Alleviating human poverty: A successful model promoting wildlife conservation in China

Xumao Zhao1,2 | Paul A. Garber3,4 | Ming Li2,5

1State Key Laboratory of Grassland Agro-Ecosystems, Institute of Innovation Ecology, Lanzhou University, Lanzhou, China
2CAS Key Laboratory of Animal Ecology and Conservation Biology, Institute of Zoology, Beijing, China
3Department of Anthropology and Program in Ecology and Evolutionary Biology, University of Illinois, Urbana, Illinois, USA
4International Centre of Biodiversity and Primate Conservation, Dali University, Dali, China
5Center for Excellence in Animal Evolution and Genetics, Chinese Academy of Sciences, Kunming, China

Abstract
Protecting biodiversity and reducing human poverty is a global challenge to all countries, including China, which has high biodiversity, large urban centers, and a large human population. Here, we discussed the effects of policies designed to alleviate poverty (Ecological Emigration, Ecological Restoration and Protection, and Ecotourism) on the conservation status of primates in China. We present evidence that improving human well-being and increasing the income of poor people in rural areas of China over the past two decades has had a positive effect on the population persistence of several species of nonhuman primates. However, we also identify inadequacies in the implementation of this policy which include the construction of infrastructures that fragment remaining forests and disrupt opportunities for gene flow, as well as practices associated with reforestation and the planting of monocultures rather than restoring natural habitat. Accordingly, we suggest that prioritizing biodiversity protection and habitat restoration in the implementation of China’s current economic policies to alleviate poverty represents a successful model for wildlife conservation.

Keywords
conservation, ecological emigration, ecological restoration and protection, eco-tourism, poverty alleviation policy, primate

1 | INTRODUCTION

In the past decade, countries in all regions of the world have identified protecting natural ecosystems and reducing human poverty as global challenges as outlined in the Convention on Biological Diversity and the Millennium Development Goals (Barrett, Travis, & Dasgupta, 2011). The World Wildlife Fund (WWF) reported that from 1970 to 2016, the global population of wildlife has declined by an average of 68%, and animal populations in many low-income tropical regions have decreased by as much as 94% (WWF, 2020). We are now confronting
the sixth mass extinction event, also referred to as the Anthropocene extinction (Barnosky et al., 2011). This extinction event has been driven largely by the unsustainable demands of a small set of consumer nations whose actions have resulted in the conversion of species-rich natural landscapes, in particular in tropical regions, into monocultures for industrial agriculture, cattle ranching, mining, and the construction of transportation networks (Estrada, Garber, & Chaudhary, 2020). Degradation of these ecosystems has exacerbated poverty, income inequality, and food insecurity in developing countries as the majority of goods produced are exported to global markets (Estrada et al., 2020; Estrada, Garber, & Chaudhary, 2019; Tallis, Kareiva, Marvier, & Chang, 2008). Approximately 60% of the world’s poorest people live in tropical regions (Gross, 2007).

Nonhuman primates represent an indispensable component of tropical and temperate community biodiversity, play a key role in ecosystem services (seed dispersal, pollination, predator-prey relationships, carbon sequestration), are important to the livelihood and religion of many peoples and cultures, and provide critical models for the study of human evolution, biology, behavior, and the threat of emerging diseases (Estrada et al., 2017, 2018, 2019). However, nonhuman primates are facing an impending extinction crisis, with 65% of over 500 species listed by the IUCN as vulnerable, endangered, or critically endangered (IUCN, 2020). Nonhuman primate population decline has been driven by human activities, principally the destruction of tropical rainforests. For example, between 2002 and 2020 some 64.7 million ha of humid primary forest has been lost (Global Forest Watch, 2021), with the greatest losses occurring in countries with the greatest number of primate species (Estrada et al., 2018).

China is one of the most primate-diverse countries in Asia. It is home to 25 extant primate species including lorises, macaques, colobines (langurs and snub-nosed monkeys), and gibbons (Li et al., 2018). Eighty percent of China’s primate species are listed as threatened by the IUCN (Li et al., 2018). Between 47.2–73.2% of the current primate distribution in China occurs in areas characterized by impoverished human populations (Zhao et al., 2021). Therefore, effective conservation strategies to protect China’s primates also must address social and economic issues needed to improve human well-being (Li et al., 2018).

Poverty remains a pervasive economic reality among the majority of citizens in southwestern China, which also is an important biodiversity hotspot for primates (Li et al., 2018). In 2017, the Chinese Ministry of Environmental Protection defined poverty as living on less than 1 $ a day. In addition, more than 80% of the poverty-stricken counties and 95% of poverty-stricken population in China live in areas that are considered ecologically fragile in the face of expanding industrial agriculture and climate change (Deng et al., 2016). Across these counties, the average index of ecological fragility, a measure of the “potential impacts of changing natural, social, economic, environmental, and health risks on the local human population” (Li, Wei, et al., 2017), is high and strongly correlated with poverty. Thus, with its human population of more than 1.4 billion people, China is facing a difficult and often contradictory set of decisions needed to balance the economic costs and benefits of development with the goals and benefits of conservation and environmental sustainability (Marques et al., 2019; West et al., 2014). In the face of rapid economic and technological advancement, increased educational opportunities, and its expanding human capital of scientists, the Chinese government has initiated a set of national policies designed to alleviate poverty and sustainably protect the environment. Here, we discuss the impact that policies focused on ecological immigration, habitat restoration, and ecotourism have had on alleviating poverty, promoting environmental sustainability, and conserving wild primate populations in China.

2 | ECOLOGICAL EMIGRATION: MITIGATING THE NEGATIVE EFFECTS OF HUMAN ACTIVES ON PRIMATES

The policy of ecological emigration, designed by the National Development and Reform Commission of China, represents a plan to relocate more than 10 million people from ecologically fragile and biodiverse areas by 2050. This program was initiated two decades ago, principally in the provinces of Mongolia, Gansu, Ningxia, Qinghai, Xinjiang, Tibet, Shaanxi, Yunnan, and Guizhou. By significantly reducing the demand for and restricting the hunting and capture of wild primates for meat, traditional medicine, and as amulets, this policy has had a positive effect on the conservation of nonhuman primates (Table S1, Supporting Information and Figure 1). Ecological emigration also can reduce local deforestation. Estimates indicate that residents living in regions, inhabited by the Endangered Yunnan snub-nosed monkey (Rhinopithecus bieti), consume an average 120–180 m³ of wood for house construction and fuel every year (Zhou, 2013). By reducing the size of the local human population and providing government assistance in the form of nonforest construction materials and cooking fuel (marsh gas), the remaining members of the community have reduced their dependence on local forest products.
Similarly, ecological emigration is expected to reduce the negative impacts of grazing, the collection of medicinal plants, wild vegetables, and mushrooms, and the clearing of forest for farmland on native wildlife (Figure 1). For example, between 1994 and 2016, the ecological emigration of 44,712 people from Lanping and Diqing counties, Yunnan Province (data from https://www.neac.gov.cn/ in 2016 and http://www.xinhuanet.com/ in 2017) is correlated with a 50% increase in the population of the Yunnan snub-nosed monkey (Zhao, Ren, Li, Garber, et al., 2019; Zhao, Ren, Li, Xiang, et al., 2019). Other studies indicate that the relocation of 1.47 million people from Sichuan, Shaanxi, and Hubei Provinces (Sang, 2015; Yu & Ni, 2016) and 3.23 million people from Guangxi and Chongqing Provinces has resulted in recent increases in the local population size of several endangered and critically endangered primate species (i.e., Rhinopithecus roxellana, Trachypithecus leucocephalus, Trachypithecus francoisi, and Nomascus hainanus; Table S1).

At present, China’s policy of ecological migration has not been uniformly implemented across all primate habitat regions, and in some areas the ecological migration policy has resulted in negative consequences for wildlife and the environment. For example, Guo (2016) reported that in Guizhou Province, a recent government program designed to repopulate the region resulted in the loss and fragmentation of mixed temperate broad-leaved and coniferous forests. In addition, in some regions policies initially designed to balance the needs of humans and wildlife were ignored in an attempt to maximize the immediate

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**FIGURE 1** Effects of ecological poverty alleviation on primate survivorship. The upward arrow represents a positive influence, and the downward arrow represents a negative influence.
goal of alleviating poverty. A case in point is the introduction of free-range horses and cattle into the Wanglang National Nature Reserve and the Baimaxueshan National Nature Reserve, which threaten the survival of giant pandas (Ailuropoda melanoleuca) and Yunnan snub-nosed monkeys (Li, Pimm, Li, Zhao, & Luo, 2017; Zhao, Ren, Li, Xiang, et al., 2019). In addition, immigrants are forced to leave their culture for a different environment, which has a negative effect on cultural adaptability particularly for ethnic minorities, such as religion, cultural traditions, living customs, and eating habits (Qi, 2011). Also, the moving for migrants to new cities and towns has not only changed their original life-style and but also made employment difficult, which has a negative impact on their livelihoods. In the process of ecological migration, the poor supervision might result in the local people's aversion and resistance, which is not conducive to the social stability in some areas. Furthermore, ecological migration can cause ecological capacity of land at lower level, severe ecological deficits, and negative impact on sustainability of the ecosystem in immigration areas (Wang, Hu, & Wu, 2018). Given that the policy of ecological migration can have both positive and negative effects on biodiversity and ecosystem’s health, detailed studies of the carrying capacity of local environments and species-specific differences in the response of wildlife to habitat modification are needed prior to the implementation of ecological migration policies.

3 | ECOLOGICAL RESTORATION AND PROTECTION: A DRIVING FACTOR IN PRIMATE POPULATION INCREASE

China’s long-standing policy of agricultural development required to feed its large human population has resulted in severe and widespread ecological degradation (Bryan et al., 2018; Godfray et al., 2010). In an attempt to mitigate the effects of environmental damage, the Chinese government has initiated programs of reforestation, afforestation, and habitat restoration such as Three-North Shelter Forest Program, the Natural Forest Protection Project (NFPP), the Grain to Green Program (GTGP) (Li, Wei, et al., 2017), and the Reverting Farmland to Forest Program.

Reforestation, which involves returning tree cover to previously deforested areas, is a first step in environmental recovery and alleviating poverty. State and local governments in China have invested 16.7 billion RMB to employ more than 1 million poor people as forest rangers to engage in reforestation programs (https://baijiahao.baidu.com/s?id=1646816419308189310&wfr=spider&for=pc). To date, 5,930,000 km² of land has been reforested (native and non-native trees were planted) (data from https://www.xuexi.cn/ in 2021). To this end, in Foping county, Shaanxi Province, between 1978 and 2020 the percent of forest coverage increased from 80.7 to 90.3% after 88.7 km² of farmland was reforested (National Bureau of Statistics, 2020). This provides additional habitat for the Sichuan snub-nosed monkey (R. roxellana) (He et al., 2018). Similarly, the amount of forest and forest coverage in the protected area of the Shennongjia National Natural Reserve (NNR) increased by 36% over a 40-year period after the implementation of the NFCP and the Sloping Land Conversion Programs (NFCP). The area of expanded habitat for the Sichuan snub-nosed monkeys increased by 14.3% (Wang et al., 2017) (Table S1). Similar reforestation programs have resulted in increases in the population size and viability of other primate species (Table S1). However, there exist several challenges associated with afforestation and reforestation including pest control or the potential for disease vectors with the planting of non-native species or large stands of monocultures, as well as the need for a sustained commitment to effective postplanting management (Wu & Zhao, 2018).

Between 1986 and 2017, the cumulative investment by the Chinese government in afforestation, or the planting of trees in naturally unforested areas increased from 10 billion RMB to 86.9 billion RMB per year (Li, Wei, et al., 2017). This served as both an environmental and employment program and resulted in an increased rate of per capita income in western China that was 30–50% higher than in wealthier regions. Some 150 million people have benefited financially from this program over the past 10 years and this has resulted in moving 3 million Chinese citizens out of poverty (Li, Wei, et al., 2017) (data from https://www.xuexi.cn/ in 2021).

Ecological restoration represents a long-term commitment to return an impacted environment back to a natural ecosystem and takes decades to accomplish. Restoration provides the most benefit to native wildlife including primates. Although reforestation provides some benefits for primate conservation, these are limited because the resulting forest does not closely resemble the original forest in terms of plant and animal species composition and habitat complexity. Programs of reforestation and afforestation in the native range of several gibbon species in China (Nomascus concolor, Nomascus nasutus, Nomascus leucogenys, Hoolock leuconedys, and Hylabates lar) have not benefited these primate species and two of these taxa (N. leucogenys and H. lar) are now considered extirpated from China (Fan, 2017; Li et al., 2018) (Table S1).
Ecotourism, which is regarded by many to represent a more ecologically friendly industry than traditional tourism (Li, Wei, et al., 2017), can play an important role in offsetting conflict between wildlife conservation and economic development, especially in poverty-stricken areas (Goodwin, 1996; Li, Wei, et al., 2017). The National Development and Reform Commission and the National Tourism Administration created the National Development Plan for Ecotourism in China (2016–2025). This program calls for ecological protection to be given top priority in ecotourism (http://www.gov.cn/xinwen/2016-09/06/content_5105784.htm).

Wild primates have long been regarded as an important component of economic development and tourism (Puentes & Gamerl, 2005; Hsu & Kao, 2009; Xu, 2004). In this regard, Xu (2004) reports that ecotourist sites in the natural forests occupied by rhesus macaques (Macaca mulatta) and Tibetan macaques (Macaca thibetana) can result in stable coexist, if managed properly and limitations are placed on the number and activities of ecotourists. Ecotourism worldwide has taken many forms ranging from small privately owned businesses to large government run agencies. In 2011, Hainan Province established China’s first experimental demonstration area of forest tourism (Geng, Li, & Zhang, 2017). The goal of this program was to achieve the goals of both sustainable economic development and environmental protection. Ecotourism in China has resulted in the creation of protected areas and national parks as a buffer between safeguarding natural areas and promoting economic development (Xu et al., 2017). For example, between 2003 and 2013 ecotourism focusing on R. bieti in the Baimaxueshan NNR, Yunnan Province, resulted in an increase in local family income of from 9,697 to 16,727 RMB per year (Xu, 2004; Zhou, 2013). In Shennongjia NNR, revenue generated from ecotourism increased from 1,585,000 USD in 2005 to 3,390,000 USD in 2010, with some proportion of these funds benefiting people in the local community (Xiang et al., 2011). Ecotourism also provides an opportunity to educate both the local community and the public on issues of conservation and biodiversity.

However, when not strictly controlled, ecotourism can have large-scale negative effects on the environment (Figure 1). This depends on the number of tourists allowed into the facility, damage caused and primate habitat lost by the construction of ecotourism infrastructure including hotels, restaurants, souvenir shops, roads, and rail networks, increased water and air pollution, increased garbage and human waste, and conflicts between tourists and primates (Guo et al., 2020; Ji, Li, Sun, & Zhu, 2010; Jones-Engel & Engel, 2005). For example, the construction of an aerial tram and roads in the Fanjingshan NNR resulted in reducing the area available to the last remaining wild population (<350 individuals) of the endangered R. brelichi to less than 28 km² (Guo et al., 2020). Finally, wild primates also are susceptible to many of the same set of bacterial and viral diseases as humans, and therefore the potential for disease transmission is extremely high (Jones-Engel & Engel, 2005). Thus, if ecotourism adheres to the principle of environmental protection first, it can play an important role in wildlife protection. However, if ecotourism is based on an economic-first policy, it will likely have a negative impact on biodiversity and environmental protection. We suggest that ecotourist sites careful assess their impact on primates and the environment and strictly limit the number of tourists.

The WWF suggests that protecting and managing natural resources is essential to eradicate poverty (WWF, 2006). Furthermore, the WWF advocates that the Earth’s natural ecosystems can be protected if environmental and social policies are implemented that integrate the economic needs and aspirations of local communities with the pragmatic benefits of conservation and the sustainable use of natural resources (WWF, 2006). However, across many primate range countries, large tracts of forests have been converted for arable and grazing lands to produce food for international markets, rather than enhanced food security for the local population (Estrada et al., 2019, 2020). If business-as-usual continues, global demands for forest-risk food and nonfood commodities will result in catastrophic losses in natural habitat and biodiversity, hasten primate extinctions, and create food insecurity for many of the world’s poor (Estrada et al., 2017).

Alleviating poverty remains a necessary and critical priority (Xi, 2019). In the face of climate change and environmental deterioration, it is the world’s poor who are the most vulnerable. National and international programs designed to reduce income inequality, expand green technologies to promote sustainable food production, restore natural landscapes, protect biodiversity and ecosystem services, and increase carbon sequestration must remain our highest priority. In this regard, China’s policies of ecological poverty alleviation can serve as a model for promoting primate conservation and economic
development. Since 1990, 8.5 M ha of China’s land has been afforested and between 2000 and 2017 afforestation has accounted for 25% of the net increase in leaf area in China (Chen et al., 2019). Although afforestation can represent an initial or short-term conservation tool, habitat restoration must remain the ultimate goal of China’s 21st century conservation efforts. Ecological migration and reducing rural poverty can benefit wildlife including primates, by reducing anthropogenic disturbance, promoting habitat restoration, and allowing populations of endangered species such as the giant panda to recover (Swaisgood, Wang, & Wei, 2017). However, if China is going to protect its biodiversity and fragile natural ecosystems, conservation-oriented economic policies will need to be updated and improved to meet the continued challenges of alleviating poverty, reducing air, water, and soil pollution, and improving the health and well-being of its citizens, while prioritizing stewardship of the environment.

As of 2021, China has fully lifted 832 counties and 98.99 million people out of poverty. The increase in per capita disposable income in China’s remaining poverty-stricken counties was 0.2–1.7% higher than that of rural residents nationwide (National Bureau of Statistics, 2020). Increased income in the local human community has resulted in increased conservation efforts and protection for some primate species. However, for other taxa this has not been the case. Thus, the goal to alleviate poverty must be based on an economic policy that results in a sustainable balance between the needs of nature and human needs (Ma, Hu, Wang, Yu, & Wei, 2020). To achieve this goal, it is imperative that people living in rural areas of China and people living in the large cities of China be educated to the fact that our survival is dependent on promoting environmental conservation and biodiversity. At present, the policies of ecological migration and ecotourism only have played a limited role in raising conservation awareness and educating the Chinese public. Environmental protection requires a change in the behavior and lifestyle of all global citizens, governments, and business leaders now and in the future (Hua et al., 2016).

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

AUTHOR CONTRIBUTIONS

Xumao Zhao and Ming Li and designed the research. Xumao Zhao and Ming Li conducted the research. Paul A. Garber provided comments. All authors contributed to writing the manuscript.

DATA AVAILABILITY STATEMENT

All data have been provided.

ETHICS STATEMENT

All research methods adhered to Chinese legal requirements and complied with protocols approved by the State Forestry Administration of China and the American Society of Primatologists principles for the ethical treatment of primates.

ORCID

Ming Li https://orcid.org/0000-0001-5689-6270

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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