

**Appendix S1.** Changes of gibbon populations within nature reserves in China since 1980s, and information about reserves where gibbons have occurred. Key: gr., family groups; sin., singletons; ind., individuals (i.e., all individual gibbons from family groups and singletons).

ID	Gibbon	Nature Reserve	Level	Level at founded	Year founded	Year upgraded	Area (km <sup>2</sup> )	Gibbon presence-NR founded	Gibbon presence-2010s	1980s	1990s	2000s	2010s
1	<i>Hylobates lar</i>	Nangunhe-Original	National	Provincial	1980	1994	72.5	Yes	No	19-27 ind. <sup>1,2</sup>	10 ind. <sup>3</sup>	Extinct <sup>4</sup>	
2	<i>Hoolock tianxing</i>	Gaoligongshan-South	National	Provincial	1983	1986	1264.9	Yes	Yes	18-19 gr. <sup>1</sup>	20-50 gr. <sup>5</sup>	20-22 gr. <sup>6</sup>	15 gr.+8 sin. <sup>7</sup>
3	<i>Hoolock tianxing</i>	Gaoligongshan-Middle	National	Provincial	1983	1986	382.5	No	No	Extinct <sup>1</sup>			
4	<i>Hoolock tianxing</i>	Tongbiguan-Ruili	Provincial	City-level	1992	2002	165.0	No	No	Extinct <sup>1</sup>			
5	<i>Hoolock tianxing</i>	Tongbiguan-Longchuan	Provincial	Provincial	1986	NA	51.3	Yes	No	5 gr. <sup>1</sup>	4-8 gr. <sup>5</sup>	Extinct <sup>6</sup>	
6	<i>Hoolock tianxing</i>	Tongbiguan-Yingjiang	Provincial	Provincial	1986	NA	219.6	Yes	No	5-7 gr. <sup>1</sup>	Extinct <sup>5</sup>		
7	<i>Hoolock tianxing</i>	Tongbiguan-Yingjiang extended	Provincial	Provincial	2017	NA	124.4	Yes	Yes		30-50 gr. <sup>5</sup>	17-18 gr. <sup>6</sup>	23 gr.+3 sin. <sup>7</sup>
8	<i>Hoolock tianxing</i>	Longling-Xiaoheishan	Provincial	Provincial	1995	NA	62.8	?	No			Extinct <sup>*</sup>	
9	<i>Nomascus hainanus</i>	Bawangling	National	Provincial	1980	1986	297.7	Yes	Yes	4 gr. with 21 ind. <sup>9</sup>	4 gr. with 18-19 ind. <sup>10</sup>	2 gr. with 13 ind. <sup>11</sup>	4 gr. with 25 ind. <sup>12</sup>

10	<i>Nomascus hainanus</i>	Jianfengling	National	Provincial	1976	2002	240.9	Yes	No	Extinct <sup>8</sup>			
11	<i>Nomascus hainanus</i>	Wuzhishan	National	Provincial	1985	2003	134.3	No	No	Extinct <sup>8</sup>			
12	<i>Nomascus hainanus</i>	Limushan	Provincial	Provincial	2004	NA	117.0	No	No	1-2 gr. <sup>8</sup>		Extinct <sup>13</sup>	
13	<i>Nomascus hainanus</i>	Diaoluoshan	National	Provincial	1984	2008	183.7	?	No	Survived until 1983 <sup>11</sup>	Extinct <sup>13</sup>		
14	<i>Nomascus hainanus</i>	Yinggeling	National	Provincial	2004	2014	505.3	No	No	1-2 gr. <sup>8</sup>		Extinct <sup>13</sup>	
15	<i>Nomascus hainanus</i>	Jiayi	Provincial	Provincial	1981	NA	76.1	?	No				Possibly Extinct <sup>13</sup>
16	<i>Nomascus nasutus</i>	Bangliang	National	Provincial	2009	2013	66.4	Yes	Yes			3 gr. <sup>14</sup>	5 gr. <sup>15</sup>
17	<i>Nomascus leucogenys</i>	Xishuangbanna-Shangyong	National	Provincial	1980	1986	315.2	Yes	No	14-15 gr. <sup>1</sup> ; 5 gr. <sup>16</sup>	Extinct <sup>17</sup>		
18	<i>Nomascus leucogenys</i>	Xishuangbanna-Mengla	National	Provincial	1958	1986	1158.4	Yes	No	13 gr. <sup>1</sup> ; 4 gr. <sup>16</sup>		Extinct <sup>17</sup>	
19	<i>Nomascus leucogenys</i>	Huanglianshan	National	Provincial	1983	2003	598.6	?	No	Extinct <sup>1</sup>			
20	<i>Nomascus concolor</i>	Wuliangshan	National	Provincial	1986	2000	331.5	Yes	Yes	225-250 gr. <sup>18</sup> ; 117-144 gr. <sup>19</sup>	160-300 gr. <sup>20</sup> ; 100-116 gr. <sup>21</sup> ; 115 gr. <sup>22</sup>	98 gr. <sup>23</sup>	87 gr. <sup>24</sup>

21	<i>Nomascus concolor</i>	Ailaoshan	National	Provincial	1981	1988	683.5	Yes	Yes	133-190 ind. <sup>1</sup> ; 40-60 ind. <sup>25</sup>	160-300 gr. <sup>20</sup> ; 42-59 gr. <sup>21</sup> ; 130 gr. <sup>26</sup>	40-60 gr. <sup>21</sup>	170-180 gr. <sup>27</sup>
22	<i>Nomascus concolor</i>	Jinping-Fenshuiling-Fenshuiling	National	Provincial	1986	2001	206.3	No	No	Extinct <sup>21</sup>			
23	<i>Nomascus concolor</i>	Jinping-Fenshuiling-Xilongshan	National	Provincial	1997	2001	239.7	Yes	Yes		10-15 gr. <sup>21</sup>	1-2 gr. <sup>28</sup>	
24	<i>Nomascus concolor</i>	Daweishan	National	Provincial	1986	2001	382.6	No	No	Extinct <sup>28</sup>			
25	<i>Nomascus concolor</i>	Huanglianshan	National	Provincial	1983	2003	598.6	Yes	No		5-10 gr. <sup>21</sup>	1-3 gr. <sup>28</sup>	
26	<i>Nomascus concolor</i>	Lincang-Lancangjiang	Provincial	Provincial	1999	NA	311.2	Yes	Yes	24 gr. <sup>1</sup>	1-2 gr. <sup>21</sup>		2 gr. <sup>29</sup>
27	<i>Nomascus concolor</i>	Nangunhe-extended	National	National	2003	NA	428.9	Yes	Yes	23 gr. <sup>1</sup>	3-10 gr. <sup>30</sup> ; 5-10 gr. <sup>21</sup>		2 gr. <sup>29</sup>
28	<i>Nomascus concolor</i>	Yongde-Daxueshan	National	Provincial	1986	2006	175.8	Yes	Yes		20-30 gr. <sup>21</sup>		4 gr. <sup>31</sup>
29	<i>Nomascus concolor</i>	Nanpenghe (Xuezhulinshan)	Provincial	Provincial	1999	NA	322.3	Yes	Yes				1 gr.+1 sing. <sup>29</sup>
30	<i>Nomascus concolor</i>	Maguan-Gulinjing	Provincial	County-level	1982	2002	69.6	Yes	No		Survived until 1996 <sup>28</sup>	Extinct <sup>28</sup>	

31	<i>Nomascus concolor</i>	Malipo-Maguan-Laojunshan	Provincial	Provincial	1986	NA	44.5	Yes	No	Survived until 1993 <sup>28</sup>	Extinct <sup>28</sup>
32	<i>Nomascus concolor</i>	Niuluohe	County-level	County-level	1983	NA	16.8	Yes	No	Survived until 1986 <sup>28</sup>	Extinct <sup>28</sup>

\*Unpublished data from field survey by our team.

### Literature cited

1. Yang, D., Zhang, J. & Li, C. A survey on the population and distribution of gibbons in Yunnan Province. *Medical Biology Research* **3**, 22–27 (1985).
2. Yang, D., Zhang, J. & Li, C. Preliminary survey on the population and distribution of gibbons in Yunnan Province. *Primates* **28**, 547–549 (1987).
3. Guo, G. & Wang, Z. Survey on the white-handed gibbon in Nangunhe valley in China. *Chinese Primate Research and Conservation News* **4**, 7–9 (1995).
4. Grueter, C. C. *et al.* Are *Hylobates lar* extirpated from China? *International journal of primatology* **30**, 553–567 (2009).
5. Lan, D., Ma, S. & Han, L. Distribution, population size and conservation of Hoolock gibbons in west Yunnan. in *Studies on Mammal Biology in China* 11–19 (China Forestry Press, 1995).
6. Fan, P. *et al.* Distribution and conservation status of the Vulnerable eastern hoolock gibbon *Hoolock leuconedys* in China. *Oryx* **45**, 129–134 (2011).
7. Zhang, L. *et al.* Influence of traditional ecological knowledge on conservation of the skywalker hoolock gibbon (*Hoolock tianxing*) outside nature reserves. *Biological Conservation* **241**, 108267 (2020).
8. Liu, Z., Yu, S. & Yuan, X. Resources of the Hainan black gibbon and its present situation. *China Wildlife* **6**, 1–4 (1984).
9. Liu, Z., Zhang, Y., Jiang, H. & Southwick, C. Population structure of *Hylobates concolor* in Bawanglin Nature Reserve, Hainan, China. *American Journal of Primatology* **19**, 247–254 (1989).
10. Song, X. *et al.* Census Hainan black gibbons (*Hylobates concolor hainanus*) in Hainan Island. in *Zoological Studies in China* 696–701 (Chinese Zoology Society, 1999).
11. Zhou, J. *et al.* Hainan black-crested gibbon is headed for extinction. *International Journal of Primatology* **26**, 453–465 (2005).
12. Turvey, S. T. *et al.* *International Conservation Planning Workshop for the Hainan Gibbon: Final Report.* (2015).
13. Turvey, S. T. *et al.* 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**, e22593 (2017).

14. Chan, B. P. L., Tan, X. F. & Tan, W. J. Rediscovery of the critically endangered eastern black-crested gibbon *Nomascus nasutus* (Hylobatidae) in China, with preliminary notes on population size, ecology and conservation status. *Asian Primates Journal* **1**, 17–25 (2008).
15. Ma, C. *et al.* Transboundary conservation of the last remaining population of the cao vit gibbon *Nomascus nasutus*. *Oryx* (2019).
16. Hu, Y., Xu, H. & Yang, D. The studies on ecology in *Hylobates leucogenys*. *Zoological Research* **10 (Suppl)**, 61–67 (1989).
17. Fan, P., Fei, H. & Luo, A. Ecological extinction of the Critically Endangered northern white-cheeked gibbon *Nomascus leucogenys* in China. *Oryx* **48**, 52–55 (2014).
18. Haimoff, E. H., Yang, X. J., He, S. J. & Chen, N. Census and survey of wild black-crested gibbons (*Hylobates concolor concolor*) in Yunnan Province, People's Republic of China. *Folia Primatologica* **46**, 205–214 (1986).
19. Lan, D. Preliminary study on the group composition, behavior and ecology of the black gibbons (*Hylobates concolor*) in southwest Yunnan. *Zoological Research* **10 (Suppl)**, 119–126 (1989).
20. Bleisch, W. & Chen, N. Conservation of the black-crested gibbon in China. *Oryx* **24**, 147–156 (1990).
21. Wang, Y., Jiang, X. & Feng, Q. Distribution, status and conservation of black-crested gibbon (*Hylobates concolor*) in China. *Acta Anthropologica Sinica* **19**, 138–147 (2000).
22. Jiang, X. & Wang, Y. Population and conservation of black-crested gibbons (*Hylobates concolor jingdongensis*) in Wuliang Nature Reserve, Jingdong, Yunnan. *Zoological Research* **20**, (1999).
23. Jiang, X., Luo, Z., Zhao, S., Li, R. & Liu, C. Status and distribution pattern of black crested gibbon (*Nomascus concolor jingdongensis*) in Wuliang Mountains, Yunnan, China: implication for conservation. *Primates* **47**, 264–271 (2006).
24. Luo, Z. Survey on populations and distribution of Western black crested gibbons (*Nomascus concolor jingdongensis*) from Wuliang Shan National Nature Reserve. *Sichuan Journal of Zoology* **30**, 283–287 (2011).
25. Ma, S. & Wang, Y. The recent distribution, status and conservation of primates in China. *Acta Theriologica Sinica* **8**, 250–260 (1988).
26. Ma, S. L. The progress of studies on Yunnan black-crested gibbons. *Chinese Primate Research and Conservation News* **2**, 3 (1993).
27. Fan, P. The past, present, and future of gibbons in China. *Biological Conservation* **210**, 29–39 (2017).
28. Ni, Q. & Ma, S. Population and distribution of the black crested gibbons in southern and southeastern Yunnan. *Zoological Research* **27**, 34–40 (2006).
29. Zhao, Q. Population status and conservation of western black crested gibbons in Lincang, Yunnan. (Anhui University, 2015).
30. Lan, D. & Guo, G. Present status on conservation of primates in Lincang district of Yunnan. *Chinese Primate Research and Conservation News* **4**, 4–7 (1995).
31. Sun, G. *et al.* Population, distribution and conservation status of western black crested gibbon. *Forestry Construction* **1**, 38–43 (2012).

## Appendix S2. Methods to calculate gibbon population size in 1980s.

For populations with records of gibbon groups only (Appendix S1), we multiplied them with an average group size, using 3.6 individuals per group for *Hoolock tianxing* (Zhang et al. 2020), 6.4 for *Nomascus nasutus* (Ma et al. 2019), 6.4 for *N. concolor* (Fan et al. 2006), 6.7 for *N. hainanus* (Deng et al. 2017), and 3.75 for *N. leucogenys* (Harding 2012). We did not have records for several gibbon populations in 1980s, so we used the first available records in a later decade to substitute (n = 6), or these populations were excluded from our analysis when no later records were available (n = 3).

## Literature cited

- Deng H, Zhang M, Zhou J. 2017. Recovery of the Critically Endangered Hainan gibbon *Nomascus hainanus*. *Oryx* **51**:161–165.
- Fan P, Jiang X, Liu C, Luo W. 2006. Polygynous mating system and behavioural reason of black crested gibbon (*Nomascus concolor jingdongensis*) at Dazhaizi, Mt. Wuliang, Yunnan, China. *Zoological Research* **27**:216–220.
- Harding LE. 2012. *Nomascus leucogenys* (Primates: Hylobatidae). *Mammalian Species* **44**:1–15.
- Ma C, Trinh-Dinh H, Nguyen V-T, Le T-D, Le V-D, Le H-O, Yang J, Zhang Z, Fan P. 2019. Transboundary conservation of the last remaining population of the cao vit gibbon *Nomascus nasutus*. *Oryx*.
- Zhang L, Guan Z, Fei H, Yan L, Turvey ST, Fan P. 2020. Influence of traditional ecological knowledge on conservation of the skywalker hoolock gibbon (*Hoolock tianxing*) outside nature reserves. *Biological Conservation* **241**:108267.

## Appendix S3. Comparison of management effectiveness scores for reserves or management areas between decades, using Friedman rank sum tests.

Period compared	Score group	Sample size (N)	Friedman chi-squared	P-value
Since 1980s	Score_all	5	15	0.002**
	Score_A	5	14.5	0.002**
	Score_B	5	14.5	0.002**
	Score_C	5	14.755	0.002**
	Score_D	5	14.02	0.003**
Since 1990s	Score_all	13	24.154	< 0.001***
	Score_A	13	23.160	< 0.001***
	Score_B	13	20.118	< 0.001***
	Score_C	13	26.000	< 0.001***
	Score_D	13	22.392	< 0.001***

**Appendix S4.** Gibbon population trends and corresponding management score changes/percentage changes in consecutive decades.

Nature reserves	Trends <sup>1</sup>	Period s	Management score change					Management score change (%)				
			All	A	B	C	D	All	A	B	C	D
Nangunhe-Original	de	80s-90s	NA <sup>2</sup>	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nangunhe-Original	de	90s-00s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gaoligongshan-South	in	80s-90s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gaoligongshan-South	st	90s-00s	45.7	11	12.2	9.5	13	326	138	488	380	1300
Gaoligongshan-South	de	00s-10s	21.97	5	7	4.3	5.7	37	26	48	36	41
Tongbiguan-Longchuan	st	80s-90s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tongbiguan-Longchuan	de	90s-00s	19	5	3	8	3	35	28	18	133	21
Tongbiguan-Yingjiang	de	80s-90s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tongbiguan-Yingjiang extended	de	90s-00s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tongbiguan-Yingjiang extended	in	00s-10s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bawangling	st	80s-90s	17	7	6	3	1	68	70	60	150	33
Bawangling	de	90s-00s	22	5	7	5	5	52	29	44	100	125
Bawangling	in	00s-10s	12	3	4	5	0	19	14	17	50	0





Yongde-Daxueshan	de	90s-10s	51	6	11	13	21	104	29	69	217	350
Maguan-Gulinjing	de	90s-10s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Malipo-Maguan-Laojunshan	de	90s-10s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Niuluohe	de	80s-90s	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

<sup>1</sup>Population trends: de: decrease; st: stable; in: increase.

<sup>2</sup>NA: no available data on management scores.

**Appendix S5.** Coefficient and SE for each variable for logistic regression models analyzing the relationship between gibbon population trends (decrease vs. non-decrease) and change/percentage change of management scores of reserves.

Change of management scores			Percentage change of management scores		
Variables	Coefficient	SE	Variables	Coefficient	SE
(Intercept)	0.155	1.705	(Intercept)	-0.977	0.929
Score_all	-0.036	0.058	Score_all	0.338	0.664
Score_A	0.044	0.240	Score_A	0.849	1.548
Score_B	-0.125	0.183	Score_B	0.045	0.308
Score_C	-0.234	0.293	Score_C	-0.003	0.517
Score_D	-0.133	0.170	Score_D	0.204	0.217