The Millennium Seed Bank Project delivering Target 8 of the *Global Strategy for Plant Conservation*

Paul P. Smith[1], Clare Trivedi, Anne Cochrane, Andrew Crawford and Michael Way

[1] Seed Conservation Department, Royal Botanic Gardens, Kew, Wakehurst Place, UK.

Introduction

The Millennium Seed Bank Project (MSBP) International Programme is a ten year global conservation programme (2000-2010), conceived and managed by the Seed Conservation Department at the Royal Botanic Gardens, Kew (Smith *et al*., 1998). The two principal aims of the Project are to:

- Collect and conserve 10% of the world's wild seed-bearing flora, principally from the drylands, by the year 2010.
- Develop bilateral research, training and capacity-building relationships worldwide in order to support and to advance the seed conservation effort

The MSBP currently works with partners in around 50 countries across five continents, and its main outputs and activities are: effective partnerships, high quality collections; removing researchable constraints; technology transfer and public awareness.

The focus of the seed collecting and conservation programmes in partner countries depends on national and institutional priorities. In many cases the emphasis is on the collection of rare and threatened species towards achieving Target 8 of the *Global Strategy for Plant Conservation* (GSPC): *'60 per cent of threatened plant species in accessible ex situ collections, preferably in the country of origin, and 10 per cent of them included in recovery and restoration programmes.'*

This paper represents a progress report, including up to date statistics on seed banking of threatened species, problems encountered in achieving this target, and case studies of how such collections are being used for conservation purposes.

Progress towards Target 8 amongst MSBP partners

Table 1 shows progress towards achieving Target 8 of the GSPC amongst MSBP partner institutions where collection and reintroduction of threatened species is a central aim of the country programme.

For the purposes of this analysis, threatened species include extinct in the wild, critically endangered, endangered, vulnerable, near threatened and data deficient taxa, or categories equivalent to these. Least concern species are not included in the analysis.

Western Australia is the only state/country to have achieved Target 8 at the time of writing, with both 70% of threatened species conserved, and 13% of threatened species reintroduced. The United Kingdom has achieved the threatened species conserved target (78%), but not the reintroduction target. MSBP partner countries that are likely to have conserved more than 60% of their threatened flora ex situ by 2010 are Botswana, Namibia and South Australia. Most countries are unlikely to achieve the second part of the Target -10% of threatened species in recovery and restoration programmes. The reasons for this are discussed below.

The seed conservation programme with INIA Chile is typical of an MSBP partnership. This programme has successfully made over 700 collections of seed, of which over 70% of the taxa are endemic to Chile. Amongst the collections is *Menodora linoides* (Oleaceae), a shrub which was considered extinct, but was recently rediscovered in the wild (see Figure 1).

Figure 1. Fruit of Menodora linoides *(Oleaceae), Cabildo, V Region, Chile*

Other endangered species from which seed has been collected include *Dalea azurea* (Critically Endangered); *Placea lutea* (Rare); *Tigridia phillipiana* (Rare); *Adesmina resinosa* (Vulnerable); and *A. balsamica* (Rare). Reproductive biology trials of *Dalea azurea* are currently underway to ensure that adequate numbers of seedlings can be re-introduced to the wild in coordination with local authorities.

Country/state	**Species focus***	**No. of threatened species from which seed collected**	**Total no. of threatened species on list**	**Percentage of threatened species collected**	**No. of species reintroduced**
Australia - Northern Territory	R,T	5	1191	0.5	1
China	R,T	2	234	1	0
Australia-Tasmania	R,T	23	734	3	0
Austalia-Victoria	R,T	39	967	4	5
South Africa	R,T,U	147	2683	5.5	4
Georgia	R,T,U	15	156	10	0
Australia-New South Wales	R,T	56	572	10	2
Chile	R,T	64	402	16	3
Malawi	R,T,U	33	206	16	1
South Australia	R,T	61	356	17	17

Namibia	R,T,U	8	24	33	7
Botswana	R,T,U	14	39	36	0
Western Australia	R,T	259 815	372** 2618***	70 31	48
United Kingdom	R,T	219	282	78	5

Table 1: Progress towards Target 8 amongst Millennium Seed Bank Project institutional partners, where threatened species are the focus of seed collecting programmes (R= rare; T= threatened; U= utilitarian; ** Declared Rare Flora; *** Declared Rare and Priority Flora).*

Problems encountered in achieving Target 8

Absence of a red list or up to date, accurate information on threatened species

In MSBP partner countries such as Burkina Faso, Mali, Lebanon and Jordan no national red list of plants is available to our institutional partners. In other countries, such as Madagascar, Kenya, Botswana and Malawi, existing red lists have deficiencies.

For example, Of the 43 taxa on the Botswana red list (Golding *et al*., 2002) 22 are data deficient, 13 have misspelled author's or species names, and 10 names are either out of date or have ambiguous taxonomies (Smith & Balding, 2007). In addition, 14 rare, endemic taxa are not on the red list.

The MSBP has tackled this problem by employing a team of 12 people in Kew Herbarium, comprising specimen digitisers, literature researchers, Geographical Information System (GIS) specialists and conservation assessment officers. This team, working with in-country partners, digitises specimen information where no up to date red list assessments are available in order to produce preliminary conservation assessments. In this methodology specimen data from rare or threatened taxa are mapped in a GIS and used to calculate extent of occurrence and area of occupancy. From this a preliminary red list assessment is calculated using a simple algorithm. Where possible, other information is taken into account, such as habitat intactness estimated from satellite imagery, number of populations inside or outside protected areas etc. In addition, where species are designated data deficient or there are taxonomic problems, the team is able to add new information. To date the MSBP herbarium team and partners have produced 4500 preliminary conservation assessments (Target 2 of the *Global Strategy*) in 10 countries. The taxa that this analysis identifies as most threatened are prioritised by MSBP seed collection teams

Absence of accessible data on the locality, phenology and identification of threatened species

Knowing the names of your threatened species doesn't necessarily make it easy to find and collect seed from them. Seed collectors need accurate locality and phenology information, and they need plant descriptions and images in order to recognise the plant when they are in the field. To this end, the same specimen information that is used to produce preliminary conservation assessments can be used to locate and identify species in the field. The MSBP herbarium team have produced 26 collection guides covering 2255 taxa from 10 countries to date. For each taxon covered in a collecting guide there is detailed locality data, a phenology chart showing when the plant is likely to be in seed, a detailed description of the taxon, and at least one image. These guides enable our seed collectors to be in the right place at the right time and able to identify the target plant.

Absence of infrastructure for processing and storage of seed

Seed storage for orthodox species (about 90% of plant species) is not a high technology procedure. Seeds need to be dried down to 5-7% moisture content then stored in a cold room, usually at 4°C for short term storage or -20°C for long term storage. The drying stage is particularly critical because if a seed is not dry when frozen it will be killed. The MSBP has provided drying and freezer facilities to ca. 30 partner

institutions over the past seven years. We have also provided advice on seed bank design to 19 institutions in 10 countries worldwide.

Absence of skills enabling collection, handling and storage of seed

Having good facilities and equipment is pointless unless you know how to use them. For this reason, the MSBP has expended a considerable amount of time, effort and money on training people in seed conservation techniques. This training has comprised formal courses delivered at the MSB and regionally, exchange technical visits to the MSB and informal training on the job. The main focus areas for training have been seed collecting, seed handling, seed germination and seed storage. To date, the MSBP has trained 1181 people in seed conservation techniques, including 64 exchange visits and 31 PhD programmes.

Constraints associated with using seed in reintroduction programmes

The major challenge associated with Target 8 is species reintroduction. Few countries carry out species reintroduction programmes. This is partly because reintroductions are seen as a last resort, but also because they can be expensive and may fail for a wide number of reasons (see below).

The first step towards using seeds for reintroduction is successful germination. The MSB currently carries out more than 10,000 germination tests a year. Every collection of over 500 seeds that is accessioned into the bank is tested for germinability. However, achieving germination is not always straightforward. For most of the species accessioned into the MSB nobody has tried to germinate them before. In addition, some taxa exhibit dormancy mechanisms that need to be overcome if successful germination is to result. Dormancy may be physical, morphological or physiological, and not only does the mechanism have to be elucidated, but procedures for breaking it have to be developed before germination can be achieved in the laboratory or nursery (Baskin & Baskin (1998).

If germination can be achieved, successful establishment *in situ* does not always follow. There are many reasons for this. Using appropriate ecotypes of the right provenance or ensuring adequate genetic diversity in reintroduced populations may be crucial (e.g. see Vilas *et al*., 2006). Microbial symbionts, such as rhizobial bacteria or mycorrhizal fungi may be important, as will pollinators, seed dispersers and associated plant species. Alternatively, natural attrition through disease, predation or drought may be enough to knock out small populations of reintroduced species in the process of acclimation.

Western Australia's Department of Environment and Conservation (DEC) Threatened Flora Seed Centre (TFSC) currently holds 815 (or 31%) of the extant taxa on Western Australia's 2006 Declared Rare and Priority Flora list (see Table 1 above). This includes 70% of the extant taxa on the Declared Rare Flora list. These collections have been made over a 14 year period from late 1992 to the present. The MSB partnership has enabled the Threatened Flora Seed Centre to accession 474 of these 815 conservation-listed taxa. Since 1998 DEC has established 48 threatened (DRF) plant reintroductions. Thirty-three of these have utilised seed from the Threatened Flora Seed Centre. This amounts to 13% of the Declared Rare Flora being used in recovery. Although TFSC collections of DRF taxa exceed Target 8 of the GSPC, many of the existing TFSC conservation collections are small, and do not adequately represent the diversity of the taxon. In addition, collections are of insufficient size to meet recovery efforts. Further collection is needed for ongoing conservation, maintenance, duplication, distribution and recovery.

Conclusions

The examples above show that Target 8 is achievable. The strength of the MSBP network is in the diversity of experience and expertise of the partners. From the increasing number of examples of reintroduction programmes in the literature, it is clear that for reintroductions to be successful, a multidisciplinary approach needs to be employed, using molecular, ecological and horticultural knowledge to maximise survival and long term establishment. In most of the MSBP partner countries, this kind of expertise and experience is in

short supply. The rationale going forward is to use the expertise that does exist in places like Australia to promote best practice throughout the network.

This paper has concentrated on the technical challenges associated with achieving Target 8. As has been shown, these are surmountable. The biggest constraints to success remain lack of political will and funding. A technical network such as the Millennium Seed Bank Project partnership comes at a cost - £50 million to secure 10% of the world's flora in safe storage in 10 years. The model is proven, but further funding will be needed to extend the network further, and to start to tackle the technical challenges associated with species reintroductions and habitat restoration. The CBD and its signatory governments need to enable the technicians to get on and achieve the targets that the CBD has set. The GSPC is a test of credibility for the CBD – will it ever actually achieve anything useful, or will it remain an expensive talking shop?

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