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How to conserve threatened Chinese plant species with extremely small populations?

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ABSTRACT

The Chinese flora occupies a unique position in global plant diversity, but is severely threatened. Although biodiversity conservation in China has made significant progress over the past decades, many wild plant species have extremely small population sizes and therefore are in extreme danger of extinction. The concept of plant species with extremely small populations (PSESPs), recently adopted and widely accepted in China, lacks a detailed description of the methodology appropriate for conserving PSESPs. Strategies for seed sampling, reintroduction, protecting PSESP locations, managing interactions with the local human population, and other conservation aspects can substantially differ from those commonly applied to non-PSESPs. The present review is an attempt to provide a detailed conservation methodology with realistic and easy-to-follow guidelines for PSESPs in China.

1. Introduction

China is a globally recognized biodiversity center, harboring more than 30,000 higher plant species of which approximately 10,000 are endemics (Yang et al., 2005). Besides tremendous diversity and high endemism, the Chinese flora contains a large number of relic lineages of plant taxa. All these features give the Chinese flora a unique position in global plant diversity. Unfortunately, rapid economic development, population growth, intensive agriculture and the over-harvesting of timber and medicinal plants have led to serious destruction or alteration of the natural environment which has resulted in the extinction or decline of many species. At least 200 species have become extinct over the past 50 years (Chinese State Report on Biodiversity Editorial Committee, 1998) and *c.* 5000 species are currently threatened or on the verge of extinction, making China one of the highest priorities for global biodiversity conservation. Destruction and/or fragmentation of natural habitats in virtually all biomes of China are the most important causes of plant extinction. I will not go into the history of plant conservation in China as this subject is beyond the scope of this paper. Nor will I cover the current situation with protection of threatened species in China as this information can be found elsewhere (Liu et al., 2003; López-Pujol et al., 2006; Huang, 2011). Instead, my goal here is to present an analysis of current conservation practices in China, make a rough estimation of their effectiveness, and, after identifying the problems, to propose some possible solutions.

The major document regulating plant conservation in China is *China's Strategy for Plant Conservation* (China's Strategy for Plant Conservation Editorial Committe, 2008), which formulated the nation's commitment to plant conservation and established targets to reduce the ongoing loss of plant diversity. Implementation of this plan is coordinated by the Chinese Academy of Sciences, State Forestry Administration and the Ministry of Environmental Protection. The strategy serves as a framework for Chinese plant conservation and includes 16 targets. The two targets most relevant for conservation of endangered plant species aim to protect ~90% of China's national key protected plants through *in situ* efforts (Target 7), and to reintroduce 10% of China's threatened plant species to

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their natural habitats and establish monitoring programs to track management success (Target 8). However, the progress of plant conservation in China is impeded by several factors. First, the criteria for prioritizing species to be protected are unclear. Second, detailed methodological conservation guidelines that can be efficiently applied to threatened species in China are absent.

In 1999, the State Council of China promulgated a list of National Key Protected Wild Plants (First Group) of 419 species to be legally managed and protected by the central government. In 2004, Wang and Xie (2004) published the *China Species Red List* (Vol. 1) based on IUCN classifications and academic experts recommendations, which substantially differed from the National Key Protected Wild Plants list. Unfortunately, only plant species listed in the latter list have been subject to conservation actions (Ma et al., 2013). The incongruence between the two lists has left many threatened species out of active conservation. In addition, the IUCN Red List approach has recognized limitations (Possingham et al., 2002; de Grammont and Cuaron, 2006; Miller et al., 2007; Mace et al., 2008; Harris et al., 2012) as will be discussed below.

In 2012, the State Forestry Administration of China formulated the "Conservation Program for Wild Plants with Extremely Small Population in China" as their 2012–2015 operational plan. The term "extremely small population" refers to a population having a narrow geographical distribution which has resulted from some negative external factors over a long time, and whose numbers are smaller than the minimum required to prevent extinction (State Forestry Administration of China, 2012). This was an important stage in Chinese plant conservation. Indeed, most endangered Chinese plant species are represented by very small populations (hereafter PSESPs), and must be the first priority for conservation. A survey conducted by the State Forestry Administration between 1997 and 2003 identified 189 national key protected wild plant species, most of which have fewer than 5000 individuals, with 11 having fewer than 10 individuals in natural populations. It should be noted that these numbers do not distinguish reproducing and non-reproducing adults, and may also include very young plants that will never reach adult stage.

Surprisingly, the newly formulated Chinese policy focus on PSESPs (Ren et al., 2012) has not been followed by amendments to the routinely applied plant conservation methodology. Although PSESPs have received much attention in the recent literature (Ren et al., 2012; Ma et al., 2013; Ma and Sun, 2015; Sun and Han, 2015; Yang et al., 2015b), no publications have provided a detailed description of the methodology appropriate for conserving PSESPs. The conservation methods appropriate for PSESPs are briefly presented in Ma et al. (2013). Undoubtedly, all the steps the authors propose are appropriate and important, but details on how they should be performed are not provided. Strategies for seed sampling, reintroduction, protecting PSESP locations, and interaction with the local population can substantially differ from those routinely applied to non-PSESPs. Ren et al. (2012) summarize the appropriate conservation strategies for PSESPs in China as involving: "(1) initiating the national key protected wild plants resources survey and established resource information systems; (2) improving the network of nature reserves and focusing on *in situ* conservation; (3) establishing networks for national botanical gardens and strengthening *near-in situ* conservation and *ex situ* conservation; (4) increasing the construction of breeding centers and combining *in situ* and *ex situ* conservation; (5) combining habitat protection and habitat restoration; (6) improving and expanding the species' living space; (7) rationally combining conservation, germplasm preservation, and sustainable utilization; and (8) conservation may also include overall planning; government guidance, participation and cooperation by scientists, government, and the public in creating realistic policies and regulations, and emphasis on international cooperation and public education". Some of the listed measures can be easily understood and are unquestionably very important, e.g., "combining habitat protection and habitat restoration". Others are equally important but require some explanation and more details. For example "improving the network of nature reserves and focusing on *in situ* conservation" is indeed an important task, but how should the network be improved: by an increase in number of reserves, changes in reserve management, closer coordination between the reserves or something else? Unfortunately, this is not explained. An urgent necessity for properly described conservation methodology for PSESPs motivated this study. The present review is an attempt to provide a detailed conservation methodology with realistic and easy-to-follow guidelines for PSESPs in China.

2. Identification of the species protection category

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. However, although the general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk, the system criteria do not work well when applied to PSESPs. The IUCN Red List Criteria assume that the populations exhibit a normal demographic structure in which all the life cycle stages are present. This, however, is rather the exception than the rule with Chinese PSESPs. The fact that the species is represented by a very small population(s) is already an alarm that something is wrong with its demographic structure. Indeed, virtually all species with extremely small population sizes have abnormal population demographic structures. Some lack saplings, others lack seedlings or produce no seeds. Application of the IUCN rules related to decrease in area of occurrence/occupancy or population size has no meaning if most or all the individuals comprising a population cannot reproduce or the seeds produced do not germinate. This means that for many, if not most, of the PSESPs the current protection status is misleading and these species are actually at the very verge of extinction. For example, *Davidia involucrata* is not even included on the list of threatened Chinese plants, but all the natural populations of this species show no signs of regeneration. The majority of the plants in natural populations of this species are old (>50 years old) trees and no seedlings/saplings have been observed in these populations for the last few decades (Ma and Li, 2005; Zhang et al., 2008). The seeds produced are viable, but they do not germinate under natural conditions. On the other hand, thousands of *D. involucrata* trees have been produced artificially for landscaping in cities and many have been planted in Botanical Gardens and Arboreta. Has the artificial production and planting helped the species recover? There are no indications that it has. This example shows that neither reduction in the area occupied by a population or the population size itself can provide a reliable estimate of how endangered the species is. Similarly, Li et al. (2012) showed that lack of naturally regenerated seedlings in *Metasequoia glyptostroboides* calls into question the criteria used to define conservation program success, and suggested that the criteria for delisting species should not be based solely on the number of extant plants and their distribution ranges. Other examples of species for which no seedlings have been observed in natural populations include *Magnolia sinica* (Wang et al., 2015), *Camellia changii* (Ren et al., 2014), *Acer yangbiense* (Weibang Sun, personal communication), *Quercus (Cyclobalanopsis) sichourensis*, *Pinus squamata*, *Nyssa yunnanensis*, *Annamocarya sinensis*, *Malania oleifora*, *Camellia fascicularis*, *Glyptostrobus pensilis*, *Diploknema yunnanensis*, and *Euryodendron excelsum* (Sun, 2013). I propose that distorted population demographic structure must be adopted as