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Plant species with extremely small populations conservation program: achieving Kunming–Montreal global biodiversity targets

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Conservation programs for plant species with extremely small populations (PSESP) have been successfully implemented for several decades in China. Here we highlight how their inclusion in several national conservation policies helps meet targets of the Kunming–Montreal Global Biodiversity Framework (KMGBF) and show how lessons from these programs can be applied more widely.

Plant diversity is under serious threat at global, regional, and local levels, which in turn poses a risk to human wellbeing. Approximately 25% of evaluated plant species are believed to be endangered [1], leading to the potential loss of genetic resources of numerous plant species that may become extinct. In addition, if measures are not taken to reduce the factors that contribute to the decline of plant diversity, significant changes in ecosystem structure and functional degradation are expected in the near future.

According to the newest *Red List of Biodiversity in China – Higher Plants* (2020)[i], issued by the Ministry of Ecology and Environment and the Chinese Academy of Sciences, there are 36 072 plant species in China, of which 3942 species are threatened with extinction. Resources are not available to simultaneously conserve all these threatened plant species, so the conservation action concept of PSESPs has been developed [2]. This prioritizes the conservation of plant species with fewer than 5000 mature individuals in total and fewer than 500 mature individuals in each isolated population [3]. Plant species with fewer than 1000 or even 100 mature individuals are given the highest priority for urgent rescue conservation actions [4]. Since 2009, around 100 PSESPs have been successfully conserved by various conservation actions, including establishing mini-reserves, *near situ* conservation (establishment of populations at sites near the wild populations), *ex situ* conservation, population reinforcement, and reintroduction and restoration. The first botanical garden involved in PSESP, Kunming Botanical Garden, has successfully established *ex situ* populations of 86 species. An additional 240 PSESPs in southwest China have had comprehensive field surveys, data documentation, and germplasm resources conserved through the national key program supported by the Ministry of Science and Technology [3]. Moving forward, inclusion of PSESP conservation in national policies and plans, such as the new Ecological Redline Policy (ERP) and the 14th Five-Year Plan (2021–2025) for National Economic and Social Development is the long-term target for 2030.

The KMGBF[ii] agreed in December 2022 aims to halt and reverse biodiversity loss. The framework has four long-term goals for 2050 and 23 global targets that specify actions that need to be initiated immediately and completed by 2030. Here we identify nine targets from the framework that align with the objectives and implementation of conservation actions for the PSESP (Table 1).

The main long-term goal of the KMGBF is to reduce threats to biodiversity, which includes eight urgent targets. Six of these targets can be achieved by implementing conservation actions in the PSESP programs. Target 1 aims to prevent the loss of areas of high biodiversity importance though spatial planning. This aligns with China's Ecological Redline Policy, which considers PSESP presence when identifying such areas. Target 2 focuses on restoring degraded habitats to improve biodiversity and ecosystem services. Restoration is a key tool in the PSESP program, with *Malania oleifera* being used to restore karst ecosystems in southwest China. Target 3 aims for 30% protected area coverage by 2030. The establishment of mini-reserves for PSESP populations, totaling approximately 3000 ha so far, contributes to achieving this target (Table 2). Additionally, the definition of 'other effective area-based conservation measures' in Target 3 could potentially include the much larger areas protected under the Ecological Redline Policy.

The PSESP program focuses on species-level conservation and targets plants under immediate threat of extinction. This aligns perfectly with Target 4, which calls for 'urgent actions to halt human-induced extinction of known threatened species', and also emphasizes the importance of genetic diversity. Actions promoted include *in* and *ex situ* conservation and sustainable management. Target 5 addresses the need to prevent over-exploitation of economically valuable plants, which can apply to the many PSESPs that have high economic value [2]. For example, *M. oleifera* is currently the best candidate for the production of nervonic acid, a fatty acid of considerable medical interest [5,6]. As a result, large amounts of fruit from wild trees have been harvested over consecutive years, resulting in a scarcity of seedlings in their natural habitat.

Targets 6 and 7 deal with invasive species and pollution impacts, respectively, which are not major concerns for the existing

Table 1. The goals, targets, and main contents of the Kunming–Montreal Global Biodiversity Framework in relation to the PSESP conservation program

Goal[a]	Target[b]	Main content	How implementation of the PSESP program can promote the target
1. Reducing threats to biodiversity	1	Ensure that all areas are under participatory integrated biodiversity inclusive spatial planning and/or effective management processes addressing land and sea use change, to bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030	Areas where PSESPs are located are protected according to Ecological Redline Policy (ERP) guidelines for identifying areas of high biodiversity importance
	2	Ensure that by 2030 at least 30% of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration	*Ex situ* conservation and reintroduction of PSESPs that grow in degraded habitats facilitates restoration
	3	Ensure and enable that by 2030 at least 30% of terrestrial, inland water, and of coastal and marine areas – especially areas of particular importance for biodiversity and ecosystem functions and services – are effectively conserved and managed through protected areas and other effective area-based conservation measures	Several mini-reserves have been established for *in situ* conservation of populations of PSESPs outside nature reserves. Areas protected under the ERP may qualify as 'other effective area-based conservation measures'
	4	Ensure urgent management actions to halt human-induced extinction of known threatened species and for the recovery and conservation of species, in particular threatened species, to significantly reduce extinction risk, as well as to maintain and restore the genetic diversity within and between populations of native, wild, and domesticated species to maintain their adaptive potential, including through *in situ* and *ex situ* conservation and sustainable management practices, and effectively manage human–wildlife interactions to minimize human–wildlife conflict for coexistence	This is the focus of the PSESP program. Moreover, conservation genomic studies are a core part of the PSESP approach to conservation and ensure that conservation actions for each species are optimized for maintaining genetic diversity and adaptive potential
	5	Ensure that the use, harvesting, and trade of wild species is sustainable, safe, and legal, preventing over-exploitation, minimizing impacts on non-target species and ecosystems, and reducing the risk of pathogen spill-over, applying the ecosystem approach, while respecting and protecting customary sustainable use by indigenous peoples and local communities	Prevention of over-exploitation is one of the key requirements for conserving PSESPs with high economic values, such as *Malania oleifera*, *Paris* spp., *Firmiana major,* and orchids
	8	Minimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solution and/or ecosystem-based approaches, while minimizing negative and fostering positive impacts of climate action on biodiversity	Comprehensive field surveys provide accurate location data for the species distribution models used to predict climate change impacts. Genomic data can be used to identify populations vulnerable to genotype–environment mismatch, so appropriate conservation actions can be taken
3. Tools and solutions for implementation and mainstreaming	14	Ensure the full integration of biodiversity and its multiple values into policies, regulations, planning, and development processes, poverty eradication strategies, strategic environmental assessments, environmental impact assessments and, as appropriate, national accounting, within and across all levels of government and across all sectors, in particular those with significant impacts on biodiversity, progressively aligning all relevant public and private activities, fiscal and financial flows, with the goals and targets of this framework	The PSESP program has been widely adopted in China at the national and provincial government levels and, for individual species, by local governments. Financial support comes from both national and provincial governments. PSESPs have been incorporated in national guidelines for environmental impact assessment and provincial regulations for biodiversity conservation
	21	Ensure that the best available data, information, and knowledge are accessible to decision-makers, practitioners, and the public to guide effective and equitable governance, integrated and participatory management of biodiversity, and to strengthen communication, awareness-raising, education, monitoring, research, and knowledge management, and, also in this context, traditional knowledge, innovations, practices, and technologies of indigenous peoples and local communities should only be accessed with their free, prior, and informed consent, in accordance with national legislation	Most PSESP data can be accessed online by decision-makers, practitioners, and the public[iv]. Several books on PSESP have been published in Chinese to build awareness

Table 1. (continued)

Goal[a]	Target[b]	Main content	How implementation of the PSESP program can promote the target
	22	Ensure the full, equitable, inclusive, effective, and gender-responsive representation and participation in decision-making, and access to justice and information related to biodiversity by indigenous peoples and local communities, respecting their cultures and their rights over lands, territories, resources, and traditional knowledge, as well as by women and girls, children and youth, and persons with disabilities, and ensure the full protection of environmental human rights defenders	PSESPs that occur in remote areas can only be conserved with the informed participation of local communities, including ethnic minorities

[a]Only two of four long-term goals are shown.
[b]Numbers refer to the targets of the PSESPs program.

PSESPs currently but may become so in the future. Target 8 deals with climate change, which will likely impact all wild species. The extensive genomic data collected for PSESPs will enable the identification of populations and species vulnerable to genotype–environment mismatch under future climates [7], while the comprehensive field surveys provide the data needed to predict climate change impacts and to identify sites where new populations could be established, using species distribution models.

In addition to these targets for reducing threats to biodiversity, the implementation of the conservation actions for PSESPs also promotes three additional targets of the KMGBF: Targets 14, 21 and 22. Target 14 emphasizes the integration of biodiversity into policies, regulations, planning, and development processes at all levels of government and across all sectors. The clarity and simplicity of the PSESP concept have facilitated its widespread adoption in China, from the national to provincial levels and local levels of government. Fiscal and financial support for conserving PSESPs comes from both national and provincial levels. Target 21 focuses on access to data, which is also a goal of the PSESP program. Most PSESP data can be accessed online[iii], and several monographs have been published in Chinese, providing information on the conservation and research progress of PSESP (e.g., the conservation and research progress in Yunnan, documenting 152 PSESPs). Finally, Target 22 addresses the importance of inclusive representation and participation

Table 2. Examples of successful programs for the integrated conservation of PSESP in China [9]

Species	Location and individual numbers	Conservation actions	Mini-reserves
Acer yangbiense	Two sites in Dali, Yunnan; 577 individuals	*Ex situ* conservation: four sites; *in situ* conservation: one site; reintroduction: three sites	Three sites covering a total area of 95 ha
Manglietiastrum sinicum	Seven sites in southeast (SE) Yunnan; 52 individuals	*Ex situ* conservation: two sites; *in situ* conservation: six sites; reintroduction: four sites	One site where both *M. sinicum* and *M. ventii* occur, 2700 ha
Manglietia ventii	Five sites in SE Yunnan; 2452 individuals	*Ex situ* conservation: two sites; *in situ* conservation: two sites; reintroduction: one site	
Craigia yunnanensis	Six sites in south and SE Yunnan, plus one site in Guizhou; 102 individuals	*Ex situ* conservation: three sites; *in situ* conservation: four sites; reintroduction: one site	One site, 30 ha
Nyssa yunnanensis	Two sites in south of Yunnan; ten individuals	*Ex situ* conservation: five sites; *in situ* conservation: one site; reintroduction: one site	One site, 10 ha
Quercus sichourensis	Two sites in SE Yunnan, plus one site in Guizhou; 11 individuals	*Ex situ* conservation: two sites; *in situ* conservation: one site; reintroduction: two sites	One site, 5 ha
Malania oleifera	16 sites in SE Yunnan and West of Guangxi, 14 000 individuals	*Ex situ* conservation: two sites; *in situ* conservation: three sites; reintroduction: one site	None
Pinus squamata	One site in Qiaojia, Zhaotong, north part of Yunnan, 34 individuals	*Ex situ* conservation: seven sites; *in situ* conservation: one site; reintroduction: one site	None
Dipteronia dyeriana	Three sites in SE Yunnan, 14 969 individuals	*Ex situ* conservation: three sites; *in situ* conservation: one site; reintroduction: one site	None
Firmiana major	Eight sites in North Yunnan and South Sichuan province, around 5000 individuals in total	*Ex situ* conservation: two sites; *in situ* conservation: one site; reintroduction: one site	One site, 6 ha
Poncirus × *polyandra*	Extinct in the wild, only three individuals cultivated in Fumin, Yunnan	*Ex situ* conservation: three sites; *in situ* conservation: no sites; reintroduction: one site	None

in decision-making. Given that many PSESPs in China occur only in mountainous areas inhabited by minority ethnic groups, the informed participation of local communities is essential for their conservation. For example, the Bai minority participate in the conservation of *Cinnamomum chago*, whose fruits can be harvested for use as nuts and to extract oil [5].

Within China, the successful implementation of PSESP conservation, together with other national conservation actions – such as the construction of National Botanical Gardens (for *ex situ* conservation) and National Parks (for *in situ* conservation) – will contribute significantly to achieving the biodiversity conservation targets of the KMGBF. Moreover, there is nothing China-specific about the need for national, regional, and local support for conservation, or the advantages of clear definitions and achievable aims, so the PSESP conservation framework could also serve as a model for similar initiatives in other countries around the world. The PSESP concept has already been adopted for plant conservation in Mexico [8] and Italy [9], and the first international training course on conservation of PSESPs was held in China in 2023, with participants from 12 Asian countries [10]. It is difficult to estimate the total number of plant species globally that meet the PSESP definition, because conservation risk assessments are usually based on a small geographical range rather than small populations, but it will almost certainly exceed 10 000. Given that these species are likely to be the ones in most immediate danger of extinction, it is clear that a geographically broader application of the PSESP concept could make a substantial contribution to meeting global plant conservation targets.

The PSESP program has so far focused on vascular plants, but this focus reflects its origin in botanical gardens, and a taxonomically broader application of the concept is possible. Within China, the application of the PSESP concept to bryophytes and macrofungi has been proposed, and the concept has been applied in Yunnan Province to the conservation of several vertebrate species, including a bat (*Rhinopithecus tieti*), two species of gibbons (*Hoolock tianxing* and *Nomascus concolor*), the takin (*Budorcas taxicolor*), and the green peafowl (*Pavo muticus*) [11].

Finally, the success of the PSESP programs has, to a large extent, depended on its restriction to plants with extremely small populations. This has ensured a focus on the plant species in immediate danger of extinction, resulting in a total number of species whose conservation appears achievable – and thus fundable – at the national level, and it has created local conservation flagships that attract public and official support. It has also allowed the effective use of the full conservation toolbox, including molecular genetics. If the concept was broadened to include all threatened plant species – around 4000 species in China – it would lose most of these advantages. However, many currently threatened species of plants and animals have larger populations, yet still need urgent conservation action [12]. Many of the general lessons from the successful PSESP programs can also be applied to these species, including the need to start with exhaustive field investigations, the importance of ensuring informed local support, and the necessity of species-specific conservation actions. The PSESP program in China has acted as a training ground for plant conservation in China and could serve a similar role in other countries.

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Declaration of interests

The authors declare no competing interests.

Resources

[i]www.mee.gov.cn/xxgk2018/xxgk/xxgk01/202305/t20230522_1030745.html

[ii]www.cbd.int/gbf

[iii]http://psesp.genobank.org/

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