



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

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ABSTRACT

Target 8 of the Global Strategy for Plant Conservation 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'.

Botanic gardens make a significant contribution to *ex situ* conservation of wild species with more than a third of plant species represented in botanic gardens collections. These collections are a combination of living collection and seed banked material. Seed banking can provide an efficient form of conservation for wild plant genetic diversity.

Information from Botanic Gardens Conservation International's (BGCI) databases (GardenSearch, PlantSearch, ThreatSearch and GlobalTreeSearch) has been analysed as well as survey data to report on global, regional and national seed banking trends.

Information from BGCI's databases indicates that there are at least 350 seed banking botanic gardens in 74 countries. In total 56,987 taxa have been banked including more than 9000 taxa that are threatened with extinction. 6881 tree species are stored in *ex situ* seed bank collections. More than half (3562) of these tree species are single country endemics and represent species from more than 166 countries.

This study suggests that institutions are increasingly conserving plant species via seed banking. However the majority of species in collections that have a conservation assessment are not threatened with extinction. This disjunction between species that are threatened and those conserved in seed banks needs to be addressed. Data from BGCI's databases can be used to enable prioritisation of threatened plant species for collection and conservation in seed banks. Further recommendations for botanic gardens involved in seed conservation are presented.

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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).

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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 met 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 1
Examples of global, regional and national level seed bank targets.

Target 2020 targets	Main implementer	Facilitators
Global		
Double the number of threatened species in seed banks	BGCI's Global Seed Conservation Challenge (GSCC)	200 GSCC member botanic gardens
400 IUCN red listed species in 2015		
25% of the world's bankable species conserved (Kew, 2016)	RBG Kew's MSBP	MSB Partnership institutions
Regional – Multi country		
500 vascular plant species (Müller et al., 2017)	The Alpine Seed Conservation and Research Network	5 plant science institutions in 4 countries (France, Switzerland, Italy, Austria)
National		
60% of Korea's native plant species (Choi et al., 2017)	Korea National Arboretum	
75% of Australia's threatened species (excluding orchids) (Australian Seed Bank Partnership, 2014)	Australian Seed Bank Partnership	12 botanic garden and plant conservation institutions
10,000 China's native taxa (Cai, 2015)	Germplasm Bank of Wild Species Kunming Institute of Botany, Chinese Academy of Sciences	71 organisations including botanic gardens, nature reserves and universities
75% threatened plant species Botnischer Garten & Botanisches Museum Berlin (2015)	The Dahlem seed bank at the Botanic Garden and Botanical Museum Berlin	
Regional – Sub country		
100% of the California flora (Meyer, 2015)	California Plant Rescue Project	Conservation organisations, botanic gardens and seed banks
75% of the regions threatened species conserved in seed banks or living collections New England Wild Flower Society (2017)	New England Wild Flower Society	

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