

Dramatic decline of wild South China tigers *Panthera tigris amoyensis*: field survey of priority tiger reserves

Ronald Tilson, Hu Defu, Jeff Muntifering and Philip J. Nyhus

Abstract This paper describes results of a Sino-American field survey seeking evidence of South China tigers *Panthera tigris amoyensis* in the wild. In 2001 and 2002 field surveys were conducted in eight reserves in five provinces identified by government authorities as habitat most likely to contain tigers. The surveys evaluated and documented evidence for the presence of tigers, tiger prey and habitat disturbance. Approximately 290 km of mountain trails were evaluated. Infrared remote cameras set up in two reserves captured 400 trap days of data. Thirty formal and numerous informal interviews were conducted with villagers to document wildlife knowledge, livestock management practices, and local land and resource use. We found no evidence of wild South China tigers, few prey species, and no livestock depredation by tigers reported in the last 10 years. Forest areas designated as tiger reserves, averaging about 100 km² in size, are too small to support even a few tigers because commercial

tree farms and other habitat conversion is common, and people and their livestock dominate these fragments. While our survey may not have been exhaustive, and there may be a single tiger or a few isolated tigers still remaining at sites we missed, our results strongly indicate that no remaining viable populations of South China tigers occur within its historical range. We conclude that continued field efforts are needed to ascertain whether any wild tigers may yet persist, concurrent with the need to consider options for the eventual recovery and restoration of wild tiger populations from existing captive populations.

Keywords Extinction, *Panthera tigris amoyensis*, restoration, South China tiger.

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Introduction

The historical range of South China tigers *Panthera tigris amoyensis* stretched over a vast landscape of 2,000 km from east to west and 1,500 km from north to south in China. From the east it ranged from Jiangxi and Zhejiang Provinces at about 120°E westward through Guizhou and Sichuan Provinces at about 100°E. The most northerly extension was in the Qinling Mountain and Yellow River area at approximately 35°N to its southern extension in Guangdong, Guangxi and Yunnan Provinces at 21°N (Lu & Sheng, 1986; SFA, 1998).

As recently as the early 1950s the South China tiger was reported to number more than 4,000 in the wild when it became the target of large-scale government 'anti-pest' campaigns promulgated by Chairman Mao

Zedong's 'Great Leap Forward' (Lu & Sheng, 1986; Tan, 1987; Shapiro, 2001). The effects of uncontrolled hunting were compounded by extensive deforestation and probable reduction in available prey, large-scale relocations of urban populations to rural locations leading to fragmentation of tiger populations and increased vulnerability to local extinction from stochastic events (Lu & Sheng, 1986; Shapiro, 2001).

In 1973 the Regulation Regarding the Protection of Wildlife Resources classified the South China tiger as a third category species "protected by controlled hunting." In 1977 it was upgraded to second category level "protected and prohibited from hunting species." In 1979 it was given first category status of full protection, but this new status had little effect as hunters neither accepted nor apparently respected the Regulation. Numbers of wild tiger continued to decline and by 1982 only an estimated 150–200 wild South China tigers remained (Lu & Sheng, 1986).

Tiger population estimates continued to decline through the 1980s, despite its listing as Category I on China's national register of endangered animals and the creation of three reserves for its protection. During this period evidence of wild tigers in central China was scattered and seldom confirmed (Lu & Sheng, 1986; Lu, 1987; Gui

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& Meng, 1993). The last systematic tiger field survey (Koehler, 1991) found possible signs of tigers and tiger cubs in 11 protected areas in Sichuan, Guangdong, Hunan, Jiangxi and Fujian Provinces. No tigers were directly observed; evidence was limited to sightings of tracks, scrapings and reported sightings by local people.

The State Forestry Administration of China (SFA) made the preservation of the South China tiger a priority in its Agenda 21 initiative in 1995. Subsequently, referring to data from Chinese biologists, the IUCN Cat Specialist Group estimated the wild population to be 30–80 individuals (Jackson, 1993; Nowell & Jackson, 1996). A 1995 unconfirmed report from SFA suggested that 6–13 tigers remain in Jiangxi Province with another 4–5 tigers in Fujian, Guangdong and Hunan Provinces, giving a total of fewer than 20 individuals left in the wild. This estimate was based upon secondary tiger signs observed during 147 survey days over 2 years.

Five years of subsequent fieldwork by SFA resulted in the collection of over 2,000 pieces of information by May 2000, including eyewitness sightings, tigers roaring, tracks, scratches, hair and skeletons or parts of tiger prey. While no direct sightings were confirmed, the evidence seemed to suggest that an unknown number of South China tigers still persisted in several locations. Most of the supposed tiger range is dominated by settlements, crop lands and rapid industrial development (Gui & Meng, 1993). While the collection of unconfirmed information was promising, no intensive, systematic, scientific field study had been undertaken in more than a decade.

To address the need for a comprehensive approach to tiger research and conservation, SFA representatives drafted the *China Action Plan for Saving the South China Tiger* (SFA, 1998). The South China Tiger Protection Program was established to support an international cooperative project with SFA to train, equip and advise Chinese survey teams to census wild South China tigers in the provinces of Jiangxi, Fujian, Zhejiang, Hunan and Guangdong in south-central China. This study was intended to assist SFA to establish where and how many South China tigers remain in the wild and their probability of survival. In addition to searching for photographic or physical evidence of wild tigers, a further objective was to assess secondary sign of tigers and their prey, human disturbance, livestock depredations, tiger-related human conflict, and forest resource exploitation in these areas.

Methods

Field studies were carried out between 7 March and 30 July and 23 October and 12 December 2001. Prior to fieldwork 30 SFA staff were trained in survey methodology, including protocols for field observations, basic tiger

ecology, and use of global positioning systems (GPS), maps, and compasses during a 3-day workshop. An additional 13 researchers were trained in the field. Following preliminary reviews of reserves, 1–3 day reconnaissance trips were undertaken by field and local forestry staff to document and assess current habitat conditions in promising reserves. Further field surveys and remote camera placement were prioritized based on reported tiger and/or prey sign and the highest potential for photographing tigers. Based on these assessments, field surveys were carried out in eight of the most promising national, provincial, and county level reserves in Fujian, Jiangxi, Zhejiang, Hunan and Hubei Provinces (Fig. 1; Table 1).

Information collected by field teams, including wildlife and human signs and habitat descriptions, were located and noted using GPS and recorded on standardized field survey forms. The forms were translated into Chinese so that survey data could be easily recorded by non-English speaking Chinese staff.

The Chinese authorities refer to any sign left by a tiger (scats, scratches on trees, scrapes on the ground, footprints, hair, and vocalizations) as a 'trace'. Local informants and knowledgeable forestry officials were used to identifying both tiger traces, and non-tiger traces. This convention is used in this paper. Reports of tiger traces were investigated in five additional unprotected areas during single-day confirmation assessments. Where field observation suggested a possibility of tigers or prey, infrared-activated remote cameras and passive trail monitors were set up. Six Trailmaster remote camera and monitoring units (five active, one passive) were placed in Yihuang South China Tiger Reserve and Hupingshan National Reserve, following extensive ground-truthing surveys. The cameras were deployed along core area trails, ridges, and ravines where field reconnaissance suggested a high likelihood of finding wildlife.

The surveyed reserves were situated in steeply bisected mountainous terrain. The few trails that could be walked to sample for secondary tiger and tiger prey sign typically followed ridge top contours. Sample distances were small (< 15 km) in four of the six reserves because of their small size (Table 2) plus the extremely limited access we had in Wuyunjie. A local informant survey protocol was created and interviews were given prior to field surveys (Appendix). The informant surveys were designed to document trends in local wildlife populations, livestock management, and forest resource practices and poaching pressures by local villagers. Local forestry staff identified informants. The interviews served as a reliability check of reports, by using pictures of animals, life-size drawings of tracks, and questioning to assess the reliability of informant information. We used subjective measurements to describe habitat quality. Forests with tall trees

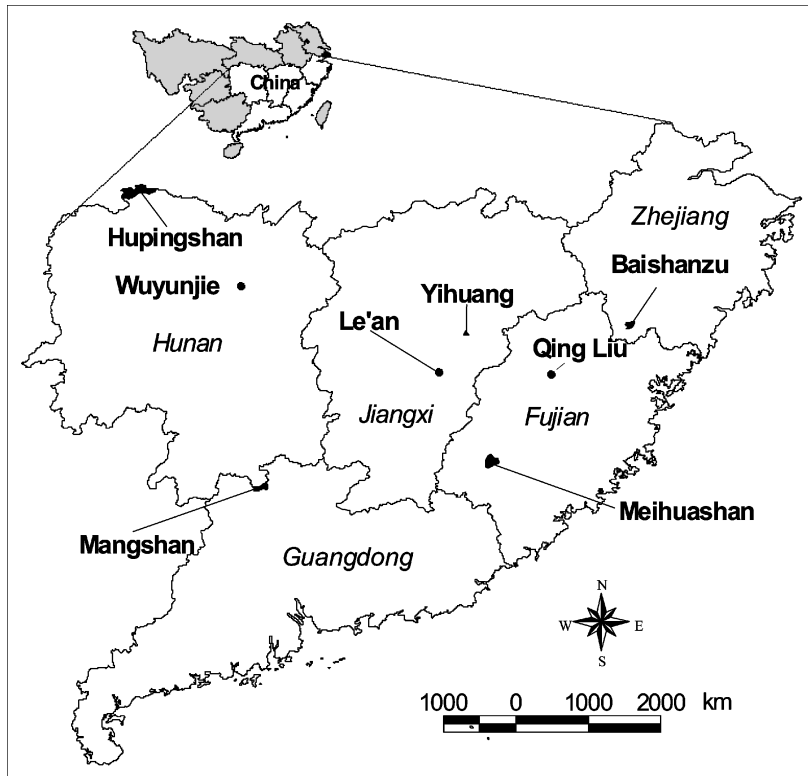


Fig. 1 The location of the eight reserves (see Table 1), in five provinces of South-central China, in which tiger surveys were carried out in 2001.

of various species and extensive shrub and ground cover, available water and no evidence of logging were considered to be high quality; forests that had extensive conversion to conifer plantations that were overrun by people and livestock and where extensive harvesting was occurring were considered to be low quality.

Results

After nearly 8 months of field work, including surveying 288 km of trails, 1,056 man-hours in the field, and 392 camera trap days, no evidence of tigers was found in any of the eight reserves (Table 1). Evidence for possible tiger prey species, including muntjak *Muntiacus* sp., wild pig *Sus scrofa*, serow *Naemorhedus sumatraensis*, tufted deer *Elaphodus cephalophus* and Sambar deer *Cervus unicolor*, was found in five locations. Of 20 potential tiger traces reported to and investigated by the field team, none were confirmed as tiger. No scats observed by the field team could be positively verified as being from tigers.

An assessment of the occurrence of wildlife sign, human-wildlife interactions, presence of domestic livestock, presence of patrols, human population numbers and land use, and overall subjective habitat quality was made for each reserve. This information was used to compare the potential value of these sites as possible tiger reserves, summarized in Table 2 and below.

Baishanzu National Reserve, Zhejiang Province

Most of the reserve is pine and fir plantation, especially on most mountain ridges. Seven monitoring stations staffed around the clock regulate reserve visitation and deter extraction of resources. Fifty domestic goats were released in March 2001 to help “feed the cats”. Few people live in the reserve, but villages occupy surrounding valleys. Logging was prevalent inside the reserve and numerous tourists hike inside the core area. Fourteen scats were collected from Baishanzu Reserve by forestry staff but were considered to be small carnivores based upon their consistent small diameter (<1.5 cm) and hair and bone remains of small rodents.

Meihuashan National Reserve, Fujian Province

This reserve has steep, rugged mountains 600–1,950 m above sea level. Twenty-five villages occupied by >3,500 people are located within the reserve, with the majority inhabiting the buffer zone. The villages are surrounded by a sprawling patchwork of crop fields and rice terraces, and family-managed bamboo stands also occur within a mosaic of scattered broad-leaf and pine forest fragments. We observed high levels of human and livestock disturbance in the core area. We were informed that most farmers graze their cattle in the mountains unsupervised for c. 9 months of every year.

Table 1 Reserve size, number of people living in reserves, summary of threats and field observations, and qualitative evaluation of potential as tiger habitat in eight reserves considered most likely to contain remnant wild South China tiger populations.

Evidence and threats	Reserve category and name							
	National				Provincial		County	Unprotected
	Baishanzu	Meihuashan	Hupingshan	Mangshan	Wuyunjie	Yihuang	Le'an	Qing Liu
Reserve size (km ²)								
Core zone	30	50	200	80	245	120	30	NA
Buffer zone	10	161	100	40	51	100	15	NA
Experimental zone	69	10	366	80	42	360	55	NA
Total area	109	221	666	200	338	580	100	NA
People living in reserve								
Total	42	>3,500	27,000	1,500	500	23,000	>5,000	NA
People km ⁻²	0.4	16	40	7.5	1.5	40	50	NA
Signs encountered								
Tiger	none	none	none	none	none	none	none	none
Prey	low	low	low	low	low	low	low	none
Conflict and disturbance								
Livestock depredation	none	none	medium	none	none-low	none-low	none-low	low
Human fatalities	none	none	none	none	none	maybe one ¹	none	none
Bamboo or timber harvest	high	high	medium	medium	high	high	high	high
Presence of patrols ²	medium	none	high	medium	low	none	none	none
Overall habitat quality ³	low	low	medium-high	medium-high	low	low	medium	low
Overall likelihood of tigers	low	low	medium-high	low	low	low	low	low

¹One possible, but unconfirmed, death reported in 1999.

²Low = present but <1 route per month; medium = 1 route per month; high = 1 route per week.

³None, no impact/presence observed; Low, insignificant impact/presence observed; Medium, impact/presence observed; High, significant level of impact/presence observed.

Hupingshan National Reserve, Hunan Province

The reserve manager claimed he observed a tiger in 1999, and he was able to accurately identify wildlife photos. All 16 informants indicated an increase in wild pig populations recently but only two reported tiger traces within the last 2 years. Only four of 16 informants could accurately identify the larger cats (clouded leopard *Neofelis nebulosa*, leopard *Panthera pardus* and tiger) by name. The other 12 referred to them all as *lahu*. Only one informant had experienced any livestock loss within the last 2 years, but did not know how they had died. Numerous wildlife trails intersect the main trail. We recorded 69 traces (identified by local forest staff) of wild pig, tufted deer, serow, leopard cat *Prionailurus bengalensis*, and civet (probably *Viverra indica*). Of the 84 photographs taken during 123 trap days, we identified people, livestock or domestic dogs in 73; the remaining 11 included one wild pig, one tufted deer, one cape hare (probably *Lepus capensis*, seven consecutive photographs minutes apart), one leopard cat (three consecutive photographs), three golden pheasants *Chrysolophus pictus*, and

one unidentified bird. Thus, only two photos of tiger prey were taken. We observed no commercial logging inside the reserve.

Mangshan National Reserve, Hunan Province

We observed only one old wild pig trace. Three informal interviews suggested that wild pig, tufted deer, serow, and sambar were present but few and declining. All informants correctly identified the large cats; one informant reportedly observed possible tiger trace 2 years ago. Officials informed us that many people enter to cut firewood, collect medicinal plants and trap animals. Tourism is a major source of income for the reserve, and there are signs, trails and new hotels inside both the buffer zone and the core area.

Wuyunjie Provincial Reserve, Hunan Province

We were shown nine plaster casts of tracks from the reserve, made in early 2001. Overall lengths and widths of the tracks averaged 16–21 cm, suggesting that they may

Table 2 Summary of distance and time covered, encounters and traces, and number of trap days and photographs in six of the eight reserves surveyed for tigers. Data for Mangshan reserve was not included because the intensity of fieldwork was lower, and we determined that an extended ground survey was not warranted in Le'an reserve after our initial field assessment indicated a high degree of disturbance.

Characteristics	Reserve Category and Name						Total
	National			Provincial		County	
	Baishanzu	Meihuashan	Hupingshan ¹	Wuyunjie	Yihuang	Qing Liu	
Trails							
Distance (km)	6.1	6.6	82.5	8.5	173	11.6	288.3
Man-hours	70	50	296	80	500	60	1,056
Encounters and traces							
Livestock and people ²	38	33 (97%)	179 (72%)	36	360 (88%)	38	684 (85%)
Wildlife ²	0	1 (3%)	69 (28%)	0	47 (12%)	0	117 (15%)
Tiger ²	0	0	0	0	0	0	0
<i>Total</i>	38 (100%)	34 (100%)	248 (100%)	36 (100%)	407 (100%)	38 (100%)	801 (100%)
No. trap days and photographs							
Trap days ³	0	0	123 ⁴	0	269 ⁵	0	392
Human/domestic livestock			73 (95%)		44 (96%)		117 (95%)
Wildlife			4 (5%) ⁶		2 (4%) ⁷		6 (5%)
Tiger			0		0		0
<i>Total photographs</i>			77 (100%)		46 (100%)		123 (100%)

¹Since reserve borders demarcating Hupingshan and Houhe Reserves were not well defined and only separated by a political boundary, results were combined for simplicity.

²Includes both direct and indirect encounters.

³One phototrap-day represents a 24 h monitoring period. Cameras and monitors were programmed to operate continuously.

⁴Six Trailmaster units were deployed during 5 November 2001–12 December 2001.

⁵Six Trailmaster units were deployed during 9 May 2001–7 July 2001.

⁶This includes photos of one tufted deer, one pig, three leopard cats, and seven hares; but the leopard cat and hares were sequential photos of the same animal taken minutes apart so they were counted as one event. Only the first two animals are considered tiger prey.

⁷This includes photos of two different Sambar deer.

be from a tiger or a large leopard. In our brief survey no wildlife sign was found. We observed extensive signs of bamboo harvest inside the reserve.

Yihuang South China Tiger Reserve, Jiangxi Province

Commercial fir and pine are common. Approximately 400 families live in the core area, defined by a ridge above 800 m. Rice is cultivated up to and into the core area. Two large towns, Shenggang (15,000 people) and Zhonggang (10,000 people) occupy both surrounding valleys in the experimental zone. We formally interviewed 14 local villagers in Yihuang who reported that many wildlife species were now rare or no longer observed. Twelve informants stated that, because of the death of a local snake hunter in 1999 due to an unconfirmed tiger attack or because they had heard people talk about hearing the tiger's roar, they believed tigers still remain in Yihuang. When using picture identification, villagers were generally unable to differentiate the felines (tiger, leopard and clouded leopard), referring to them all as *laohu* or tiger. Many of the families regularly harvest

bamboo and timber within the reserve with little or no knowledge of regulations. Although all firearms were reportedly removed in April 2001, we observed that some men still had rifles. Dozens of steel leg-hold traps were observed for sale in local markets, reportedly intended for leopard and/or tiger.

Six infrared remote cameras were placed inside the core area along trails located at various elevations (800–1,300 m) and in various habitats (grassland, scrub, fir and pine) for a total of 269 trap-days. Of the 46 photographs, two were of sambar deer and the rest were domestic cattle and people (Table 1). Nearly 90% of traces we observed in the reserve were caused by humans or livestock. The remaining 10% included prints, scats and rubs from sambar, serow and wild pig. One scat offered as a tiger trace was an owl pellet. Twenty-four of 26 villagers informally interviewed had livestock and only one claimed to have lost a cow in the last 10 years, and did not know how it had died. In comparison, most of the informants said they had experienced frequent livestock losses to predators prior to 1990. Many other farmers in our numerous informal discussions provided

similar responses. Livestock graze within the reserve, including its core, for 9–10 months of the year. They are not supervised and overnight corrals are infrequently used.

Le'an County Reserve, Jiangxi Province

There is a small village located in the core area. The forest supports broad-leaf, pine and bamboo species. We observed a large timber extraction site located a few kilometres from the boundary of the core area. Bamboo is harvested annually and livestock-grazing practices, as elsewhere, were unsupervised and occurred nearly year-round, with no confirmed tiger depredation. Local farmers stated that wild pigs were sometimes a crop pest and were dealt with by snare or leg hold traps. One informant reported a recent unconfirmed tiger roar.

Qing Liu County Forests, Fujian Province

This unprotected patchwork of pine plantations and mixed forest stands is used primarily for timber harvesting and sap extraction. Small areas of isolated secondary, broad-leaf forests remain but are saturated with well-used trails. We were shown two unrecognizable plaster casts of footprints and told of possible recent tiger traces (prints, scrapes, vocalizations and livestock depredation) from November 2000. A putative tiger scratch, two scrapes and a print reported by forestry officials were revisited but were too weathered to be distinguishable or measurable. Human litter was abundant and timber trucks passed frequently. An informant described a sharp decline in many wildlife populations in recent years, including muntjak, wild pig and serow. We observed a fresh muntjak and wild pig on sale in the local market. No patrolling or enforcement of forest resource extraction was observed. Livestock traces were frequently encountered, with only one unverified livestock depredation report in the last few years.

Other tiger trace reports

In addition to the eight reserves, the field team investigated 20 other potential tiger trace reports from five different localities in Fujian, Jiangxi and Hunan Provinces. These reports by village farmers to local forestry bureau staff included tiger sightings, tracks, ground scrapes, tree scratches, faeces and vocalizations. The areas where these observations occurred were not located in protected reserves. The team conducted 1-day investigations at these sites to cross-check informant knowledge via photograph and/or trace diagram identification and confirm if the trace was still visible. No reports could be confirmed as being of tiger.

Discussion

The most striking finding was the complete absence of any verifiable evidence of wild South China tigers. We recognize that our camera trapping data for tigers are too low to sufficiently assess tiger absence; a minimum of 1,000 trap days are considered necessary to rigorously test this (Carbone *et al.*, 2001). Likewise our camera trapping data for tiger prey are also low. Nevertheless, we photographed only two Sambar deer in Yihuang and one wild pig and one tufted deer in Hupingshan, for a combined prey rate of 0.7–1.6 prey per 100 trap days. In comparison, Griffiths (1994) found prey trapping rates of 7–10 prey per 100 trap days in mountainous tropical forest of Gunung Leuser National Park, Sumatra, Indonesia; Franklin (2003) found prey rates of 21–47 prey per 100 trap days in lowland tropical forest of Way Kambas National Park, also in Sumatra. Given, however, the great differences between tropical forest in Indonesia and subtropical evergreen broadleaf forest in China, these comparisons are probably meaningless.

The potential limitations of the camera trap data become less pertinent when our data are viewed as subsets of a combination of observations that include few observations of prey secondary sign, frequent encounters with people and livestock (both with cameras and as secondary sign), observations of leg hold traps for sale in villages near tiger reserves, and frequent extraction of wood, bamboo and other plants from the reserves. The designated core areas of the reserves were ridge tops and adjacent terrain down steep slopes, and much of this habitat was shrub or comprised of commercial tree plantings (Plate 1).

Despite the reputed abundance of sightings and putative tiger traces reported, none could be confirmed and we failed to find any compelling evidence to indicate that



Plate 1 A westerly view of the core area of Yihuang South China Tiger Reserve.

any wild tigers remain in the areas we surveyed. While it is possible that tigers may occur in areas we surveyed or in areas we have not yet surveyed, the complete lack of physical or photographic evidence of tigers or their prey, the high degree of habitat disturbance, the small size of remaining forest patches, and the lack of confirmed tiger attacks on abundant livestock point to the disconcerting conclusion that no South China tigers remain in the wild.

Sites identified by Koehler (1991) as possible tiger habitat are spatially separated by a matrix of agriculture and disturbed habitat and are, for the most part, probably too small to maintain viable tiger populations even if tigers were found. Fourteen of 19 reserves that cover the historical range of the South China tiger are approximately 100 km² or less; the other five are 180–705 km². Considering the near complete absence of suitable prey, only the larger areas could support even a single or several tigers.

Based on the results of our survey, we believe that Hupingshan National Reserve showed the most promise for supporting wild tigers. It has the most diverse and intact habitat, the greatest abundance of prey and small carnivores, and the least influence from human encroachment. The Hunan Provincial Forestry Bureau has plans to expand the core area inside the reserve and to lengthen the border with neighbouring Houhe Reserve in Hubei Province, effectively doubling its size.

Wuyunjie Provincial Reserve was not sufficiently evaluated to rule out the possibility of tiger presence, but because the site had a diverse and intact forest and sufficient water, it was considered better than the other sites we visited, even though no prey were observed in the brief survey. Its present size is too small to accommodate more than a few tigers.

Le'an County Reserve, Baishanzu-Fengyuanshan National Reserve, and Mangshan National Reserve are all too small and have levels of human encroachment or extraction of resources that are too high to support wild tigers. Le'an County Reserve, and the adjoining western portion of Yihuang South China Tiger Reserve, is relatively intact but most of the area is unprotected. In Baishanzu-Fengyuanshan National Reserve logging was significant, and fir *Cunninghamia* sp. monocultures are prevalent. Few people live inside the reserve and active patrols are present. In Mangshan tourism and construction of hydroelectric dams are serious threats.

Qing Liu forests and Meihuashan National Reserve, and Yihuang South China Tiger Reserve have high levels of human encroachment inside the core areas, intense bamboo, timber and medicinal plant harvesting, and intense grazing pressure for most of the year. There were no active patrol efforts, no verified tiger sign and few tiger prey. All reserves are small (<200 km²) and insular.

The only known remaining South China tigers occur in Chinese zoos, and the present population struggles with extreme loss of genetic diversity. As of October 2001, 47 South China tigers are in captivity, all derived from only six founders, and no new lines have been introduced since 1970 (Traylor-Holzer & Tilson, 1996). The Chinese Association of Zoological Gardens (CAZG), using demographic and genetic analyses based on data from the CAZG South China Tiger Studbook (Li, 1995), drafted a South China Tiger Masterplan in 1995 (Wang *et al.*, 1995).

The State Forestry Administration of China are currently initiating efforts to reintroduce individuals from this captive population into potential tiger habitat, which will include habitat restoration, prey stocking and 'barbarization' of captive tigers. The *China Action Plan for Saving the South China Tiger* (SFA, 1998) provides a blueprint for initiating conservation and restoration programmes for China's remaining tigers. But given the precarious status of the captive population and the additional information provided by this study, this plan will need to be updated before a credible restoration programme can proceed. Captive breeding and restoration specialists will need to be consulted to evaluate the risks and benefits of different management scenarios.

Our review of the available physical evidence and our field surveys in eight areas considered by Chinese authorities to be the most likely areas to contain wild tigers strongly suggests that the South China tiger is extinct in the wild. Even if a few individual tigers remain, no existing protected areas are sufficiently large or undisturbed to support a viable wild population. While we recommend that SFA continue long-term monitoring using remote cameras, to increase confidence of tiger status and to learn more about habitat characteristics to better inform potential recovery efforts, we also urge Chinese conservation authorities to focus their efforts on ensuring the health and safety of the remaining captive animals. The captive population, for better or for worse, may be all that is left between restoration and extinction of *Panthera tigris amoyensis*.

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References

- Carbone, C., Christie, S., Conforti, K., Coulson, T., Franklin, N., Ginsberg, J. R., Griffiths, M., Holden, J., Kawanishi, K., Kinnaird, M., Laidlaw, R., Lynam, A., Macdonald, D.W., Martyr, D., McDougal, C., Nath, L., O'Brien, T., Seidensticker, J., Smith, D.J.L., Sunquist, M., Tilson, R. & Wan Shahrudin, W.N. (2001) The use of photographic rates to estimate densities of tigers and other cryptic prey. *Animal Conservation*, **4**, 75–79.
- Franklin, N. *Conservation biology of the Sumatran tiger in Way Kambas National Park* (2003) Unpublished PhD thesis, University of York, York, UK.
- Gui, X.J. & Meng, S. (1993) The challenge and strategies for management of the South China tiger *Panthera tigris amoyensis*. Paper presented at the Global Tiger Forum, 4 March 1994, New Delhi, India.
- Griffiths, M. (1994) Population density of Sumatran tigers in Gunung Leuser National Park. In *Sumatran Tiger Population and Habitat Viability Analysis Report* (eds R. Tilson, K. Soemarna, W. Ramono, S. Lusli, K. Traylor-Holzer & U. Seal), pp. 93–102. IUCN/Species Survival Commission Captive Breeding Specialist Group, Apple Valley, USA.
- Jackson, P. (1993) The status of the tiger in 1993 and threats to its future. *Cat News*, **19**, 5–11.
- Koehler, G. (1991) *Survey of Remaining Wild Population of South China Tigers*. WWF Project 4152/China Final Project Report. Unpublished Report, WWF, Washington, DC, USA.
- Li, Y. (1995) *South China Tiger Studbook*. Unpublished Report, Chongqing Zoo, Chongqing, China.
- Lu, H. (1987) Habitat availability and prospects for tigers in China. In *Tigers of the World: The Biology, Biopolitics, Management, and Conservation of an Endangered Species* (eds R. Tilson & U. Seal), pp. 71–74. Noyes Publications, Park Ridge, USA.
- Lu, H. & Sheng, H. (1986) Distribution and status of the Chinese tiger. In *Cats of the World: Biology, Conservation and Management* (eds S. Miller & D. Everett), pp. 51–58. National Wildlife Federation, Washington, DC, USA.
- Nowell, K. & Jackson, P. (1996) *Wild Cats: Status Survey and Conservation Action Plan*. IUCN, Gland, Switzerland.
- State Forestry Administration (SFA) (1998) *China Action Plan for Saving the South China Tiger*. Unpublished Report, State Forestry Administration, Beijing, China.
- Shapiro, J. (2001) *Mao's War Against Nature: Politics and the Environment in Revolutionary China*. Cambridge University Press, Cambridge, UK.
- Tan, B. (1987) Status and problems of captive tigers in China. In *Tigers of the World: The Biology, Biopolitics, Management, and Conservation of an Endangered Species* (eds R. Tilson & U. Seal), pp. 134–148. Noyes Publications, Park Ridge, USA.
- Traylor-Holzer, K. & Tilson, R. (1996) Population management evaluation. In *Medical, Reproductive and Management Evaluation of South China Tigers in China* (eds R. Tilson, D. Armstrong, E. Miller, A. Byers, K. Traylor-Holzer, G. Brady, M. Wang & Z. Xie), pp. 51–58. Unpublished Report, Minnesota Zoo, Apple Valley, USA.
- Wang, M., Tilson, R., Traylor-Holzer, K., Manansang, J. & Seal, U. (1995) *South China Tiger Studbook Analysis and Masterplan*. Unpublished Report, Minnesota Zoo, Apple Valley, USA.

Appendix

The appendix for this article is available online at <http://journals.cambridge.org>

Biographical sketches

Ronald Tilson initiated the Tiger Information Center (<http://www.5tigers.org>) and the Minnesota Zoo's Adopt-A-Park programme, which provides *in situ* support for both Javan and Sumatran rhino conservation in Indonesia. Tiger conservation and tiger-human conflict, both in the wild and the private sector, are his major interests.

Hu Defu has worked on Asian wild ass and gazelle in northwestern China, and is now working on the naturalization of Przewalski horses in Xinjiang.

Jeff Muntifering has worked on wolves in Minnesota and grizzly bears in Alaska, and his current field interests are on the behaviour and ecology of cheetah in Namibia.

Philip Nyhus has been associated with the Sumatran Tiger Conservation Program since 1995 and The Tiger Foundation, Canada, since its inception. His research interests include interdisciplinary approaches to biodiversity risk assessment and human-wildlife conflict.