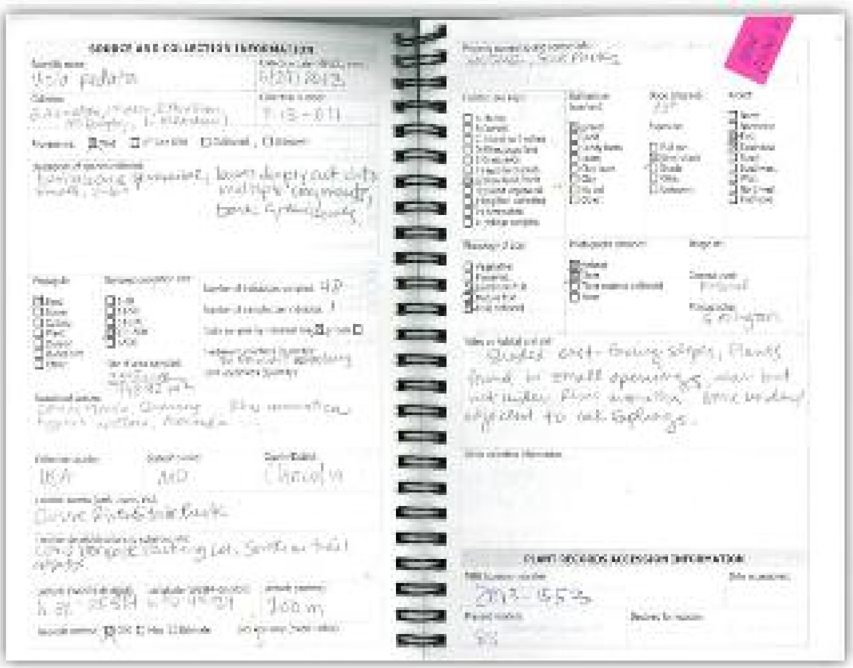


Figure 2: Collecting book page

critical. In 2011, it became a top priority to redesign and integrate our database systems to support a large scale increase in living collections acquisitions, horticulture processes, and curatorial details for plant conservation. The new Living Collections Management System (LCMS) was released in July 2013.

> ***"Expertise of staff from across MBG's disciplines, including horticulture, taxonomy, ecology, and conservation, all provided input to help develop and test a truly cutting-edge tool."***

Plant conservation activities currently supported by LCMS

Management of *ex situ* collections

The Missouri Botanical Garden has recently increased its efforts towards building and managing living collections to support Target 8 of the Global Strategy for Plant Conservation. Additions of both native plants of conservation concern and critically endangered species at the global level are key components of MBG's collections development. Any collection or other addition of plant material to the living collection requires high quality field data. This data adds enormous value to a specimen and allows for its effective use in conservation, education, and research.

To support this effort, field collecting books were developed in-house and fields were added and rearranged in the LCMS to match the field books exactly. This promoted high quality field data collection and increased data entry efficiency. Links to MBG's renowned Tropicos database further help integrate taxonomy, references, and specimen data from associated herbarium collections.

The tracking of plants and maintaining accurate and up-to-date accession records are core functions of any plant records database system. The LCMS features a web-based user interface, and can therefore be accessed from any web-enabled device, including PCs, tablet computers, and mobile phones. This enables records to be updated directly in the database by horticulturists as they work in the gardens. The LCMS is also directly connected to MBG's mapping data via ArcGIS Server. Using mobile tools developed specifically for mobile devices, records can be updated in the LCMS and plants can be moved to new locations on the map either using heads-up digitizing or the device's on-board GPS.

> ***"One of the most important tasks of the living collections is the development of knowledge of plant cultivation and its subsequent documentation for future use."***

The development of horticultural propagation protocols and cultivation techniques can play a primary role in species recovery and capacity building. The propagation module in the LCMS allows for recording of propagation methods. A wide range of data is captured as the process unfolds, including dormancy breaking treatments, pretreatments, growing media, light levels, container used, and growing environment. This data can quickly and easily generate propagation and cultivation protocols for a given species. These protocols form the foundation of any recovery plan and are particularly useful when dealing with ultra-rare plants.

The workflows associated with MBG's plant recording have changed significantly to make use of the modern features of the LCMS. Most processes are now digital, saving time and effort over previous paper-based processes. Furthermore, it has allowed for the decentralization of plant records, ensuring every horticulturist has the

Figure 3: Collection data screenshot

ability and responsibility to aid in maintaining plant records. These changes have prepared us for the ability to increase the value of our collections for conservation. Over the past three years, incoming wild source material has increased 957%, thanks in large part to innovations within the LCMS.

Exchanging records with other botanical institutions

At the outset of any plant conservation project, the first questions are generally: Is a given taxon or flora represented in living collections held by other institutions? What levels of diversity are held? And how good are the associated collection records? In order to facilitate the sharing of this information to help others with conservation projects, several tools were built into the LCMS. In addition to a large number of standard search fields, LCMS also has a query builder, enabling any data to be searched, filtered, and displayed in a report or exported for sharing with others. There are also many pre-configured reports for commonly requested information, including a report that generates a file for uploading inventory data to the BGCI PlantSearch database.

Exchanging seed via *index seminum*

The LCMS facilitated the production of MBG's second *index seminum* catalog for sharing of wild collected plants with other institutions around the world. Seed bank accessions are marked for sharing in the LCMS, and a report generates a catalog which is linked on MBG's website. As requests are received via e-mail, appropriate records are marked as shared. Later, the LCMS produces reports showing who requested which seed, and QR code labels are printed for the seed packets prior to mailing.

Access to collections data by researchers and visitors

The web functionality of the LCMS allows for instant accessibility to data anywhere that an internet connection is available. MBG has regular requests for use of its collections to support a wide range of research projects, much of which is related to conservation. A link to search the LCMS is provided on MBG's online plant material request form, and is often included in e-mails responses to researchers requesting information on the collections. Aforementioned links to Tropicos and GIS mapping data makes it easy for researchers and visitors to see associated scientific data and where the actual plant is located in the garden. In addition, MBG staff find the living collections data useful while they are field collecting, enabling comparison of database records of a given taxon in the wild, where cell phone service is available.

Figure 4: Collecting data on an iPad in the orchid collection

> *"To discover and share knowledge about plants and their environment in order to preserve and enrich life."*
> Mission of the Missouri Botanical Garden

MBG's living collections provide almost endless educational opportunities. At the most basic level, the LCMS supports the production of plant display labels; over 5,000 new labels are produced each year. Labels can be requested via the web interface by any registered database user, and the LCMS facilitates the organization, review, and production of label orders.

On a higher level, building plants of conservation concern into collections, together with associated stories about the plants, allows us to highlight the value of plant and habitat conservation. The improved infrastructure, additional fields, and links to mapping and Tropicos have provided a stable and robust platform on which to build future interactive mobile multimedia, including games, crowdsourcing activities, and social media. By leveraging the living collections data through these apps, we can transform our visitors' experience and increase their appreciation of plants.

Plant conservation activities to be added to LCMS

Seed cleaning, seed banking, and viability testing

In 2012, MBG set up a seed bank for the purpose of conserving the flora of Missouri. This new initiative supports Target 8 of the Global Strategy for Plant Conservation. Current seed collections focus in the Ozark Plateau region, due to the high species diversity found there. LCMS supports all accessioning and tracking of seed collections for the seed bank, and a new module to support seed cleaning and viability testing is currently being developed. As with propagation records, the data associated with seed cleaning and viability testing will be available via reports within the LCMS web portal.

Habitat restoration and critically endangered species conservation

The skills necessary for cultivating and curating *ex situ* plant collections are becoming increasingly utilized as a core part of plant conservation. As the LCMS was developed, consideration for using the LCMS to support wider conservation projects was incorporated into the overall design of the system. This is a growing program area at MBG, and following are two examples of conservation projects the LCMS will be developed to support.

At the habitat level, MBG is conducting prairie, glade, and woodland restoration at the 2,100 acre Shaw Nature Reserve (SNR). Horticulturists, ecologists, geneticists, and taxonomists are working to develop methods and database solutions to track plants at the individual, population, and habitat level. The ultimate goal is to utilize the data recording, mapping, and tracking functions of the LCMS to evaluate the success of our restoration efforts from the standpoints of both species and genetic diversity. The SNR project gives us the opportunity to test our methodologies and develop a system that will support restoration efforts around the world.

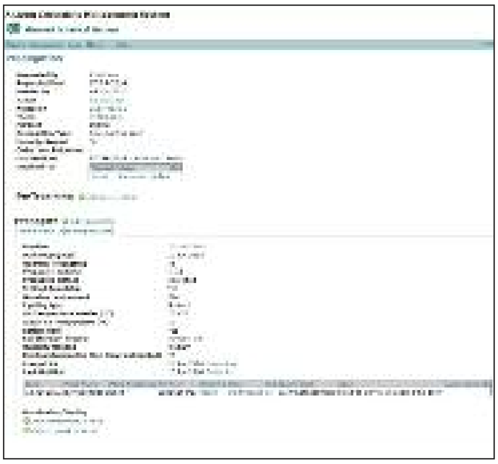


Figure 5: Propagation data screenshot

Figure 6: Query builder

In partnership with the Mauritian Wildlife Foundation and the Mauritian National Parks and Conservation Service, MBG is developing a program to support propagation and restoration of the critically endangered Mauritian flora. Out of the 315 endemic species on Mauritius, 63% are threatened. MBG is currently working on a propagation list of 50 taxa that each have less than 10 individuals left in the wild. The LCMS will be used for recording and analysis of propagation data, and also the recording, mapping, and tracking of species and populations. However, in order to make full use of the LCMS in remote locations like Mauritius, disconnected editing features will be added.

Collections planning and climate change

Several other fields and functionality are in the process of being added to the LCMS related to collections planning and climate change. These include phenology, cause of death, and hardiness testing, and will be coupled with weather data from our on-site weather station. This will allow us to plan for the preservation of existing collections and better target taxa from appropriate climates into specific microclimates at MBG. Adaptive climate-based planning for what can be grown in collections, utilizing horticulture and climate data, is set to become more critical in our collections planning as we experience ever increasing effects of climate change.

The new living collections management system is more than a simple plant records database. It is an advanced tool to aid MBG in the conservation and management of almost every aspect of the living collections and horticulture activities. MBG's achievements in building its collections to support plant conservation over the last three years would not have been possible without the LCMS. Our ability to utilize the exceptional power of this new tool increases each day as we apply it to new conservation challenges.

Figure 7: QR code labels

Search MBG's living collection online at http://www.livingcollections.org/mobot/Home.aspx

Andrew Wyatt, Rebecca Sucher
Missouri Botanical Garden
4344 Shaw Blvd
St. Louis
Missouri, 63110 USA

Author: Dr Lucy Sutherland

INTEGRATED BOTANICAL INFORMATION SYSTEMS – THE AUSTRALIAN SEED BANK ONLINE

Until 2012, there had been little effective data sharing between Australia's conservation seed banks. The Australian Seed Bank Partnership has been collaborating with the Atlas of Living Australia to create a distributed database for Australia's conservation seed collections.

ASBOnline – The Australian Seed Bank Online is a hub within the Atlas of Living Australia and gives ready access to data on Australia's collections in conservation seed banks.

Introduction

Over recent years, in Australia there have been significant efforts to make biodiversity information more accessible and useable. The Atlas of Living Australia (the Atlas) is a biodiversity informatics facility that aggregates data on Australian organisms and improves access to biodiversity national datasets and information held in museums, herbaria and biological collections across the country (http://www.ala.org.au/). Furthermore, the Atlas is the Australian node of the Global Biodiversity Information Facility (GBIF).

The Atlas is demonstrating significant success in coordinated planning and delivery of digitised content from Australia's biological collections and in organising these and other data resources in support of a broad range of uses including plant conservation, taxonomy and collections management, land management and planning, ecosystem research and biodiversity discovery. Consequently, it has been a logical step for the Australian Seed Bank Partnership (the Partnership) to collaborate with the Atlas to build an accessible online seed information resource drawing on collections data captured by members of the Partnership and integrating this information with other relevant data records within the Atlas, including Australia's Virtual Herbarium.

Australian Seed Bank Online

Various databases are used by the collecting institutions to record their collection events, with some institutions using multiple databases for historic reasons. The Australian Seed Bank Online is an information sharing hub, via the Atlas, which operates as an aggregator of data supplied directly by the Partnership's member institutions (http://asbp.ala.org.au/). The Atlas allows Australia's conservation seed banks to keep their existing and locally maintained databases and web sites. This hub gives the collections a 'common' presence on the web and creates a shared and integrated view of Australia's conservation seed bank resources.

The filter facets within the Australian Seed Bank Online enable collections made by several institutions in a specific biogeographic region to be selected and mapped. The maps produced assist with planning future collection sites, for example the prioritisation of areas prone to fire. Here the map of collections made through the Australian Alps illustrates large areas where collections have not been made, particularly in the southern part of this biogeographic region.

A key step in orchestrating this collaboration has been negotiating agreement on shared data definitions and file formats (ABCD and Darwin Core) and getting agreement that the data provided is licensed and attributed under a Creative Commons Attribution 3.0 Australia Licence.

What does the Australian Seed Bank Online offer?

Australia's seed storage and research facilities, largely part of botanic gardens in the state capital cities, gather and manage foundation scientific information on Australia's native flora, including seed species identification, origin and provenance, morphology, germination protocols and dormancy alleviation techniques, storage characteristics, phenology and ecology (Cochrane *et al*., 2009). The work conducted on these *ex situ* collections generates scientifically verifiable information that can provide enabling technologies to support diverse plantings for the restoration of Australia's landscapes and safeguarding rare and threatened species.

A known challenge in restoration work is the need for greater plant knowledge to increase ability to use understorey and groundcover flora. Part of this is seed related and Merritt and Dixon (2011:425) argue that the shortfalls in seed knowledge, including the phenology and seed maturation for most wild species and the lack of knowledge about triggers to break dormancy, prevents germination at the time of sowing.

Consequently, the overall objective of the *Australian Seed Bank Online* project has been to create a virtual seed bank that is a useful resource beyond the Partnership to support the scientific, conservation and restoration work of researchers, students, practitioners and community groups, as well as the horticultural and nursery industry.

The *Australian Seed Bank Online* is used to support plant and ecosystem conservation in several ways, including:

a) Planning and prioritising *ex situ* conservation work as part of the core activities being undertaken by Australia's botanic gardens and partner organisations (Box 1).

b) Examining the seed collection data, combined with collection data from Australia's Virtual Herbarium (also available through the Atlas), to build longitudinal data on phenology and any associated changes over time, as well as determining the natural distribution of the species.

c) Guiding collecting techniques and germination protocols through the provision of information on seed and fruit morphology for specific species.

d) Providing accurate information to government and industry to support threat abatement activities and address emerging and existing biosecurity issues related to native flora (Box 2).

e) Tracking and reporting Australia's biodiversity conservation efforts in regards to the implementation of the Convention on Biological Diversity (Box 3).

Box 1: Identifying national priorities for *ex situ* collection

Australia is contributing to the Royal Botanic Gardens Kew and Global Trees Campaign's project, which aims to collect and conserve seed from the world's rarest, most threatened and most useful trees. Australia's contribution to this project is to collect and conserve 380 species. The Australian Seed Bank Online has been an essential tool for planning and coordinating this project involving nine seed banking partners in Australia. The distributed database has enabled the Partnership to create a target list of eucalypt species that are not currently represented in *ex situ* seed collections.

Simple filtering tools enable the collections of legislatively threatened species to be identified and a species checklist to be created. This list can then be compared to the total list of recognised eucalypt taxa according to the Australian Plant Census (http://www.anbg.gov.au/chah/apc/). Collections of threatened eucalypts made prior to the year 2000, and banked before the adoption of international seed banking standards as part of the first phase of the Millennium Seed Bank Partnership, have also been identified and prioritised for collecting.

In addition, the data can be viewed and analysed within the Atlas's advanced spatial portal. The spatial portal is a highly advanced geospatial system that provides rich functionality not found directly within the *Australian Seed Bank Online*. The spatial portal enables users to build a picture of ecological systems and individual species using supplied spatial layers such as soils, vegetation communities, fauna, topography, climate and aspect – just to name a few. These mapping tools can support the detailed project planning for translocation or restoration of threatened species, communities or habitats, including the selection of regionally appropriate species for biodiverse plantings suitable for changing climatic conditions (Booth 2012a, Booth 2012b).

Box 2: Responding to biosecurity issues

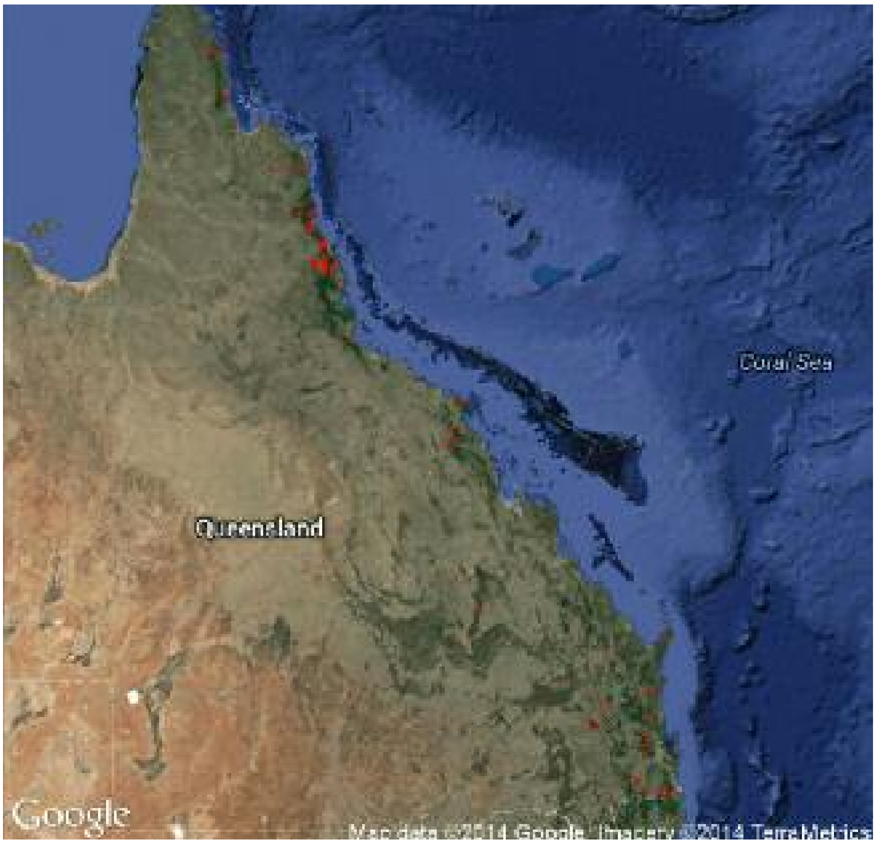
The Australian Government recently prepared the 'Threat Abatement Plan for Disease in Natural Ecosystems caused by *Phytophthora cinnamomi*'. During the preparation of this plan, the Australian Seed Bank Partnership was able to respond to a government query on *ex situ* collections of species susceptible to *Phytophthora cinnamomi* and present a national picture. The report on the collections resulted in the allocation of government funds to enhance *ex situ* collections of nationally threatened species at risk from the cinnamon fungus.

The recent arrival of *Puccinia psidii* (myrtle rust) in Australia in 2010, has resulted in the database being used for:

a) determining what susceptible species are being held in *ex situ* collections to support plant species and community recovery;

b) examining if there are multiple population collections within a species range;

c) prioritising species and populations for *ex situ* collection for use in screening to identify resistance to the myrtle rust.



The Australian Seed Bank Online can be used to examine collections from specific vegetation communities, such as Rainforest and Vine Thickets in Queensland, to ascertain their representation within conservation seed banks and assist with collections planning.

Box 3: Tracking and reporting

The *Australian Seed Bank Online* has enabled the Partnership to access quantitative data for inclusion in Australia's 5th National Report to the Convention on Biological Diversity. This reporting included the number of accessions and species held in Australia's conservation seed banks, and specific information on number of seed collections of legislated threatened species. Furthermore, the database also enables national reporting to the Global Partnership for Plant Conservation on Target 8 of the Global Strategy for Plant Conservation.

Challenges

The process of creating the Australian Seed Bank Online by bringing together collection records from multiple sources has presented challenges. There needs

“The Australian Seed Bank Partnership's mission is a national effort to conserve Australia's native plant diversity through collaborative and sustainable seed collecting, banking, research and knowledge sharing.”

to be further refinement of the tool to improve the relationship between science and practice to enable accessible information that can inform successful restoration of biodiverse landscapes and conservation of Australia's rich flora. Some of these challenges include:

- Presenting data on seed treatments and test results that is understandable and accessible to a range of users. There is currently great variability in how this data is recorded by conservation seed banks.

Jenny Guerin, Dan Duval, Denzel Murfet and Thai Te (left to right) have recently been making collections in the Great Victoria Desert in South Australia . Detailed information regarding location and field conditions of the collection site(s) are recorded to provide data for conservation purposes (Botanic Gardens of Adelaide).

Most often it is recorded as qualitative data that is presented in a 'notes field' and this makes the data difficult to present in a consistent form.

- The issues around sensitive data, especially specific location information that might result in damage/harm to the species. In Australia, there is complexity around the federated system where each State and Territory conservation agency treats the sensitivity of information in their jurisdiction differently (Tann and Flemons 2009). This can limit the use of databases for site specific conservation planning.

Future opportunities

In the future, Australia is looking to include botanic gardens' living collections data within the Atlas. This additional data will provide information that can improve knowledge of species climatic requirements and assist with management of restoration of landscapes for conservation under climate change. Booth's recent paper on using the Atlas and the Global Biodiversity Information Facility to improve understanding of tree species climatic adaptability illustrates how databases can be used for managing forests for both commercial and conservation objectives under climate change (Booth 2014). Booth's methods could be applied to examine Australian plant species growing beyond their natural climatic range by drawing on botanic gardens living collections data and the herbarium and seed collections data that provide excellent information on the natural distribution of native species.

> *"Building ex situ seed collections provides a resource for future use and an insurance policy for Australia's native plants and forests against threats such as myrtle rust and cinnamon fungus."*

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Dr Lucy A. Sutherland
Australian Seed Bank Partnership
Australian National Botanic Gardens
GPO Box 1777, Canberra ACT 2601 Australia

Australian Seed Bank online:
http://asbp.ala.org.au/
http://www.seedpartnership.org.au/
https://www.facebook.com/australianseedbankpartnership

Authors: Ericka Witcher and Michael Calonje

USING GIS TO LEVERAGE PLANT COLLECTIONS DATA FOR CONSERVATION

Geographic Information Systems provide powerful and flexible tools that gardens can use to enhance their collections.

Introduction

Botanical gardens vary widely in their scope and fields of interest but are typically concerned with growing living plant collections to advance research, conservation, and education. Botanical gardens contribute to plant conservation in many ways, including the production and dissemination of research leading to an increased understanding of plant diversity (Global Strategy for Plant Conservation, Objective 1), the conservation of plant diversity by managed *ex situ* cultivation (GSPC Objective 2), and the promotion of education and awareness about plant diversity (GSPC Objective 4) (Wyse Jackson, 2004). Developing plant collections of high scientific and conservation value requires that a great deal of data are collected and recorded, and that these remain available for analyses. These data, typically stored in a database, include field collected data (e.g. specimen data, locality information, morphometric measurements) as well as data collected at the garden (e.g. planting locations, phenology and horticultural care records). Plant collections data can be visualized, analyzed and interpreted with a Geographic Information System (GIS) to further advance plant conservation by helping develop living plant collections, manage them and optimize their usage.

“The high standard of tree collection maintenance at the Montgomery Botanical Centre has been recognized by ArbNet, the Aboretum Accreditation program, which has recently awarded MBC level IV accreditation.”

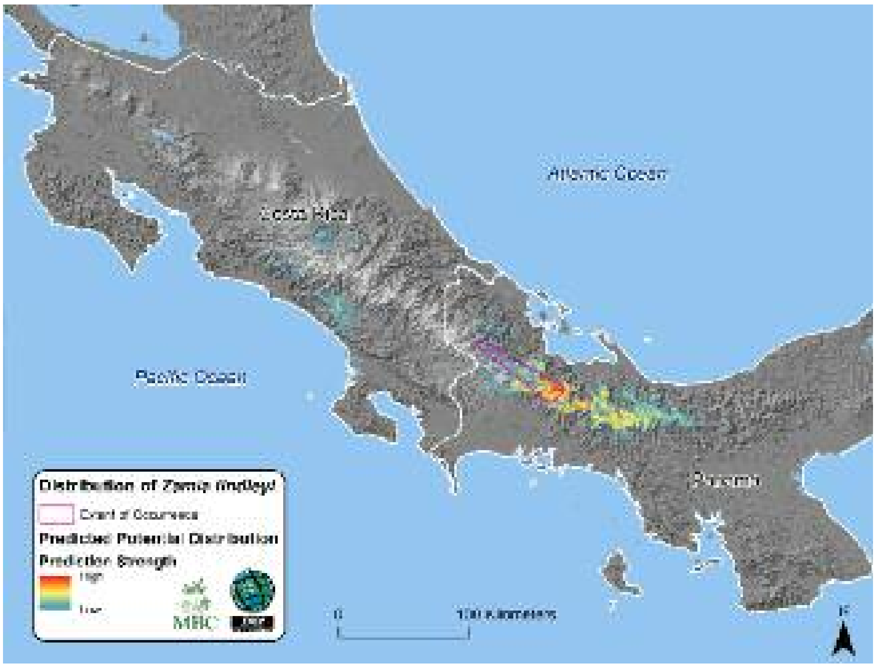

Figure 1: Potential distribution of Zamia lindleyi *(Michael Calonje)*

Applications for botanical data and garden processes in GIS

Montgomery Botanical Center (MBC; Coral Gables, FL) is a botanical garden specializing in palms and cycads. The living collection is population-based, extensively documented, and derived mainly from habitat-collected seed which is germinated and cared for at the nursery and then planted out into the grounds of its 120-acre landscape-designed garden. An extensive amount of data related to MBC's living collection is collected and stored in BG-BASE collections management software. These data include wild collection data for each accession, as well as data collected in the garden such as notes on horticultural care, phenology, and plant gender (for dioecious cycads and palms). These data are routinely imported into ArcGIS

(ESRI, Redlands, CA) to enhance the development and management of the living collection, and to disseminate information to promote conservation awareness and education.

Collections development

Field expeditions undertaken by MBC biologists typically combine field research with collecting of germplasm using a sampling protocol that results in an adequate genetic representation of each species at the garden. The protocol includes collecting seeds from multiple wild populations throughout a taxon's geographic range, and separately collecting seeds from multiple mother plants within each population. GIS is used to plan for these expeditions by mapping previously known collections to determine itineraries which can increase the efficiency of the collection effort while maximizing the resulting diversity of the collections. Planning can be done by simply visualizing existing data layers such as occurrence data, roads, and topography, or by combining these layers in spatial analyses. At MBC, occurrence data combined with topographical data and environmental layers has been used in MAXENT niche modeling software to predict species distributions in order to identify potential new habitats where a particular species may be found. This method was successful in field locating new populations of *Zamia encephalartoides* in Colombia and has been used to map the potential distribution of *Zamia lindleyi* in the highlands of Panama (Fig.1).

By mapping collections data from garden collections and herbarium specimens, MBC's biologists are able to identify unusual distribution patterns in taxa that may merit additional field study. In this way, MBC researchers may identify unusually disjunct populations to target for additional fieldwork. This additional fieldwork has resulted in the discovery of several new species of *Zamia*, including *Z. huilensis, Z. tolimensis*, and *Z. pyrophylla*. This distribution data is also used with GIS software to determine the geographical range (Area of Occupancy and Extent of Occurrence) of different species in order to assess their conservation status. MBC's biologists have prepared several conservation evaluations for the IUCN's Cycad Specialist Group using modern GIS techniques.

Collections management

Maps provide a way to quickly and easily locate plants within gardens, but they can do more for collections management than just catalogue collections. Botanical gardens operate as caretakers of rare, threatened, and endangered plants. These plants come from different habitats all over the world and consequently may have widely different horticultural requirements. Maps of the garden, combined with expedition and horticultural data, staff

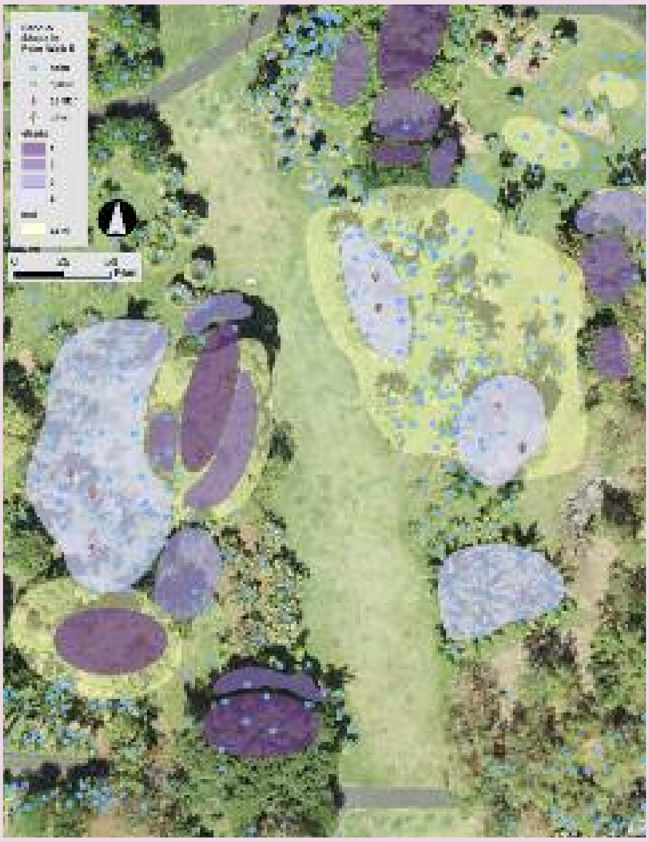

Figure 2: MBC Staff used their collective knowledge of the grounds to delineate these desirable sandy and shady areas to plan for future plantings of sensitive species (Ericka Witcher, Christina Dupuy, and Laurie Danielson)

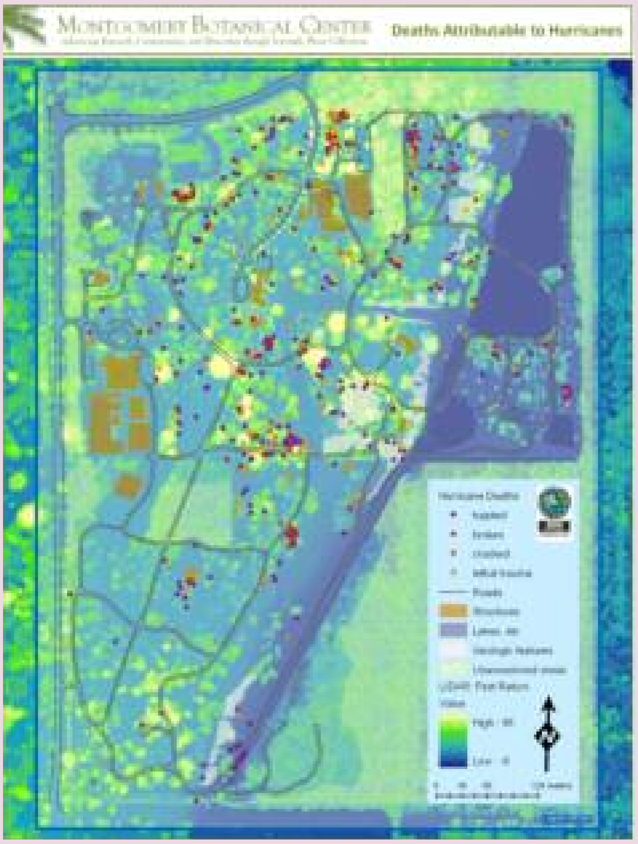

Figure 3: All hurricane deaths recorded in the database over the last 20 years were projected onto a Digital Elevation Model (DEM) of the property (Ericka Witcher)

knowledge and previous planting results, assist with finding the ideal location in a garden for plants. Curators of living plant collections at MBC worked with GIS staff to delineate areas of desirable sandy soil near varying degrees of shade to assist with next year's landscape plan (Fig.2). A GIS also facilitates examination of changes to the landscape both within and around the garden and their impact on plant collections. Relationships between climate change and other environmental data can be examined for impact on phenology and other botanical attributes, once a large enough dataset is developed. MBC database information relating to hurricane damage on the property was projected onto a lidar-based canopy map to check for spatial correlation (Fig.3) – the palm *Syagrus botryophora* will no longer be planted near open areas; coming from a non-hurricane area of Brazil it has difficulty withstanding these storms (Griffith, *et al*., 2013). Spatial data can also be relevant to horticultural problems, particularly on larger properties: disease and invasive pest or plant infestations can be mapped to reveal their range and method of spreading, especially in combination with time-aware data and/or utilities maps, thereby contributing to decisions for treatment and prevention (Fig.4).

Germplasm banks (seed, pollen, etc.) and distribution programs are increasingly seen as vital aspects of any plant conservation program. They promote conservation by providing plants to horticulture and lessening the demand for wild collected plants, by serving as a genetic repository that can be used to reintroduce species into dwindling or extinct populations, and by promoting redundancy by widely distributing germplasm. Detailed plant records including phenology, plant gender, and horticultural care are stored in MBC's database and used in GIS to create maps of which plants in the garden are most likely to have mature seed or pollen for harvest at any given time. GIS is also used at MBC to develop a breeding program for *Cycas micronesica*, a cycad from the Mariana Islands which is considered critically-endangered due to pressure by the Cycad Aulacaspis Scale (CAS; *Aulacaspis yasumatsui*) and other alien pests (Marler and Lawrence, 2012). Maps are used to identify plants derived from the same wild populations and collected from separate mother plants in order to perform in-population pollination crosses (Fig.5) and prevent inbreeding. The gender of individual plants is also mapped to further facilitate crossing.

Collections use

The re-introduction of endangered plants to appropriate habitat locations is also facilitated by a GIS. Many of the same spatial analyses that are performed on

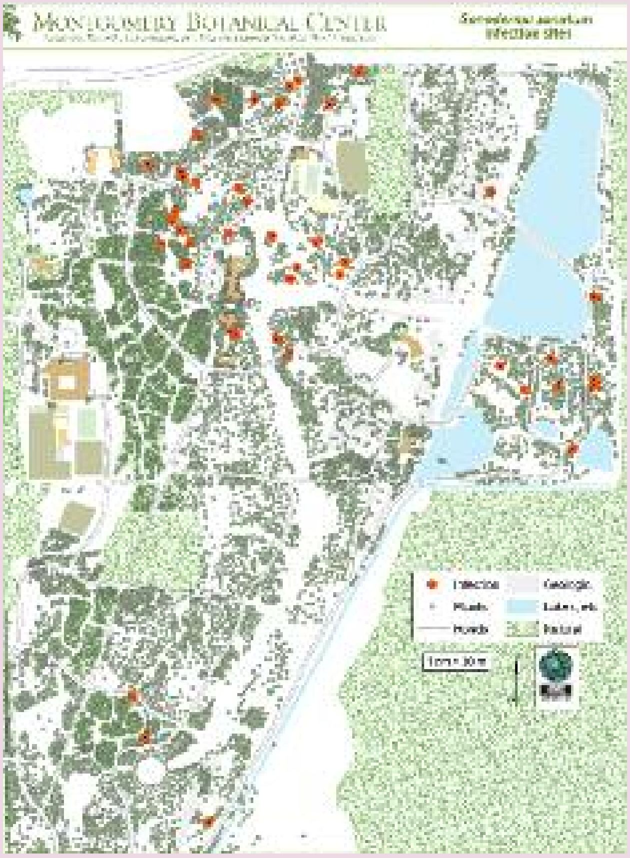

Figure 4: Map tracking infection sites of the fungus Ganoderma zonatum (Ericka Witcher)

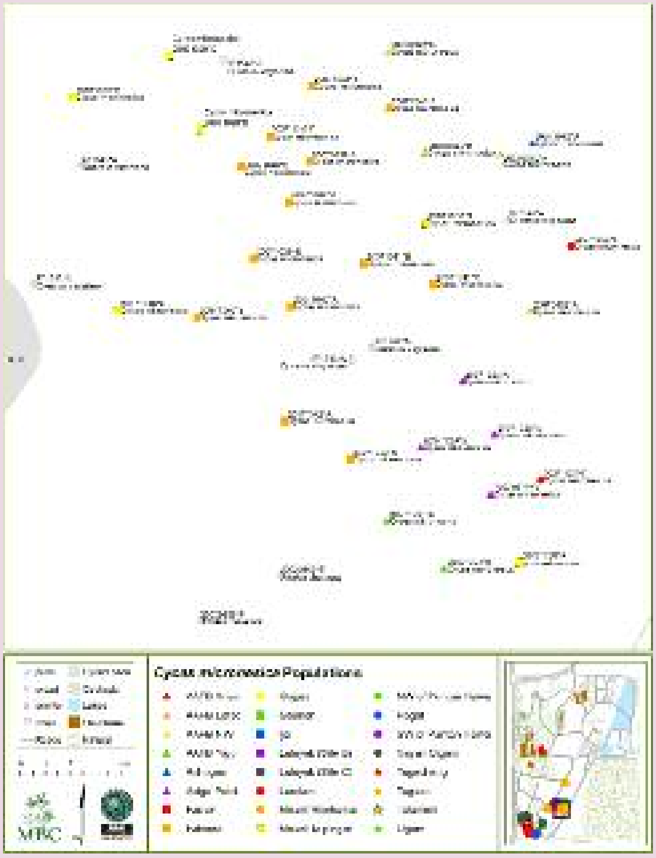

Figure 5: MBC staff and seedbank volunteers use a map to ensure provenance consistency when hand-pollinating Cycas micronesica with different accession numbers (Ericka Witcher, Michael Calonje)

areas to narrow the search for potential existing plants can be applied to find areas suitable for restoration, this time with the incorporation of political boundaries as well as social and economic considerations, in addition to ecological factors. Many places undergoing restoration work have come hard won, and the success of species planted back into the area can be just as imperative to the protected status of the land as it is to the continued existence of the species (Rademacher, 2012). A database incorporated into a GIS can project historical and herbarium data onto potential locations, include collection data such as soil, light, grade and aspect, and integrate aerial and remote sensing imagery and data of the surroundings, further bolstering proposals for environmental protection along with guiding specific re-introduction locations (California Department of Transportation, *et al*., 2009). Later, the planting locations can be monitored and tracked. The attempted re-introduction of the Franciscan Manzanita (*Arctostaphylos franciscana*) in San Francisco, California parks serves as an excellent example of this process: a species of manzanita was thought extinct in the wild until a plant was found in a San Francisco construction site, other extant specimens were located in botanic garden collections, and GIS was used to find preliminary potential reintroduction sites, based in part on garden horticultural data, and to develop part of the monitoring plan (Quirós, 2011 and California Department of Transportation, *et al*., 2009).

Botanical conservation education, in particular, may come most readily to botanical institutions. Data-integrated maps are a compelling medium that present data as a narrative that occurs over time, or in comparison to other relatable themes. Due to their visual nature, maps are conducive to conveying complicated information in an understandable way across language and cultural barriers. This is a useful aid for MBC biologists when communicating with colleagues around the world. They are able to utilize information provided by local people, whether laymen or scientists, in conjunction with their own findings to better grasp a taxon's range, ecological niche, social value, etc. by accounting for its spatial and temporal data. In turn the biologists can compile local data into a bigger picture via comprehensive maps to help locally with issues of conservation awareness. On the home front, MBC has used maps for conservation education purposes at nearly every stage: with school children looking for examples of Florida native plants, funding of expeditions and collaborations, researchers examining data, and published findings. Many GIS software developers offer platform services as well (e.g. ESRI's ArcGIS), meaning maps and data can be created and made available via the Internet, smartphones and other mobile devices, expanding the reach of a single garden's resources to a truly global scale. A quick look at MBC's Champion Trees via webmap application can be found here on ArcGIS Online: http://www.arcgis.com/home/item.html?id=69f6225d0b14452698ced6078c339878

Conclusion

GIS is a powerful and flexible tool that gardens can use to enhance collections development and management and expand their outreach and usage. Rigorous data stewardship combined with spatial interpretations and analyses can support the spectrum of plant conservation efforts, from discovery to restoration, adding to the legacy of botanical collections handed down to us and preserving them for the future, and fostering understanding of global biodiversity.

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Thanks to the entire staff at Montgomery Botanical Center for their tireless stewardship of the collections and their many contributions to botanical research, conservation, and education. The MBC GIS program is made possible by an ESRI Conservation Program grant, allowing for ongoing software and support services; and by a Stanley Smith Horticultural Trust grant, providing funding for all GIS hardware and equipment.

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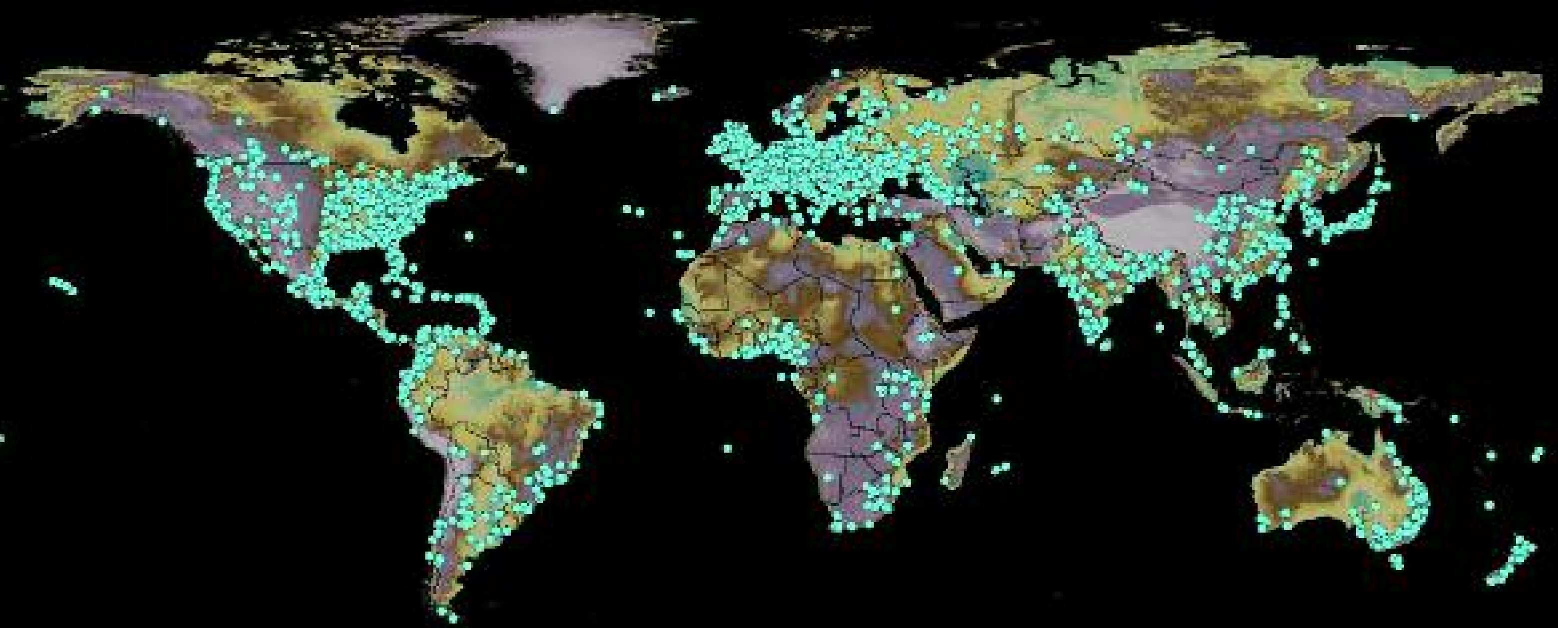
Ericka Witcher
Collections Supervisor
Montgomery Botanical Center
11901 Old Cutler Road
Miami, FL 33156-4242
USA

Authors: Adam B. Smith, Matthew A. Albrecht and Abby Hirdi

"CHAPERONED" MANAGED RELOCATION



A plan for botanical gardens to facilitate movement of plants in response to climate change

Distribution of the world's botanical gardens. BGCI. 2013. GardenSearch online database. Available at www.bgci.org/garden_search.php.

Introduction

Anthropogenic climate change promises to outpace the ability of many plant species to migrate (Corlett & Westcott 2013). As a result, ecological communities may lose species, with some even expected to suffer extinction (Thomas *et al*., 2004). One proposed solution to this dilemma is "assisted migration," in which species would be intentionally transferred outside their historical ranges into locations they could have reached were climate change occurring at a slower pace (Schwartz & Martin, In press). Along with other conservation measures, such as seed banking and *in situ* management, assisted migration could help ensure the survival of many species.

Unfortunately, assisted migration also poses many risks, and this has made it the center of a vociferous debate over ethics and ecological pragmatism. Namely, moving species outside their historical ranges risks: a) introducing species that could become invasive; b) transferring pests and diseases that may harm other species; and c) hybridization with closely related, rare species and dilution of their gene pool (Schwartz & Martin In press). Moreover, past transfers of plants between gardens have unfortunately encouraged these problems (Hanspach *et al*., 2008).

To date proponents of assisted migration have attempted to allay these fears by development of risk assessment and management frameworks (Muller & Hellman, 2008). Nonetheless, risk assessment and management can never fully eliminate all risks, and even well-intentioned transfers can result in ecological calamities (Webber *et al*., 2011).

"Chaperoning"

Here we propose a program of "chaperoned" assisted migration, in which botanical gardens serve as waypoints for transferred species. A program of chaperoned migration would entail:

- moving species outside their historic distributions;
- growing species in regularly-managed *ex situ* settings like those provided by botanical gardens;
- moving species within their potential dispersal envelopes and evolutionary/ecological context;
- curating species to be managed as separate wild-collected specimens;
- screening species on a regular basis for invasiveness, pests, diseases, and hybridization;
- ensuring species' survival as climate changes.

Drawing on the unique resources and expertise that botanical gardens offer (Primack & Miller-Rushing, 2009), chaperoned assisted migration can help address serious concerns about "unchaperoned" assisted migration. First, host gardens could offer ongoing screening for invasiveness, pests, and diseases. Indeed, many gardens already serve as integral parts of national screening programs (e.g. The Australian Network for Plant Conservations' *Guidelines for Translocation of Threatened Plants in Australia*[1] or the Council of Europe and BGCI's *European Code of Conduct for Botanic Gardens on Invasive Alien Species*[2]). Regular care by horticultural staff would enable early detection of problem species that may otherwise go undetected if they were transplanted to natural settings; and sterile horticultural practices can help reduce transfer of diseases and pests between plants. Finally, species conservation programs in botanical gardens could extend their work on rare species biology to study how plants respond to climatic variation beyond their historical ranges.

Second, chaperoning could help alleviate concerns over hybridization and reproduction by managing species as individual wild-collected accessions to ensure their provenances as time passed. Risks from hybridization could be managed if only clonal propagation

Plant species reintroduced to their historic range may need to chaperoned across a network botanical gardens to keep pace with climate change

Box 1: "Chaperoned" managed relocation versus "unchaperoned" managed relocation

Most of the controversy over managed relocation has assumed that species will be "unchaperoned," meaning they would be transferred from one natural place to another. While chaperoned managed relocation will not alleviate all risks, it has several notable advantages over unchaperoned translocation.

Risk	Solution offered by chaperoned managed relocation
Transferred species may become invasive	On-going monitoring for invasiveness; ease of eradication if plants become problematic
Transferred species may spread novel pests or disease	On-going monitoring for pests and disease; well-developed horticultural techniques for disease prevention; relative ease of eradication compared to populations in natural settings
Transferred species may hybridize with other threatened species	Wild-collected accession management disallows progeny of crosses with non-wild collected accessions or wild-collected accessions of other populations; gardens can remove species with which target species might cross
Logistical requirements	Transplanting and care of populations in gardens much easier and regular than in natural settings
Identifying appropriate locations for transplantation	Much easier to transfer plants from garden to garden than locating natural areas with requisite permitting and adequate protection
Laws may restrict transloca-tions across national/subnational borders	Translocations much more acceptable within an institutional context

Delphinium variegatum

were used for accession replication, closely-related species were removed from the living collection and/or progeny of unknown origin were not included in the collection. Likewise, transferred species may be left without their native pollinators, so horticultural staff could stand in for missing pollinators with controlled or manual pollination.

Capacities and needs

Chaperoning species may be easiest in regions with a high density of gardens since they offer multiple opportunities for moving species as climate change progresses. Worldwide there are over 3,000 gardens, most of which are located in eastern North America, Europe, Japan, and eastern Australia (Figure 1). In other regions, strengthening existing capacities and founding of new gardens is likely of high priority.

Despite the promise gardens offer for screening of invasiveness, pests, and diseases, worldwide only 5% of the world's gardens report having an invasive species policy or screen for invasiveness (BGCI GardenSeach Database 2013)[3]. Likewise, only 16% of gardens report having a research program relevant to conservation or ecology (BGCI GardenSeach Database 2013)[4]. In addition, the botanical garden community will need to refine protocols for prioritizing species of conservation concern, and managing the genetic integrity of their living collections. This will require greater integration between their conservation, horticulture and ecology programs. These are important areas for improvement that are necessary for chaperoning the migration of species in response to climate change (Hanspach *et al*., 2008).

An integrated strategy

We believe chaperoned assisted migration will be most effective if it is part of an integrated conservation strategy that also includes seed/tissue/pollen banking, *in situ* management, reintroductions, and legal protections. Indeed, chaperoning may be the best strategy for a minority of species, such as those that are not known to reproduce in the wild, can be vegetatively propagated (i.e., perennials), or have recalcitrant seeds that cannot be easily stored in seed banks (Walters *et al*., 2013).

Meeting the challenge

Engaging in an effective, cautious program of chaperoned managed relocation will be challenging and resource-intensive. Thus it will be necessary to establish inter-garden cooperative agreements, working groups, and databases. However a number of

Box 2: What species are good candidates for chaperoned managed relocation?

Some species will be inherently insensitive to climate change, especially if they live in habitats that will be relatively unaffected by climate (e.g., freshwater springs). Other species will be able to migrate adequately to stay within their preferred climate. In general, good candidates for chaperoned managed relocation are species that are:

- sensitive to climate change;
- unable to migrate;
- rare and either declining or not reproducing in the wild;
- are not responding to other conservation measures;
- and are difficult to store in seed banks because their seeds are on the recalcitrant end of the orthodox-recalcitrant spectrum.

Identification of candidate species is a difficult but necessary task before investing resources in a program of chaperoned managed relocation.

There are several frameworks for assessing species' vulnerability to climate change. In the US, one of the most commonly used frameworks is NatureServe's Climate Change Vulnerability Index (http://www.natureserve.org/prodServices/climatechange/ccvi.jsp), which estimates vulnerability using species' dispersal ability, exposure to past climatic variability, dependence on other species (like pollinators), restriction of specific habitats, and genetic variation (if known).

Other vulnerability assessments use species distribution modeling to estimate exposure to climate change. These can be incorporated with methods like those used by NatureServe to estimate overall vulnerability to climate change.

Risks to the system from which plants are taken must also be assessed. In some cases threatened animals may depend on target plant species. Likewise, there may be cultural objections to moving plants from/into a location. These methods do not necessarily incorporate current threats to species (e.g. by invasive species). In some instances climate change could actually alleviate threats to some species (e.g., by disfavoring an invasive herbivore), but in many cases they may also worsen current threats.

national and regional botanic garden networks already exist that could provide the institutional framework for the transfer of species within countries or regions.

Gardens must also balance conservation with all other mission objectives. Furthermore, there is likely to be a need for the further development of capacity in many gardens, especially in conservation and invasive species management. However, we also see promise in the network and expertise that gardens offer to support programs of assisted migration.

Echinacea tennesseensis *was successfully reintroduced into the wild and is grown as wild-collected specimens in botanical gardens beyond its native historic range*

Discussion paper

A discussion paper providing further details of the proposed chaperoned managed relocation plan, as well as an example of how this might work in practice – the case of *Trifolium stoloniferum* (Running buffalo clover) - is available on the BGCL website. Please visit: http://www.bgci.org/climate/chaperoned-migration/

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Adam B. Smith and Matthew A. Albrecht
Centre for Conservation and Sustainable Development
Missouri Botanical Garden
POB 299, St Louis
MO 63199, USA

Pennisetum villosum *and* Oxalis pes-caprae *have long distance propagation modes, enabling them to escape readily from planting sites (O. Filippi).*

Notes

[1] http://www.anbg.gov.au/anpc/publications/translocation.html

[2] http://www.issg.org/pdf/publications/Heywood&Sharrock-2013.pdf

[3] Any garden reporting a positive response to the "Invasive Species Monitoring" or "Invasive Species Policy" fields in the GardenSearch database were assumed to screen for invasiveness and/or have an invasives policy.

4 Any garden reporting a positive response to "Conservation Program", "*Ex Situ* Program", "Reintroduction Program", "Conservation Biology", "Conservation Genetics", "Ecology", "Ecosystem Conservation", "Invasives Species Biology", "Pollination Biology", "Restoration Ecology", "Land Restoration", or "Plant Pathology" fields were assumed to have scientific experience in conservation biology or ecology.

Author: Eduardo Dalcin

CULTIVATING BITS AND BYTES

Introduction

For many years botanical gardens have been recognized as the guardians of knowledge about plants. Compiling specimens from all over the world in their collections, both preserved in their herbaria, or alive in their gardens, they attracted and housed researchers and experts. This work of botanical gardens generated much of today's knowledge of plants, and this was further transmitted to the wider society through their education and outreach programmes. However, this is about to change.

The way in which the information is generated and consumed by society has changed dramatically in the last decade. With the advent of information and communication technologies (IT), especially with the "Internet boom", we are facing a new kind of science - "Network Science" (Nielsen, 2011), and also a new kind of society.

Scientists working on the Brazilian Flora Checklist Online.

Botanists and computers

Botanists have been exploring the use of computers for quite some time. For example, in 1962 the paper "*Data-processing for the Atlas of the British Flora*" was presented at a symposium entitled "*The applications of data-processing methods to research in the biological sciences*", sponsored by the American Society of Plant Taxonomists, the Botanical Society of America and Ecological Society of America; in Corvallis, Oregon, USA (Perring, 1963). Since then, huge progress has been made, especially during the 1980s and '90s. In December 1982, the Systematics Association held an international symposium on Databases in Systematics where Allkin and Bisby (1984) noted:

"...The feeling that we were experiencing a period of rapid technological development, particularly in the effectiveness of small computers and the availability of database software..."

Following that, the first meeting of the Taxonomic Databases Working Group (TDWG), was held at the Conservatoire et Jardin Botaniques, in Geneva, Switzerland, in September 1985 to establish international collaboration among biological database projects. TDWG, a not for profit scientific and educational association affiliated to the International Union of Biological Sciences aimed to promote the wider and more effective dissemination of information about the world's heritage of biological organisms for the benefit of society at large.

The capacity and competence of the early pioneers in biological databases permeated through the institutions where they worked and resulted in the development of new departments of "Scientific Information" and "Biodiversity Informatics". Today this interface between information science and biodiversity has become of great strategic importance to many botanic gardens and their staff have become

Orchid specimens in the laboratories of the Xishuangbanna Tropical Botanic Gardens (Barney Wilczak)

experts in the field of ‘biodiversity informatics’ - a new term coined around 1992 by a Canadian Consortium (Berendsohn, 2013).

Bringing data sets together

More recently, botanic gardens have used new biodiversity informatics technologies to consolidate, assemble and publish their vast knowledge of the world’s plant diversity. Of particular note are the efforts of the Royal Botanic Gardens, Kew and the Missouri Botanical Garden, to publish in 2010 “The Plant List” – the first ever list of botanical names of all known plant species. The Plant List was created by combining multiple checklist data sets held by these institutions and other collaborators.

“The Plant List was created in response to Target 1 of the Global Strategy for Plant Conservation (GSPC), which called for a widely accessible working list of known plant species to be created by 2010. It is available on–line at www.theplantlist.org”

Version 1.1, of the Plant List, which was released in September 2013, includes new data sets, updated versions of the original data sets and improved algorithms to resolve logical conflicts between those data sets. Version 1.1. includes: 642 plant families, 17,020 plant genera and 1,064,035 scientific plant names of species rank. Of these 350,699 are accepted species names and 242,712 names are yet to be resolved.

Compiling a list of the accepted Latin name for most species, with links to all synonyms by which that species has been known, is a huge step towards an system that may offer a unique and stable reference to the taxonomic concept which those names intend to represent, allowing information and knowledge related to those taxa concepts to be linked and brought together.

Beyond a list of plants

The tenth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP 10) was held in Japan in 2010. At this meeting, a consolidated update to the Global Strategy for Plant Conservation (GSPC) was adopted, with sixteen updated global targets for plant conservation, including Target 1 of developing, by 2020, an online Flora of all known plants.

In response to this, a document “*A World Flora Online by 2020: a discussion document on plans for the achievement of Target 1 of the Global Strategy for Plant Conservation by 2020*” was prepared by the Missouri Botanical Garden, the New York Botanical Garden, the Royal Botanic Garden Edinburgh, and the Royal Botanic Gardens, Kew. This led to the launch of the World Flora Online in India, at an event held during COP 11 in October, 2012.

The first World Flora Online (WFO) Meeting was held at Missouri Botanical Garden, USA, in July 2012. On that occasion, the participating institutions were invited to sign a Memorandum of Understanding (MoU), in order to compose an “informal international consortium to facilitate the achievement of a World Flora Online by 2020”.

Examining plant labels at Auckland Botanic Garden, New Zealand

The MoU also provides an expression of interest for organizations to become involved in an international World Flora Online (WFO) project .

At that meeting also, two working groups were created in order to define the technology and taxonomic aspects of the WFO implementation.

The massive presence of botanic garden institutions (Berlin, Edinburgh, Geneva, Kew, Missouri, New York and Rio de Janeiro), in the Technical Working Group reflects the high level of Biodiversity Informatics capacity and competence amongst these institutions.

Looking to the future

Initiatives such as The Plant List and The World Flora Online will have a huge impact on conservation projects, where such authoritative databases will offer a 'one-stop-shop' to access the best available information on the world's plants.

One example is the on-going work on threat assessments of Brazilian plants, which is coordinated by the National Center of Flora Conservation - CNCFlora, in Rio de Janeiro Botanical Garden, Brazil. This relies heavily on the Brazilian Flora Checklist Online in order to compile all the information available about the assessed species. In turn, the Brazilian Flora Online will make an important contribution to the World Flora Online.

World Flora Online Meeting, July 2012

In this new world, where computers talk to each other, bits and bytes flow through an overwhelming network of high tech hardware which embraces every almost every corner of the planet. Data readily reaches millions of households, through a myriad of handheld devices and mobile phones. Botanic gardens have been part of this revolution – and have learned – and are still learning new tricks to reach their audience.

From being amongst the pioneers of the biodiversity informatics revolution, botanic gardens are today becoming the one of the pillars of a global infrastructure of biodiversity information, where the most optimistic envisage an era where an efficient monitoring of biodiversity will promote and ensure the effective conservation, and sustainable and fair use of biodiversity for all.

World Flora Online Technical Working Group Edinburgh, November 2013

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Eduardo Dalcin
Instituto de Pesquisas Jardim Botânico do Rio de Janeiro
Diretoria de Pesquisas
Núcleo de Computação Científica e Geoprocessamento
Rua Pacheco Leao 915, Jardim Botânico
Rio de Janeiro
22460-030 Brazil

Author: Dave Aplin

A GLOBAL SURVEY OF LIVING COLLECTIONS

Evaluating plant collections can significantly contribute to the efficient use of limited funds – but relatively few botanic gardens carry out such evaluations.

Plant collections held by botanic gardens perform valuable roles. They can be used to improve human well-being (e.g. Waylen, 2006), or contribute towards the conservation of threatened species (e.g. Sharrock & Jones, 2009) and ecosystems (e.g. Yu *et al*., 2008). They also provide invaluable material to support plant research (Crane *et al*. 2011). To facilitate the preparation of a forthcoming update of the Darwin Technical Manual for Botanic Gardens, a questionnaire was developed to discover more about these globally rich and varied living collections. The information below highlights the preliminary results from this questionnaire.

A global response

The survey was promoted by a number of organisations and networks including BGCI, the Mexican Association of Botanic Gardens, the American Public Gardens Association and PlantNetwork in the UK. It was greeted enthusiastically by members of these networks with great willingness to take part as indicated by the number of enquires and responses received between 30th April and 5th June, 2014. In total, 176 institutions responded. Five gave data representing multiple gardens (e.g. the National Trust in the UK and the South African National Biodiversity Institute) that increased the number of participatory gardens to 349. To avoid biasing results it was decided that the results would reflect individual institutions rather than individual gardens, although in the majority of instances an institution comprises a single garden.

In total 44 countries responded (Fig. 1), these included: (The numbers in brackets denote the number of institutions taking part from each country - if greater than one).

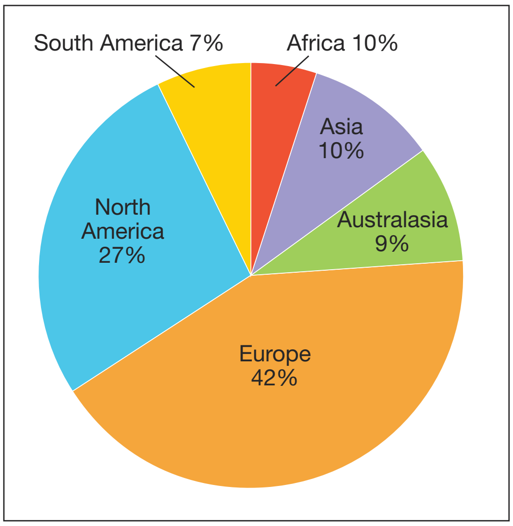


Figure 1: Location of gardens responding to the survey by continent using the United Nation's classification of countries by major area and region of the world.

Argentina, Australia (12), Austria (2), Azerbaijan, Belgium (2), Brazil, Bulgaria, Canada (6), Chile, China (8), Colombia, Denmark, Ethiopia (2), Finland, France (4), Georgia, Germany (5), Greece, Hungary, Iceland, India (3), Italy (3), Lithuania, Luxembourg, Mexico (8), Monaco, Namibia, Netherlands (4), New Zealand (6), Nigeria, Poland (5), Portugal (4), Romania, Russia (9), Singapore, Slovakia, South Africa (3), South Korea (3), Spain (3), Switzerland (2), Turkey, United Kingdom (20), Ukraine, United States of America (41).

The distribution of responses broadly reflected the known global distribution of botanic gardens previously displayed graphically in cartograms (BGCI, 2007)

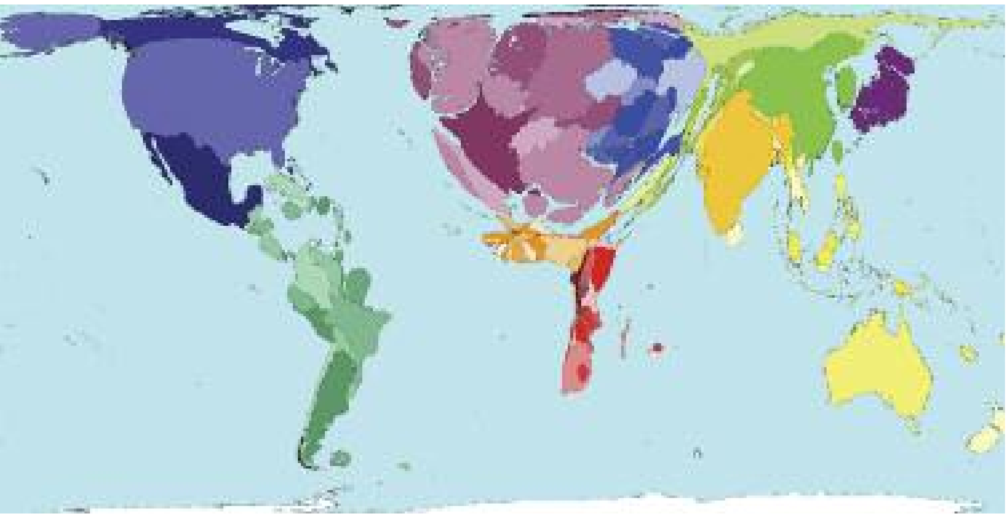


Figure 2: Global distribution of botanic gardens. The cartogram re-sizes territory according to the number of botanic gardens within a given area. A large number of botanic gardens in Europe shows a ballooning of this continent, contrasted by the situation in Africa. Map data was obtained from the BGCI GardenSearch database and IUCN's list of plant species per country (1997). (url ref: www.worldmapper.org/images/largepng/271a.png: Also used in Cuttings Vol 4 (3) 2007)

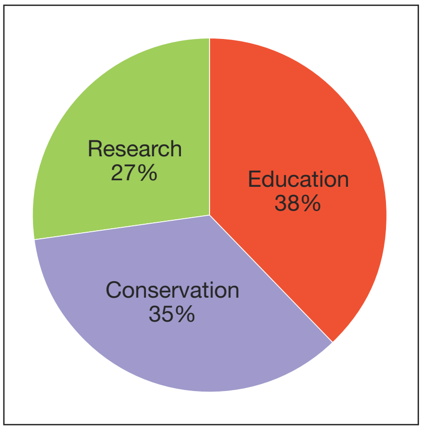


Figure 3: The importance of education, conservation and research as a main function. In order to reflect the bias between the recorded priorities for each role the results have been weighted. The most important role(s) for each institute were allocated four points, with those ranked second given three points; and those placed third two points. These values were then totalled and expressed as a percentage. In this survey it is possible for a single institute to list more than one role as most important. A total of 97% of respondents highlighted their main role(s).

with the United States of America and the United Kingdom providing most responses (Fig. 2). This value may also have been biased because the questionnaire was conducted in English which is an official language in only nine of the responding countries.

What do botanic gardens see as their main roles?

The questionnaire asked institutions to indicate their main role(s). Four possible options were provided: education; research; conservation; and a free text field 'other'. Each garden had an option to rank these in order of importance, provide joint ranking where appropriate or dismiss an option if it was felt unimportant. In the design of the survey it was decided that horticultural display would be a key element that all gardens share, for this reason it was not specifically highlighted in this question.

Overall, respondent gardens highlighted education as their most important role with conservation highlighted as a close second (Fig. 3). It is therefore evident that respondent gardens view both education and plant conservation important topics to focus their attentions. Predictably, research came third as this pursuit often lends itself to larger, established gardens with strong academic links.

Among the roles listed under the free text 'other' category were: botanical reference, cemetery operation, collecting, cultural, display, ecotourism, historical estate preservation, outreach, passive recreation, production for propagation, restoration of mind and spirit, tourism, urban oasis and well-being.

Quantifying plant diversity

This part of the questionnaire concentrated on the number of accessions cultivated in gardens and on the number of accessions grown at different taxonomic hierarchies.

In total 1,786,917 accessions were recorded in cultivation from 135 (74%) of the 176 responding institutions.

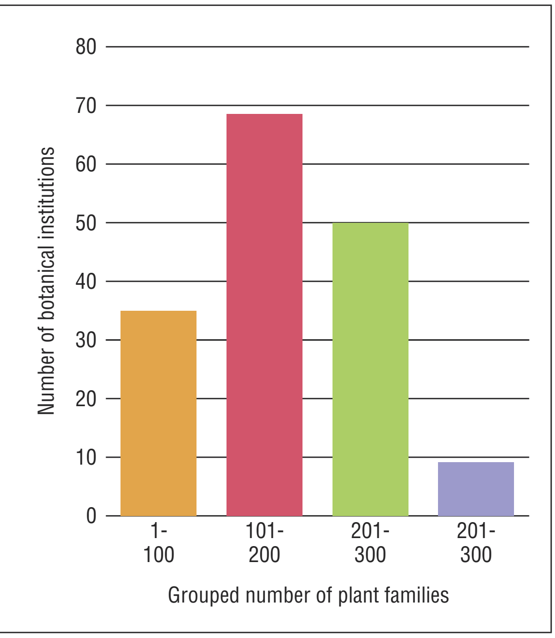
41 institutions were unable to provide a figure for the total number of accessions grown, the main reason given was problems with consulting the plant records database for this information.

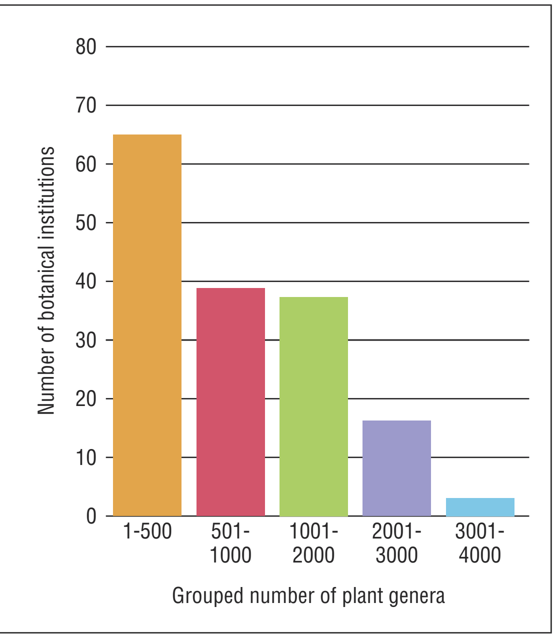
Verification and provenance

Growing a diverse range of plant material is important for many gardens but also of significance is whether an accession has been formally verified and its origin recorded. These factors are especially important for institutions involved in conservation and research.

CRITERIA	Highest value	Lowest value	Average	% respondents answering
No. accessions	225,989	6	13,537	74
No. families	347	12	170	92
No. genera	3,800	42	938	92
No. species	16,613	78	3,251	90
No. taxa	32,539	8	5,267	81

Table 1. Accession and taxonomic hierarchies for plants cultivated in botanical institutions. Values highlight the highest, lowest and average values recorded. In each criterion the percentage of institutions answering the specific question is provided.





These criteria gave the lowest response rates of the questionnaire with only 55 – 62% of respondents answering the questions (see Table 2). Reasons for the lack of information included problems retrieving information from plant record databases, and information on written records which were not easily calculable.

Left: Figure 4: The distribution of plant families (grouped in 100s) cultivated at 161 responding institutions. Most (118) institutions have between 101-300 plant families in collection, where only a few (9) had over 300 families represented. The gardens of the Royal Botanic Garden Edinburgh had the highest number of plant families (347) with Botanic Garden Meise, Belgium the greatest number for a single garden (345).

Below left: Figure 5: The distribution of plant genera (grouped in 1000s) cultivated at 161 institutions. 142 institutions had less than 2001 genera in collection. The Jawaharlal Nehru Tropical Botanic Garden and Research Institute, India had the largest number of genera in cultivation with 3,800.

Living collections policies and evaluation

The final two questions of the survey related to the Living Collections Policy (LCP) and collection evaluation. The LCP question was specifically worded: 'Does your institution have a comprehensively written Living Collections' Policy that involved multiple stakeholders in its preparation and is easily accessible to staff'. This question was answered by 99% of respondents with 39% confirming that they did have a collections policy (Table 3). The final question looked at evaluating the collection with the question: 'Does your garden undertake auditing or evaluation of the living collections?' and asked for details for the type of evaluation. In most cases the details provided were targeted at routine curatorial practices, such as making inventories and checking the health of the collection. Only a few (20%) responded with examples that demonstrated a systematic approach to assess the value of collections (Table 3).

CRITERIA	Highest value	Lowest value	Average	% for respondent institutes	% respondents answering
Accessions verified	37,269	0	4,129	32	58
Accessions wild (W)	41,303	0	2,334	14	62
Accessions wild (Z)	34,090	0	1,038	6	55

Table 2. Highest, lowest, average values for all respondent gardens for verified accessions and wild and in-direct wild origin accessions. The total number of accessions in each criteria were totalled and expressed as a percentage of the total number of accessions provided (percentage for respondent institutions). In each criterion the percentage of institutions answering the specific criterion question is provided. (W) = direct wild origin; (Z) = indirect wild origin.

CRITERIA	% answering 'yes'	% respondents answering
LCP	39	99
Evaluations	20	73

Table 3. Highlights the percentage of institutions answering 'yes' to a Living Collection's Policy (LCP) and conducting some type of evaluation of the collection that is not considered routine curatorial practice. '% respondents answering' refers to the percentage of institutions from the total answering these specific questions.

Discussion

Conducting a survey over a brief period provides a snapshot of the global extent of living collections in a particular timeframe and generates baseline data against which to compare changes in collection demographics in the future. It was the intention that the survey would actively contribute towards the development of the forthcoming technical manual and potentially highlight real issues for plant conservation. The use of *ex situ* plant material for conservation (and research) relies on two fundamental principles: the names on the labels being correct (verified) and the accession having sufficient associated data to be useful.

Target 8 of the Global Strategy for Plant Conservation calls for 75% of threatened plant species to be in *ex situ* collections by 2020. BGCI's PlantSearch database is considered a valuable tool to monitor progress towards Target 8 by recording the number of threatened plants in *ex situ* collections. However, this survey illustrates the need to use the database with caution. If, as these current results suggest, an average of only 14% of accessions in collections are from known wild origin and only 32% of accessions are verified, many plants in collections may not be of great conservation value. Because of this the true plight of some taxa may be unwittingly masked, with the database suggesting an over-estimate of the number of threatened taxa in collections that are legitimately fit-for-purpose with respect to conservation.

One of the mechanisms for helping to strategically develop and maintain a plant collection independent of staff is a Living Collections Policy. From the gardens surveyed only 39% had a written policy that involved multiple stakeholders in its preparation and was easily accessible to staff. One of those that did not was Botanischer Garten und Botanisches Museum Berlin-Dahlem. This garden however, has developed 'collection concept' documents that highlight the use and objectives of plant holdings in accordance with focal areas in research, conservation and education (pers. comm., Albert-Dieter Stevens, 09/05/2014).

Evaluating plant collections (not including routine curatorial activities) occurs in only 1 in every 5 institutions. This is surprising because the institutions that have undergone this process (e.g. Botanic Garden Meise, Montgomery Botanical Center) have found the results revealing and invaluable (see Aplin, 2008, 2013) and significantly contribute to the efficient use of limited funds.

Limitations of the survey

- The survey was conducted in English only and this may have excluded some respondents.
- The analysis looked at the entire holdings of each respondent garden and there was no allowance for investigating increased bias towards wild-gathered accessions or targeted verification in recent years.
- There was no account for data quality in the survey, some accessions listed as wild-gathered may have scant or no associated data.
- Wild-collected plants and verification are two different processes which are reported separately. It is not possible to report the percentage of verified and wild-gathered material without further investigation.

Despite these limitations, the survey results did reveal some interesting information and it is hoped that this can be used as a basis for further investigation and case studies aiding the targeted approach to *ex situ* conservation.

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Dave Aplin
BotanicalValues
6 Greenford View, Higher Frome Vauchurch
Dorchester, Dorset
DT2 0AS
UK

Authors: Kalani Seymour and Sophie Leguil

CULTIVAR CONSERVATION IN THE UK

Databases provide an essential tool in identifying threatened cultivars in garden collections

Introduction

Plant Heritage, a UK & Ireland based membership charity which promotes conservation through cultivation, has been preserving cultivars, amongst other taxonomic levels, in National Plant Collections® since the 1980s. Since 2009, through our Threatened Plants Project we have been particularly concentrating on cultivars. We are listing, genus by genus, all named cultivars ever grown in gardens in the UK & Ireland; identifying those which are so rare as to be threatened; amassing data indicating their Plant Heritage Value, a new, broad measure of conservation worthiness (Seymour, 2012); and promoting practical conservation of the most worthy.

The worth of cultivars derives from both their biological diversity and the cultural heritage which they represent and embody. Although wild plant conservation has been practised for decades, it was not until 2010 that Aichi Target 13 of the Strategic Plan for Biodiversity 2011-2020 recognised the global conservation importance of cultivated plants: safeguarding genetic diversity *"including other socio-economically as well as culturally valuable species"*.

Assessing the plant collections at Cambridge University Botanic Garden

Cultivated plant rarity and therefore level of threat, we have stated (Morris *et al* 2010), derives from commercial availability and whether it still exists in gardens. Cultivars, of course, are not present in the wild to go back to. We use the RHS Plant Finder to measure availability (which goes back as far as 1987 when it was published by the Hardy Plant Society), as many garden plant records as we can access, and the RHS Horticultural Database and International Cultivar Registration Authorities to check nomenclature and usage.

In brief, two-thirds of cultivars found in the UK and Ireland are threatened; nearly half of these are Critical in cultivation (CRic) – i.e. not found growing; over half are Endangered in cultivation (ENic) – that is only recorded at 1 or 2 garden sites, and not readily available from nurseries. We would like to see threatened plants surviving at a minimum of 3 sites, and therefore merely be categorised as Vulnerable in cultivation (VUic). This may be achieved within a single organisation with multiple sites – see examples later.

[1]Find out more at http://ntbg.org/breadfruit/index.php.

Accession screen for Pulmonaria *'Red Freckles'*

Gathering external plant records

BGCI helped us trial a dataset extracted from the PlantSearch database[1] in early 2012. At that time cultivar names were often not recognised in the import function, leading to lack of completeness in uploaded plant records. We applaud the recent announcement of PlantSearch using more names from the RHS Horticultural Database in order, *inter alia*, to facilitate the management of cultivar names (David & Wilson 2013).

The Multisite search hosted by the Royal Botanic Garden Edinburgh[2] has been extremely useful for querying RBGE, RHS and Hillier Gardens live plant records in one portal, as has ePIC from Kew[3]. We also used the self-hosted data at National Botanic Garden Glasnevin and Kilmacurragh[4] and from Cardiff Parks[5]. Because these are freely available online, we have been able to use volunteers working remotely to carry out collections checking for the presence of threatened cultivars and the discovery of previously unrecorded potentially rare cultivars.

We used BGCI's GardenSearch database[6] to enable a volunteer, Gary Jones at Plumpton College, to request cultivar-only plant records from many public gardens in the UK & Ireland. He also contacted PlantNetwork members and was successful in acquiring full or partial cultivar records from over a hundred organisations. Records have been received in a variety of formats, such as paper lists, Microsoft Excel spreadsheets or database extracts. These are kept confidential in the office and used for the purposes of the project.

Including those for our own National Plant Collections®, Plant Exchange and Plant Guardians[7], we currently hold plant records from 819 garden sites or conservation schemes, many updated within the last year. In the future, we hope to acquire even more from botanic and university gardens, local councils or plantsman's gardens, so please feel free to send us your records of cultivars held in gardens open to the public in the UK or Ireland.

A list of threatened cultivars

The first ever A-Z list of cultivars threatened in cultivation in the UK & Ireland has just been published on the Plant Heritage website[8].

There are more than a thousand genera with cultivars commercially available in the UK & Ireland. To date 363 genera have been listed by the project, of which 273 have been assessed for the existence of threatened cultivars, and these names are being checked. The published list contains 126 genera from *Abelia* to *Zingiber*.

We are investigating the future use of Scratchpads[9], the Natural History Museum's open biodiversity platform, to publish and share the list of threatened cultivars and other information that we have collected, such as pictures or historic data. However, integration has proven difficult to date as cultivated plant names come in a wide variety of formats.

Evaluating conservation status

We evaluate conservation status from recorded presence in gardens: threatened cultivars recorded as growing in gardens are Endangered, or, seldom, Vulnerable.

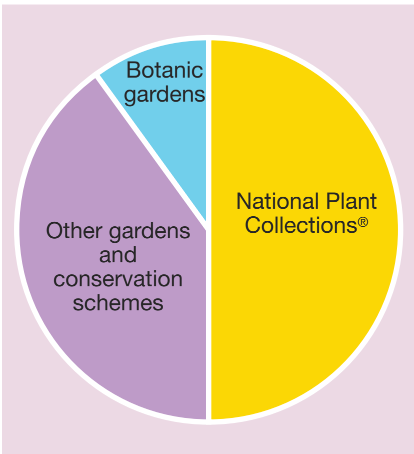

Figure 1: The percentage of threatened plants growing in different types of collections

Eleven percent (1,808) of threatened cultivars have been found in botanic gardens, despite a traditional focus on wild taxa: 562 at Royal Botanic Gardens, Kew and Wakehurst Place, 471 at Royal Botanic Garden Edinburgh's four gardens, 272 at National Botanic Garden Glasnevin and Kilmacurragh, 159 at the National Botanic Garden of Wales, 118 at Cambridge University Botanic Garden, as well as 78 at Sheffield Botanic Garden, 75 at the University of Oxford Botanic Garden and 73 at St Andrews Botanic Garden (Fig.1).

Gardens planned for aesthetic appeal and historic plantings also contain many threatened cultivars, a total of 39% (6,611): mainly RHS gardens 2,699, Hilliers 1,105, National Trust 478, National Trust for Scotland 340, Yorkshire Arboretum 283, Eden Project 228, Exbury Gardens 217, Savill & Valley Gardens 198, Bressingham 136 and High Beeches Garden 100.

Pulmonaria *'Red Freckles' (RHS/Carol Sheppard)*

Chrysanthemum *'Cottage Lemon' CR originally obtained from NCH Judy Barker*

National Plant Collections safeguard 50% all the threatened cultivars that have been found growing, 8,464.

National Plant Collections
National Collection Holders use a variety of information curation formats led by Microsoft Excel, Word and Access and their Mac and open versions, and many paper based methods (e.g. card indexes, bound notebooks, herbarium sheets, leaflets, printed catalogues). Other methods include Demeter (a proprietary database still used by English Heritage and National Trust for Scotland), Persephone (recently developed by other Collection Holders), BG-Base, IrisBG, Arboretum DB, BG-Recorder, Brahms, Cactusbasepro, Dataease, Growmaster, Omnis 7, and their own websites.

Early results of the project communicated to both potential and existing National Collection Holders have enabled them to take propagation measures for the plants that are uniquely held, and acquire threatened cultivars that they did not yet grow, thus increasing the conservation value of their collections.

RHS

The RHS (Royal Horticultural Society) is a UK-based charitable organisation that owns four demonstration gardens, holds seasonal plant shows and events, and provides a wealth of horticultural expertise to professionals and amateurs alike.

Rupert Wilson, one of the Horticultural Information team at RHS Garden Wisley, has helped the work of the project by providing data exports from the *RHS Plant Finder* dataset, part of the RHS Horticultural Database. The RHS, which makes the living collections information from its four gardens generally available through the RBGE Multisite search as well as BGCI PlantSearch, provided additional information on request for those genera with >200 taxa not supported by online querying, regarding which gardens threatened plants are located in. The RHS' flagship garden at Wisley turns out to be the single richest site for threatened cultivars: 2,333 taxa, of which more than 1,000 are uniquely held.

The RHS Horticultural Database has now been updated to highlight these cultivars within the living collections tables, making it easier for gardeners, curators and Plant Records officers to keep track of this valuable genetic resource. This has resulted in renewed interest and enthusiasm amongst senior management for actively supporting conservation of these threatened cultivars within the four RHS gardens.

National Trust

The National Trust is a non-governmental conservation charity whose purpose is to look after places of historic interest or natural beauty across England, Wales and Northern Ireland for the benefit of the nation. The Trust owns over 200 historic houses with gardens, many of which contain National Plant Collections, some established as early as 1981. In 2012, a 5 acre purpose-built facility, the Plant Conservation Centre, was opened to propagate and distribute historically or botanically important, rare or threatened plants from original specimens in Trust gardens and parks. Contract propagation is also available.

So far, 436 different cultivars assessed as rare enough to be threatened have been recorded as growing at 87 National

Fuchsia *Overbeck Ruby*

The National Trust's Plant Conservation Centre

Trust properties, 82 of which are held within existing National Plant Collections®. 180 cultivars have been found nowhere else to date.

The National Trust plant curation team has started flagging on their database cultivars that have been assessed as Threatened by the project, in order to prioritise which plants to propagate first to make sure they are not lost to cultivation. At their Head Gardeners Conference in August 2013, a tabulation of significant plants across 100 properties included 970 Plant Heritage Threatened cultivars alongside several thousand of National Trust specific value. Survey work and upload of existing survey data is ongoing.

Botanic Gardens

If you send us a cultivar list, we will return a report of threatened plants including those unique to your garden (which enables you to check whether they are still alive and take conservation measures if applicable), and add previously unrecorded names to the national threatened list.

Many cultivars which at first appear rare and therefore threatened are in fact common plants, but entered into databases with somewhat varying names. This variability of names (for example, typographical transpositions of letters or phonetic transcribing of cultivar epithets, as well as valid nomenclatural corrections) makes it difficult for database-only curation and identification of threatened plants.

Other gardens

Smaller gardens and conservation schemes play an active role in the preservation of threatened cultivars, as they often grow plants of historical and local importance.

Goals

Our aim is to return Threatened plants from Critical to Endangered, and Endangered to Vulnerable, and if possible to no longer Threatened; or to document if they are not worthy of further conservation: for example wrongly named, lookalikes, or superseded breeders' experiments.

Since plants which are Endangered in cultivation are most frequently found at only one garden site, every new partner and location is extremely helpful, and we look forward to working more closely with BGCI and many others in the future.

More about plant records

Find out more at the PlantNetwork meeting Rethinking Plant Records, where the Plant Records Group reconvenes on 1st October at RHS Garden, Harlow Carr[10]. We will be there as will representatives from the RHS and the National Trust's Plant Conservation Centre.

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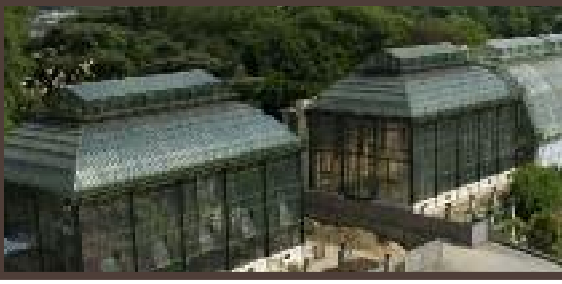
Kalani Seymour and Sophie Leguil
Threatened Plants Project Coordinators
Plant Heritage,
12 Home Farm,
Loseley Park,
Guildford,
Surrey GU3 1HS
UK
TPP@plantheritage.org.uk

Notes

[1] http://www.bgci.org/plant_search.php
[2] http://rbg-web2.rbge.org.uk/multisite/multisite3.php
[3] http://epic.kew.org
[4] http://www.botanicgardens.ie/nbg/cat.htm
[5] http://apps2.cardiff.gov.uk/plantguide/
[6] http://www.bgci.org/garden_search.php
[7] www.nccpg.com
[8] http://www.nccpg.com/tpp/Technical-data.aspx
[9] http://www.scratchpads.eu/
[10] http://plantnetwork.org/?p=13172



EUROGARD VII
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EUROGARD VII, the Seventh European Botanic Gardens Congress

European botanic gardens in the Decade on Biodiversity
Challenges and responsibilities in the countdown towards 2020

National Natural History Museum, Paris
July 6-10, 2015

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To register your interest, please contact eurogard.2015@mnhn.fr.
The Conference website will be available shortly.

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Botanic Gardens Conservation International

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

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