

Strengthening the conservation value of ex situ tree collections

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SUPPLEMENTARY MATERIAL 1 Interview questions administered to members of the botanical garden and conservation communities.

1. How do we prioritize conservation of tree species globally, given the number of threatened taxa and the lack of information on the status of many species, and the difficulties with consistent nomenclature?
2. Provide some examples of complementary ex situ and in situ tree conservation projects that can be used as models or examples of gardens that have dedicated tree conservation programmes and have made a significant contribution to securing the future of threatened trees (i.e. integrated models that resulted in the conservation of a rare tree species).
3. Should we measure a collection's conservation value based on accession depth (number of each threatened species)? What about the percentage of wild-collected specimens?
4. Is there anything we can learn or adapt from the zoo breeding model? How do we adapt this approach for thousands of tree species, given that zoos are dealing with only c. 100 species?
5. In your opinion, what are the greatest assets gardens can provide for tree conservation worldwide?
6. What are the greatest challenges gardens face with respect to tree conservation?
7. Why should gardens focus on the conservation value of their collections among all other priorities?
8. What is our collective capacity to make progress in tree conservation? How do we increase this collective capacity?
9. Who else can we work with to achieve tree conservation goals?

10. What are some steps gardens can take to help interpret tree conservation? Or prioritize education?

11. How do international policies help or hinder conservation efforts?

12. Is there one change that could take place that would significantly strengthen gardens' abilities to do effective ex situ conservation?

SUPPLEMENTARY MATERIAL 2 The *Acer pentaphyllum* conservation grove at Quarryhill Botanical Garden, Glen Ellen, California, USA.

Acer pentaphyllum is a Critically Endangered maple native to Sichuan province in China. The one remaining population of c. 200 trees spans 2 miles of a river valley in southwestern Sichuan. The trees are threatened by grazing livestock and soil erosion as a result of road construction. The population faces an imminent threat from the ongoing construction of a power plant and an associated dam project that will eventually flood the valley. Since 2001 the Quarryhill Botanical Garden has been conducting regular collecting trips to monitor these last remaining trees and collect seed for an ex situ conservation grove. The *A. pentaphyllum* conservation grove at Quarryhill now consists of 200 individuals from 17 wild accessions, which exceeds the number of individuals in the wild population. Tree scientists are conducting ecological experiments on the collection, such as testing various mycorrhizal treatments to optimize growth conditions. The garden is also working with local officials and the community around the wild population in Sichuan to promote in situ protection of the species. However, the impending dam project means there is little hope for in situ protection of *A. pentaphyllum*. The Quarryhill conservation grove is the only option for protecting this species to enable future reintroduction to China. The *A. pentaphyllum* conservation grove at Quarryhill Botanical Garden is an example of how one garden can take the initiative to protect a threatened tree species that requires urgent attention and cannot be protected in situ. Quarryhill prioritized *A. pentaphyllum* for conservation, based on its level of endangerment, the degree of impending threat (imminent and fatal), and the mission of the institution (to conserve, study and cultivate the flora of Asia). The size of the conservation collection, which is derived exclusively from wild-collected seed, ensures that it is representative of the

genetic diversity of the species and is sufficient for future reintroduction programmes. The ongoing research programmes at Quarryhill to assess ideal growing conditions and propagation techniques for *A. pentaphyllum* will improve the chances of survival and successful reintroduction of the species in the future.

Information on Quarryhill Botanical Garden was presented at the 5th Global Botanic Gardens Congress by William McNamara.

SUPPLEMENTARY MATERIAL 3 Building resources and capacity for tree conservation at The Morton Arboretum, Lisle, Illinois, USA.

The Morton Arboretum acknowledges the need for large, well-resourced gardens to promote tree conservation globally. As part of its global tree conservation efforts The Morton Arboretum has established two programmes to build capacity and improve resources for conservation-focused gardens worldwide. Firstly, the Center for Tree Science is a strategic initiative to facilitate collaboration, integrate the multiple dimensions of tree science research, and enable researchers to more efficiently address important research questions. The Center for Tree Science focuses on two major areas of research: urban trees and threatened trees in the wild. The outcomes of this initiative will include creating new knowledge of tree care and conservation, and training a new generation of tree scientists, resulting in healthier urban trees and reduced extinction rates globally. The second programme initiated by The Morton Arboretum to promote tree conservation is ArbNet, an interactive community of arboreta that fosters professionalism and builds global networks. ArbNet produces and collates a variety of tree conservation resources, including guides, publications, conservation frameworks, policies, case studies and an interactive online discussion forum. It also administers an arboretum accreditation programme that recognizes four levels of achievement based on specified criteria of professional practice. The higher levels of accreditation require an agenda for tree science and planting and a conservation role in the Global Trees Campaign. Through the Morton Register of Arboreta, an international database of tree-focused gardens maintained on the ArbNet website, gardens can identify potential collaborating institutions for scientific, collection, or conservation activities. These two programmes put into action several of the recommendations proposed here. ArbNet is designed to improve coordination between gardens and promote collaboration through its online discussion forum and the Morton

Register of Arboreta. It also builds capacity and facilitates the participation of smaller gardens in tree conservation efforts by providing resources and benchmarks to implement conservation programmes and improve collections. By generating new research and knowledge the Center for Tree Science will provide leadership in scientifically informed tree conservation, with an emphasis on enhancing training opportunities and disseminating results to academia, the garden community and the general public.

Information on the Morton Arboretum was presented at the 5th Global Botanic Gardens Congress by Nicole Cavender.

SUPPLEMENTARY MATERIAL 4 The International Conifer Conservation Programme at the Royal Botanic Garden, Edinburgh, UK.

Of the 615 species of conifer 34% are threatened with extinction (IUCN, 2013). The International Conifer Conservation Programme (ICCP) has been leading global conifer conservation action and research for >20 years. In addition to conducting global threat assessments, mapping species distributions, conducting field surveys and researching propagation techniques for exceptional species of conifer, the ICCP also operates an innovative programme of safe sites for ex situ conservation of threatened conifers. The safe site programme is a key element of the ICCP's strategy of integrated conservation management to prevent conifer extinction, emphasizing a combination of in situ and ex situ conservation strategies, scientific research, public education, and horticulture. Safe sites for growing threatened conifers are selected based on several criteria: institutional longevity, horticultural expertise, a location conducive to growing conifers, public access for education, and management that has a genuine interest in tree conservation. The ICCP has partnered with >200 safe sites, including public parks, private estates, Forestry Commission land, golf courses, hotels, monasteries and hospitals. In total, these sites are growing 13,500 plants of 180 species of conifer, 70% of which are threatened. The ICCP collects seeds and cuttings for safe sites from wild populations of threatened species according to a collecting strategy that emphasizes genetic diversity and broad representation of the gene pool. Through the safe site programme the ICCP puts into practice many of the recommendations to improve tree conservation efforts globally and to enhance the conservation value of ex situ living tree collections. Coordinating conservation efforts across institutions and collaboration with smaller gardens form the foundation of the programme. The Royal Botanic Garden Edinburgh administers the ICCP by working with and supporting a broad range of smaller, less well-resourced public and

private gardens. The ICCP provides the plant material, labels, and horticultural and scientific training to the safe sites, and benefits from the exponential increase in the number of trees protected, the outsourcing of custodial care for ex situ collections, and a wider choice of growing sites. With an emphasis on science-based conservation and capturing genetic diversity in the safe site collections, the ICCP exemplifies a conservation-focused collection mentality. The safe site programme also opens up new opportunities for public engagement and interpretation, as each safe site can connect with a different sector of the public. Finally, through its combination of in situ and ex situ research and conservation activities, the ICCP illustrates integrated conservation management in action, which is the most effective approach to combat the loss of tree biodiversity.

Information on the ICCP was presented at the 5th Global Botanic Gardens Congress by Martin Gardner and David Rae.

SUPPLEMENTARY MATERIAL 5 Developing integrated tree conservation approaches through the Global Trees Campaign: Brackenhurst Botanic Garden, Kenya.

The Global Trees Campaign was launched in 1999 as a joint initiative between Botanic Gardens Conservation International and Fauna & Flora International to secure the future of threatened tree species. The Global Trees Campaign provides direct support to tree conservation programmes, building their capacity and promoting the conservation of trees to local communities, governments, conservation groups and the horticultural industry. The Global Trees Campaign supports or collaborates on dozens of projects, including reforestation projects, establishing ex situ conservation collections and providing conservation-focused education programmes in local communities. One programme that is directly supported by the Global Trees Campaign, with financing from the Ashden Trust (UK), is the Brackenhurst Botanic Garden in Limuru, Kenya. Established in 2001, Brackenhurst was created by clear-cutting 30 acres of non-native eucalyptus and wattle and replanting the area with native species of East African tropical sub-montane forest. Despite 100 years of eucalyptus plantations on the site, a healthy sub-montane forest has established and rare native species of birds, mammals and insects are being observed in the area. In 12 years the reforested area has grown to a closed canopy over 60 acres. Several conservation initiatives have been initiated, including propagation programmes for rare native woody plants, botanical tours, ecology education programmes, a native tree

nursery, a native seed collecting collaboration with the Millennium Seed Bank and a long-term reforestation monitoring programme that documents growth and ecological aspects of the reintroduced native trees. Brackenhurst Botanic Garden is a model for reforestation using native species in Africa, where 3.4 million ha of forest cover are being lost annually and >1,000 species of native trees are threatened (Forest Resources Assessment). Through in situ reforestation, establishing native tree nurseries, collecting seed for ex situ collections and providing educational programmes and employment opportunities for local communities, Brackenhurst illustrates effective integrated conservation management in action. In areas where there is a need for capacity building, the support of the Global Trees Campaign and international botanical gardens and arboreta is essential to prevent tree extinctions.

Information on the Global Trees Campaign and Brackenhurst Botanic Garden was presented at the 5th Global Botanic Gardens Congress by Sara Oldfield.