The contribution of botanic gardens to ex situ conservation through seed banking

Katherine O’Donnell*, Suzanne Sharrock

Botanic Gardens Conservation International, Descanso House, 199 Kew Road, Richmond, Surrey, United Kingdom

1. Introduction

The Global Strategy for Plant Conservation (GSPC) was adopted by the Convention on Biological Diversity in 2002 and updated in 2010. The strategy provides the overall framework for plant conservation at the global and national level and consists of 16 output-oriented targets. Target 8 of the GSPC calls for ‘at least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes by 2020’ (CBD, 2010). A number of countries have developed national responses to the GSPC including Mexico, Brazil and China, while others are implementing them through their National Biodiversity Strategies and Action Plans and many mention the GSPC in their National Reports to the CBD.

Botanic gardens (including arboreta and associated research facilities) are one of the main institutions involved in ex situ conservation of wild species with 30% of known plant diversity accounting for 105,634 species held in the world’s botanic gardens (Mounce et al., 2017). These collections can consist of whole plants, seed or tissue cultures.

Collections conserved as seed are referred to as ‘seed banked’. Seed banking as a form of conservation has traditionally been used for crop species. However, over the past two decades an increasing number of botanic gardens and other botanical institutions are establishing seed banks for the purpose of wild plant conservation (Lupton et al., 2017; Gautier, 2004; Fahey, 2013).

* Corresponding author.
E-mail address: katherine.odonnell@bgci.org (K. O’Donnell).

Keywords:
Seed banking
GSPC
ex situ conservation
Conservation assessments
Botanic gardens

Plant Diversity 2017 xxx (2017) 1–6

Contents lists available at ScienceDirect

Plant Diversity


http://journal.kib.ac.cn

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Botanic garden seed banks are also involved in the conservation of wild species that are related to crop species. An example of this is the ‘Adapting Agriculture to Climate Change’ project (2011–2020) (Dempewolf, 2014). Through this project the Global Crop Diversity Trust (GCDT) is currently working with Royal Botanic Garden (RBG) Kew’s Millennium Seed Bank Partnership (MSBP) on securing the primary and secondary gene pool members of 29 of the world’s major crops.

Seed banking involves collecting seeds from wild plants, drying and storing them in cool conditions. In order for seed collections to be of conservation value certain protocols must be adopted. The MSBP has developed seed conservation standards which represent current best practice for long term conservation of orthodox seeds (MSBP, 2015). The seed collections are then available and can be used as required for research, reintroduction, or restoration (Cochrane, 2007; Hardwick et al., 2011; Miller et al., 2016). Seed banks provide insurance against threats to plants in situ including habitat loss and degradation, introduction of alien species, over-exploitation, pollution, disease and climate change. Seed banking is increasingly being used as a method of conservation for a variety of reasons:

- Estimated to cost as little as 1% of in situ conservation
- Can represent a range of genetic diversity if harvested from a population of individuals
- Can be stored in a relatively small space
- Seeds of many species can survive for hundreds of years in conditions of low humidity and low temperature (Li and Prichard, 2009)

Many botanic gardens are contributing to the achievement of Target 8 through seed banking wild species (CBD, 2009) (Williams and Sharrock, 2010). A variety of targets have been developed by institutions and networks at the global, regional and national levels (Table 1). In mega diverse Brazil, a recent feasibility analysis concluded that by seed banking 1500 species between 2016 and 2020 Target 8 could be meet and would be economically feasible (Teixido, 2017).

Monitoring progress towards Target 8 at a global scale has previously been problematic due to the limited information on which species are being conserved where, and which of these are threatened. Some countries will have this information at the national level, however for mega-diverse countries with a high number of threatened species and a lack of resources Target 8 is an ambitious task.

Within the botanic garden community are some of the world’s largest and most sophisticated seed banks that work at global and national levels. For example Royal Botanic Gardens RBG Kew’s Millennium Seed Bank in the United Kingdom, the Germplasm Bank of Wild Species (GBOWS) in China and RBG Sydney’s Plant-Bank in Australia but, equally importantly, a wide network of small scale but very effective seed banks are conserving local plant diversity at either the national or regional level.

Botanic Gardens Conservation International (BGCI) has for the past 30 years been collating information from its network of botanic gardens. BGCI’s website (http://www.bgci.org) currently hosts four open access databases namely GardenSearch, PlantSearch, ThreatSearch and GlobalTreeSearch. These databases provide useful tools for plant conservation, aiding the effort of botanic gardens to measure progress, identify gaps and prioritise plants for conservation action. The data contained in these four databases have been analysed along with in-depth data gathered from BGCI’s network of botanic gardens related to seed banking activities.

Below, a review of the progress being made by the botanic garden community in achieving Target 8 of the GSPC and report on global, regional and national seed banking trends is presented. Recommendations for botanic gardens conserving plant species through seed banking programs are highlighted.

### 2. Theory/calculation

BGCI’s GardenSearch (http://www.bgci.org/garden_search.php) database is an online directory containing data from botanical institutions around the world. This database includes 3379 institutions (BGCI, 2017) and is used to determine the extent and geographical spread of botanic gardens involved in seed banking.

BGCI’s PlantSearch (http://www.bgci.org/plant_search.php) database is a global database of living plant, seed and tissue collections with data from over 1145 botanical institutions around the world (BGCI, 2017). PlantSearch does not hold collection information from all 3379 institutions in GardenSearch, however it does represent the most comprehensive list available of wild plant diversity that are conserved in ex situ-collections. PlantSearch acts as an essential tool for monitoring and reporting on progress towards Target 8 of the GSPC (Sharrock et al., 2014). PlantSearch data is used

<table>
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<tr>
<th>Table 1</th>
<th>Examples of global, regional and national level seed bank targets.</th>
</tr>
</thead>
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<tr>
<td>Target 2020 targets</td>
<td>Main implementer</td>
</tr>
<tr>
<td><strong>Global</strong></td>
<td></td>
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<tr>
<td>Double the number of threatened species in seed banks</td>
<td>BGCI's Global Seed Conservation Challenge (GSCC)</td>
</tr>
<tr>
<td>400 IUCN red listed species in 2015</td>
<td>RBG Kew's MSBP</td>
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<tr>
<td>25% of the world's bankable species conserved (Kew, 2016)</td>
<td></td>
</tr>
<tr>
<td><strong>Regional – Multi country</strong></td>
<td></td>
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<tr>
<td>500 vascular plant species (Müller et al., 2017)</td>
<td>The Alpine Seed Conservation and Research Network</td>
</tr>
<tr>
<td><strong>National</strong></td>
<td></td>
</tr>
<tr>
<td>60% of Korea's native plant species (Choi et al., 2017)</td>
<td>Korea National Arboretum</td>
</tr>
<tr>
<td>75% of Australia's threatened species (excluding orchids) (Australian Seed Bank Partnership, 2014)</td>
<td>Australian Seed Bank Partnership</td>
</tr>
<tr>
<td>10,000 China's native taxa (Cai, 2015)</td>
<td>Germplasm Bank of Wild Species Kunming Institute of Botany, Chinese Academy of Sciences</td>
</tr>
<tr>
<td>75% threatened plant species Botnischer Garten &amp; Botanisches Museum Berlin (2015)</td>
<td>The Dahlem seed bank at the Botanic Garden and Botanical Museum Berlin</td>
</tr>
<tr>
<td><strong>Regional – Sub country</strong></td>
<td></td>
</tr>
<tr>
<td>100% of the California flora (Meyer, 2015)</td>
<td>California Plant Rescue Project</td>
</tr>
<tr>
<td>75% of the regions threatened species conserved in seed banks or living collections New England Wild Flower Society (2017)</td>
<td>New England Wild Flower Society</td>
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Please cite this article in press as: O'Donnell, K., Sharrock, S., The contribution of botanic gardens to ex situ conservation through seed banking, Plant Diversity (2017), https://doi.org/10.1016/j.pld.2017.11.005
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