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

Chapter 5: Collection Record Management Systems

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Chapter 5:
Collection Record Management Systems

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5.0 DEFINITIONS

Accession: Plant material (individual or group) of a single taxon and propagule type with identical or closely similar parentage acquired from one source at the same time.

Accession number: For tracking purposes, an accession is catalogued and assigned a unique identifier (number or code) associated with additional information.

Acquisition: Plant material prior to being accepted into the plant collection and catalogued as an accession. The term can also denote the process of gathering plant material before its incorporation into the plant holdings of the botanic garden.

Asset codes: Codes in the form of barcodes or Quick Respond (QR) codes which link electronically an item (asset) to a master record that provides further information about the item (for ease of tracking, reporting and data selection throughout a record system).

Batch number: A sequential reference number assigned to a group of samples of the same or a different taxon, received from one source at the same time.

Collection number: A unique sequential reference number that is assigned to a plant specimen/sample by the plant collector for the purpose of cross-referencing source information.

De-accessioning: The process of removal of all or part of the accession from the botanic garden, while related plant information is retained in the database.

Plant records: A suite of collection policies, databases, maps and other related files that document the plant holdings of the botanic garden.

Provenance: The original source of the plant material. The term is used both to denote a location (wild population or nursery-grown) and a concept (wild-collected or cultivated stock).

Qualifier: Qualifier in the form of a digit, letter or other data symbol is used as an extension of the accession number to distinguish a batch of the same taxon from the same source.

Serial number: A sequential series of numbers given to a batch of plants received at the same time.

Taxon (pl. taxa): A group of plants that form a botanically named unit, including all their components, e.g. *Fagus sylvatica, F. sylvatica* 'Aspleniifolia', *F. sylvatica* Atropurpurea Group, *F. sylvatica* f. *purpurea, F. sylvatica* var. *purpurea* and *F. sylvatica* 'Purpurea Tricolor' are six taxa of the same species.

5.1 INTRODUCTION

The historical significance of an object in the collection lies not in itself alone but also in the information relating to it. Carl E. Guthe (1964)

KEY MESSAGE

Documentation should be systematised and structured to be useful since data that are randomly organised and stored – as accurate and noteworthy they may be – are of limited value if the information cannot be traced, extracted and updated.

The defining feature of a botanic garden is the management of its documented collections of living plants. The documentation process normally involves a record system whereby each acquisition of a taxon that enters the botanic garden is provided with a unique identification, i.e. an accession number (Section 5.4.1). This number links the plant material to various data and information. Each botanic garden has documentation needs that are specific to its vision and mission (Chapter 1, Section 1.2.4) and collection policy (Chapter 3), upon which the plant holdings and programmes of the institution are built. The development of a documentation process that captures all required data is a challenging task as there is no one model that fits every botanic garden's needs and resources. However, whatever the individual information needs, there is a basic structure that is useful for most institutions.

This chapter presents generic guidance for the establishment of standardised documentation systems and related methods and technology in use in botanic gardens. Each acquisition of a taxon should come with relevant information which should be kept securely for future reference and use. Gathering and documenting the important and vital details pertaining to the acquisitions that will become part of the collections, should never be done retrospectively as information may prove irretrievable at a later stage. As the collections grow in size and scope, so too do the related volume and detail of information.

Management decisions for tracking, analysing, planning and assessing the significance and quality of the collections are dependent on the available, documented information. Randomly organised and stored data, no matter how accurate and noteworthy, is ineffective unless the documentation is systematised, i.e. it should have a structure to be useful. Keeping information on collections is not a random exercise and requires well-thought-out prioritisation and foresight, as well as an in-depth understanding of the workings of the institution.

Regular and rigorous data collection, tracking, updating and maintenance are also needed to ensure that documented information is current. It cannot be overemphasised that well-documented collections give added value and distinguish botanic gardens from institutions such as public parks or display gardens.

5.2 THE COLLECTION RECORD MANAGEMENT SYSTEM: THE BOTANIC GARDEN'S WORKING MEMORY

KEY MESSAGE

A botanic garden's collection record management system is closely linked to the collection policy of the institution, and is a fundamental tool for the development, management and review of the plant holdings.

A collection record management system comprises the mechanisms and processes of collecting, recording, tracking and producing relevant information or data for the effective and efficient curation and utilisation of the botanic garden collections (Box 5.1). This system is an important and evolving resource, and, built over time, becomes the institution's working memory. This is a legacy that will outlast any staff member, team or project, and is an essential element of an institution's future strategic decisions.

The development of a suitable collection record management system is closely linked to the botanic garden's collection policy, which is the common thread that informs and guides the development, management and review of the plant holdings (Chapter 3). Usually a subset of the collection policy, the plant records management procedure prescribes acquisition and documentation standards to ensure core data are captured and retained (Section 5.4). It will also detail de-accessioning and disposal standards, as well as the requirement of regular inventory checks to ensure that the living collection information is updated and current.

With the establishment of international, multilateral agreements including CITES, CBD or the Nagoya Protocol (Chapter 4), a growing number of botanic gardens ensure that their collections are properly documented and tracked. This includes obtaining all relevant legal agreements and permits on the acquisition and use of the plant material, as well as their entry and maintenance in the collection record management system. Although it is best-practice to devise a collection policy at the inception of a new botanic garden (Chapter 1, Section 1.7), this is often not the case. Such an instance is the Singapore Botanic Gardens which had procedures for managing its plant records in place since 1996, prior to drafting its collection policy in 2010.

Box 5.1 Key values of a collection record management system

- **Care and control of collections** by providing information that helps locate plants, manage internal movements, undertake inventories and respond to audits. This improves security and reduces the risk of loss or possible invasiveness of collections, assists in maintaining details of conservation, and ensures that uses are in accordance with any agreements attached to the collection. Documented data will enhance the management of *ex situ* collections as well as of *in situ* conservation/restoration projects over time, and forms a basis for evaluating conservation success or failure.

- **Facilitating the use of collections** by supporting publications, collection interpretations, educational programmes, material for research, and display development. The collection records will therefore need to be accessible to staff, researchers and visitors for specific uses. Exchange of records among botanic gardens and with other interested organisations can be facilitated with a good collection record management system. Botanic gardens with documented data of their collections and facilities, may utilise this information in future management decisions, for instance to address climate change. Collections' records can be of added value for conservation and restoration work if propagation protocols are recorded for the species grown.

- **Preserving information** about plants in the collections for future planning. Long-term availability of information is an overarching aim of a collection record management system.

5.3 CORE COMPONENTS OF A COLLECTION RECORD MANAGEMENT SYSTEM

To be effective, a system does not have to be complex. In fact, the system should be as simple as the complexity of the collection allows. Karol A. Schmiegel (1988)

Two main elements are essential to a collection record management system: Defining what is required versus what is optional information, and identifying what file management system (be it manual or digital) is appropriate to hold and process an institution's information needs within its available means.

It is critical that all required core information of the collections is available and complete (Chapter 3), and that optional but relevant data is also accessible when necessary. The collection record management system requires an in-depth analysis pertaining to the scope of the plant holdings against the number of staff and resources available. These elements will affect the amount of detail selected for the system to handle, which must contain standards for format, terminology and continuity (Hohn, 2004).

The file management platform is the building block of the record system. The scope of the system will require comprehensive documentation including registration, cataloguing, indexing, information retrieval and collections' control data. The documentation system is driven by inputs and therefore it should facilitate organising these in a way that supports the botanic garden's objectives and provide meaningful outputs. This is best accomplished by involving botanic garden staff in the design, development, implementation and maintenance of the system using manual and/or automated means. A system's success depends upon the accurate and efficient recording and retrieval of information that has been reliably keyed and connected to the plants in the collections (Sawyers, 1989). The information must be easily retrievable, interpreted, sorted, and reorganized. In short, a curator should be able to find information on the plant holdings simply and easily, and feel confident that they are all documented and that all documentation also includes records of collections that no longer exist at the botanic garden.

Some botanic gardens may be well-advised to start with the fundamentals of a record management system, and begin documentation at a general level of detail to become more specific and extended over time as their capacity increases. Others may find it more practical and suitable to build a comprehensive system from the outset (Hohn, 2004). While striving to capture as much detail as possible may be desirable, this can lead to incomplete documentation, for instance due to inconsistency in providing information or lack of time to follow-through in collecting and documenting the data for each accession in the collection.

Figure 5.1 Screenshot of a section of the accession register in BG-BASE software from Singapore Botanic Gardens (Section 5.5.2)

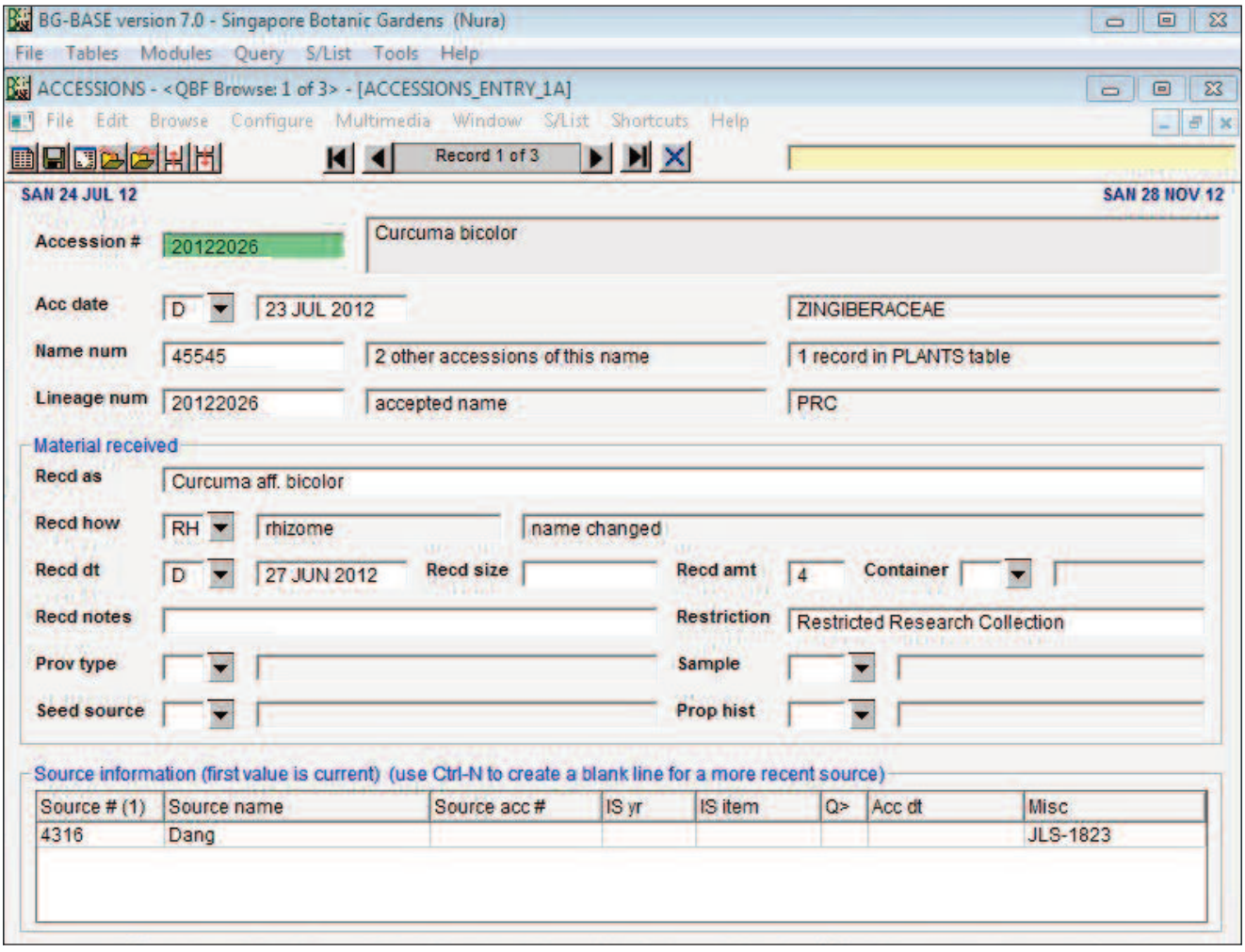
5.4 PROCEDURES AND DOCUMENTATION REQUIREMENTS OF A COLLECTION RECORD MANAGEMENT SYSTEM

It is important to monitor the plants from the moment they arrive in the botanic garden and to maintain the records even after the plant has died, been lost, given away or discarded. The curatorial staff should structure entry procedures and protocols. These need to take into account the background decisions which must be made to serve the documentation requirements of new and existing plant material. This is achieved through accessioning, de-accessioning, labelling and mapping and continuous monitoring. To keep consistent records and maintain the link between the records and plants, accessioning, labelling and mapping procedures should be streamlined and integrated with clear procedures.

5.4.1 Accessioning

KEY MESSAGE

An accession entering the collection is assigned a unique number for tracking. This reference will stay with the plant material and its supporting documentation, and is never deleted, transferred or reassigned to another plant.



Accessioning is the registration process by which a plant acquisition (Chapter 3, Section 3.4) becomes a permanent part of the collection, and more precisely a part of the records, i.e. an 'accession'. An accession is defined as 'plant material (individual or group) of a single taxon and propagule type with identical or closely similar parentage acquired from one source at the same time'. It will be assigned a unique number for tracking purposes. The accessioning process is the beginning of an inventory of the botanic garden collection. Many botanic gardens will simply enter all acquisitions in an accession register regardless of the plant's status, intended use, or the predicted length of stay within the collections. This approach creates a more consistent and simplified documentation process and reduces the chances of samples not being captured in the record system. It also means that every accession will have some documented history within the institution however brief its stay in the collection.

The accession register is a permanent, official record of all the plant holdings of the botanic garden, documented in sequential order by accession number (Figure 5.1). Additional documents and information, such as propagation and cultivation data, phenological observations, Material Transfer Agreements (Chapter 3, Section 3.6.1), permits, etc. are also part of the register.

Primary data usually captured for plant material entering into the botanic garden includes:

- **Accession number**

At the accession stage, all the information about the origin of the plant material is recorded. Each individual or group of identical-parentage will have to be assigned a unique accession or inventory number. This reference will stay with the plant material and its supporting documentation once it enters into the collection and is never deleted, transferred or reassigned to another plant (Box 5.2).

It should be noted that for wild-collected taxa, a single accession will be regarded as one that had been collected from one site by the same collector on the same date. Subsequent collections of the same taxon from the same collection site should be regarded as a new accession (Leadlay and Greene, 1998).

A botanic garden should never practise giving all plant material in the one incoming batch (which may contain several species) the same accession number (effectively becoming a batch number). Occasionally, an accession does consist of a mixed collection in which case it should be re-accessioned as soon as this has been recognised, while the individual taxa contained within the accession will need to be assigned different numbers.

The accession number should not be re-used if the plants die or are given away. Similarly, it should not be changed intentionally during the life-time of the plant. Generally, it is however advisable to assign a new reference number to a plant that has been propagated from the original accession. This is particularly true for propagation using seeds. They may be the product of hybridisation and a new accession number will help to monitor whether hybridization has occurred. In particular, individual specimens of trees and other long-lived plants raised from one accession (e.g. seed collection or cuttings) should be given separate accession numbers for ease of monitoring and documenting.

Botanic gardens will encounter plants in their collections that have lost their accession labels. Data from the last inventory check should help to relink the unlabelled plants to their earlier records, provided the plant species and location are matching, as well as the physical plant size and related records in the database are reasonably congruent. In situations where any unlabelled plants remain unaccounted for ensuing the inventory check as well as following interviews with staff on the site's planting history, the process of 're-accessioning' will follow. This means that plant material without a label that can no longer be linked to available database records is provided with a new accession number.

Box 5.2 Accession number types

Botanic gardens use varying forms of accession numbers with digits and letters. The simplest is a running serial number (e.g. 1,2,3,4...), but this is not widely employed as its management may become challenging if there are a great many accessions, in addition to conveying very little information. The longer a number, the easier errors can occur in transcription, etc.

A more common system is to incorporate the last two digits of the year when the accession was received, followed by a 4- or 5-character running number, e.g. 982460, i.e. the 2460th accession added to the collection during 1998. This system is simple, but is tricky for older botanic gardens as, for instance, there is no distinction possible for collections received in 1898 and 1998. Institutions that initiate an accessioning system are well-advised to include the full 4-digit year. Botanic gardens currently using only 2-digits to indicate the year, should consider switching to a 4-digit as of January 1st of any particular year. For example, if the institution used the 4-digit year followed by a sequential number increment, the accession number 20140100 will read as the plant material recorded in 2014 and received as the 100th accession in that year.

Some botanic gardens use more complex systems usually involving up to 12 characters including letters and signs as well as numbers, e.g. 107 2014 2460 (107=batch number, 2014=year, 2460=serial number) or 2014 W 2460 (2014=year, W=origin of material, 2460=serial number). If a botanic garden has decided to use signs for accession numbers in its written ledgers/accession reports, a decision must be made early to include these or otherwise in the computerised version. Consistency will be vital for retrieval purposes.

Further, it should be noted, that a group of clones or members of a line may be given the same accession number indicative of their genetic similarity. Propagules of a taxon are most often assigned and share a single accession number as a batch. Each successfully grown propagule from the respective batch may then be distinguished with qualifiers such as a digit, letter or other data symbol extension of the accession number. For instance, a batch of ten seeds of *Dipterocarpus tempehes* collected in August 2005 in the MacRitchie Reservoir, Singapore, was given the accession number 20050717, representing the seven hundred and seventeenth (717th) accession added to the garden in that year. Whenever individual plants are raised from this seed batch, they are given the same accession number but different alphabet qualifiers to distinguish them: 20050717*A / 20050717*B / 20050717*C / 20050717*D, etc. The addition of such qualifiers to each progeny resulting from this seed collection allows their tracking as part of the same accession number.

In instances where the database records show that the unlabelled plant material of the same taxon could originate from different sources, a new accession number should be assigned, labelling the source as 'mixed' with indication of the old accession numbers that may be involved. Latter should be noted as inactive with reference to the new, mixed-source accession thereby keeping the inventory process up-to-date. Often, unlabelled plants may be an indication of either lapses in following protocols to properly update records, or unauthorised additions by staff or the public.

• Identification and verification of the name

If the accession does not have a name, it should be identified as soon as possible. At a practical level, a temporary name may be assigned giving its family and/or generic affinities, for example, Myrtaceae (family) aff. (related to (affine)) *Eugenia* (genus). This will help to distinguish the plant or accession in the botanic garden and help communication.

Not all plant material that comes into the botanic garden is correctly named or identified, even after it has been accessioned and studied. Verification is a procedure for checking that a previous identification is correct, or for assigning a name to an unnamed accession (Box 5.3).

The information relating to the identity of a plant requires agreement amongst botanic garden staff on what taxonomic system of classification is followed within the institution. It should be decided by all staff in the horticulture and research branches what system is to be adopted consistently throughout the record process. This determines questions such as which plant families are to be recognised and which genera belong to which family, as well as which genera are to be accepted. Any ambiguity in the use of the names must be resolved to prevent the plants of the same taxon being recorded in the same system under two or more different names. Taxonomic classification systems have evolved over time. Earlier systems such as those by Bentham and Hooker, Engler, Cronquist, Dahlgren, etc. have been superseded by the Angiosperm Phylogeny Group (APG) Classification System which employs molecular technology. APG I was the first version of a modern, mostly molecular-based system of plant taxonomy published in 1998. It has been superseded by revisions in 2003, 2009 and 2016 – APG II, APG III and APG IV, respectively.

There are online databases that try to resolve the dilemma of accepted names of the world's flora and utilise the APG classification system. For instance, these include The Plant List and the World Checklist of Selected Plant Families for verification of current names and spelling.

• Source of the plant material

An essential part of accessioning is recording the source of the plant material received. This should be elaborated with information on the origin or provenance of the material (Chapter 3, Section 3.4.3). The more information available about the origin and history of the accession, the more value the accession will have for research and conservation. Equally, information obtained on material of wild or cultivated origin is useful for reference and other purposes. Source information on plant material which had been collected directly from the wild will help users assess the variability of the taxon in the natural environment, and is vitally important for conservation purposes.

Box 5.3 Verification of names

Checking and verifying names involves two separate procedures:

(i) Identification – which is the determination of a plant as being identical with or similar to a particular taxon. This procedure uses taxonomic experts, taxonomic reference books such as floras and monographs and other scientific materials such as accurately named herbarium voucher specimens or living plants that had previously been correctly determined by the taxonomist.

(ii) Nomenclature – which is concerned with the determination of the correct scientific name of a known plant according to a nomenclature system. This naming is regulated by internationally accepted rules laid down in the International Code of Nomenclature for algae, fungi, and plants and the International Code of Nomenclature for Cultivated Plants.

Thus this procedure establishes that the name is:

(i) the current and preferred one (and correctly spelt) under the rules of nomenclature and;
(ii) the appropriate one to be assigned under the system of classification used in the botanic garden.

Source: Leadlay and Greene (1998)

An accessioned specimen with inadequate source or provenance information can be considered for de-accessioning should related plant material with more comprehensive documentation on its origin become available. An exception to this is when a botanic garden is maintaining a special collection of cultivars, or when limited or no wild material remains, as in the case of very rare or highly threatened taxa.

Source information should include (see also Chapter 3, Section 3.4.3):

- From whom it was obtained: information on wild collected plant material should include collector's name, collection number and date of collection. Likewise, for cultivated plant material, information should be provided as to the nursery's or donor's name, date of receipt and address;
- Whether it is of wild source or not: if from the wild, where it was collected from (i.e. locality, habitat and collection details); similar information for cultivated plants, would help to track the original source of the parent material (e.g. country), but this may not be available from many nurseries;
- Details of compliance with international treaties and Material Transfer Agreements (Chapter 3, Section 3.6.1; Chapter 4, Sections 4.5.2 and 4.6.1): such agreements must be recorded and linked to the accession as part of the source for future reference and utilisation of the plant material and its progenies.

It is essential that the details of the source of the material be added and stored in the plant collection record system at the time of accessioning as this information will be challenging to retrieve at a later stage.

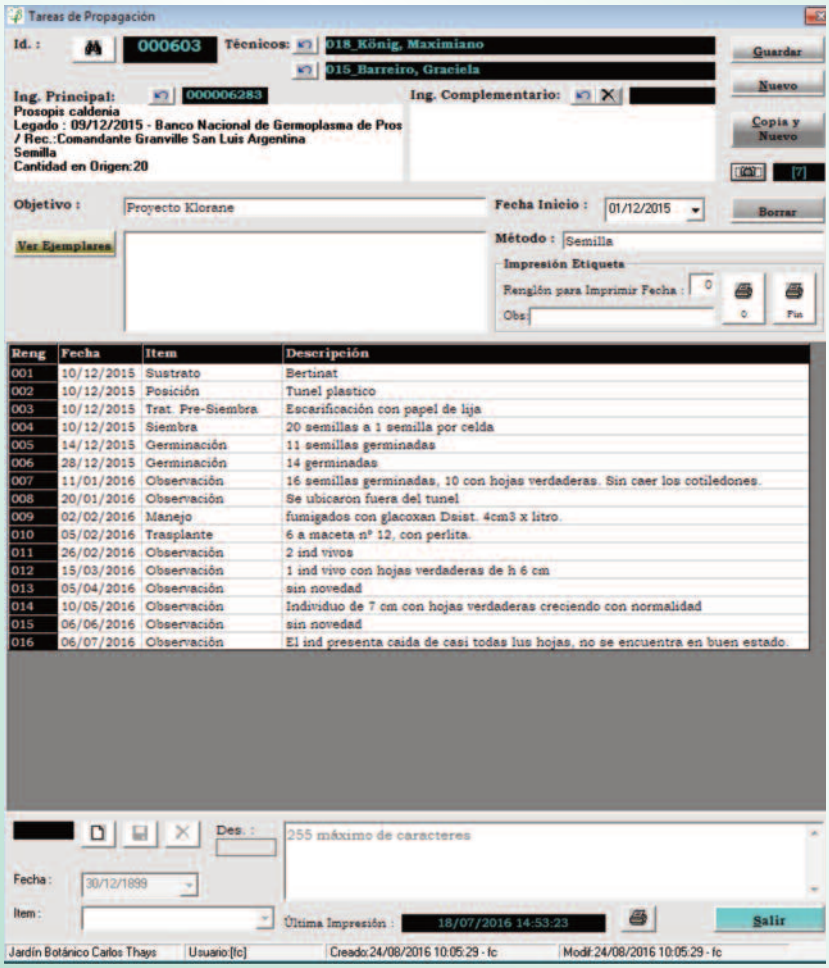
- **Propagation, cultivation and other biological data**

It is very valuable to record the propagation and cultivation methods used and results obtained including the conditions under which plant material has been established in the botanic garden (Figure 5.2). These details are vital for conservation and for restoration purposes *in situ*.

Information about plant growth development, flowering and fruiting, i.e. plant phenology, etc. derived from regular observations of the plants in cultivation should be recorded as well. It is also important to register pests and diseases (Chapter 6, Sections 6.4 and 6.8) during cultivation and the response to adverse environmental factors such as extreme climatic conditions. These data are critical to ensure due maintenance and monitoring of each accession.

Staff of the Ethiopian Biodiversity Institute discussing the importance of maintaining accurate propagation records. (Image: BGCI)

Figure 5.2 Screenshot of a propagation report generated by a bespoke record management system tailored to the institutional needs of Jardín Botánico Carlos Thays, Buenos Aires, Argentina



- **Use of the plant material**

Information may be stored regarding an accession's use in research projects, pharmaceutical screening, DNA typification, plant breeding, etc. or whether the plant material had been provided to and or received by other botanic gardens and institutions. In this context, it is important to note and record whether plant material held is subject to any legally binding international, regional or national regulations, laws and agreements (Chapters 3 and 4).

- **Integration of different collection types**

As part of each living accession's documentation, herbarium vouchers (Chapter 7, Section 7.1.3) should be prepared whenever possible. These can be important to verify the identification at a later date or if name changes occur as the result of a revised taxonomy; this highlights the value of integration of different collection types. Besides herbarium specimens, a botanic garden may also assemble seed, pollen, carpological, DNA or spirit collections. These should be recorded and documented in the database in accordance with the institution's plant collection record system.

The record system a botanic garden creates or purchases off-the-shelf (Section 5.5.2), can either be specific to the living plant collection or have a wider recording capability to include non-living collections and further accessory collections such as herbarium specimens, photographs, botanical artworks, publications and artefacts.

5.4.2 Labelling

Having accessioned the material, it is very important to keep the link between accession record and the plant in the collection by means of labels. Each plant or batch of plants should have a label at all times on which the accession number and name are clearly shown. The accession number and name are the key to unlock the information about the plant.

The basic standard information displayed on a permanent plant label would normally include the following information about the accession:

1. Plant family name;
2. Accepted scientific name of the species;
3. Common name(s);
4. Distribution range or origin;
5. Accession number as recorded in the institution's database.

If a plant's identity remains to be botanically verified, this should be indicated on the label. Before fabrication of accession labels, the following should be considered:

- The label must contain the accession number in readable form.
- The label material is reasonably durable and does not deteriorate rapidly.
- Labels are adjustable and/or removable and do not harm the plant.
- The placement of the label is consistent, for example, placing the labels on trees at eye-level.
- The method of attachment and placement deters as much as possible label-plant separation.

In collections where there are many plants together or on public display, it is good practice to include a second label either buried in the ground or at the bottom of the pot (inside), so that if a label is stolen, lost or switched, the plants' data are nevertheless securely linked to the accession.

Plant labels may be made from laminated paper, engraved plastics and metals, laser-engraved metals, embossed metals, photo-sensitive metal coatings and other types of materials (see also Chapter 7, Section 7.3.8).

Plant label categories

a. **Temporary label:** This is the first label attached to the plant material when it arrives at the botanic garden to ensure the sample can be located once the accession is assigned and the primary label (see below) is fabricated. This label is also utilised during a general inventory check on the collection, and any plant material missing any form of label is tentatively identified and tagged temporarily, while awaiting accessioning and fabrication of primary and/or permanent labels.

Examples of temporary labels. Singapore Botanic Gardens. (Images: Nura Abdul Karim)

b. **Primary label:** This label is usually fabricated immediately after the plant material received has been reported and accessioned. It is normally used in the nursery. This type of label will include the accession number as a bare minimum, or may include the scientific name and family of the material or even barcodes if the institution utilises such asset codes (see below).

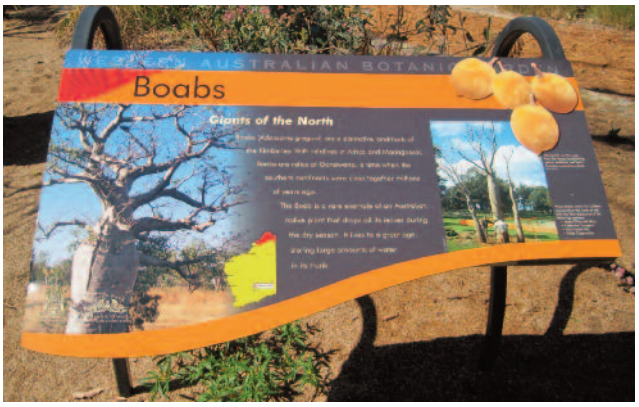
Examples of primary labels. Bali Botanic Gardens, Indonesia (top) and Singapore Botanic Gardens (above). (Images: Nura Abdul Karim)

c. **Secondary/Permanent label:** This label is fabricated for permanence when the material is planted out in the botanic garden. Secondary/permanent labels also serve as a brief informative feature to identify the plant material on display to visitors.

Examples of permanent labels. Bali Botanic Gardens, Indonesia (top); Bonn Botanic Garden, Germany (left); and Singapore Botanic Gardens (right). (Images: BGCI and Nura Abdul Karim)

Examples of permanent labels used over the last century in Stellenbosch University Botanical Garden, South Africa. The printed, brown labels with barcodes incorporated (far left) are the labels currently in use, followed by older, engraved plastic, porcelain and aluminium labels. (Image: Martin Smit)

d. **Interpretative label:** An interpretative sign or label generally serves as an educational tool. It is designed to inform the visitors by providing and highlighting interesting facts about the plant species or the whole thematic collection.



Interpretive sign. Kings Park & Botanic Garden, Australia (Image: Annette Patzelt)

Interpretive sign. Yachay Botanic Garden, Ecuador. (Image: Joachim Gratzfeld)

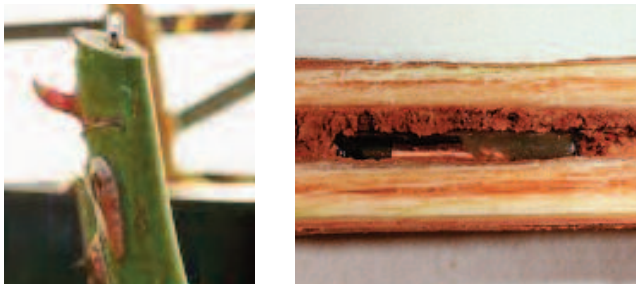
e. **Labels with bar code and QR code:** In addition to the standard information as described above, botanic gardens are increasingly placing asset tracking features, i.e. asset codes, on their accession labels, such as bar codes and Quick Response (QR) codes to augment and facilitate their automated documentation processes. These asset codes are linked to the institution's central database. Bar codes and QR codes allow for rapid, more accurate, consistent and direct collection of inventory, evaluation and other types of field data. These coded features can be read with handheld data loggers/scanners or even portable computers such as iPads and tablets that utilise downloadable scanning applications connected to the computerised database software. Transcription and other types of manual data recording errors are reduced with the utilisation of such new technology. Bar codes or QR codes can be fixed or engraved to accession labels if the fabric is weatherproof and UV resistant.

This asset code system is commonly in use in herbaria, such as the Western Australia Herbarium, the Royal Botanic Gardens Kew Herbarium, the Royal Botanic Garden Edinburgh Herbarium and the Singapore Herbarium. Equally, various botanic gardens have incorporated barcodes in to their nursery plant labels linked to their database systems, allowing rapid inventory checks and updates by staff and/or volunteers.

Extensive plant data can be linked to these asset codes thus serving as a new form of information collection and dissemination. Labels incorporated with such asset tracking features are increasingly employed by botanic gardens, and visitors can download suitable apps with appropriate scanning software to their personal mobile devices such as smartphones, tablets and iPads to read this special label information. This technology is fast evolving and is revolutionising the style of collection interpretation for educational outreach to the botanic garden visitor.

Label with QR code. Chadwick Arboretum & Learning Gardens, United States. (Image: Chadwick Arboretum & Learning Gardens)

f. **Radio Frequency Identification chips:** Building on the growing popularity of asset tracking systems, methods for the potential use of Radio Frequency Identification (RFID) microchips are being developed to find ways to streamline and improve the permanent collections' inventory and labelling process. RFID electronic chips used for instance in tracking live animals, is one of the technological advances with the promise of application for outdoor plant inventory checks. If RFID chips could be successfully imbedded into the plant tissue, the need to tie accession labels to the plant would belong to the past. However, besides the high cost of microchip production, there are numerous technological hurdles for application of RFID to plant-life, including detecting and reading these microchips inside plant tissues with high water content. What is more, the lifespan of microchips may be limited if they are not designed with an internal power source and/or are not recharged before depletion of the energy.



RFID chip implanted in a rose (left) and grapevine (right) and used in trials for certifying stock, monitoring pests and mapping. (Images: Associazione Toscana Costitutori Viticoli)

5.4.3 Mapping

Maps are visual representations of records and spatial information (Rakow and Lee, 2011). They include points, lines and shapes with possible enhancement such as colours, pop-ups, or animated graphics. As such, maps are a simple and clear communication tool. They are only effective and meaningful once the basic inventory needs of the collection are met. Accurate inventories are therefore critical to the mapping process. Mapping should either be carried out concurrently with or following on from the inventory process, but should never be undertaken in place of the inventory process. Increasingly, mapping is becoming an important aspect of collection management. Maps document the exact locations of accessioned plants in the botanic garden, and serve as an important safety net and backup when display labels and accession tags are inadvertently or deliberately removed or vandalised (Box 5.4).

A map of the botanic garden allows the collections' locations to be coded and mapped with coordinates to specify the position of each plant. Such maps presenting the location of individual or groups of plants are often prepared as part of the development of a new botanic garden, but are also useful if they are created once in operation. Maps are digitised for future manipulation and use such as updating and monitoring of mapped items over time.

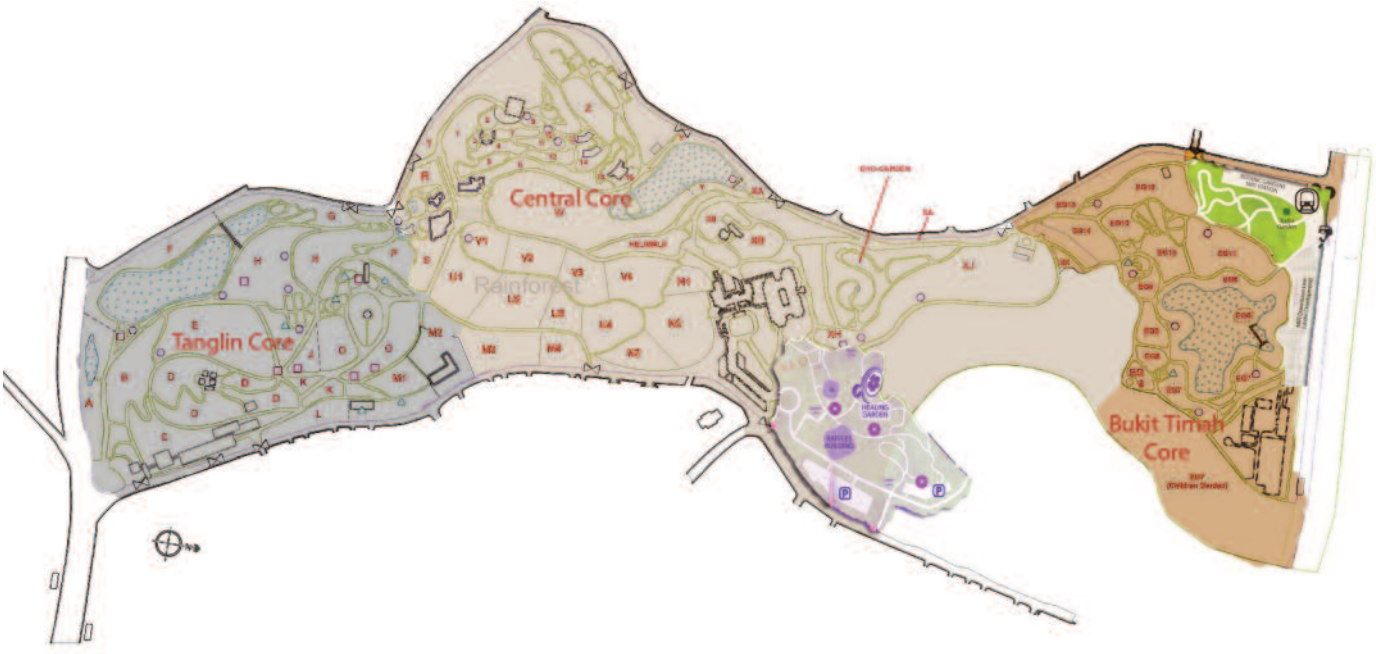
If the preparation of a proper base map is not possible in the early stages of the development of a botanic garden, the institution may wish to divide its grounds into manageable sized areas or create a grid system. Each area/grid may be given codes which are linked to the accessions located in that particular area (Figure 5.3). This list of accessions at each coded location should be maintained if a map with coordinates of the plant position is unavailable. Once a suitable digital mapping programme has been established, the digital maps linked to the core records of the collection will become very useful to internal and external users.

Box 5.4 Main roles of a good map

- Maps provide clarity and ease of comprehension for the user. A plant location point or shape on a scaled map is unambiguous. In comparison, representing a location accurately with words is impractical.
- Maps can show change over time. Text and tables cannot capture and display changes very well over time and related charts may therefore have to be created.
- Maps can raise questions and encourage thorough analysis regarding the development and management of the collections. For example, patterns where plants thrive or fail can be discerned easily, and planning or designing landscapes and facilities can be carried out efficiently based on topography and hydrology maps, etc.
- Maps can be visually attractive. People enjoy looking at and contemplating information that is presented in an interesting and attractive manner. Maps can connect the collection to new audiences and their needs. They can raise the use of the institution and its collections and allow new correlations and links.
- Maps can also display useful non-plant information such as the location of utilities (e.g. water and gas pipes), artworks, interpretation signs and memorial seating.

Source: Adapted from Rakow and Lee (2011)

Figure 5.3 Map of Singapore Botanic Gardens showing coded areas linked to accessions



5.4.4 Stocktaking and Monitoring

Regular stocktaking or inventory checks should be undertaken to ensure that the accessioned collections are traceable and tracked particularly for audit purposes (Chapter 3, Section 3.7). Stocktaking is a check that the plant and its label are still present. It will encourage staff to look for and check every accession on a regular basis, and may lead to recording of additional data such as flowering and fruiting times. This can be achieved by using special index cards or specified forms, which are supplied to those responsible for the day-to-day care of the plants for annotating as necessary. Cards or forms are returned to the records office and used for updating the database. In this way botanic garden staff can help with stocktaking and updating without necessarily needing special knowledge of the software system utilised. However, if direct collating via a digital format is preferred and staff or volunteers who are computer-savvy are available, then such records can be captured digitally via handheld devices linked to the database. The curator should oversee the amount and quality of feedback from the collections. All records should be dated and initialled, i.e. the reference of the responsible staff is indicated (Leadlay and Greene, 1998).

5.4.5 De-accessioning

In the strictest sense, de-accessioning is the process of amending the records of plants removed from the botanic garden, but not the actual disposal of the record (Chapter 3, Section 3.6.3). Accessions may be removed if, for example, research or conservation priorities change, or for aesthetic or health reasons. Other grounds for de-accessioning may include the availability of new plant material with greater vigour or if current accessions are proving to be invasive. The related plant record should note the specific reason why the material was felt to be inappropriate or is no longer required by the botanic garden.

In summary, a plant is de-accessioned if it is:

- Dead, and no seed or clone is remaining;
- No longer relevant to the objectives of the botanic garden;
- Missing;
- Very toxic or dangerous in other ways, for instance a diseased plant that is likely to infect other accessions;
- A potential weed or an invasive.

However, it is critical to maintain the record on a de-accessioned plant, as this information may prove relevant in the future and could answer questions such as:

- Why it died;
- Whether it was given away or stolen;
- Who the recipient organisation was;
- Where more stock can be obtained if needed;
- Whether it had been propagated in the botanic garden.

It is worth mentioning cases where plants which were thought to be dead or missing from the collection were in fact overlooked, dormant or mislabelled. Following through with a proper process of de-accessioning will allow this to be rectified by restoring the accession along with its linked information, as the record as such had not been removed or deleted.

All potential de-accessions other than truly dead samples should be reviewed by the relevant botanic garden staff before the actual de-accessioning. Dead or diseased plants are normally de-accessioned at the discretion of the curator or collection manager. When adequate provenance information is not available for a particular taxon, de-accessioning is usually recommended; however, it is again at the discretion of the collection manager to make the final decision as some rare and endangered species which are not known to be cultivated elsewhere, may need to be retained regardless of the lack of information on the plants' origin to prevent potential extinction.

5.5 RECORD SYSTEM TOOLS AND SOFTWARE

5.5.1 Tools for Recording Collections

There are three alternative/complementary methods of holding accession data:

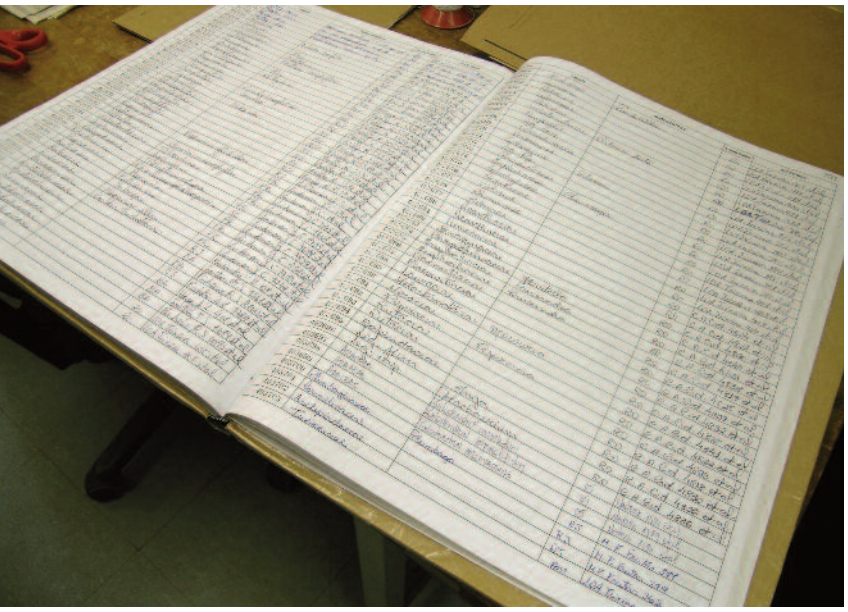
- Ledger/notebook;
- Index card or sheets kept in a loose-leaf folder;
- Computerisation (e.g. computer database).

While ledger, notebooks and index cards are earlier forms of archiving information, the digitisation of botanic garden collection data has seen major developments in recent years. Contemporary computerised record database systems are interconnected with mapping capabilities, and can be accessed via the internet or as internal standalone systems of the botanic garden. Ultimately though, it is the specific needs and available resources of the institution that influence the selection of a particular data recording system. The importance of collection management lies not so much in the method of storage but in capturing and recording all pertinent data required for the curation and use of the plant material.

Essential accession information, including accession number, name, date of accession, propagule type, source and location can be recorded in a ledger/notebook. However, the space for adding more information about the accession is usually very limited. Further, if a botanic garden has many taxa, searching through the ledger manually for a specific plant will take time and sorting this information can turn out to be very difficult. As such, it is recommended that the ledger is used to store only the initial information known about an accession when it was received. Further notes, such as transfer history, disease and pest problems etc. can be recorded on a card. An alternative is to record each accession on a card which can be indexed and filed under the plant name and accession number, or on paper forms which can be filed in ring binders or filing cabinets instead of using ledgers.

The design of an index card depends on its intended use, for instance for:

- Accessioning new material (in the absence of a computerized system);
- Collecting data from existing collections/labels/ledgers etc. for input to an existing or projected computerized system;
- Collecting data from the various departments of the botanic garden for updating a central database;
- Processing taxonomic reference data for labelling, etc.



Ledger book of Rio de Janeiro Botanic Garden. (Image: Kate Davis)

In a smaller botanic garden with less than 1,000 living plant holdings, records could be kept and maintained using paper or index cards. However, if the collection size increases, maintaining and managing records becomes much more complex and difficult to master with index cards. Nevertheless, this method will always remain a cheap and convenient way of compiling and consulting records – and can always be used as the input source for a computer database.

Computerisation provides many advantages in the management of the records. Data may be held in the following ways:

- Word processing documents;
- Spread sheets;
- Relational databases.

Opting for relational databases to store and process collection data in computers is highly advisable. If records are held in this way, specific fields may be linked with each other, which will enhance the sorting of the information in an almost infinite variety of ways. Holding data in Word processing documents and in spread sheets limits the sorting capacity of the computer system. However, the use of Word processing and spreadsheet software to store collection data is still acceptable for smaller scale botanic gardens with few staff trained in database management.

Making the transition from a card- or paper-based system to a computerized system, or upgrading from one computer system to another, can be costly. This includes not only the initial capital costs of the equipment and software but expenditure for continued maintenance and staff training. Ultimately, the advantages generally outweigh the disadvantages by a considerable margin.

Once digitised, the information can be used not only for the curation of the collections, but to provide fast access to all parts of the data, to re-sort entries and/or automatically produce reports or labels. In this way, a multitude of forms of information can be produced, such as catalogues of plants in cultivation, seed lists and inventories of plants belonging to a taxonomic group or growing in a particular area of the botanic garden. Further, links to computerized mapping systems can be established, and serve as an educational and interpretative tool by means of public-access terminals or websites to the database.

5.5.2 Software Types

KEY MESSAGE

Given the often substantial investment needed to purchase, maintain and update a collection record management system, the selection of the appropriate software packages requires both diligence and foresight, let alone long-term commitment by the botanic garden to support the system.

Many commercial database software packages are available at a reasonable cost. In addition, commercially provided systems generally include an initial and annual technical support package and staff training, installation assistance, availability of upgrades and compatibility with other devices such as handheld scanners, tablets, iPads or notebooks. Some may have a high initial purchase cost but in the long run the benefits of an appropriately selected system will outweigh the expenditure.

Computer mapping for botanic gardens is becoming rapidly and readily available, and is expected to evolve into a standard part of collection record systems in the future. Botanic gardens should therefore consider the advantages of linking the database with maps in terms of added value and more efficiency in managing collections. Botanic gardens with good map and database links are able to develop customised online search engines for plants of interest, including their location and images, and monitor the horti- and arboricultural management of the collections. Examples of such customised online search engines developed by botanic gardens are the Longwood Gardens Plant Explorer and the Purdue Arboretum Explorer. These allow the plant collection and facilities information to be shared with ease, as well as assist staff and visitors to navigate and locate plants or places of interest without difficulty (Case study 5.1).

CASE STUDY 5.1

Living Collections Data Management at Longwood Gardens, United States

Kristina Aguilar, Kennett Square, Pennsylvania

The original plant records system at Longwood Gardens, Pennsylvania, USA, dated back to 1955. As with all early systems, it relied on card files and accession log books, but as technology evolved, so did the plant records system. It grew from an early off-site mainframe system, to an in-house, custom-made Microsoft Access database, to the current server-based commercial databases, BG-BASE and BG-Map.

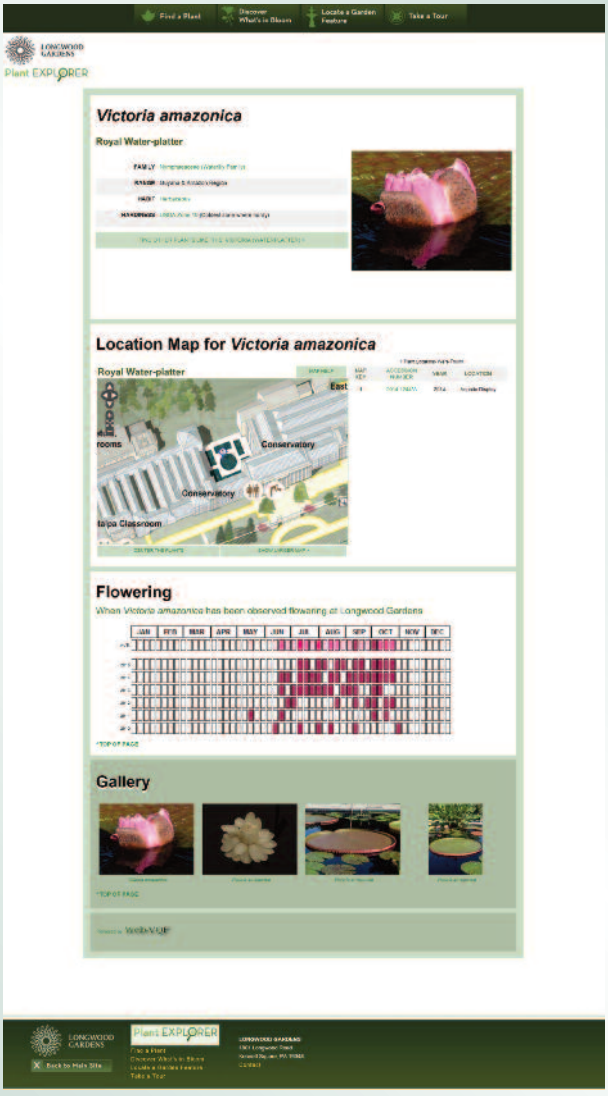
When BG-BASE was acquired in 2006, the database had little descriptive plant information and no images. A team of trained volunteers was assembled to research and enter such data and take digital images. Students doing a one-month rotation in the Plant Records office would also gather cultural and inventory information while learning about plant records management and databases. Early electronic field data collection was accomplished using personal digital assistants or pocket PCs to record bloom dates and inventory information. As technology evolved and mobile devices and wireless networks became more sophisticated, Longwood Gardens commissioned the development of an app in 2011. This app allows staff, students and volunteers to record data from the living collections, which are then sent through the wireless network to the plant records database server and uploaded into BG-BASE. Thousands of bloom dates are captured each year using this app.

Electronic plant mapping began with the implementation of BG-Map in 2005, building on Longwood Gardens existing early-1960s grid system for manually locating outdoor accessions on a map. Today, the precise location of trees and shrubs in the living collections, as well as the location of herbarium specimens, is recorded using a centimetre-level accurate GPS system. As a part of the Plant Records Management intern's yearly project, students learn to map new woody plant accessions coming into Longwood Gardens each year. These GPS coordinates are uploaded into BG-Map and can be searched, queried and displayed on an AutoCAD base map of the property.

As early as the 1980s, Longwood Gardens sought to utilize the plant records system to share horticultural information with visitors by disseminating accessioning, cultural and plant characteristic data. This idea of making plant records available to the public was behind the development of the Longwood Gardens Plant Explorer online plant collection database, launched in 2010. It combines data, maps and images from BG-BASE, BG-Map and Longwood Gardens' digital asset management system through both a public and a staff interface. The latter allows staff to print inventories, review accession records, and report changes to the Plant Records office via e-mail. Plant Explorer also links the information in the plant records system with Longwood Gardens' Continuing Education Program and the Garden Highlights section of the main website, unifying plant nomenclature across the organisation.

As a way of further connecting the public with Longwood Gardens' varied collections, Staff Recommended Tours were written to supplement plant records data in Plant Explorer. Each tour has a theme and introduction, followed by a list of plants that support the theme. For one of the most popular tours, Longwood Gardens' Champion Trees, QR codes linking directly to Plant Explorer were developed and placed outdoors next to each plant for visitors to scan.

Longwood Gardens will continue to utilize technology to make plant records a centralized part of its working culture. The convenience and flexibility of a web-based plant records system that can be viewed from any computer, tablet or smart phone has enabled staff to capture types of information never before recorded in a plant records database at Longwood Gardens, including tree health assessments, disaster priority codes, soil and tissue test results, integrated pest management records and seasonal plant display locations. The result is a knowledge-rich database that allows staff to make informed decisions regarding the plant collection and facilitates the sharing of our intellectual capital with the world.



Screenshot of Longwood Gardens Plant Explorer online search engine.

Botanic gardens may choose to purchase off-the-shelf software or create their own bespoke relational databases with programmes such as MySQL or Microsoft Access. Development of bespoke systems, however, is a time consuming exercise and will require specialist programmers and financial resources. The ease and high standards of commercial software have persuaded many botanic gardens to purchase 'ready to use' database software packages and customise these for their own use.

Examples of some of the most widely used (but by no means limited to these) commercial database software packages include:

• BG-RECORDER

BG-RECORDER counts among the earliest plant record management software packages. Developed by Botanic Gardens Conservation International (BGCI) at the beginning of the 1990s, it provides a Microsoft Access template to help botanic gardens manage their botanical collections. Compatible with the International Transfer Format (Box 5.5), BG-RECORDER 2000, is offered free of charge to BGCI members.

• BG-BASE (bg-base.com)

BG-BASE is a database application written primarily to handle the information management needs of institutions and individuals holding living and/or preserved collections of biological material. The system was first developed at the Arnold Arboretum of Harvard University in 1985 and has since been installed in over 200 institutions around the world. The application facilitates basic inventory control, but also enables users to fully document, label and curate their collections in six broad categories, while following all relevant international data standards:

1. Collection management (living collections, herbarium and museum collections, seed banks, DNA repositories, etc.);

2. Taxonomy/nomenclature (any level from kingdom to sub-form, cultivar, cultivar group, etc.);

3. Distribution (from global to exact latitude/longitude);

4. Bibliography (books, journals, unpublished references, images);

5. Conservation (threats, conservation status, protected areas, laws and conventions, etc.);

6. Management and administration (addresses, institutional affiliations, education programmes, etc.).

The modular design of the system provides a seamless interface to all data, instead of having to use separate database systems for each area. The modules include:

- Living Collections module (includes image, propagation, and seed bank management;
- Preserved Collections module (herbaria management);
- Conservation module;
- Web / HTML Export module;
- SQL / ArcGIS Connector module;
- BG-Capture module (mobile data collection).

Each module is further customizable, with the user having the ability to (amongst others):

- Turn fields on and off;
- Make fields required or skipped;
- Provide default values for commonly entered data;
- Configure user defined, institution specific fields;
- Create language specific help files;
- Generate bespoke drop-down lists.

Web module users form part of a 'virtual collection' shared with other BG-BASE sites around the world. End users can then search for help in multiple locations through a single Web search form.

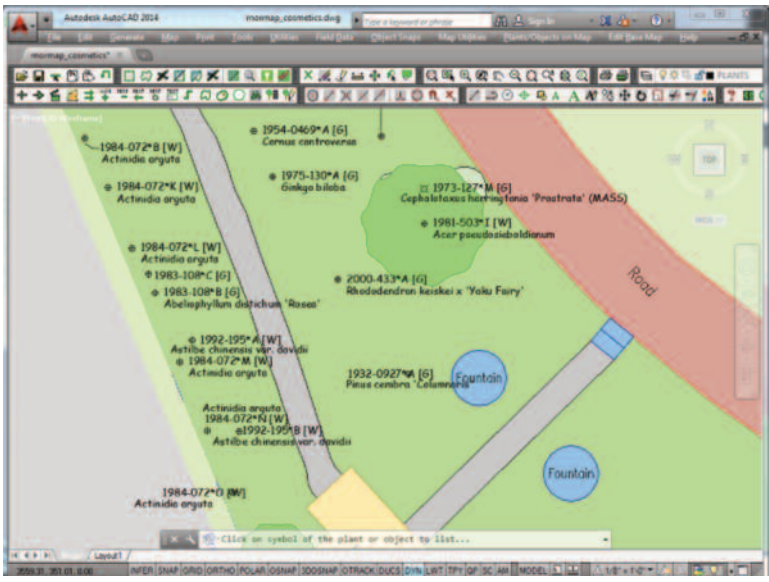
Extensive reporting capabilities exist via canned reports, a menu driven Report Wizard, or via a direct command line interface.

For linkage of digital maps to BG-BASE data, BG-Map and Esri ArcGIS are available to meet the mapping needs of the botanic garden. These software programmes also allow the recording of botanic garden ground data via handheld equipment to be uploaded to the central BG-BASE database (Case study 5.2):

- **BG-Map (bg-map.com):** Mapping of accessions from BG-BASE (via AutoCAD software) and updating of inventory via handheld portable devices e.g. ipads or Android mobiles, can be carried out in conjunction with BG-Map. BG-Map is a mapping software that links directly to BG-BASE without the need for exporting, and with the optional Web interface, users can access a wealth of information about a botanic garden and its collections, including maps and images.

- **Esri ArcGIS (esri.com/software/arcgis):** Mapping can also be carried out via ArcGIS. The ArcGIS Connector Module of BG-BASE facilitates the synchronization of relevant BG-BASE data with the high-end mapping software ArcGIS.

The software is neither open source nor free of charge, and includes an annual technical support fee.



Morris Arboretum, United States, map display showing tree location and canopy sizes created by BG-Map software that utilises the data recorded in BG-BASE. (Image: BG-Map)

CASE STUDY 5.2

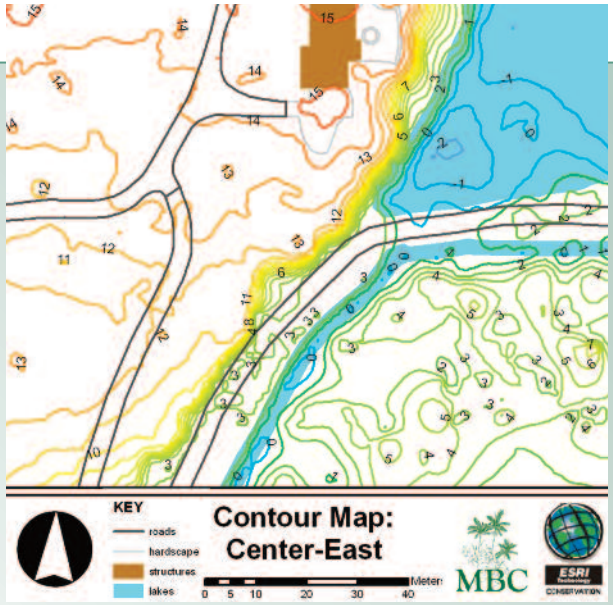
Living Collections Data Management at Montgomery Botanical Center, United States

Erica Witcher, Miami, Florida

Montgomery Botanical Center (MBC) is a non-profit botanic garden established in 1959 in Coral Gables, Florida, USA. With more than 26,000 plants in the nursery and grounds representing more than 1,300 taxa, the majority of which are from wild-collected seed, accurate and meticulously-maintained records and maps are an integral part of MBC's mission of 'advancing research, conservation, and education through scientific plant collections.'

The population-based, documented collections emphasize palms, cycads and tropical conifers, which together comprise 85% of the total holdings. The plants' habits allow them to be planted out, mapped, numbered, and labelled as individual specimens, an ideal situation for conducting research. To achieve this, MBC uses BG-BASE for its plant records in tandem with Esri's ArcGIS software platform for maps and analysis. As seeds arrive from expeditions, they are accessioned into the nursery with relevant collection and habitat information added to the database. All data pertinent to their germination and initial growth are recorded in separate tables. As they reach a more mature stage and are planted out, data related to their planting is likewise recorded and entered into another table. The latter contains years of additional notes relating to the phenology and life events (and death, if it occurs) of the plant. Each plant's record is accessed by its unique 8-digit accession number with letter qualifier (e.g. 20110123*A). This accession number is listed on the label attached to the plant, along with species name, family name, provenance and sex (in the case of cycads); all plants in the grounds collection have a permanent label. Because each plant is a separate entity with a unique identifier, each label is likewise unique.

MBC's maps were originally in CAD format oriented on a local coordinate system. This served the needs of staff for many years, but in 2008 a software grant from Esri and a monetary grant from the Stanley Smith Horticultural Trust allowed for the purchase of a Trimble GeoXH professional-grade GPS unit and the creation of georeferenced maps. Known points from within the CAD layers were marked in the field with the GPS unit as precisely as possible. The CAD layers were then imported into the ArcGIS ArcMap program and georeferenced one at a time based on these points, including utilities and annotation layers (digital notes and labels corresponding to layer features). Once georeferenced, the MBC property could be viewed as part of the surrounding landscape, with a definite location. Publicly available and free remote-sensing data, such as aerial ortho-photographs and lidar-derived digital elevation models, were easily downloaded and added to maps, adding new methods of analysis and ways to view the property. Staff were able to identify the tallest and broadest trees, create an elevation map with delineated contours to highlight key low spots on the property, and project phenology and experiment data on to maps for research, all in highly customized displays. Volunteers and interns without intimate knowledge of the collections and plant locations could assist with routine field actions such as label replacement and the annual inventory, while visitors and researchers could be quickly directed to plants of interest, because such information could be easily shown in printed maps designed for their particular use.



Contour map portion of Montgomery Botanical Center created with Esri ArcGIS by utilising data from BG-BASE.

An ArcGIS connector module provides a linkage between BG-BASE and ArcGIS mapping software. SQL and XML are used to facilitate the synchronization of geo-referenced data between the two systems. Synchronization intervals are controlled by a user-defined scheduler, which may be configured to run every few minutes or longer.

MBC maintains its mapping work within the ArcMap environment without the use of BG-BASE ArcGIS connector module. To project data stored in the database, the database is first queried, then exported into an Excel spreadsheet. The accession numbers associated with each record serve as unique identifiers to link the information to the map table coordinates, and thus onto the map. This same linking can be done for virtually any data, as long as it is tabulated in a spreadsheet. The process, however, is unidirectional. Map location information (such as area code, quadrant number, or date of GPS survey) must be entered manually into the database. Similarly, when plants die or are transplanted or have a change in epithet, their information must be updated in both the database and the map table.

It is worth noting that, in addition to the digital linking of data between database and maps via Excel spreadsheets, the conveyance of all other information between nursery and grounds staff to the database and map staff is done with color-coded paper forms, so data entry and editing remains controlled by limiting write-access to only a few people. This not only ensures consistency in coding, querying, and terminology within the database records and map files, but also provides an instinctive visual organisation of handwritten data, accessible to all staff regardless of technological literacy, as well as a hardcopy backup in case of input errors.

How data is organized and accessed directly impacts how it is used and gathered by staff in the grounds and nursery, and the reverse is also true. Technology that facilitates this relationship has a very influential role to play in any botanic garden.

- **IrisBG (irisbg.com)**

IrisBG is a relational database application able to handle the information management needs of institutions and individuals holding living and/or preserved botanical collections. The software has been in development since 1996 and is regularly improved and updated based on feedback from the user community. IrisBG offers complete information management and covers these main areas:

1. Collection management (living and herbarium collections, seed banks, plant history, tasks, plant inspections, botanic garden tours, assets, botanic garden maps, etc.);
2. Taxonomy and nomenclature (formalized recording of all taxonomic levels, hybrids, synonyms, authors, references, etc.);
3. Localities and collectors (origin of plant material, coordinates and map support, etc.);
4. Literature and web references (books, journals, electronic documents, web links, etc.);
5. Maps (multiple map types, internet and custom map providers, plant origin and botanic garden location);
6. Images (integrated image handling with support for external image libraries);
7. Contacts (institutions, donors, nurseries, etc.);
8. Reports and labels (flexible report and label production, multiple file formats);
9. Data exports and imports (BGCI PlantSearch and Darwin Core export, import from spreadsheets, etc.);
10. Multi-lingual support (data entry in several languages, all writing systems supported);
11. Internet publishing (share collection information with visitors, web solution for smartphones, tablets and PC with multi-lingual support);
12. Seed exchange (seed store, *Index seminum* web solution, International Plant Exchange Network (IPEN)).

IrisBG is compatible with international data standards and the data can either be hosted on a local SQL database or used with a cloud database service. Data quality is ensured through data validation, referential integrity and access control. In addition to using PC and laptops, data can also be recorded on a portable device or be loaded onto the system via spreadsheets using the data import feature. Software licences can be purchased in a wide range of combinations, including a configuration where multiple gardens can share one database installation. The software is not open source and therefore not free of charge, and includes an annual technical support fee. The system is regularly updated and enhanced, based on user input.

- **BRAHMS (herbaria.plants.ox.ac.uk/bol)**

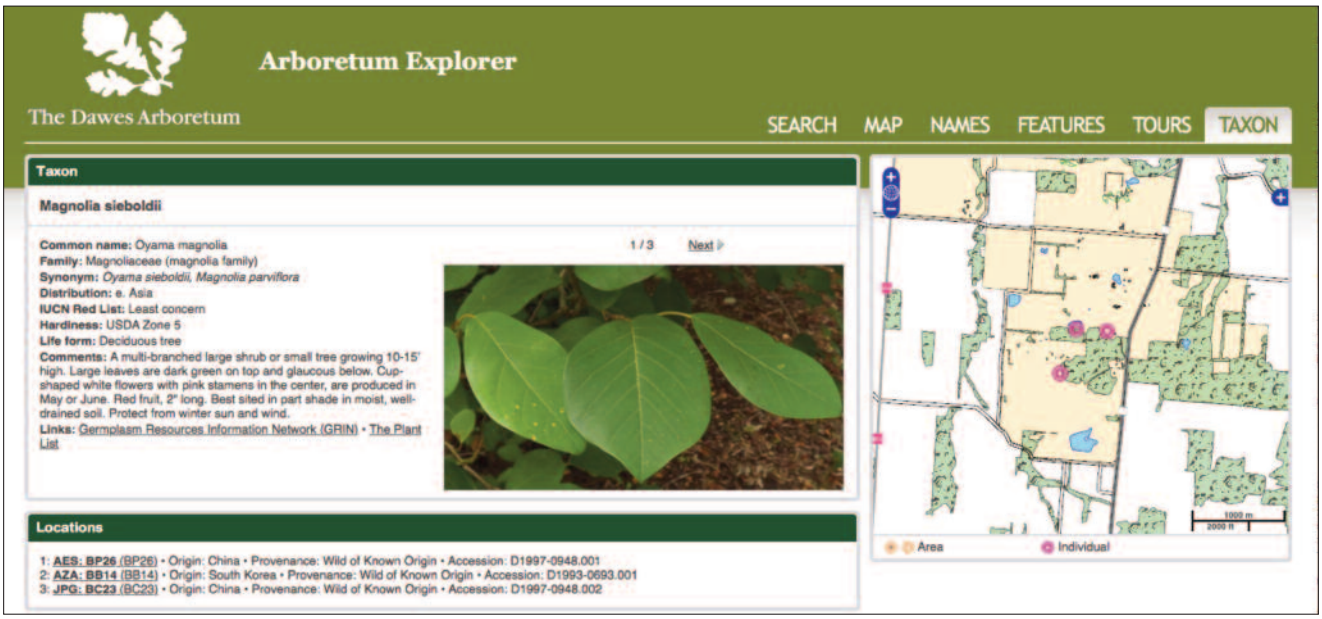
BRAHMS was originally designed and developed for use in herbaria. However, in 2010, a Living Collection module was added to cater for demands of managing data of both living and preserved collections. The living collection module is linked through to the main BRAHMS taxonomic framework. BRAHMS is a relational database application able to handle information management needs of institutions and individuals holding collections of biological material. It is compatible with international data standards. The system is regularly updated and enhanced based on user input. It is not open source and not free of charge. With BRAHMS, collection localities can be described in detail with the pinpoint location map of the botanic garden's areas and thematic zones linked to the data. BRAHMS also covers the six broad categories mentioned above (see BG-BASE).

- **Atlantis BG (botgard.bio.uu.nl/index.php?name=Atlantis%20BG&topic=Introduction)**

Atlantis BG is a relational database for botanic gardens created by Utrecht Botanic Gardens. It is able to handle the information management needs of institutions and individuals holding living and/or preserved collections of biological material. It covers the general needs of collection data storage and allows searches for plant information in the database from the Web interface. It is compatible with relevant international data standards, but is not open access.

- **KE EMu (kesoftware.com)**

This database is a collections management system mainly for museums but can be customised for use by botanical institutions. It was developed to manage collection types of various fields and topics such as culture, anthropology, archaeology, science and technology, paintings, sculpture, photographs, textiles and digital objects. It can also record natural history collections relating to zoology, earth sciences, palaeobiology, botany, horticulture and physical anthropology. It has a Web interface and also allows access to data via mobile devices. The software is not open source and not free of charge.



Accession information of The Dawes Arboretum generated by IrisBG software. (Image: IrisBG)

• Ghini (ghini.github.io)

Ghini is a desktop application for managing plant collections, primarily designed for botanic gardens and arboreta. A GPL (free and collaborative open source) project, Ghini started as Bauble in 2004 at the Belize Botanic Gardens. Institutions can choose to use Ghini as it is, or can contribute to its development by proposing and sponsoring features. A geographic web interface to the database is planned for early 2017.

• Customised databases

Customised databases for collection management are mainly established by institutions that are IT-competent and require independence to manipulate and link data to other computer applications based on individual needs. In-house database systems are usually relational with specific, customized fields. Smaller institutions may utilize flat and non-relational databases such as MS Excel, MS Word or a general database such as MS Access to create their own data management systems.

Box 5.5 Use of the International Transfer Format (ITF) for Botanic Garden Plant Records

The International Transfer Format for Botanic Garden Plant Records (ITF) is a standard format by which information about living plants, as held by botanical institutions, particularly botanic gardens, may be exchanged between organisations. It is a means for structuring the transfer of data or recorded knowledge about a single plant accession from an originating (sending) institution to a receiving institution.

Building on the earlier system published in 1987, the International Transfer Format for Botanic Garden Plant Records, Version 2 (ITF2) was launched in 1998, in response to requests from botanic gardens to incorporate additional data fields for transfer within botanic gardens and to allow for a more flexible format. ITF2 incorporates a procedure allowing for further data fields to be identified and exchanged between institutions. The system provides a convenient guide to the kinds of information (i.e. set of fields or information categories for a database) that could and should be recorded. The basis and purpose of the ITF is to pass on and share information with other institutions about individual accessions, such as where and when the plant was collected, and by whom. These fields are accession-based. This information can be elaborated with additional data from other sources, for example taxonomic information (plant family, synonyms); geographical distribution of the taxon in the wild; conservation status assessments; economic uses of the plant; bibliographic information about the taxon; or details about the place of origin (country, province or region, latitude and longitude). This latter information applies to the species and is applicable to all accessions of that species. The data from other sources can always be added at a later date.

The ITF was designed by botanists and horticulturists who have learnt from experience which accession information is necessary when undertaking plant research. Although intended to assist electronic exchange of plant information primarily between botanic gardens, it has been used by many institutions in the design of their collections databases, and is believed to remain relevant despite the rapid development of information system technology.

Source: Leadlay and Greene (1998)

Box 5.6 Sharing botanic garden data via BGCI's databases

BGCI maintains two globally unique and publicly accessible databases: GardenSearch and PlantSearch.

GardenSearch

BGCI's GardenSearch database is effectively an on-line, searchable directory of the world's botanical institutions. In addition to thousands of botanic gardens and arboreta, GardenSearch also includes gene and seed banks, network organizations, and zoos. Each GardenSearch profile includes nearly 150 fields providing information on garden location and staff contacts, as well as presence or absence of expertise, facilities and programmes aimed at supporting plant conservation and research. Data contained in GardenSearch is primarily provided and managed by individual institutions.

The database is freely available to all online users via the BGCI website. The database can be searched by country or keyword and an advanced search facility allows combinations of data fields and geographical location to be searched and the results mapped. All botanic gardens are encouraged to keep their GardenSearch profile up-to-date.

PlantSearch

PlantSearch provides a list of the plant taxa being cultivated and conserved by botanic gardens and related institutions around the world. PlantSearch includes over one million records representing over 400,000 taxa, with data uploaded by more than 1,000 contributing institutions. It is the only comprehensive global database of plant species in *ex situ* collections and through its linkages to the global IUCN Red List, allows threatened species to be identified in *ex situ* collections. Additional onward links from PlantSearch provide a vast array of species level data to be easily accessed. While all plant name records in PlantSearch are linked to the provider's record in the GardenSearch database, this link is not visible, thus all records in PlantSearch remain anonymous to public users.

PlantSearch is used to measure progress toward Target 8 of the Global Strategy for Plant Conservation by tracking which threatened species are in botanical collections throughout the world. Managers of living botanical collections (plants, seeds, or explants) are encouraged to upload plant lists to the PlantSearch database on an annual basis to demonstrate and enhance the conservation value of living collections, and connect living collections to the global botanical community of conservationists, educators, horticulturists, and researchers.

For institutions that contribute data to PlantSearch, the database provides a useful collections management tool and connects individual collections to the global botanical community. PlantSearch allows data contributors to easily identify threatened taxa in their own collections and also find out how many other collections maintain the same taxa.

Full instructions on how to contribute data to Plantsearch are provided on the BGCI website: bgci.org/plant_search.php

CASE STUDY 5.3

Botalista, an open source tool to manage botanic garden collections – Conservatoire et Jardin botaniques de la Ville de Genève (CJBG), Switzerland

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In 1994, a staff member of the Conservatoire et Jardin botaniques de la Ville de Genève (CJBG) published her highly innovative thesis 'Un système d'information botanique : contribution au désenclavement de l'information'* on the subject of the use of relational databases for the integration of various research and collection management projects in one system, with the aim of sharing approaches, data, methods and applications. Since then, the CJBG has continued to develop this database management system known as 'Système d'information botanique de Genève' (SIGB).

SIBG allows users to manage:

- Herbarium collections;
- Living collections; and
- Information linked to research projects such as plant check lists, floras, taxonomy (nomenclature, synonymy, locality information, etc.).

These different components share the same basic information such as stakeholders, authorities, collectors, localities, etc. Initially, SIBG used proprietary technology including Oracle databases and Oracle Forms applications. In 2008, the component of the SIBG relevant to the management of the living collections ('SIBG-JIC for Jardin', 'Index Seminum' and 'Conservation'), was migrated to an open source, client server (JAVA) but still uses the Oracle engine.

**Zellweger, C. (1994): Un système d'information botanique : contribution au désenclavement de l'information. Thesis No. 400. Faculty of Economic and Social Sciences, University of Geneva.*

A partnership agreement between the cities of Geneva and Paris

A study carried out to update the collection management system of the Jardin botanique de la Ville de Paris (JBVP) revealed that existing tools were inadequate and that the SIBG-JIC would encompass most of the functional needs of JBVP. This gave rise to the establishment of a partnership agreement between the two cities to jointly further develop the information management system. On the one hand, this has enabled the city of Paris to promptly access SIBG-JIC (in use by JBVP staff since 2014) and avoid a costly investment for a new development. On the other hand, this partnership between the two cities has facilitated the joint use of resources needed to realise further functional developments including an open source portal for the benefit of all botanic gardens and institutions.

***Botalista*: A management tool available to all**

To further facilitate the use of this open source database, SIBG will ultimately be offered to all botanical institutions free of charge. This software, called 'Botalista' will be based on the following technologies:

- Open source database (MySQL, MariaDB or PostgreSQL);
- Three-tier application with JAVA as the main engine and the Web interface in AngularJS;
- Communication with other available platforms with RESTful Web Services.

The software will be made available via interdependent modules (management of nomenclature, acquisitions, etc.) allowing interested institutions to install these based on their individual needs.

***Botalista*: A partnership project**

This ambitious project is led by the cities of Geneva and Paris. However, other parties and institutions are invited to join this collaborative venture, to capitalise on additional expertise, address further needs, improve existing modules and devise additional functionalities.

5.6 DATA SHARING

Increasingly, botanic gardens are making their collection information available online. Web-accessible records assist external enquirers and potential research or conservation partners to view collection information such as the availability or existence of a particular taxon. This creates the potential for better coordination of regional and international collections exchange and joint conservation programmes, for instance for the management of threatened or potentially invasive taxa. On the other hand, it is also important to note that the data sharing platform has the ability to create different levels of accessibility to sensitive information. At the discretion of the curator or collection manager, this information can be restricted or suppressed from the general users' view in the shared platform, for instance, exact information on the location of a rare, highly sought-after plant, to prevent the data from falling into the wrong hands.

Certain standard formats must be created for uploading data held by different institutions into an agreed central database before sharing in order to facilitate reading of the data by the various software involved. Systems such as the International Transfer Format (ITF) (Box 5.5), simple Comma-Separated Values (CSV) format or Extensible Markup Language (XML) format offer ways in which data can be filed for uploading into a central database.

Examples of shared collection database sites are the BG-BASE Multisite Searches webpage, the open source application *Botalista* (Case study 5.3) and the BGCI GardenSearch and PlantSearch databases (Box 5.6).

Sharing of botanical information at all levels is vital to rationalise and coordinate collection priorities and promote a more comprehensive approach to multi-institutional collection management. More widely practised, it may also encourage individual institutions to improve the accuracy level of their plant records as well as increase awareness by the staff of the value of the collections. In turn, this may invoke a shared responsibility for collection management and instil the importance of maintaining standards and accuracy of data.

5.7 CONTINUED STAFF TRAINING

Assigning staff or volunteer(s) to be in charge of the maintenance of the collection record management system is a prerequisite. Such responsibility also implies continued training in the management of records and record-keeping in general. Staff must be familiar with the institution's plant data management procedures and policies, and regularly track plant holdings to ensure that plant material is not lost and that the record system provides an accurate representation of the actual plants in the collection.

It is vital for all members of staff (and volunteers) to understand the need for thorough record-keeping, for example:

- The importance of accurate records for effective management and curation of the collections, or to accurately respond to queries;
- To ensure that information is not lost when staff leave if it is not written down or documented;
- The procedures for transferring information from the botanic garden to the record system, e.g. the germination protocols of an accession, the movement of plants to another institution, the death of the last plant of an accession, etc.;
- The need for correct labelling of plant material, for instance to minimise errors during propagation such as loss or switching of labels;
- To facilitate regular audits of the collections (Chapter 3, Section 3.7) and ascertain that the accessions in the database are still present and living, as well as to ensure that information is updated.

Efforts should be made to train staff in record-keeping, hard- and software tools, methods and use. Cross-training, in terms of providing briefings to botanic garden staff from various departments on the importance and procedures of the collection record management, may help improve the functioning of the botanic garden, as well as overcome the loss of information if there are changes in staff (Leadlay and Greene, 1998).

Training of Pha Tad Ke Botanic Garden staff on collections' record management. (Image: Rik Gadella)

5.8 SECURING THE RECORDS

KEY MESSAGE

A duplicate of the plant records should always be established. Backup copies can be regularly and quickly generated by a computerized system. As an insurance policy, these backup copies are best kept at a separate site from the botanic garden's main collection record management system.

However well records are maintained (either in hard copy or on the computer), they must be protected from accidental loss. This is generally achieved by generating backup copies in a safe location away from the main centre. If paper records are maintained, they should be stored in a secure and safe location protected from damage by fire, floods, hurricanes and other hazards. A duplicate copy of the records should always be established. While this is challenging for card-held records, duplicate copies are easily generated with a computerized system which can produce backup copies regularly and quickly on media of small physical size (compact discs and detachable hard drives). Backup copies are best kept at a separate site from which the original system can be fully restored, should this become necessary.

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