THE OMAN BOTANIC GARDEN (2): COLLECTIONS POLICY, NURSERY CONSTRUCTION, EXPANDED PLANT PRODUCTION AND INITIAL TREE TRANSLOCATION

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ABSTRACT

The first paper in this series outlined the vision for the Oman Botanic Garden and detailed the early plant collections and propagation. This paper focuses on the Oman Botanic Garden collections policy, construction of a new nursery on the site, subsequent expanded production and initial attempts at mature tree translocation.

INTRODUCTION

As discussed in paper 1, the Oman Botanic Garden represents a new model for botanic gardens in the 21st century (Patzelt *et al.*, 2008). The 423ha site (Fig. 1) will display all major habitats which occur in Oman. This will include *Olea europaea* and *Juniperus excelsa* woodland of the northern mountains, the monsoon-affected *Anogeissus dhofarica* forests of southern Oman, which is dominated by endemics, as well as the central fog desert, gravel, sand and salt deserts, and wadi ecosystems. Several habitats, like the high mountain vegetation and the monsoon-affected woodlands from southern Oman will be housed in climate controlled biomes, whereas the plant communities growing under arid conditions will be planted outside and an irrigation system will be installed.

Focusing exclusively on the native flora and vegetation of Oman and its botanical heritage, the Oman Botanic Garden will also illustrate the links between plant diversity, culture and traditional knowledge on a wide range of plant uses. The composition of the collection acknowledges the responsibility of the current generations to halt the extinction of species, the degradation of ecosystems, the loss of traditional knowledge and the unsustainable use of natural resources.

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Fig. 1 The Oman Botanic Garden site is a highly diverse landscape of dramatic beauty. Photo: Annette Patzelt.

OMAN BOTANIC GARDEN PLANT COLLECTIONS POLICY

The flora of the Arabian Peninsula has so far been poorly represented in any botanic garden on a global scale (Anon, 2001[5]). Botanic gardens worldwide do not adequately reflect the Arabian plant diversity and the number of accessions of Arabian plants is the smallest of all botanic garden living plant material (Anon, 2001). Southwest Asia and the Middle East only have a small number of botanic gardens, although the area accounts for an estimated 58,500 species. Over 6 million living plant accessions exist in botanic gardens worldwide; only a few of these accessions derive from Arabian material.

A range of logistical constraints precluded the incorporation of Arabian plant species into botanic gardens in the region which accordingly reduced their direct contribution to *ex situ* conservation. These constraints were due partly to an imbalance of institutional resources between regions, but also to the fact that most botanic gardens in the region are young institutions. Dedication to the development of extensive plant collections for public displays has had no history in Arabian society. Additional constraints lie in the fact that some areas were, and still are, difficult to reach and only recent developments have allowed access to some remote areas.

[5]This is a summary of the main findings of the review printed in BGCNews 3(6) June 2001, about the plant genetic resource collections of botanic gardens worldwide, as a contribution to decision V/26 on Access to Genetic Resources of the Conference of the Parties to the Convention on Biological Diversity. The full original text can be found at http://www.biodiv.org/programmes/socio-eco/benefit/bot-gards.asp

The Oman Botanic Garden is the only garden in the region which now aims to develop comprehensive *ex situ* conservation. Its living collection aims to fill existing gaps and will provide a resource facility for conservation and education of the flora and vegetation of the country and for the whole region. All plant material in the Oman Botanic Garden will be of wild origin and at least 95% of the collection will be verified. These are very high standards to set, very rarely achieved by any botanic garden. To fulfil this vision, plants have to be acquired through a great many field collection trips across all of Oman.

This field work requires strict policies and protocols to create an orderly process, ensure that priorities are followed and that confusion or duplication is avoided. A fundamentally important part of the plant collection process, from the very first collection trip, has been the gathering and recording of information on all the plants, including date of collection, name(s) of collectors, location (GPS coordinates; longitude, latitude and altitude), locality, type of material, life form, soil type, associated flora, local uses and descriptions. Voucher herbarium specimens, vegetative material for genetic analysis and photographs are also collected.

All collections follow the Garden's collection policy which aims to:

- create the richest collection of Oman's plants possible, with regard to total numbers, species diversity and diversity within species
- ensure that the living collection fulfils and integrates with the habitat agenda of the Garden
- create and maintain one of the best managed and documented botanic garden collections in the region
- acquire all material from the wild as sustainably as possible, including seed collection of species with conservation concerns and collection of mature plants as 'plant rescue measures'
- ensure the collection is 'fit for purpose' so that it can make a positive contribution to research, conservation, education and training
- make the collection as accessible and attractive as possible
- provide long-term planning and continuity for the collection and guard against short-term policy changes

Field work is planned carefully to ensure that the correct plants are collected, at the right time, in appropriate numbers and that standards of collection data are maintained. A realistic lead-in time is arranged in order for field work to be well organized. Field trips are continuously taking place. The focus in the first few months of 2009 was on species of the sand desert and of the northern gravel desert, as these two habitats will be the first to be constructed in the Garden. There were also field trips to the western and eastern Hajar mountains, the Dhofari mountains and Musandam.

Plant collection is prioritised according to growth forms, so that trees and perennial shrubs, as long-lead propagation species, are given priority over subshrubs, herbs and annuals. Short-lead propagation species are usually collected in larger numbers.

All seeds are then accessed, dried, cleaned and stored in the short-term seed bank, until selected for propagation (Fig. 2). All information is recorded in seed processing data sheets. Cuttings are processed directly.

NURSERY DESIGN AND CONSTRUCTION

Building up the living collection started in early 2006, with extensive field collection trips and propagation. Although working under very basic rented nursery conditions, the living plant collection grew rapidly in the first two years (Patzelt *et al.*, 2008), while the Oman Botanic Garden nursery was under design and construction.

To grow the vast quantity and range of plants necessary to plant all the habitat and amenity areas of the Oman Botanic Garden, a much larger and more sophisticated nursery was built on site. This new nursery was designated as Phase 1 of the garden construction. Building work started in early 2008 and the main structures were completed in June 2008.

The nursery consists of a potting and propagation building, an office building, 2600m^2 of glasshouse facilities (Figs. 3 and 4), 4000m^2 of polythene tunnels, 3000m^2 shade house, 3000m^2 outside standing area and storage areas. All the glasshouses are tall with 5–6m high gutters and have pad and fan evaporative cooling systems.

Once the nursery was sufficiently complete, the 51,000 plants which had already been propagated and grown-on needed to be moved over 30km to the new site. The move to the new nursery facilities was carried out within six weeks and it was a significant

Fig. 2 Botanist Laila Al Harthi supervising the short- and medium-term seed bank and selecting the seeds for propagation in June 2009. Photo: Annette Patzelt.

Fig. 3 Towards the final stages of Oman Botanic Garden nursery construction. Concrete is being pumped in to form the floor of the Propagation Glasshouse in July 2008. Photo: Leigh Morris.

Fig. 4 The Oman Botanic Garden nursery in June 2009. Photo Annette Patzelt.

milestone in the short history of the Garden. It took much planning and coordination (Fig. 5) and the 'Green Team' celebrated the first plants moving into the new nursery in June 2008 (Fig. 6).

The supply of water of a suitable quality and the management of high temperatures are the most important factors in setting up a botanic garden in a hot, arid, desert area. The installation and management of an efficient and accurate irrigation system with recycling systems in the nursery was of fundamental importance and the nursery has been equipped with mobile benches with an ebb-and-flood matting system, as well as an overhead sprinkler irrigation system in all growing areas. Both systems are computer-controlled, but can also be operated manually. The 4-zoned propagation house also contains a mist system and fogging chambers. The temperature reduction within the glasshouses and polytunnels is achieved by a pad and fan system, which was installed to bring temperatures down to less than 30ºC (even if temperatures outside are above 45ºC). To achieve this reduction, regular maintenance and back-up facilities are crucial.

Compared to other botanic garden nurseries it is believed that the new facility at the Oman Botanic Garden is the largest and one of the most technically advanced on the planet. It is more representative of a large commercial horticultural cropping facility, but such a facility is needed to produce the 350,000 or more plants required for the habitat displays that are planned.

Fig. 5 Dr Annette Patzelt (far right) and the Oman Botanic Garden graduates, in a rented tunnel in Seeb, planning the relocation to the new nursery site in April 2008. Photo: Leigh Morris.

Fig. 6 Production Supervisor, Khalid Al Farsi carrying a few of the 51,000 plants into the new shade house in June 2008. Photo: Annette Patzelt.

PLANT PRODUCTION FROM JUNE 2008 TO JUNE 2009

Currently, all the Oman Botanic Garden plants are located in the nursery where they are being grown until planting into their final location in the habitat zones. This habitat zone planting will be phased and plant propagation and production is being scheduled to fit in with habitat construction completion dates. The first habitat zone planting is expected to take place in early 2010 and the final plants will go in to the biomes in 2011.

A detailed nursery production list has been developed, which accurately lists all the species, the size and number required for all the habitat areas. This extensive list also includes data such as the growth form, habitat importance, Red List status (Patzelt, 2008), seed bank data, propagation and cultivation success rates and protocols. This list is constantly evolving but has already been the main reference for field work planning for three years, as well as being used for propagation and cultivation management. It is also a fundamental reference for the consultant architect that is designing the Garden.

The targets within the production list provide a useful way of prioritising and auditing work and also, when necessary, of improving standards. Clearly, propagation is the primary factor that will determine the successful achievement of production targets. As most of the species have not been cultivated before, new propagation protocols must be developed. It is recognized that successfully achieving the production targets will also be influenced by external factors such as staff shortages and the amount of material collected. However, they are of crucial importance in the acquisition of the collections of the Garden.

The new nursery is proving to be an excellent facility in terms of its size and physical structures and the focus of work has been on the development and implementation of production procedures. A key factor in achieving this has been the procurement of the essential nursery supplies such as tools, equipment and consumables. Some supplies are available in Oman, but most are imported and timescales on delivery have proven to be variable.

Systems and protocols have been initiated for propagation (Fig. 7), potting, plant handling, irrigation and pruning as well as pest and disease monitoring and control. Standard nursery practices are employed, but tailored to the requirements of the Omani flora, climate and availability of supplies.

The team is facing a number of challenges in growing such a diverse range of plants, most of which are new to cultivation. Initially there were few pests and diseases, however, as time has gone on many have appeared, such as the predictable aphids and red spider mites. While it is the intention of the Garden to implement non-pesticidal management, current practices are integrated and involve the use of some chemicals (Fig. 8).

The team has discovered, unsurprisingly, that when Omani plants, which are more used to harsh and arid conditions, are fed and watered within the nursery, some of them start to grow extremely quickly. This can lead to two problems: soft growth that is more prone to pests and diseases and unnaturally lush and leggy plants. The Garden needs to produce large plants and it is important that they look wild. The challenge is to control the feeding and watering regimes and use techniques such as pruning and spacing to create these more natural-looking plants.

Fig. 7 Three members of the Oman Botanic Garden Propagation Team in the new nursery building, taking cuttings of *Juniperus excelsa* ssp. *polycarpos* in July 2008. Photo: Leigh Morris.

Fig. 8 Ismail Al Balushi, one of the Horticultural Assistants, carrying out a preventative fungicide spray in the Propagation Glasshouse in February 2009. Photo: Leigh Morris.

INFORMATION RECORDING

Despite being a young garden under establishment, the Oman Botanic Garden is striving to be a leader amongst botanic gardens in maintaining plant records and the latest techniques of data capture, recording and access.

As well as during plant collection, once in cultivation, all plants are checked and monitored on a daily basis. Information is meticulously recorded by the team for all plant propagation and production activities and techniques. All information, from the growing media mix to the hormone strength used, is being databased. The aim is to develop precise protocols for growing all 1,200 Omani plant species and, as very few of the Omani plants have been cultivated before, much of the work is experimental.

Regular stocktaking provides an essential mechanism for assessing trends and checking whether the production targets have been achieved. For reviews to be accurate, collection information must be up-to-date and therefore stocktaking is carried out every second month. To allow for consistent and complete information in the collection, inspection takes place continuously (Fig. 9).

The stocktake, as part of the routine curation of the living collection, includes the number of living families, genera, species, taxa, accessions, individual plants and the number of red-listed species. Data on the production list are up-dated on a weekly basis, to allow for efficient planning of field work, propagation and cultivation.

In 2008, the Garden transferred all of its collection data into the plant collection database, *BG-BASE*™ (supplied by Kerry Walter, Royal Botanic Garden Edinburgh,

Oman Botanic Garden Living Collection Inspection Sheet

Person(s): Annette Patzelt	Date: 19.4.2009
Greenhouse or Location Number: A1B	General Observations: Some batch labels do NOT contain the necessary full information, e.g. habitat code missing.

Bench Number	Plant(s)	Habitat	Problem(s)	Necessary Action	Action Carried Out (Y/N)
1	Dionysia mira	D 16 I	Habitat code on batch labels missing	KF to ad information	
1	OBG 8 and OBG 7	D 14 II	Batch label missing	KF to place batch label	
1	17495	?	Batch label was in wrong pot	None, already corrected by AP	
1	Ephedra pachyclada	D 16 I	Some Batch labels missing	KF to place batch label	
1	Juniperus excelsa subsp. polycarpos	D 16 I	Subsp. on batch label missing	KF to add information	
2	Olea europaea subsp. cuspidata	D 15 I	Subsp. on batch label missing	KF to add information	
3	Sideroxylon mascatense	D 15 II	Some batch labels missing	KF to place batch label	
3	Grape 18010	G 22	No latin name on batch label; habitat code missing	KF to add information	

Fig. 9 Example of a Living Collection Inspection Sheet. These ensure that collection information is up-to-date.

U.K. and Mike O'Neal, Holden Arboretum, Ohio, U.S.A). The Garden intends to incorporate new techniques and technologies such as the use of barcode labels in the nursery.

Labels are the key to linking information held in the database to the plants in the living collection and they are critically important for the curation and use of the living collection. Two types of labels are currently used at the Garden. These are:

- Batch labels which have been hand-written in the past, but are now usually printed labels. They are used for identifying plants before they reach their permanent destination in the habitat zones. They contain the accession number, scientific name, habitat code, propagation target, and propagation date
- Individual plant labels with the qualifier number

MATURE TREE TRANSLOCATION

Most of the plants grown in the Garden will be propagated from seeds or cuttings. However, it was decided that some mature trees would have to be collected from the wild, in order to provide some sense of maturity within the biomes and to enable the Garden to effectively display plants that would otherwise take a long time to grow. Having some variety in the age of the plants within a habitat planting will also help greatly to 'age' the habitat plantings and make them look more natural.

The Oman Botanic Garden team was keen that they did not send out the wrong message and thereby encourage the practice of digging up trees from the wild and so, as part of the collection policy, a translocation policy was instigated, whereby only mature trees would be collected as a 'plant rescue' from sites that are being destroyed, for example for road construction. The disadvantage of such a policy is that there is often little time to prepare the trees for moving by root pruning in advance, so losses were expected to be quite high.

Key framework tree species were identified during the design phase and such trees were prioritised for translocation such as *Maerua crassifolia* for the Northern Gravel Desert habitat, *Juniperus excelsa* ssp. *polycarpos* for the Northern Mountains Biome and *Anogeissus dhofarica* for the Southern Biome. In December 2008 a team went to Dhofar to collect specimens of *Anogeissus dhofarica* from a site of road construction. The road team were very helpful and provided diggers, trucks and drivers to get the trees out of the ground and to a Royal Court Affairs farm in Salalah where they would be held to recover from the initial translocation shock (Figs. 10, 11 and 12).

From another site of road construction in northern Oman 31 trees and shrubs were translocated (Figs. 13 and 14) with a greater than 60% survival success rate. The southern Oman transplanted specimens are showing an even higher success rate.

Fig. 10 Mature specimen of *Anogeissus dhofarica* (Combretaceae) being excavated from a site of road construction in Dhofar in December 2008. Photo: Leigh Morris.

Fig. 11 After lifting, the top growth was severely reduced and the roots were watered and rootballed in preparation for moving to a nearby Royal Court Affairs Farm in December 2008. Photo: Leigh Morris.

Fig. 12 Mature specimens of the near-endemic *Anogeissus dhofarica* after translocation to the temporary holding site at the Royal Farm in Salalah. Note the water tanker and drip irrigation that was installed. Photo: Leigh Morris.

Fig. 13 Khalid Al Farsi and Leigh Morris pruning a *Maerua crassifolia* (Capparaceae) during the tree translocation process in February 2009. Photo: Annette Patzelt.

In some sites it has been possible to receive more notice so that trees could be prepared for translocation to reduce the initial shock. This is of fundamental importance when moving conifers and the team root-pruned 10 specimens of *Juniperus excelsa* ssp. *polycarpos* on a site designated for farm construction in the Northern Hajar Mountains (Fig. 15). The plan is that these trees will then be dug up after 12 months and moved to the nursery.

Overall, the Oman Botanic Garden has developed greatly during its first 12 months in the new site and much has been learned by all members of the 'Green Team' (Fig. 16) that will help them in the coming years. There are undoubtedly many challenges to come, but the vision of this iconic botanic garden in Oman's desert is coming to fruition.

Fig. 14 *Maerua crassifolia* and *Lycium shawii* (Solanaceae) directly after planting in the tree bags at the Oman Botanic Garden nursery in February 2009. Photo: Annette Patzelt.

Fig. 15 One of the Horticultural Assistants carrying out the root pruning of a *Juniperus excelsa* ssp. *polycarpos* in December 2008. Photo: Leigh Morris.

Fig. 16 The Oman Botanic Garden 'Green Team', photographed on December 16 2008, the day of the official nursery opening. Photo: Leigh Morris.

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