Need of a paradigm shift to conserve endangered species in China's national park system

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CHINAS EVOLVING NATIONAL PARK DESIGNATIONS AND SINGLE LARGE PROTECTED AREA OR SEVERAL SMALL PROTECTED AREAS (SLOSS) DEBATE

As of 2021, the International Union for Conservation of Nature estimated that there are over 6,000 national parks (NPs) in more than 100 countries, most of which are strongly focused on endangered species.[1] Over the past 6 years, China has invested US $20 million in developing the Giant Panda National Park (GPNP) and a further US $16 million in establishing the Northeast China Tiger and Leopard National Park (NCTLNP). Additionally, a naturally protected area (PA) management system with NPs as the main body was planned to be built, along with the newest Asian Elephant National Park. These NPs promote the conservation of specific rare or endangered species at the landscape scale by incorporating a diaspora of small, former PAs into a single management unit to address the conservation gaps and issues of overlapped management among PAs (Figure 1A, top two).

However, existing NPs in China have not yet been developed to include several local populations. For example, the GPNP includes only 13 of 33 local giant panda (*Ailuropoda melanoleuca*) populations, covering only 58.48% of the total giant panda habitat, while excluding local populations in the Qinling, Xiaoxiangling, and Liangshan ranges (Figure 1B).[2] Similar problems have been affecting conservation of the Amur tiger (*Panthera tigris altaica*) in the NCTLNP, which includes only one of the three known core distribution ranges. Although the largest Amur tiger population is covered under NPs, protection of marginal populations and habitats remains insufficient.

Consequently, these geographically extensive but costly species-specific NPs aim to not only address conservation gaps and disparities in the management of original PAs but also raise the problem of whether a single large PA is appropriate, as formalized by the SLOSS debate.[3]

IMPORTANCE OF LOCAL POPULATION-BASED CONSERVATION

Functional and operational intraspecific units are important concepts in population ecology, particularly landscape genetics and genomics. Isolation by distance because of geographic or other environmental factors can cause dispersed local populations to exhibit genetic, morphological, behavioral, and life history differences.[4] Consequently, managing these populations according to a single set of criteria may prove suboptimal.

In some cases, conservation of local populations in NPs has been neglected. For example, in the case of the grizzly bear (*Ursus arctos*) population in the Yellowstone National Park, conserving the overall population of grizzly bears rather than distinct genetic populations within the park was the prime focus. Consequently, genetic diversity within local populations was lost, which could have negative consequences for the long-term survival and adaptability of this species. Similar cases were observed for the Northern Rocky Mountain gray wolf (*Canis lupus*) population in the Yellowstone National Park, the African forest elephant (*Loxodonta cyclotis*) in the Virunga National Park, red-cockaded woodpecker (*Leuconotopicus borealis*) in the southeastern United States, and the Arabian oryx (*Oryx leucoryx*) in the United Arab Emirates (UAE). These cases highlight the importance of considering the conservation of local populations and their genetic diversity within NPs.

POSSIBLE APPROACHES FOR IMPROVEMENT

We propose that a SLOSS analysis should be performed for the major existing NPs in China. Three possible management methods should be evaluated: (1) integration of all regions by eliminating fragmentation and managing them under a single regime, (2) integration of some areas under unified management but other areas under independent management, and (3) independent management of each local population (Figure 1A, bottom).

Here, we use giant pandas as examples to address these questions. In China, 33 local populations of wild giant pandas have been recognized; however, although the newly established GPNP contains several local populations,[2] the park's boundary was designated by considering the habitat limits and the administrative boundaries of pre-existing nature reserves rather than being guided by the natural geographic barriers that delineate local populations (Figure 1B). The park spans 590 km from north to south across 6 mountain ranges. The climate, community composition, and ecosystem functions vary considerably across the park, and local panda populations face various threats and pressures; consequently, they have likely evolved local adaptations.[2,5] Genetic differentiation between local populations from different mountains suggests that the Qinling Mountains should be managed independently (Figure 1B, bottom).

Although the minimum viable population size for giant pandas is 40 individuals, only eight of 33 local populations currently comprise more than 40 individuals, distributed in four concentrated regions (i.e., Qinling, Minshan, Qinglaishan, and Liangshan).[2,5] The giant panda habitat is subject to severe fragmentation, primarily caused by a combination of natural factors, such as large rivers, tall mountains, and seismic events, as well as human activities, including deforestation, road construction, and agricultural expansion.[2,5] Consequently, small local populations may have been isolated from neighboring large populations. These smaller populations may receive minimal gene input from the larger populations through restricted corridors. However, internal connectivity among these small populations is challenging, and they face a high risk of local extinction if they are further isolated from neighboring large populations, especially because of human intervention.[4,5]

Therefore, based on the size of local populations and their genetic differentiation, there are four core populations in these mountains (two inside GPNP and two outside GPNP; Figure 1B, top), with other small local populations functioning as "satellite" populations, comprising "source-sink" populations or metapopulations. However, the four source populations are distributed in different mountains and are isolated by natural and man-made barriers, such as rivers and roads. Accordingly, habitat management and restoration measures differ. Therefore, to manage giant pandas in the newly established GPNP, two core populations (in the Minshan and Qionglaishan mountains; Figure 1B, top) should be recognized, and habitat fragmentation should be eliminated to connect small populations. Moreover, local populations outside of the park (in the Qinling and Liangshan mountains; Figure 1B, top) should be managed by integrating existing nature reserves to create source-sink dynamics around the two large core populations.

PARADIGM SHIFT TO CONSERVE LOCAL POPULATIONS IN NPs

Analyzing giant panda populations can help in designing other species-specific NPs that can ensure continued population viability. This highlights the need for a

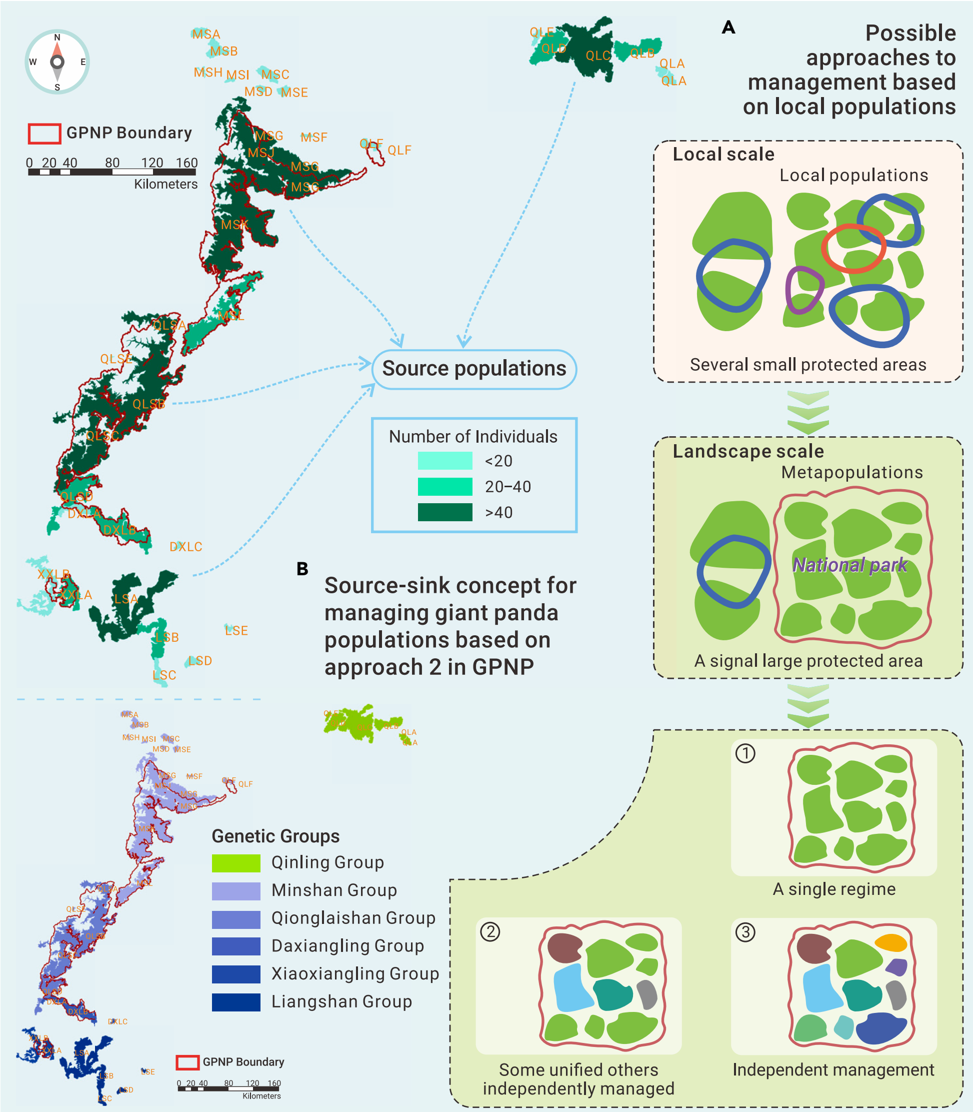

Figure 1. SLOSS debate options for China to manage NP designations (A) Three possible approaches to management based on local populations. The irregular circles with different colors indicate different types of original PAs: nature reserve (blue), scenic area (purple), and forest park (orange). The reddish-brown line depicts an NP, and the establishment of the NP integrates former individual PAs. The irregular polygons denote local populations, with different colors indicating management under different regimes. (B) Source-sink concept for managing giant panda populations based on approach 2 in GPNP. Giant pandas in different mountains (bottom) show clear genetic differentiation,[4] and the population size of local populations, labeled by uppercase font, differs (top). Data were obtained from the Fourth National Giant Panda Survey.

paradigm shift to conduct SLOSS analyses before further NPs are established to delineate local populations based on natural geographic environmental factors.[3] This should then be followed by large-scale population genetics and genomics studies to establish the genetic structure, diversity, and gene flow dynamics between local populations. In the past, several studies applied a population viability analysis (PVA) for giant pandas, but they either focused on single local populations or individual giant pandas in a reserve.[4] Thus, a spatially explicit PVA, including multiple local populations at the landscape scale, is urgently needed. A PVA should be conducted based on the existing metapopulation approach, which integrates the population size, population density, habitat area, and spatial distribution of pandas, along with environmental factors and anthropogenic disturbances affecting the local populations.[5]

CONCLUSION

In conclusion, the optimal designation and subsequent management of NPs depends on effectively integrating the general benefits of landscape-scale conservation for source-sink populations or metapopulations while being adaptive to the specific conditions and requirements of local population conservation. This can be possible by fully understanding the population structure and dynamics of protected species, based on which a theoretical framework, conservation strategies, and management measures can be proposed, thus indicating the need for a paradigm shift in China's PA system with NPs as the focus.

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DECLARATION OF INTERESTS

The authors declare no competing interests.