



China: The role of botanical gardens in conservation

Hongwen Huang,^{1,2,3,*} Peter H. Raven,^{4,*} Lisong Wang,² Jingping Liao,¹ and Qingqing Zhan¹

¹South China Botanical Garden, Chinese Academy of Sciences, Guangzhou, Guangdong 510650, China

²Lushan Botanical Garden, Chinese Academy of Sciences, Lushan, Jiangxi 332900, China

³University of Chinese Academy of Science, Beijing 101408, China

⁴Missouri Botanical Garden, St. Louis, MO 63166, USA

*Correspondence: huanghw@scbg.ac.cn (H.H.); peter.raven@mobot.org (P.H.R.)

Received: March 7, 2023; Accepted: April 24, 2023; Published Online: April 27, 2023; <https://doi.org/10.1016/j.xinn.2023.100433>

© 2023 The Authors. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Citation: Huang H., Raven P.H., Wang L., et al., (2023). China: The role of botanical gardens in conservation. *The Innovation* **4**(3), 100433.

Preserving as many as possible of the plants that support us directly as food, medicine, and building materials and indirectly by maintaining the conditions that make our lives sustainable will be an increasing challenge in the immediate future, owing to our population growth and the climate change that we are driving. With estimates that as many as a third of all kinds of organisms may have become extinct by the end of the century, it is clear that we must save as many of them and as much of their genetic diversity as we possibly can. China, which is home to more than 8% of the world's plant species, provides an important case in point.

Although Western-style botanical gardens have existed in China for only about a century, their number has increased over the years to more than 100 now. The holdings of these gardens are of particular interest, since China is home to one of the largest numbers of vascular plant species of any country, with some 31,362 enumerated in the most recent comprehensive account. Of these, 859–936 are naturalized from elsewhere, and 16,090, nearly half of the total, are endemic, i.e., found only in China. Excluding naturalized species, then, there are about 30,910 native species currently known from China. It is difficult to project how many additional native species may be found in China eventually, but a recent attempt estimates a total of approximately 36,500 species, which might turn out to be conservative.

In 2012, we initiated a project to find out how many vascular plant species were being cultivated in the botanical gardens of China.¹ We estimate that there

are about 29,581 species, 4,315 genera, and 399 families held in these gardens. Among these cultivated species are 15,693 native to China, nearly half of the total known in the country at present (Figure 1).

Globally, about a third of the estimated 360–390,000 named species are cultivated in one or more botanical gardens worldwide.² Chinese botanical gardens hold some 8% of the total (Figure 1). In view of the well-known usefulness of Chinese plants for medicinal and other practical purposes, it is important to note that some 3,733 species of useful Chinese plants are being grown in the botanical gardens of China, amounting to about a quarter of the world total of useful plant species. The botanical gardens are also essential habitats for various insects and animals, especially in tropical botanical gardens. Ideally, a native forest area should be designed in botanical gardens whenever possible.

Botanical gardens in the modern sense originated in Italy about 500 years ago as demonstration gardens of medicinal plants for medical studies in universities. By the year 1600, the worldwide trade that built up following the early voyages of exploration had begun to bring home tens of thousands of additional plant species to Europe. Comprehensive botanical gardens of the kinds we know today began to be assembled and maintained for educational and ultimately recreational purposes. They became, in effect, living museums of the plant world.

Despite the staggering increase in the global human population from an estimated 1 billion people around 1800 to nearly 8 billion today and our unsustainable use of renewable resources (www.footprintnetwork.org), it was not until



Figure 1. *Ex situ* flora as a legacy of the Anthropocene seen by a botanical garden flora in Metropolis

about 50 years ago that the magnitude of the our environmental problems became apparent. Today, most scientists consider that we have already entered the early stages of the Sixth Major Extinction Event in the entire 4 billion year history of life on Earth.³

Human activities are entirely responsible for driving this problem. In response, what should we do to save as many plant species as possible?

The situation is clearly dire, with about 20% of plant species estimated to be in danger of extinction over the next few decades, and perhaps twice that proportion by the end of the 21st century. Three approaches to the conservation of plant species are available: (1) preserving their habitat in nature, (2) growing them in botanical gardens, and (3) preserving seeds and tissue cultures in seed banks or other low-temperature facilities.

Preserving species in their native habitats is the most direct and efficient approach, but the possibilities of doing so are becoming increasingly limited. Tropical forests and other vegetation are the habitats richest in species globally, and yet we are cutting these forests so rapidly that only small patches are projected to remain in place by the end of this century. Many of the "hotspots"—areas where large numbers of unique species are concentrated—are also particularly favorable for human habitation, so that their species are subject to pressures of many kinds. Despite many efforts to adopt international agreements to preserve natural areas intact,⁴ the results have been uniformly disappointing. Most species grow in relatively poor countries with limited possibilities of diverting funds to conservation; their rich counterparts have every intention of keeping the wealth they have accumulated and getting more if possible, and so lasting global conservation is difficult to accomplish effectively. Finally, global warming will certainly make it impossible in the coming decades for many plant species to survive where they are native or to migrate if they can do so.

In view of these considerations, cultivation in botanical gardens clearly is one of the primary ways to protect plant species from extinction. A major problem, however, arises from the fact that we normally have room to grow only a small number of individuals of any given species in a botanical garden. In such gardens, we want to exhibit as many species as possible, and space is always limiting. Many plant species are dioecious or genetically self-incompatible, which exacerbates the problems inherent in growing only one or a few individuals. In addition, living plants are subject to disease, so that small populations can be wiped out suddenly. In the longer run, global warming will make it increasingly difficult to maintain some plants in the botanical gardens where they are being grown now.

The third possible strategy for plant conservation, banking seeds at low temperatures combined with tissue cultures when seeds are not available or have short lives in storage, is most effective for the long run. We can often preserve genetically adequate samples for a century or more at cold temperatures and grow them to maintain their vitality as needed. To amplify their role in conservation, many botanical gardens have set up seed banks; they have been joined

in this effort by governmental and private entities. Perhaps 70,000 species of vascular plants are currently preserved in seed banks, amounting to about a sixth of the known species.⁵ Of the 30,910 native species known for China, some 11,000 are preserved in the Germplasm Bank at the Kunming Institute of Botany.

Some recommendations for botanical gardens follow from this discussion. Networking as with the global efforts of Botanic Gardens Conservation International (BGCI's) *PlantSearch* to discover and make available complete records of all species in cultivation in botanical gardens is of key importance. The *ex situ* Flora of China project presents a guide for selecting additional to cultivate or for seed banking, with priority given to species on the verge of extinction. If we want to cultivate genetically adequate samples of plant species, we must find space in addition to the display areas of botanical gardens. We also suggest that when possible, all botanical gardens take up gathering seeds for seed banking (or tissue culture when necessary) as an important part of their activities.

Collaboration between all botanical gardens in China has the potential of making possible the effective conservation of the nation's rich and diverse flora, and current initiative China National Botanical Garden System is playing a leading role. The opportunity to preserve many species of plants is passing us by rapidly, and it is highly desirable to take action while there is still time to do so.

REFERENCES

1. Huang, H., Liao, J., Zhang, Z., et al. (2017). *Ex situ* flora of China. *Plant Divers.* **39**, 357–364.
2. Mounce, R., Smith, P., and Brockington, S. (2017). *Ex situ* conservation of plant diversity in world's botanical gardens. *Nat. Plants* **3**, 795–802.
3. Barnosky, A.D., Matzke, N., Tomiya, S., et al. (2011). Has the Earth's sixth mass extinction already arrived? *Nature* **471**, 51–57.
4. Díaz, S., Zafra-Calvo, N., Purvis, A., et al. (2020). Set ambitious goals for biodiversity and sustainability. *Science* **370**, 411–413.
5. O'Donnell, K., and Sharrock, S. (2017). The contribution of botanic gardens to *ex situ* conservation through seed banking. *Plant Divers.* **39**, 373–378.

ACKNOWLEDGMENTS

We are greatly thankful to all experts involved in *ex situ* Flora of China project for their extraordinary knowledge input and publication of *ex situ* Flora of China. We sincerely thank Mr. Zhang Yiqi and many others for their helpful efforts in collecting or sorting the raw datasets. H.H is especially grateful to Peter Crane, Steve Blackmore and Vernon Heywood for their valuable advice and critically generous reviewing this manuscript. We likewise acknowledge China National Science and Technology Infrastructure Program (2015FY210100).

DECLARATION OF INTERESTS

The authors declare no competing interests.