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Is Conservation Really Black and White?

Giant pandas. Most people, daresay everyone reading this article, have an immediate internal response to this species. What is your initial reaction? Is it positive? Or negative? Conservation success, or failure? How much do you really know about this unique species and its journey toward preservation?

Few species spark as much emotion and debate, and frequent misperception, as the giant panda. Among the general public it is a much loved icon subject to frequent anthropomorphism and occasional fanaticism. Biologists often think of it as a species fraught with reproductive issues and restrictive dietary requirements that threaten its survival. For many conservationists, it is viewed as a drain on limited resources for conservation with little return. But for many of us close to this species, the giant panda is an emerging conservation success story that demonstrates the benefits of comprehensive planning and extensive collaboration that can conserve a species, and possibly even more. Let us explain.

The Past – the 1980s and before

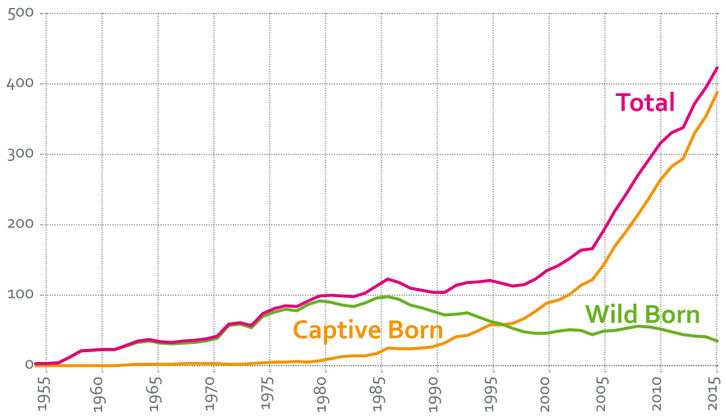
The giant panda has long been shrouded in mystery. Restricted to remote mountainous areas of western China, amazingly this species was unknown to all except local residents until 1869, even within China. This carnivore that eats bamboo and appears to have an opposable‘ thumb’ confused taxonomists and challenged early attempts to maintain captive specimens, adding to its mystic. Few individuals made it out of China for decades, making it a rare and little understood curiosity. All of that changed with Mao Zedong.

Its striking physical appeal and endemism combined with its absence from historic Chinese culture such as paintings and literature placed the giant panda in a unique position during the Culture Revolution. While Mao declared a‘ war against nature’ and rejected most cultural icons such as the Chinese tiger (Shapiro 2001), the giant panda was embraced as a symbol of modern China and acted as a catalyst, along with table tennis, to bridge relations between China and the West in the 1970s (Nicholls 2011). The resulting state gifts and eventual breeding loans of panda pairs have had widespread international impacts beyond the survival of this single species and helped to open China to the world.

For zoos receiving these high profile animals, however, breeding giant pandas posed challenges. Difficulties in breeding a solitary species with a short breeding season (1–2 day estrus once a year) and delayed implantation, combined with behavioral issues such as inexperience, incompatibility and disinterest, led to frequent reproductive failure. Newborn cubs are extremely small and altricial, which contributed to low survival. Public perception was, and often still is, that giant pandas reproduce poorly and are not viable long term in captivity. That indeed was the case at one time. All that has changed – and it is due primarily to extensive collaboration on an international scale toward common conservation goals and fueled by science. Each of the many partners in this decades-long effort has its own rich story to tell. Here we present one aspect in which we have been involved as population management advisors to the global *ex situ* population.

Figure 1

Census of the giant panda global captive population by origin from the 2015 International Studbook (data from Xie 2015).



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Pan Pan (ISB# 308), a 30-year-old wild-caught founder now retired at the Dujiangyan giant panda base, was an infamously prolific male, siring 29 cubs in 17 litters and accounting for 9% of the genetic composition of the current *ex situ* population.

The Beginning – the 1990s

At first, successful reproduction was slow and there were few surviving cubs. By 1980 the worldwide captive population had grown to 100 pandas, but most of the population was wild born. Population size remained at 100-115 pandas for many years, with births just compensating for fewer captures from the wild to prevent decline. But in 1997 something noteworthy happened – for the first time, and ever since, the number of captive-born giant pandas in captivity exceeded the number of wild-born individuals. Soon after, the population began to grow and become demographically sustainable. The future of the species in zoos was changed by a series of collaborative events that began in 1996 in Chengdu, China.

By the mid-1990s, several Chinese facilities were breeding giant pandas. However, only a few adults were successful breeders, thereby failing to capture genes from most wild-caught pandas and limiting population growth. Neonatal mortality, nutrition and health issues also plagued the population. A further complication was that captive pandas in China were managed both in zoological institutions (by the Chinese Association of Zoological Gardens – CAZG) and by State Forestry Administration (SFA) facilities such as Wolong. While institutions from these two different government ministries cooperated, there was no single, overall management strategy. Recognizing the need for a scientifically-based captive management plan, Chinese managers invited the IUCN SSC Conservation Breeding Specialist Group (CBSG) to facilitate the development of such a plan. No stranger to China, CBSG had facilitated the development of a studbook and masterplan for the Critically Endangered South China tiger just a year earlier in 1995. In late 1996, a CBSG-led team headed to Chengdu to begin this process for giant pandas.

Chinese workshop participants acknowledged their challenges and agreed that their goal was “to develop a self-sustaining population of giant pandas that will assist supporting a long-term, viable population in the wild” – a vision beyond the exhibition of pandas in zoos. International experts assisted in the analysis of problems related to reproduction and health as well as infrastructure and capacity building needs. While the challenges were great, so was the potential for success, and motivation was high. A biomedical survey of 61 giant pandas at the major Chinese breeding facilities during 1998-2000 identified behavioral, nutritional and health issues contributing to low reproductive success. Additional collaborations addressed health, capacity building and other issues. This fed into a CBSG-led workshop in early 2002 that established the structure of a Chinese scientific management committee that meets annually to share management and research achievements and to develop each year’s breeding plan (see Wildt *et al.* 2006 for more details).

We (the authors) were fortunate enough to participate in that inaugural 2002 meeting and have provided population management advice to the global giant panda program each year thereafter. Along the way we have witnessed its transformation into a well-managed, viable population that can contribute to the security and recovery of this endangered species.

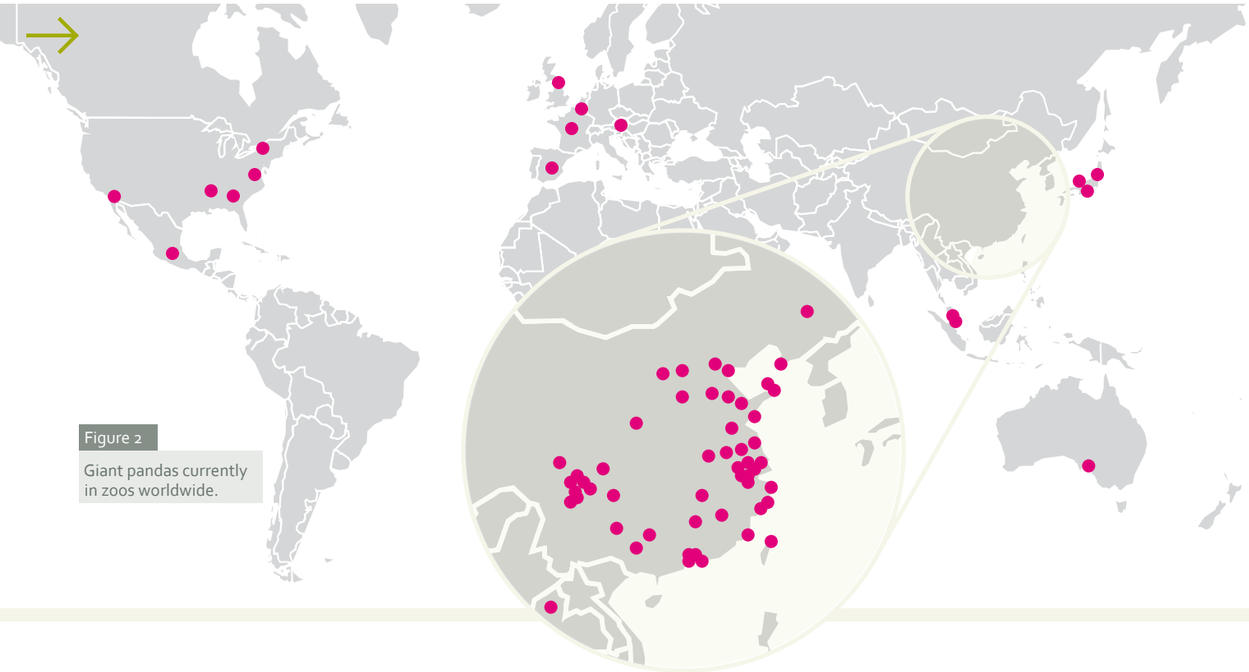

Figure 2

Giant pandas currently in zoos worldwide.

North America 17 pandas
- San Diego Zoo | US
- Memphis Zoo | US
- Zoo Atlanta | US
- National Zoological Park | US
- Toronto Zoo | Canada
- Chapultapec Zoo | Mexico

Europe 11 pandas
- Edinburgh Zoo | Scotland
- Pairi Daiza Zoo | Belgium
- Tiergarten Schönbrunn | Austria
- Zoo de Beauval | France
- Zoo Aquarium de Madrid | Spain

Asia outside of mainland China + **Australia & Oceania** 27 pandas
- Ocean Park | Hong Kong
- Seac Pai Van Park | Macau
- Taipei Zoo | Taiwan
- Chiangmai Zoo | Thailand
- Zoo Negara | Malaysia
- River Safari | Singapore
- Tokyo Ueno Zoo | Japan
- Kobe Oji Zoo | Japan
- Adventure World | Japan
- Adelaide Zoo | Australia

China 366 pandas
- Anji Bamboo Gardens
- Anyang Zoological Garden
- Baoxing Education Center
- Beijing Zoological Gardens
- Changsha Ecological Zoo
- Chengdu Research Base of Giant Panda Breeding
- Chengdu Zoological Garden
- Chongqing Zoological Garden
- Dafeng Zoo
- Dalian Forest Zoo
- Dujiangyan Giant Panda Base
- Emei Xianzhizhujian Ecological Park
- Fuzhou Giant Panda Research Center
- Guangzhou Zoological Garden
- Guilin Qixing Park Zoo
- Guizhou Forest Wild Animal Park
- Hangzhou Wild Animal Park
- Hangzhou Zoological Garden
- Hefei Wild Animal Park
- Huaying Mountain Giant Panda Wild Training Base
- Jinan Zoo
- Jinbao Paradise
- Langzhong Panda Paradise
- Lanzhou Zoo
- Linyi Botanical Garden
- Liugongdao Park
- Liuzhou Zoo
- Nanchang Zoological Garden
- Nanjing Hongshan Forest Zoo
- Ningbo Zoological Garden
- Northeast Tiger Garden
- Panyu Xiangjiang Safari Park
- Qingdao Zoological Gardens
- Sanjiang Ecological Tourism Zone
- Shanghai Wild Animal Park
- Shanghai Zoological Garden
- Shanxi Rare Wildlife Research Center
- Shenzhen Safari Park
- Shijizhuang Zoo
- Taihu Everglade Park
- Taiyuan Zoological Garden
- Tianjin Fude Zoo
- Tianjin Zoological Park
- Tianmuhu Garden
- Wenling Changyu Dongtian Scenic Spot
- Wenzhou Zoological Gardens
- Wolong Gengda Giant Panda Base
- Wolong Hetaoping Giant Panda Base
- Wuhan Zoo
- Wuxi Zoological Garden
- Xiazhuhu National Everglade Park
- Xiuning Giant Panda Ecological Park
- Xixiakou Wild Animal Park
- Ya'an Bifengxia Giant Panda Base
- Yangzhou Zoological Garden
- Yichang Children's Zoological Garden
- Zibo Yuanshan National Forest Park

The Present – 2000 to 2015

Over the past 14 years the giant panda population has developed into a demographically stable population, expanding from 152 pandas in 19 institutions in 2002 to the current (November 2015) population of 423 individuals in 78 institutions worldwide (Figure 1). While the rescue of an occasional wild individual occurs, 92% of the *ex situ* population is captive born. Annual growth ranged from 9–15% except when intentionally slowed. This demographically healthy population has a well-balanced age and sex structure that is the envy of many managed programs.

A variety of factors led to this strong population growth. Improvements in nutrition and veterinary care improved overall survival, and rearing protocols have increased neonatal survival. About 50% of litters consist of twins vs single cubs, yet it is difficult for females to rear two such altricial young that are only about 1/1000 of the size of the female at birth. The practice of periodically switching siblings between the mother and the nursery (with always one cub in each) allows both twins to survive and yet reap the benefits of being mother reared.

Improved understanding of factors affecting reproductive success has played a role, especially for females. Promoting successful mating behavior in males continues to be a challenge, and the extremely short estrus of each female leaves little time for adaptive learning. The development of successful artificial insemination (AI) procedures for giant pandas has provided a safety net. Most matings involve either natural mating by 2–3 males or natural mating by a single male followed by AI from multiple male donors, with relatively few matings relying solely on AI. Subsequent genetic testing verifies the paternity of offspring, and show that when both natural mating and AI are used, it is almost invariably the males that naturally mated with the female that are the offsprings' sires. While natural mating behavior is preferred, AI offers opportunities for reproducing genetic valuable non-breeding males and for cross-institutional transfers of sperm instead of living animals. In 2015 the first transfer of sperm from China to the US demonstrated the potential value of this technique for long-distance transfers. All of these achievements were the result of strong collaborations among dedicated managers, researchers and veterinarians within China and partner holding institutions around the world.

An important aspect in the success of the giant panda population is the concentration of pandas in a few large breeding centers in China. Within each breeding center lies a vast body of expertise in husbandry, veterinary care, and reproduction. A large number of individuals within a single facility provide options for mates when initial pairing attempts fail. Three Chinese facilities accounted for 80% of the births since 2002 and are the heart of the *ex situ* population.

Strong population growth and high levels of gene diversity retained (97%) allowed the setting of a lofty quantitative goal for this population that is seldom achievable or even considered – the retention of at least 90% gene diversity for 200 years, as originally recommended for captive populations by Soule *et al.* (1986). About 500 pandas (400–600, depending upon the intensity of genetic management) are needed to achieve this genetic goal set by the giant panda scientific committee in 2009; the population is now approaching its target size and can realistically meet this goal.

Resolving any demographic challenges to promote growth is essential for population viability, but it can be easier behaviorally, logistically and even politically than managing it genetically. Working to produce more little baby pandas is motivating. Purposefully reducing the number of cubs in favor of greater emphasis on breeding genetically valuable animals is more difficult to explain and enforce. As with most *ex situ* populations, reproductive success rates are often lower with individuals near the top of the mean kinship list, and the temptation to rely on good yet genetically over-represented breeders is strong, and especially so for giant pandas. In recent years the mantra "quality over quantity" has dominated the annual giant panda conferences and technical meetings. The genetic value of mated pairs (i. e., those with low Mate Suitability Index scores) is reported and applauded by both CAZG and SFA. While this change in priorities, from the number of baby pandas to the genetic value of those cubs, took several years before it was embraced, it now is accepted practice. As a result, gene diversity has not only been maintained but has increased from 96.9% in 2002 derived from 41 founders to 97.4% derived from 52 founders.

A One Plan Approach

Since the 1996 workshop, giant panda managers viewed the *ex situ* population as a tool to support pandas in the wild. The current officially stated goal of the *ex situ* program is:

The maintenance of a sustainable ex situ giant panda population that is genetically and demographically viable and can provide animals for release to support the wild population.

Recognized conservation roles of the *ex situ* population and related contributions of the *ex situ* community to giant panda conservation are:

- Source of giant pandas for reintroduction needs
- Insurance population against population decline or loss in the wild
- Research opportunities (e.g., disease prevention)
- Resource for developing techniques that can support wild panda conservation in China (e. g., censusing, health status)
- Economic and political benefits to support wild population conservation
- Resource for public education and public awareness

Management of the *ex situ* population is a shared collaboration between the CAZG zoos and the State Forestry Administration. Annual giant panda conferences intersperse presentations on the status, research and management of wild pandas with those of the *ex situ* population. Disease centers focus on the health of both captive and wild pandas, and *ex situ* facilities provide staging grounds for individuals transitioning between these environments.

Perseverance has been strong, and was needed when the May 2008 earthquake hit the Wolong breeding center in the mountains of Sichuan, home to 63 giant pandas at that time. The amazing dedication of and rescue efforts by the Wolong staff during this tragedy meant that only three pandas were lost in the resulting landscapes that destroyed the breeding center and 120,000 ha of giant panda habitat.

The rapid improvement in the viability of the *ex situ* population over the past two decades has been matched by similar improvements in the wild. The 2015 census, the fourth such National Giant Panda Survey completed every 10 years, estimates the wild population at 1,864 pandas, representing a 17% increase over the past decade. Advancements

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One of the 96 pandas at the Chengdu Research Base of Giant Panda Breeding, one of the primary breeding centers for the species.

The Future

have also occurred in the ecological understanding and management of wild giant panda populations. Wei *et al*. 2015 detail conservation efforts by the Chinese government that have halted population decline and outline ecological research that inform effective management actions, including the creation of 67 protected areas based on habitat models. This represents ~12% increase in giant panda geographic range since 2003 (WWF 2015).

These simultaneous achievements have laid the foundation for the next phase – the evolution of the *ex situ* population as a source population for release to reinforce existing wild panda population and/or establish new ones through reintroduction. A few trial releases have taken place since 2012 to investigate release training strategy. Now each year a few females are purposefully bred to produce offspring surplus to the needs of the *ex situ* population and are reared and trained for release. This fledgling program is expected to expand and provide direct support to the wild population.

The last 20 years have seen the development of a strong, demographically and genetically healthy giant panda *ex situ* population and significant protection of wild panda habitat and populations. Some challenges remain, however, and new ones are emerging. For *ex situ* populations, more improvements are needed to increase natural mating behavior and parental rearing opportunities. Timely paternity testing in cases of multiple possible sires will be important to maximize effective genetic management. The development of a formal genome resource bank (GRB) strategy for the systematic collection, storage and use of sperm (and other biosamples) with respect to clearly defined goals is recommended to provide additional management options and security. And of course, new opportunities await on the horizon for the development of effective reintroduction and reinforcement to support wild populations.

Wild pandas may face new challenges as habitat and land use patterns change with climate change. Other threats such as emerging diseases may come into play. Fragmentation and genetic isolation may become the biggest threat, increasing the conservation value of population reinforcement through translocation and the need for management at the meta-population level. With a third of the wild population living in non-protected areas, the expansion of protected areas would be beneficial. The large body of knowledge and research on the wild population provides real opportunities for adaptive management to address issues such as habitat quality, fragmentation, and climate change (Wei *et al*. 2015). These efforts can paint a brighter future for wild giant pandas – but the benefits do not stop there.

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Participants of the 2015 Annual Conference of the Chinese Committee of Breeding Techniques for giant pandas, representing many of the hundreds of individuals and institutions collaborating for the conservation of the giant panda.

Conserving Pandas

The giant panda serves as an umbrella species for the conservation of China's biodiversity. China's remaining endemic species are concentrated primarily in mountainous areas less impacted by human activities, much of which coincides with wild giant panda range. Over 96% of panda habitat overlaps with centers for endemic mammal, bird and amphibian species in need of protection (Li and Pimm 2015). Protection of any panda habitat therefore benefits many other endemic species.

Likewise, the giant panda *ex situ* program is serving as a ground-breaking model for the scientific genetic management of *ex situ* populations in China. Our work with the giant panda program has led to a series of capacity building efforts for CAZG in collection planning, studbook development, advanced population management and masterplanning, and to a dedication by CAZG to expand sound population management to more species within Chinese zoos. Panda breeding centers are considering expanding their population management strategies from giant pandas to their red panda populations. The success of this biologically and politically complex species program provides the tools and instills the confidence to consider intensive management for other species.

Can giant pandas be conserved in long-term, viable populations both *in situ* and *ex situ*? Should they be conserved? We think so. Long-term success appears achievable, and the benefits likely extend beyond this species – to increased capacity, increased habitat and biodiversity protection, and increased inter-agency and international collaborations with the goal of conservation. Could resources be better invested across a wider range of species? Probably. But the reality is that, at least for now, giant pandas are a high profile and attractive species that resonates with people across the globe, and conservation efforts seem to be working.

Our role has been a small one in this journey, and it has been our pleasure to watch the progress unfold around us. We thank the hundreds of incredibly knowledgeable and dedicated individuals, and especially our Chinese colleagues, for allowing us to join in on the adventure, and cheer them on to even greater future success. ■

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