

A road for a promising future for China's primates: The potential for restoration

Colin A. Chapman^{1,2,3,*}

¹ Department of Anthropology, McGill University, Montréal Québec H3A 2T7, Canada

² Wildlife Conservation Society, Bronx New York 10460, USA

³ Section of Social Systems Evolution, Primate Research Institute, Kyoto University, Inuyama 484-8506, Japan

ABSTRACT

China is one of the most dynamic countries of the world and it shelters some amazing levels of biodiversity, including some very special primate species. However, primarily as a result of forest loss, most of which occurred in historical times, approximately 70% of China's primate species have less than 3 000 individuals. Here I evaluate one road for future conservation/development that could produce very positive gains for China's primates; namely forest restoration. I argue that for a large scale restoration project to be possible two conditions must be met; the right societal conditions must exist and the right knowledge must be in hand. This evaluation suggests that the restoration of native forest to support many of China's primates holds great potential to advance conservation goals and to promote primate population recovery.

Keywords: Conservation; Forest restoration; Regeneration; Primate population dynamics

INTRODUCTION

The world is changing rapidly and China represents one of the most dynamic countries on earth and it shelters some amazing levels of biodiversity (i.e., >30 000 species of vascular plants (behind only Brazil and Colombia), ~2 340 species of terrestrial vertebrates (Liu et al., 2003)). Globally, biodiversity is being lost at an accelerating rate, with current extinction rates approximately 1 000 times higher than background rates (Pimm et al., 2014). Recent estimates suggest that 11 000–58 000 species are lost each year and that surviving vertebrate species have declined in abundance by 25% since 1970 (Dirzo et al., 2014). Humans are clearly responsible for this accelerating loss of biodiversity, including the endangerment of primates. Between 2000 and 2012, 2.3 million km² of forest

was lost globally and in the tropics forest loss increased each year (Hansen et al., 2013). To put this in perspective, this area is approximately the size of Mexico. Global estimates of the extent of wildlife over-exploitation are very poor. However, Bennett et al. (2000) estimated that six million mammals were hunted annually in Malaysian Borneo. With respect to climate change, temperatures are predicted to increase by 1.5 °C by the end of the 21st century (IPCC, 2014) and using moderate greenhouse gas emission estimates, it is projected that by 2100 75% of all tropical forests present in 2000 will experience temperatures that are higher than the temperatures presently supporting closed canopy forests (Peres et al., 2016; Wright et al., 2009).

China follows some of these patterns, but many aspects how China has changed are unique; they represent different challenges and most importantly different opportunities. For example, since 2000, China's Gross Domestic Product has increased by approximately 270% and China is now the world's largest economy (Ahrends et al., 2017). The economy has to support a population approaching 1.4 billion people (Deng et al., 2015; Wei & Ye, 2014). Both the economic and population growth have come at an environmental cost. It is estimated that China has lost between 1.9 and 2.7 million km² of its original forest in the last 2 000 years (based on models of habitat suitability; Ahrends et al., 2017); this is an area approximately the size of the Democratic Republic of Congo. This has cost China in terms of primate diversity and population size. At least three species have been extirpated from China (*Pygathrix nemaeus*, *Hylobates lar yunnanensis*, *Nomascus leucogenys*)

Received: 31 October 2017; Accepted: 25 December 2017; Online: 09 March 2018

Foundation items: Supported by the Canada Research Chairs Program, the Natural Science and Engineering Research Council of Canada, and Kyoto University

*Corresponding author, E-mail: colin.chapman@mcgill.ca

DOI: 10.24272/j.issn.2095-8137.2018.032

and the Hainan (*Nomascus hainanus*) and Cao-vit gibbons (*Nomascus nasutus*) will almost certainly not see the turn of the century without very effective conservation action (Fan, 2017; Turvey et al., 2017). Gibbons were once found from Xi'an in central China east to Shanghai and all the way south to the border (Fan, 2017; Turvey et al., 2017; Zhou & Zhang, 2013); now they are isolated in a few forest fragments to the south. Even orangutans were found in southern China only 12 500 years ago (Husson et al., 2009; Steiper, 2006), but they are no longer found on mainland Asia. A recent analysis considering 22 of the 27 primate species in China (Fan & Ma, 2018) suggests that 15 of the species have less than 3 000 individuals and that 81% of the populations of all Chinese primates are declining (Estrada et al., 2017). These sorts of statistics clearly indicate that China has lost a great deal of ground in the battle to conserve its biodiversity, but they also illustrate that China has great potential in terms of primate conservation.

The objective of this opinion article for this special issue on Primates and Primatology in China is to evaluate one road for future conservation/development that could produce very positive gains for China's primates; namely forest restoration. There is clearly the need for restoration, as many of China's primates are only found in small isolated forests; thus expanding their habitat and connecting fragments is clearly vitally needed.

MAKING RESTORATION A VIABLE CONSERVATION STRATEGY

For a large scale restoration project to be possible two conditions must be met. First, there must be the right societal conditions to make restoration possible and second the knowledge must be in hand to carry out such projects. In terms of the societal conditions, it appears that the timing is right for restoration projects. In November 1988, government of China enacted the "Law of the People's Republic of China on the Protection of Wildlife" to facilitate the protection and management of wildlife. This law is the first truly comprehensive law to protect wildlife in China. However, since 1998, the Chinese government has enacted several national biodiversity conservation regulations, such as the Natural Forest Protection Project and Ecological Forest Compensation, which have been effective in improving environmental conditions in many areas (Ren et al., 2015; Xu et al., 2009). Government financing for protected areas has also increased following the launch of the Wildlife Conservation and Nature Reserve Construction Project and the Special Fund for Capacity Building of National-Level Nature Reserves. China is investing substantially in reforestation and tree planting efforts and this has totalled more than US\$ 100 billion in the past decade alone (Ahrends et al., 2017; Li et al., 2013; Viña et al., 2016; Zhang et al., 2000; Zhang, 2015). China now has the world's largest plantation area (approx. 800 000 km² (approximately the size of Mozambique, Ahrends et al., 2017). At the same time, China is trying to reduce pressures on natural forests through strict bans on logging in primary forests and a massive expansion of its forest reserves to a current total more

than 2 500 reserves covering 1.6 million km² (this area includes 17.1% of the country, which is approximately the size of Iran or twice the state of Texas). Lastly, over the last two decades there has been a large movement of people from rural areas (i.e., next to the reserves where China's primates are found) to the cities. In fact, the urbanization rate rose from 17.9 to 52.6% between 1978 and 2012 and currently more than half of China's population live in cities (Deng et al., 2015).

In terms of the right societal conditions to make restoration possible, an area still requiring a great deal of effort is that of hunting. In many areas of southern China, where forest cover is still substantial, primate populations can be dramatically reduced because of hunting (Harrison et al., 2016). Even though some primates have Class I Protected Animals in the Chinese Wildlife Conservation Law and hunting guns have been outlawed and confiscated, illegal hunting still frequently occurs as it has been a traditional practise that is promoted by poverty in local communities, the use of wildlife for medicinal uses, and poor knowledge and enforcement of the laws (Fan et al., 2014). For example, in south-west Guangxi Province, Francois' langur (*Trachypithecus francoisi*) populations declined by 90% between the early 1980s and early 2000s, at which time the total population size was estimated to be only approximately 300 individuals found in 14 isolated populations. The researchers conducting the later survey concluded that the primary threat to the langur was hunting, primarily for traditional medicine (Li et al., 2007).

The second requirement is that the knowledge must be available to effectively carry out a large restoration projects. Globally, there are only a handful of studies about the response of primate communities to forest regeneration; however, these studies suggest that forests, and the primate community they support, can rebound very rapidly when left to recover or encouraged to recover. For example, Baya & Storch (2010) surveyed a site in Korup National Park, Cameroon that was abandoned 7–8 years previously and found populations of all eight species of diurnal primates that occur in the region; in addition, sighting frequency in this recovering area was not significantly different from other sectors of the park (Linder, 2008). In Kibale National Park, Uganda, seven years after an area of grassland was replanted with trees as part of a carbon offset program (Omeja et al., 2012), all species of diurnal primates were present in high numbers, including endangered red colobus and chimpanzee. Such studies give hope for the future.

Within China a great deal of research has accumulated over the last two or so decades that provides exactly the type of information needed for restoration/conservation efforts. To start such efforts accurate information on the state of the species to be targeted must be known. There is extensive survey information on the current size and threats to the country's primates (e.g., Chen et al., 2015; Cui et al., 2016). The synthesis of this information will be vital in determining the locations to be prioritized in restoration efforts; however, other local aspects, such as the willingness of the local population to participate in restoration and to not hunt primates must also

be considered. Next, information must be available on the habitat requirements of the species targeted for help from a forest restoration project and again, there are many detailed projects focusing on primate habitat use (Fan et al., 2009, 2012; Guo et al., 2008; Li & Rogers, 2006; Liu et al., 2013). Of particular importance if the restoration project is to involve active replanting of trees is detailed information on the diet of the primates. With this information, either the food trees of the animals can be planted, or species with similar nutritional traits can be used in the restoration effort. There have been a number of high quality studies done on the nutritional ecology of China's primates (e.g., Liu et al., 2013; Ma et al., 2017; Hou et al., 2018). To make restorations efforts more effective, it is critical to understand the severity and geographical nature of threats to primates in China other than habitat loss (e.g., live capture for trade, bushmeat, and tourism; Li et al., 2003; Xia et al., 2016; Yang et al., 2007; Zhu et al., 2013). In addition, information on conservation genetics is needed to determine the nature of corridors that can allow population mixing (Liu et al., 2015). With respect to conservation genetics, information concerning past interpopulational gene flow and landscape barriers on both short (e.g., satellite and aerial photography) and long time frames (e.g., river barriers), while rare (but see Wang et al., 2017), will be particularly valuable in determining the dispersal capabilities of primates relative to different types of barriers and can be used to provide guidance as to the nature of corridors that can be constructed to facilitate population mixing (Guo et al., 2010; Wang et al., 2015, 2017).

WHAT REMAINS TO BE DONE FOR RESTORATION IN CHINA

While this existing information is extremely valuable, what is lacking is data specific to restoration efforts and studies documenting behavioral patterns and responses of primates to the regeneration of forests. For restoration projects to be most effective, information on the survival strategies used in regenerating forests of all the major primate groups, including prosimians, macaques, colobines, and gibbons will be vital. While this is a formidable task, it also represents an exciting challenge to academics and Universities; one where the value of research can be illustrated to the government and public.

What now remains to be done is to pull this societal potential and information together to facilitate large-scale forest restoration efforts that is critically needed for primate conservation. Since so many primate species in China are only hanging on as small remnant populations that are often only composed of a few groups (e.g., the cao vit gibbon population is estimated to only involve 18 groups occupying forest patches of only 2 000 hm² with only 3–4 groups in China (Fan et al., 2011)) the only way to effectively promote conservation of these primates in the wild is through restoration. This will likely require some sort of well financed coordinating agency that is able to rally national and international scholars, conservation organizations, government agencies, and the public to first provided the needed scientific information and then to use this information to promote both natural regeneration and

reforestation efforts on a very large scale.

CONCLUSION

Primates are very charismatic and are generally liked by both the Chinese people and international groups, thus they can act as “Flagship” or “Guardian Angel” species to promote the value of restoring these lands to a native forest (Bicca-Marques & De Freitas, 2010; Simberloff, 1998). It is my opinion that this is an exciting time to integrate restoration into conservation strategies to make informed and effective conservation and management decisions for the primates of China.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

C.C. investigated and wrote the manuscript, but he benefited from talking to many friends and colleagues at the 2017 China Primatological Society in Xi'an.

ACKNOWLEDGEMENTS

I would like to thank Rong Hou and Peng-Fei Fan for helpful comments on the manuscript.

REFERENCES

- Ahrends A, Hollingsworth PM, Beckschäfer P, Chen HF, Zomer RJ, Zhang LB, Wang MC, Xu JC. 2017. China's fight to halt tree cover loss. *Proceedings of the Royal Society B: Biological Sciences*, **284**(1854): 20162559.
- Baya L, Storch I. 2010. Status of diurnal primate populations at the former settlement of a displaced village in Cameroon. *American Journal of Primatology*, **72**(7): 645–652.
- Bennett EL, Nyaoi A, Sompud J. 2000. Saving Borneo's bacon: the sustainability of hunting in Sarawak and Sabah. In: Robinson JG, Bennett EL. *Hunting for Sustainability in Tropical Forests*. New York: Columbia University Press, 305–324.
- Bicca-Marques JC, De Freitas DS. 2010. The role of monkeys, mosquitoes, and humans in the occurrence of a yellow fever outbreak in a fragmented landscape in south Brazil: protecting howler monkeys is a matter of public health. *Tropical Conservation Science*, **3**(1): 78–89.
- Chen YX, Xiang ZF, Wang XW, Xiao W, Xiao ZS, Ren BP, He CX, Sang CH, Li HS, Li M. 2015. Preliminary study of the newly discovered primate species *Rhinopithecus strykeri* at Pianma, Yunnan, China using infrared camera traps. *International Journal of Primatology*, **36**(4): 679–690.
- Cui LW, Li YC, Ma C, Scott MB, Li JF, He XY, Li DH, Sun J, Sun WM, Xiao W. 2016. Distribution and conservation status of Shortridge's capped langurs *Trachypithecus shortridgei* in China. *Oryx*, **50**(4): 732–741.
- Deng XZ, Huang JK, Rozelle S, Zhang JP, Li ZH. 2015. Impact of urbanization on cultivated land changes in China. *Land Use Policy*, **45**: 1–7.
- Dirzo R, Young HS, Galetti M, Ceballos G, Isaac NJB, Collen B. 2014. Defaunation in the Anthropocene. *Science*, **345**(6195): 401–406.
- Estrada A, Garber PA, Rylands AB, Roos C, Fernandez-Duque E, Di Fiore A, Nekaris KAI, Nijman V, Heymann EW, Lambert JE, Rovero F, Barelli

- C, Setchell JM, Gillespie TR, Mittermeier RA, Arregoitia LV, de Guinea M, Gouveia S, Dobrovolski R, Shanee S, Shanee N, Boyle SA, Fuentes A, MacKinnon KC, Amato KR, Meyer ALS, Wich S, Sussman RW, Pan RL, Kone I, Li BG. 2017. Impending extinction crisis of the world's primates: why primates matter. *Science Advances*, **3**(1): e1600946.
- Fan PF, Ma C. 2018. Extant primates and development of primatology in China: publications, student training, and funding. *Zoological Research*, **39**(4): 249–254.
- Fan PF, Ni QY, Sun GZ, Huang B, Jiang XL. 2009. Gibbons under seasonal stress: the diet of the black crested gibbon (*Nomascus concolor*) on Mt. Wuliang, Central Yunnan, China. *Primates*, **50**(1): 37–44.
- Fan PF, Fei HL, Scott MB, Zhang W, Ma CY. 2011. Habitat and food choice of the critically endangered cao vit gibbon (*Nomascus nasutus*) in China: implications for conservation. *Biological Conservation*, **144**(9): 2247–2254.
- Fan PF, Fei HL, Ma CY. 2012. Behavioral responses of cao vit gibbon (*Nomascus nasutus*) to variations in food abundance and temperature in Bangliang, Jingxi, China. *American Journal of Primatology*, **74**(7): 632–641.
- Fan PF, Fei HL, Luo AD. 2014. Ecological extinction of the Critically Endangered northern white-cheeked gibbon *Nomascus leucogenys* in China. *Oryx*, **48**(1): 52–55.
- Fan PF. 2017. The past, present, and future of gibbons in China. *Biological Conservation*, **210**: 29–39.
- Guo ST, Ji WH, Li BG, Li M. 2008. Response of a group of Sichuan snub-nosed monkeys to commercial logging in the Qinling Mountains, China. *Conservation Biology*, **22**(4): 1055–1064.
- Guo ST, Ji WH, Li M, Chang HL, Li BG. 2010. The mating system of the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*). *American Journal of Primatology*, **72**(1): 25–32.
- Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova SA, Tyukavina A, Thau D, Stehman SV, Goetz SJ, Loveland TR, Kommareddy A, Egorov A, Chini L, Justice CO, Townshend JRG. 2013. High-resolution global maps of 21st-century forest cover change. *Science*, **342**(6160): 850–853.
- Harrison RD, Sreekar R, Brodie JF, Brook S, Luskin M, O'Kelly H, Rao M, Scheffers B, Velho N. 2016. Impacts of hunting on tropical forests in Southeast Asia. *Conservation Biology*, **30**(5): 972–981.
- Hou R, Chapman CA, Garber PA, Guo S, Li B. 2018. Dietary and nutritional adaptations to extremes of northern-living by *Rhinopithecus roxellana*. *American Journal of Primatology*. (in press)
- Husson SJ, Wich SA, Marshall AJ, Dennis RD, Ancrenaz M, Brassey R, Gumal M, Hearn AJ, Meijaard E, Simorangkir T, Singleton I. 2009. Orangutan distribution, density, abundance and impacts of disturbance. In: Wich SA, Atmoko SSU, Setia TM, Van Schaik CP. *Orangutans: Geographic Variation in Behavioral Ecology and Conservation*. Oxford: Oxford University Press, 77–96.
- IPCC. 2014. Climate change 2014: synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change. In: Core Writing Team, Pachauri RK, Meyer LA. Geneva, Switzerland: IPCC.
- Li BG, Jia ZY, Pan RL, Ren BP. 2003. Changes in distribution of the snub-nosed monkey in China. In: Marsh LK. *Primates in Fragments: Ecology and Conservation*. New York: Springer, 29–51.
- Li YB, Huang CM, Ding P, Tang Z, Wood C. 2007. Dramatic decline of François' langur *Trachypithecus francoisi* in Guangxi Province, China. *Oryx*, **41**(1): 38–43.
- Li YB, Li WJ, Zhang CC, Fan MM. 2013. Current status and recent trends in financing China's nature reserves. *Biological Conservation*, **158**: 296–300.
- Li ZY, Rogers ME. 2006. Food items consumed by white-headed langurs in Fusui, China. *International Journal of Primatology*, **27**(6): 1551–1567.
- Linder JM. 2008. The Impact of Hunting on Primates in Korup National Park, Cameroon: Implications for Primate Conservation. Ph.D. thesis. The City University of New York, New York, 376.
- Liu JG, Ouyang ZY, Pimm SL, Raven PH, Wang XK, Miao H, Han NY. 2003. Protecting China's biodiversity. *Science*, **300**(5623): 1240–1241.
- Liu XC, Stanford CB, Yang JY, Yao H, Li YM. 2013. Foods Eaten by the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*) in Shennongjia national nature reserve, China, in relation to nutritional chemistry. *American Journal of Primatology*, **75**(8): 860–871.
- Liu ZJ, Liu GJ, Roos C, Wang ZM, Xiang ZF, Zhu PF, Wang BS, Ren BP, Shi FL, Pan HJ, Li M. 2015. Implications of genetics and current protected areas for conservation of 5 endangered primates in China. *Conservation Biology*, **29**(6): 1508–1517.
- Ma CY, Liao JC, Fan PF. 2017. Food selection in relation to nutritional chemistry of Cao Vit gibbons in Jingxi, China. *Primates*, **58**(1): 63–74.
- Omeja PA, Obua J, Rwetsiba A, Chapman CA. 2012. Biomass accumulation in tropical lands with different disturbance histories: contrasts within one landscape and across regions. *Forest Ecology and Management*, **269**: 293–300.
- Peres CA, Emilio T, Schiatti J, Desmoulière SJ, Levi T. 2016. Dispersal limitation induces long-term biomass collapse in overhunted Amazonian forests. *Proceedings of the National Academy of Sciences of the United States of America*, **113**(4): 892–897.
- Pimm SL, Jenkins CN, Abell R, Brooks TM, Gittleman JL, Joppa LN, Raven PH, Roberts CM, Sexton JO. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. *Science*, **344**(6187): 1246752.
- Ren GP, Young SS, Wang L, Wang W, Long YC, Wu RD, Li JS, Zhu JG, Yu DW. 2015. Effectiveness of China's national forest protection program and nature reserves. *Conservation Biology*, **29**(5): 1368–1377.
- Simberloff D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era? *Biological Conservation*, **83**(3): 247–257.
- Steiper ME. 2006. Population history, biogeography, and taxonomy of orangutans (Genus: *Pongo*) based on a population genetic meta-analysis of multiple loci. *Journal of Human Evolution*, **50**(5): 509–522.
- Turvey ST, Bryant JV, Duncan C, Wong MHG, Guan ZH, Fei HL, Ma CY, Hong XJ, Nash HC, Chan BPL, Xu Y, Fan PF. 2017. How many remnant gibbon populations are left on Hainan? Testing the use of local ecological knowledge to detect cryptic threatened primates. *American Journal of Primatology*, **79**(2): e22593.
- Viña A, McConnell WJ, Yang HB, Xu ZC, Liu JG. 2016. Effects of conservation policy on China's forest recovery. *Science Advances*, **2**(3): e1500965.
- Wang W, Qiao Y, Li S, Pan W, Yao M. 2017. Low genetic diversity and strong population structure shaped by anthropogenic habitat fragmentation in a critically endangered primate, *Trachypithecus leucocephalus*. *Heredity*, **118**(6): 542–553.

- Wang WR, Qiao Y, Pan WS, Yao M. 2015. Low genetic diversity and strong geographical structure of the critically endangered white-headed langur (*Trachypithecus leucocephalus*) inferred from mitochondrial DNA control region sequences. *PLoS One*, **10**(6): e0129782.
- Wei YD, Ye XY. 2014. Urbanization, urban land expansion and environmental change in China. *Stochastic environmental research and risk assessment*, **28**(4): 757–765.
- Wright SJ, Muller-Landau HC, Schipper J. 2009. The future of tropical species on a warmer planet. *Conservation Biology*, **23**(6): 1418–1426.
- Xia W, Ren B, Li Y, Hu J, He X, Krzton A, Li M, Li D. 2016. Behavioural responses of Yunnan snub-nosed monkeys (*Rhinopithecus bieti*) to tourists in a provisioned monkey group in Baimaxueshan Nature Reserve. *Folia Primatologica*, **87**(6): 349–360.
- Xu HG, Tang XP, Liu JY, Ding H, Wu J, Zhang M, Yang QW, Cai L, Zhao HJ, Liu Y. 2009. China's progress toward the significant reduction of the rate of biodiversity loss. *BioScience*, **59**(10): 843–852.
- Yang DD, Dai XF, Deng YP, Lu WQ, Jiang ZG. 2007. Changes in attitudes toward wildlife and wildlife meats in Hunan Province, central China, before and after the severe acute respiratory syndrome outbreak. *Integrative Zoology*, **2**(1): 19–25.
- Zhang L. 2015. Special section: balancing conservation and development to preserve China's biodiversity. *Conservation Biology*, **29**(6): 1496.
- Zhang PC, Shao GF, Zhao G, Le Master DC, Parker GR, Dunning Jr JB, Li QL. 2000. China's forest policy for the 21st century. *Science*, **288**(5474): 2135–2136.
- Zhou YH, Zhang P. 2013. Distribution and vicissitude of gibbons (Hylobatidae) in China during the last 500 years. *Acta Theriologica Sinica*, **33**(3): 258–266. (in Chinese)
- Zhu Y, Li JH, Xia DP, Sun BH, Xu YR, Wang X, Zhang D. 2013. Potential pathogen transmission risk in non-human primate ecotourism: a case study at Mt. Huangshan, China. *Life Science Journal*, **10**(1): 2754–2759.