4. Collections management

Introduction

A main aim of a botanic garden is to manage and present its collection of plants in a way that will achieve the aims and objectives of the garden, as stated in the collections policy and the business plan. This chapter discusses how to achieve a smoothly-functioning garden to fulfil these aims. The main emphasis is on the management of the living collections of plants - other collections are discussed briefly at the end of the chapter. This chapter also suggests ways to organize the management and maintenance of the plant collections.

1. Garden maintenance

A useful concept for combining general management of a botanic garden and day to day maintenance is to divide the collections into High, Medium and Low Zones of maintenance for the allocation of staff and equipment. These zones can be described in terms of the collection types they contain (e.g. rock garden, systematic beds, Cycad collection, grassland) and tasks and activities (e.g. pruning, irrigation, pest and disease control, labelling, paths) (See Table 1).

This scheme has enabled some institutions to evaluate the tasks in the garden more objectively and to devise an efficient maintenance schedule. A scheme for evaluation could take the following form:

1) secure staff participation,
2) inventory the work to be done and the resources needed to accomplish it,
3) describe each task,
4) determine standard time necessary for the task,
5) decide the frequency necessary for the task,
6) decide the schedule, e.g. weekly, monthly, with a long-term schedule for seasonal tasks,
7) implement the programme,
8) monitor work and schedules.

This system allows for objective planning and scheduling of work, instead of responding to demand and emergencies and allows priorities to be assessed on the basis of accurate information. The system can be used for routine maintenance tasks such as mulching,

Zones of maintenance	High	Medium	Low
Plant collections	- Herb garden - Bedding plants - Specimen plants - Rock garden - Systematic beds - Demonstration garden	- Arboretum - Lawns - Shrub Collections - Bulbs - New wildflower areas	- Massed tree plantings - Established mixed grasslands - Naturally occurring communities - Woodland
Activities/tasks	- Labelling & accessioning - Annual seasonal planting - Hand weeding - Detailed pest control - Hand weeding - Frequent irrigation - Hedge shearing - Topiary	- Labelling & accessioning - Mow 10-15 x per year - Shrub transplanting - Broadcast fertilizer and spraying - Routine pruning - Integrated pest management - Occasional edging - Main paths - Occasional irrigation	- Labelling & accessioning - Mow 2-3 x per year - Selective clearing - Management for safety - Remote roads and walks

Table 1 Zones of maintenance in a garden

High Maintenance
Herb Garden, US National Arboretum, Washington DC., U.S.A

pest and disease control, general plantings and also for the maintenance of collections of rare and threatened plants.

The job can be costed in terms of hours of labour, equipment and materials required, which provides a basis for prioritising tasks and ensures that a planned approach to sourcing resources can be taken. Maintenance scheduling can be managed efficiently by using a computerized landscape management system. The maintenance requirements of any particular accession, its location in the garden and any other critical information can be added to the database and the task printed out on the computer generated work schedule at the appropriate time.

2. Management requirements for the collections

Display and exhibition

Most mission statements for public gardens include the desire to provide an aesthetically pleasing environment. A beautiful garden will inspire people about the wonder of nature and provide mental relaxation. This will be a major factor in attracting visitors to the garden and will be a source of community pride and public support.

Medium Maintenance
Arboretum, Trinity College Botanic Garden, Dublin, Ireland.

Low Maintenance
Grassland, Jerusalem and University Botanical Garden, Israel

Good displays or exhibitions of plants will further the purpose of the collection, e.g. for conservation, reference, evaluation or beauty. The purpose of the collection should affect the way in which the plants within the collection are displayed. A good display of plants should be designed and evaluated in the same way as other interpretative material is produced (see chapter on Interpretation). Displays should be stimulating, intellectually satisfying, aesthetically pleasing and leave one slightly curious.

Public gardens need to present plants in the best possible way appropriate to the people who use the garden.

Thematic collections

Thematic collections do not necessarily have many specimens of each taxon grown or represent their genetic variability. These collections should be correctly identified and labelled but, depending on their purpose, they do not necessarily always need to be as well documented as the conservation collections. However, the minimum record should include: a) the name, b) origin (provenance), c) location and d) condition in the garden. The management unit is a plant or group of plants grown in a particular area of the garden.

Collections for conservation

Conservation collections aim to conserve genetically important populations of rare and endangered species held ex situ to support species recovery programmes and to provide long-term back up collections of such plants.

The size of populations of plants grown for conservation purposes tends to be very variable, and it depends on the type of plant (annual, herbaceous, shrub, tree species, etc.) and on the extent to which a garden is required to maintain different genotypes. Their permanence in the garden can also vary. Some plants may be grown as long-term parts of the collection. Others may be maintained on a temporary basis as part of a specific ex situ project or to support an in situ conservation effort.

The information recorded for taxa in the conservation collections and in field genebanks generally requires more detail than for general plantings in the garden. Additional information such as ecological data from where the plant material was collected (sun exposure levels,soil types etc.) will often help in its cultivation. Data recorded for conservation collections may include not only information on their taxonomy (names), origin, distribution, collector and date of receipt of the accessions, but also information about their ecology and biology, current status, levels of threat faced and risks of extinction observed.

Field genebanks

The term field genebank is used to define a conservation collection planted in the open ground. This is the main conservation strategy used to maintain long-lived perennials, recalcitrant species and vegetatively produced species. It also provides a useful working collection of living plans for experimental purposes. These collections aim to ensure the conservation of the different taxa (species, cultivars, etc.) and the range of variability within each taxon. The management unit of the field genebanks is usually the population, ecotype, cultivar and clone. Adequate labelling and identification of each unit is of crucial importance.

These collections must:

- contain a sufficient number of specimens from each taxon, so that the specimens of each accession ensure an adequate representation of the original population's genetic diversity;
- be properly documented;
- be labelled;
- be physically secure;
- be contained in a facility which provides long-term security;
- have a clear, efficient and fair system for access to the germplasm kept in the collection, so that potential users can have access to the genetic material and to the information held about the collection;
- be assessable for potential economic and conservation use;
- be applicable for various propagation and cultivation techniques required for its maintenance and use.

Field genebank of native plants from Kerala at the Tropical Botanic Garden and Research Institute , Kerala, India

3. Management practice

Structure and organization

A garden needs to be clear about who is responsible for the management and maintenance of its collections. The effective management of the collections will generally devolve to one individual staff member (Curator or someone of similar status). This person often reports to more senior management and works with the education, scientific and conservation staff to carry out the policy agreed by the Board, Director, Scientific and Advisory Committee or similar body. In larger gardens a curatorial structure may be created which assigns curatorial tasks for particular collections to different individuals who may themselves then report to a person (the Curator) with overall authority for the management of the collections.
In general the duties and functions of curator will be to:

- control and supervise the management and maintenance of the plant collections;
- supervise the day-to-day work to be carried out by the horticultural staff;
- supervise and be responsible for the recording of the collections;
- maintain the labelling of each taxon in the garden's display areas in good condition;
- ensure that the staff have access to the necessary training.

The curator may also take the lead in:

- making use of such available information as exists to ensure that the horticultural techniques (fertilization, watering

regimes, pest control, propagation, etc.) used are appropriate and recorded, where necessary (see spraying card in Horticulture chapter);
- or, if little information exists, carrying out and recording reasonable trials, (e.g. different kinds of cuttings, treatments for rooting, seeds treatments, etc);
- ensuring that there is a minimum number of specimens of each conservation accession to represent the genetic variation of the taxon and that the diversity of this collection is safeguarded;
- ensure there is a back-up collection of seed stored in a seed bank or living plants in the nursery in case the collection is lost through pest, disease or by accident;
- prevention of contamination of stocks, by hybridisation or miscellaneous seeding and vegetative spread of one accession into another;
- adding more taxa to the collection in accordance with the accessions policy and other constraints such as space and staffing;
- providing and manipulating habitats and microclimates (soil, sun exposure, shade) suited to the plants that are grown.

A good policy is to make one person responsible for one or more plant collections or for a particular area of the garden. This person must receive timely and appropriate training concerning the collection and general guidelines on its maintenance (for example, on what taxa are included, the importance of labelling, most valuable specimens, the significance of the collection and its purpose and uses, etc.). All staff should have a clear written job description so that they know their responsibilities, in general terms and to any particular collections that may be under their care.

Guidelines on procedures

Most gardens will develop procedures for practical curation issues. These procedures will be guided by the Collections Policy. Procedures can be published as staff handbooks or institutional manuals. These procedures provide continuity over many generations of staff change, and a standard quality of maintenance (see Box 1).

The major procedures or protocols required for the management of collections are outlined below:

1. acquisition of material;
2. labelling;
3. plant identification;
4. evaluation of collections;
5. de-accessioning;
6. procedures for accepting and releasing material;
7. monitoring process.

Record keeping procedures are discussed in the chapter on Plant Records. Horticultural procedures, such as propagation and pest and disease control, are discussed in the chapters on Horticulture and Equipment.

Box 1 Procedures

Some gardens have living collections policies or institutional manuals which describe the procedures (e.g. for record keeping and horticulture) (sometimes known more formally as protocols). With the support of the U.K. government's Darwin Initiative, BGCI worked with Kebun Raya Indonesia (KRI) to computerise their living collection records over three years. As part of this work a series of records management policies and protocols were prepared, agreed and implemented in the four KRI gardens. Protocols were designed to ensure that plant records accurately reflected the composition of the living collections and were as up to date as possible. Protocols prepared were:

- Protocol for receiving and registering accessions;
- Protocol for planting-out collections from the nursery and registering locations in the garden;
- Protocol for producing plant name labels;
- Protocol for changing names;
- Protocol for moving plants and changing bed numbers;
- Protocol for monitoring collection flowering and fruiting;
- Protocol for the propagation of living collections;
- Protocol for dead plants.

1. Acquisition

Any potential acquisition should be screened and selected in accordance with the accession policy and in accordance with legal requirements, such as the Convention on Biological Diversity (CBD) and the Convention on International Trade in Endangered Species (CITES), as discussed in the chapter on Collections Policy. Before accepting or collecting plants for cultivation, the purpose of the specimen(s) should be assessed. Each accession should only be added to the collection if the garden's resources, (funding, staff time and space) are sufficient to maintain it. Is there enough space in the nursery and staff time to propagate and cultivate the accession? Acquisitions should also be evaluated on arrival at the garden for their potential as vectors of disease and pests and their potential to become invasive or weedy. Quarantine procedures are important to ensure that disease and pest problems are avoided, especially if the stock is to be used for reintroduction programmes or in any work that involves the material potentially passing on diseases or pests to other conservation plants or into natural habitats. If the identity of the accession is uncertain it should be identified as soon as possible (see Verification below).

2. Labelling

Labelling of a living collection of plants is one of the most important and difficult of the curatorial tasks. The

types of labels used in botanic gardens and the materials available are discussed in the chapter on Equipment.

Labels in the nursery or propagation unit

Many gardens use a temporary nursery label until an accession number is assigned. Care should be taken when adding the permanent label to ensure that details are transferred accurately. In a propagation unit, where many pots/pans of seed, or many pots/pans of cuttings or grafts may be grown of the same accession, it is absolutely vital, though extremely tedious, to label every pot/pan. An old and widely applied British tradition of labelling the first pot in a row and then going bottom to top, left to right without labelling until a new accession is reached is extremely unreliable. Pots can be moved and labels misplaced. Burying an additional label in the pot will help re-identify the specimen if the visible label is lost. Nursery labels should include the collection number, and if possible, the name of the accession.

Labelled seedlings at the Conservatoire et Jardin Botanique de Mascarin, Ile de la Réunion, Indian Ocean

Illustration of dog tag and dymo

Permanent labels

Permanent plants should have an accession tag or small metal label (e.g. engraved or impressed aluminium) directly attached to every plant of the accession, preferably wired or otherwise securely fastened to one of the branches in the centre of the plant towards the base. This includes all plants that have permanent branches (including herbaceous perennials and even many alpines), even if these plants are in pots. This label is additional to the (single) display labels (whether in the soil or attached to the plant). Then if display labels are damaged, stolen, removed for scrutiny by members of the public and wrongly replaced, or removed or re-arranged (either maliciously by visitors, or picked off by birds or animals, or knocked off by gardening tools) then it is possible to re-label the accession completely accurately from information provided on the back-up accession tag. Some gardens create a map (either accurately drawn or even a simple sketch map showing the location of each plant in relation to its neighbouring plants). These maps can be a useful back-up in case all of the labels are lost.

Problems can occur in the garden when labels are detached from the plant and herbaceous plants or bulbs die down in winter. Metal labels with accession numbers included attached to long stakes could be used. One person should be responsible for the labelling of a plant collection or group of plant collections in an area of the garden and ensure that the plants should be regularly monitored for labels, replacing any that are missing, damaged or deteriorating. During stocktaking, labels should also be checked for loss or damage.

3. Plant identification

Plant name

For reference and research purposes all plants need to be correctly named if they are to have any value beyond the garden in which they are grown. A well-known local name can convey a mental picture to many people about what the plant looks like, where it grows, what it is used for and where it can be obtained. However, the scientific or Latin name is standardised by written descriptions of the plant which include the

characters (e.g. number of petals, type of fruit, position of leaves) by which it can be recognized (diagnostic characters), drawings and herbarium specimens. This means that identification can be consistent. The Latin name of a plant is a vital key to accessing the scientific literature about the plant. Names are thus an essential means of communicating information about plants.

Scientific names are given to plants through the science of biological classification or taxonomy. Taxonomy, through examining many different aspects of plants (e.g morphology, chemistry, cytology, DNA), identifies groups of plants and their relationships. These groups of plants such as families, genera, species, subspecies or varieties have occurred through evolution and are considered natural. Knowledge of these relationships can give clues to their successful management and use. For instance, related genera can often be propagated in the same way, used in a plant breeding programme or indicate sources of shared or similar chemical compounds.

These natural groups of plants such as families (e.g. Gramineae, Primulaceae, Compositae), genera (e.g *Oryza, Citrus, Ficus*), species (*Triticum aestivum, Vanilla planifolia, Bellis perennis*), subspecies (*Rhododendron fortunei* subsp.*discolor*) or varieties (*Anethum graveolens* var. *esculentum, Brassica oleracea* var *capitata*) are called taxa (singular taxon). When people refer to the number of taxa grown in a botanic garden, (unless they state the category or rank - as in this garden holds 250 genera belonging to 70 families) they are referring to the number of species, subspecies, varieties and cultivars represented in the garden.

Verification of identity and name

One should not assume that all plant material comes into a garden correctly named or that it is correctly identified even after it has been accessioned and studied. Verification is first and foremost a procedure for checking that a previous identification is correct or assigning a name to an unnamed accession. Some botanists prefer to use the terms 'determination' and 'determined' to 'identification' and 'identified'. Checking the name involves two separate procedures:

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 material such as accurately named herbarium specimens or living plants.

Nomenclature, which is concerned with the determination of the correct scientific name of a known plant according to a nomenclatural system. This naming is regulated by internationally accepted rules laid down in the **International Code of Botanical Nomenclature** (W.R. Greuter *et al*., 1994, Koeltz Scientific Books, Koenigstein, Germany). and the **International Code of Nomenclature for Cultivated Plants** (R.P. Trehane *et al*., 1995 Quarterjack Publishing, Wimbourne, U.K.). Thus this procedure establishes that the name used is:

a) the current and preferred one (and correctly spelled) under the rules of nomenclature and
b) the appropriate one to be assigned under the system of classification used in the garden (see example).

EXAMPLE

The information relating to the taxonomic identity of a plant requires some previous agreement amongst the staff of the garden about what taxonomic system of classification is followed within the institution. For example, it must be decided what taxonomic system is to be adopted consistently throughout the record. This determines questions such as: which plant families are to be recognised and which genera belong to which family; which genera are to be recognized. For instance, the genus *Polygonum* is often interpreted to include a number of different genera that are sometimes separated out under different classification systems, e.g. is *Polygonum* to be recognized in the broad sense, or split into its segregate genera, *Bistorta, Bilderdykia, Fallopia*, etc. Such questions have to be resolved to prevent plants of the same taxon being recorded in the same system under two or more different names.

Another example is as follows: a plant is received from Japan labelled *Magnolia tomentosa*. When checked, it is found to be correctly identified, but the name *M. tomentosa* (favoured for a time by Japanese botanists) is no longer currently accepted. The current name according to the World Checklist of Magnoliaceae is *Magnolia stellata*. In older lists it may appear as *M. kobus var. stellata*, so the name to be used will depend on the system currently adopted by the garden and the current name accepted under the international rules of nomenclature.

It is valuable for a botanic garden to indicate the degree to which the identity of each accession in their living collections have been checked. Some botanic gardens use a 'verification form' of which the degree to which an accession has been checked can be recorded. Clearly, in the course of its life in a particular botanic garden, an individual accession may be identified several times, by different people, possibly with different results. The ITF provides several levels of confidence in the form of a simple scale that can be applied to the verification of an accession (Table 2). The verification details should include the name of the person who has verified the plant and their institution, the date of verification, citation of literature used for identification and the annotations of previous identifications.

Description: The level to which the identification of the plant has been verified.	
U	It is not known if the name of the plant has been checked by an authority.
0 (Zero)	The name of the plant has not been determined by any authority
1	The name of the plant has been determined by comparison with other named plants
2	The name of the plant has been determined by a taxonomist or other competent person using the facilities of a library and/or herbarium, or other documented living material
3	The name of the plant has been determined by a taxonomist who is currently or has been recently involved in a revision of the family or genus
4	The plant represents all or part of the type material on which the name was based, or the plant has been derived therefrom by asexual propagation

Table 2 Verification Level taken from The International Transfer Format for Botanic Garden Plant Records (see Chapter on Plant Records)

4. Evaluation of collections

The collections should be evaluated on a regular basis to ensure that they are constituted in such a way that they contribute to the purpose(s) for which they were assembled (see Box 2). Staff, visiting curators, botanists and horticulturists can advise on the content of the collection and recommend future additions. These evaluations will contribute to the planning for future acquisitions, planting, plant removals, horticultural practices, maintenance and design needs.

The content of the collection is guided by the policy but procedures need to be in place to make the decisions about how the policy is applied. Some gardens have one or more staff members or a committee who help implement the accessions policy. Horticultural evaluations of existing plants and plantings can be undertaken by a committee of qualified and interested people (Plant Collections Committee or Living Collections Committee).

Occasional independent reviews are a helpful way of evaluating many practices within a garden, such as:

- scientific research activities, results and priorities;
- priorities for staff development and training;
- curatorial and horticultural staff priorities and practices;
- collection development;
- management methodologies and practices, etc.

The National Tropical Botanic Garden, Hawai'i, U.S.A. uses Research Associates, visiting curators and staff to advise on the curation of the collection.

Box 2 Evaluation scoresheet, after one developed by Strybing Arboretum and Botanical Gardens, San Francisco, U.S.A.

1 What is the relative importance (priority) of the plant/plant collection within the total collection in the Arboretum? Is it unique, rare or uncommon? Is it an endangered species? Is it an outstanding specimen? Does it have historical value? Is it popular with the general public? Is it appropriate to the climate and the soils?
2 Is there adequate space to accommodate a representative collection?
3 Can the plant/plant collection be maintained properly with the current staff and resources in the Arboretum?
4 Is the plant/plant collection properly located within the Arboretum? (Consider soil and microclimate conditions, as well as accessibility for both staff and public).
5 Is the plant/plant collection in good health and representative of the natural character of the plant/plants?
6 Is the plant/plant collection properly labelled and are record in order?
7 Does the plant/plant collection serve a particular educational purpose? (Is it presently an integral part of a self-guiding walk? Is it regularly included on guided tours.)?
8 Is the plant/plant collection being used for its intended purpose?
9 Is the plant/plant collection better represented in another arboretum or botanical garden in the region? (Could it be propagated for use, donated etc.?).

5. De-accessioning

De-accessioning of any unwanted plant material will follow on from any evaluation process undertaken. If a particular accession is found to be no longer required for inclusion in the living collection it may be gifted, sold or composted. In the case of a redundant research or conservation collection a procedure should be in place to ensure that it is disposed of responsibly. Plants should also be disposed of in accordance with any previously made agreements under which the original material was obtained by the garden (e.g. plant material may have been obtained subject to a material transfer agreement stating how such material might be used).

Box 3 Proposed guidelines for de-accessioning developed by the Royal Botanic Garden, Edinburgh, U.K.

For the whole collection:

1. Check that all the plants have been named and that the names have been verified recently.
2. Ensure that the cultivation and propagation requirements for the group in general are well understood and recorded.
3. Preserve and photograph specimens of the most important species, unless this has already been done in the course of taxonomic research. At present traditional herbarium sheets and spirit collections offer the only practical way of preserving plant material and from these at least the morphological structure of plants can be studied. In the future it should be possible to preserve samples of intact DNA.
4. Decide which are the "conservation" plants. These are species that are rare, threatened or endangered in the wild. This should have been determined when the collection was being cultivated but it must be checked again before disposal as the status might have changed. If in doubt about status the following groups or sources should be consulted: Botanic Gardens Conservation International; IUCN Species Survival Commission's Specialist Groups; World Conservation Monitoring Centre; the taxonomist who has been working on the group; a botanic garden, government agency or natural history society in the country concerned.
5. Dispose of the non-conservation plants; try to disperse as a collection rather than as individuals.

For the conservation plants:

6. Ascertain the cultural and propagation requirements of each species. Record the results. It is obviously better to start doing this while the plant collection is being amassed and worked on rather than at the end.
7. Preserve and photograph all the plants. Most of this work will have already been done at step 3.
8. Offer the collection to another botanic garden that has an interest in the group. This option is likely to offer the best long-term survival as plants will be tended more carefully in an institution that has a special interest in the plants (be it for research, display or cultural purposes) rather than in a garden that has only a general interest. However, there can be no guarantee that this botanic garden will want to keep the plants indefinitely.
9. Offer the remainder to a botanic garden in the plant's country of origin.
10. Consider reintroduction. Arguably this should be at the top of the list but the many problems, such as the availability of suitable sites for reintroduction and their future management means this is not yet often a practical option. At present, botanic garden collections that have been accumulated to support taxonomic, rather than conservation aims, typically have very few accessions of each species and a policy of reintroduction based on asexually propagated plants from the same individual would be seriously flawed. If it is considered, then it should be done in conjunction with the appropriate authorities in the country concerned and as part of a planned species recovery programme.
11. Offer the plants to a nature reserve nearest to their original collection point.
12. Keep the accessions as seed if possible, after taking appropriate precautions to avoid hybridization; alternatively, investigate the possibility of keeping them as micropropagules, or as deep-frozen in-vitro tissue.
13. Offer them to a gifted amateur if realistic assurances can be given about their futures.
14. If the plants are of the same accession as other individuals grown in at least 5 other botanic gardens then they can be disposed of, but ensure that the other gardens are informed.
15. If they are of different accessions or if they are grown in less than 5 other botanic gardens and cannot be responsibly gifted, then there is an obligation to keep them until any of the above criteria can be met.

These steps are intended to be responsible yet practical and realistic. There can be no guarantee that a plant gifted to another institution will be held for ever but the procedure outlined above has been designed to bestow a reasonable degree of security on conservation plants held in botanic gardens.

The Royal Botanic Garden, Edinburgh, U.K. has developed institutional guidelines on how plants may be de-accessioned from its collections (see Box 3).

6. Procedures for accepting and releasing material

Each garden should have a Code of Conduct or ethical policy on the acquisition and disposal or plant material held by the garden, as discussed in the chapter on Collections Policy. The Convention on Biological Diversity (CBD) provides a legal framework on how the movement of plants between institutions should operate. It is extremely important that botanic gardens should have a written policy with regard to how the provisions of the CBD will be adhered to in the garden. All staff should be aware of this policy (and follow it scrupulously) and know how it translates into procedures and practices.

These practices and procedures should include:

- obtaining official permission to collect plant material in their own and other countries;
- obtaining relevant permits before plant material is transferred from its country of origin to another;
- ensuring that benefits derived from the use of plant material are shared with the country of origin of the plant material;
- ensuring that plant material transferred to third parties will be used fully in accordance with the terms of the CBD.

Any benefits accruing from the use of biological diversity of another country should be equitably shared with the country of origin. Any benefits accruing from the use of our own national genetic resources should contribute to the conservation and sustainable development of the biological resources of our own country. Benefit does not simply mean financial benefit but could also mean the sharing of data, results, co-operation, technology transfer and capacity building. The is not retrospective and only concerns plant material obtained or distributed after 29 December 1993, when the Convention came into force. However, many botanic gardens believe that it is essential that they implement the spirit of the Convention by means of a voluntary code of practice for all their collections, including those plant collections obtained before the Convention came into force. Such a voluntary code can extend to botanic gardens in countries that have not yet signed and ratified the Convention.

To implement CBD policy, many gardens have developed agreements or contracts between the providers of material and the organization (or individuals) which wish to obtain the material. Botanic gardens should now only distribute plant material subject to such agreements, a practice that is in line with the provisions of the CBD. This helps to ensure that benefits arising from the use (including commercialisation) of genetic resources and benefits arising from research and development are shared with the country of origin. The CBD stresses that the provision and access to these genetic resources must be on mutually agreed terms.

Thus the movement of plant material between botanic gardens, individuals and other scientific institutions is now carefully controlled and may only be acquired under written agreements such as a Material Acquisition Agreement or Material Supply Agreement (collectively termed 'material transfer agreements'). If commercialisation is sought it should be subject to another agreement such as an Understanding, Trial Agreement or Licence Agreement (which can include Plant Breeders' Rights), Plant Material Supply Agreements etc.

The CBD clearly also affects the international seed exchange programme between botanic gardens. Traditionally, botanic gardens produced lists of seed available for free exchange (*Index Seminum*) which were sent to all collaborating gardens. An increasing number of botanic gardens include Material Transfer Agreements (MTAs) with their seed lists. Although there is no single standard MTA used by botanic gardens most include similar provisions, as outlined below. In signing these agreements, the recipients agree only to use the material for the purpose for which it was supplied at the time of application (e.g. for research, display and education). If the recipient wishes to commercialize or pass the genetic material, products or resources derived from it to a third party for commercial purposes then written permission must be sought from the garden. The recipient also agrees to acknowledge the supplier of the plant material in any publication resulting from the use of the material and submit copies of the publication(s) to them.

All plants in the garden that were received subject to an agreement should be tracked as such. A record should be kept of the use of any material from which benefits have been derived so that these benefits are shared fairly with the original source of the material.

The management of access and the benefit provisions of the Convention on Biological Diversity present major challenges for botanic gardens to implement fairly and reasonably. Nevertheless it will increasingly become both a moral and legal responsibility for botanic gardens to do so. Advice and assistance on these matters may be obtained from botanic garden organizations such as Botanic Gardens Conservation International, who can supply gardens with materials such as copies of CBD policies from other botanic gardens, texts of standard Material Transfer Agreements and guidance on how to track the use of material subject to such agreements within an individual institution.

7. Monitoring process

There should be an effective process to monitor the plant collections within the institution. Monitoring is a vital part of the process of applying collections policies. A close check needs to be kept to make sure that work is being carried out at the right time and in the right way. Structures need to be in place to allow for monitoring to take place throughout the organization.

Time should be built into the work programme for staff to accommodate reviews. Informal discussions about progress should be part of the normal dialogue between colleagues. Above this, however, there needs to be a more formal mechanism. Agreed job plans can be a focus for monitoring. These should be reviewed between the appropriate staff on a regular basis. Reviews should be kept simple; the object is to review agreed actions.

Other collections

A botanic garden does not only contain living plant collections. Most gardens host, study, conserve and transmit a varied range of materials related to the plant world. A botanic garden can also include important documentary or archival material, which is sometimes accessible to the general public and to technicians, scientists or other experts. The most important are mentioned below. All of them present specific conservation, management and documentation problems.

Herbaria Herbaria are the traditional way in which dried plant material is stored in the long-term. The majority of botanic gardens in the world maintain herbaria, sometimes numbering millions of dried specimens. The consultation of plant material in a herbarium is the everyday task of the taxonomist. Herbaria conserve the typus (type specimen) of each taxon described by botanists (an original specimen to which a particular name was first applied). They are also an important documentary fund as regards the distribution, phenology and variability of the plant species. New interest has recently arisen because of their utility for the study of the DNA and other biochemical extracts of the specimens conserved.

Libraries Apart from books, journals and other published articles relating to plants and their taxonomy and distribution, a library can contain many other published and unpublished materials, such as newspapers or collections of paintings, designs and other iconographic representations of plants. Libraries represent substantial and important documentary resources for and within botanic gardens. Although they are not elements of plant diversity themselves, they are collections of vital importance for the study of such diversity. In the last few years the libraries containing computerized databases and information have enriched the collections and documentation conserved in the botanic gardens.

Seed Banks Seed banks have become a common and important method for germplasm conservation, mainly in those botanic gardens involved in conservation programmes. They allow the storage of a large number of accessions in a small space, which are easily accessible. When the seeds are orthodox, i.e. they retain their viability for a long period of time under conditions of low moisture content and temperature (below 0ºC), they guarantee the germplasm conservation for decades and sometimes for centuries. In the case of recalcitrant seeds (seeds which quickly lose their viability when stored under conditions of reduced moisture content and temperature), the seed bank can only be used to store such material for short periods of time.

The recommended and preferred standards for long-term seed storage of orthodox species International Plant Genetic Resources Institute (IPGRI), are to:

- dry the seeds to a moisture content of below 7%;
- seal the dried seeds in a moisture-proof container such as laminated foil bags, aluminium cans or glass jars; and
- store at a low temperature of -18ºC.

Clearly this is only applied to true orthodox species. However because less is known about wild species than many crop plants, a temperature of -4°C and moisture content of 7-8% is advisable to begin with.

The activities in seed banks should take the following sequence:

- collection;
- seed preparation;
- seed drying;
- packaging;
- storage;
- periodic germination tests;
- seed regeneration;
- re-storage;
- documentation at each stage of activity.

Tissue collections The storage of germplasm in laboratory conditions (in vitro) is especially suited for the long-term conservation of recalcitrant species and vegetatively propagated species. Tissues can be stored at low temperature, under slow growth conditions or cryopreserved in liquid nitrogen at -196°C. Cryopreservation has so far been successful with only a relatively few species but is a very promising development for long-term storage. The main limitation of in vitro storage is the need for special equipment, an understanding of laboratory techniques and specially trained staff. The cryopreservation of orthodox seeds represents an advantage over low-temperature storage at -20°C, both economically and in terms of viability, as liquid nitrogen is a relatively inexpensive cryogen and the seeds retain the same viability as they had immediately before storage. Therefore regeneration

costs are lowered and viability testing is reduced. However, more research is necessary to define the mechanisms of desiccation and chilling injury and to investigate methods of alleviating it.

Pollen banks Pollen collections may be useful for research and conservation purposes although obviously they cannot contain the full complement of genetic diversity of the plants from which they are obtained. Like seeds, pollen can be divided into desiccation-tolerant and desiccation-intolerant. However, information about storage characteristics of pollen from wild species is fragmentary, existing mainly for some crop relatives and for some medicinal and forest species.

DNA banks The creation of a network of DNA banks (DNA Bank-Net) to complement activities already being undertaken in ex situ conservation and other germplasm collections can allow large quantities of genetic resources (genes, DNA) to be stored quickly and at low cost. Such storage could act as an insurance policy against rapid loss of the world's gene pool. It could be used as a tool in the study of molecular phylogenetics and systematics of extinct taxa, and genes. DNA samples have been mainly used for bio-prospecting and studies undertaken on the assessment of biodiversity. The use of DNA banks in conservation is limited, as whole plants cannot be reconstituted from DNA, although genetic material can be introduced to other genotypes for plant breeding and enhancement purposes. Its potential remains promising however.

Carpological collections Carpological collections refer to collections of normally non-viable seeds and fruits kept solely as an element for reference, study and comparison, in a similar way to a herbarium sheet. They are documentary sources useful not only in plant taxonomy but also in other disciplines such as archaeology (identification of seeds in historical sites), agronomy and weed science (identification of weed seeds in the soil or contaminated seeds for sowing), animal ethnology and nutrition (identification of food in the intestinal tracts of herbivores, ant's nests, etc.

Palynological collections Collections of pollen and other similar plant materials such as spores and micro-fossils, generally in form of preparations for microscopical study are of great interest, beyond plant taxonomy, for the development of other sciences or technologies, such as aerobiology and preventive medicine (identification of pollen and spores in the air, especially those causing human allergic diseases), archaeology and palaeobotany (study of archaeo- and paleofloras), etc.

Timber collections Collections of timbers in macroscopic samples and in sections for microscopical study, are especially useful for timber identification. These are of great interest in the industrial and commercial sectors (furniture, crafts, building, import of timbers, etc.).

Palaeobotanical collections: Although not many gardens have a Paleobotanical Unit, some gardens have important collections of plant fossils. Besides being used for the development of this science and the study of the palaeofloras and processes of plant evolution, they have complementary applications of great economic interest in stratigraphy (datation and assessment of sites containing fossil fuels: coal and oil).

Ethnobotanical collections Tools, implements, fibres, medicinal plant drugs, textiles, other artefacts made from plant materials, etc. constitute the heritage of the ethnobotanical museums that are occasionally developed as an outstanding element of botanic gardens. In addition to their undoubtedly anthropological and documentary value, these materials now have a similar use to that of herbarium sheets and plant fossils, i.e. as reference elements (or typus) of the values and applications of the plants studied and described by ethnobotanists. Ethnobotanical collections are also widely used by botanic gardens for educational purposes.

Bibliography

The Public Garden The Journal of the American Association of Botanical Gardens and Arboreta (AABGA) publishes useful articles on all aspects of public garden management. AABGA, 351 Longwood Road, Kennett Square, PA 19348, U.S.A.

Compiled by Etelka Leadlay, BGCI, from contributions by James Cullen, Stanley Smith (U.K.) Horticultural Trust, Cory Lodge, PO Box 365, Cambridge CB2 1HR, U.K., Mark Flanagan, Crown Estate Office, The Great Park, Windsor, Berkshire SL4 2HT, U.K., Andy Jackson, Royal Botanic Gardens Kew, Wakehurst Place, Ardingly, West Sussex RH17 6TN, U.K., David Rae, Royal Botanic Garden, Inverleith Row, Edinburgh EH3 5LR, U.K.and Esteban Hernández Bermejo, Jardín Botánico de Córdoba, Apdo 3048, 14080 Córdoba, Spain.