Red Pandas in China

Population and Habitat Viability Assessment Workshop

11-14 June 2012, Beijing, China

FINAL REPORT

Chinese Academy of Sciences
Institute of Zoology, CAS
Diergaarde Blijdorp rotterdam zoo
EAZA European Association of Zoos and Aquaria
Chester Zoo Act for Wildlife
San Diego Zoo
WWF
OPCF Hong Kong 香港海洋公園保育基金 Ocean Park Conservation Foundation Hong Kong
IUCN
Conservation Breeding Specialist Group
IUCN/SSC Small Carnivore Specialist Group
calgary zoo
Red Panda Network

Workshop organized by: Chinese Academy of Sciences (CAS), Institute of Zoology (IOZ); Rotterdam Zoo; and the IUCN SSC Conservation Breeding Specialist Group (CBSG) and Small Carnivore Specialist Group (SCSG)

Workshop financial support provided by: Calgary Zoo, Chester Zoo – Act for Wildlife, zoos of the European Association of Zoos and Aquariums (EAZA), IOZ (CAS), Ocean Park Conservation Fund Hong Kong, Red Panda Network, San Diego Zoo Global, World Wildlife Fund

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A contribution of the IUCN SSC Conservation Breeding Specialist Group.

Wei, F.W., Traylor-Holzer, K., Leus, K. and Glatston, A. (eds.). 2014. *Red Pandas in China Population and Habitat Viability Assessment Workshop Final Report*. IUCN SSC Conservation Breeding Specialist Group, Apple Valley, MN.

A PDF of *Red Pandas in China Population and Habitat Viability Assessment Workshop Final Report* can be downloaded at: www.cbsg.org.

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SECTION 1

Executive Summary

Executive Summary

The red panda (*Ailurus fulgens*) is a unique species that belongs to its own taxonomic family and is not closely related to any other living species. This species is very significant biologically, is of high conservation value, and has the potential to serve as a flagship for conservation across its range. Unfortunately the red panda is at risk of extinction as its habitat becomes increasingly threatened. Fewer than 10,000 red pandas remain in the wild, distributed over two subspecies (perhaps even two species) and five range countries. In China it is estimated that 6,000 – 7,000 red pandas remain in the wild. Recent rapid population declines have been reported for the species in China (40% decline over the last 50 years) (Wei and Zhang 2011), which is similar to the rates of decline observed across the species' range (Choudhury 2001). A better understanding of the threats to the red panda and its habitat are urgently needed to develop an effective conservation plan to address these threats.

This workshop is the second in a series of three Population and Habitat Viability Assessment (PHVA) workshops, each devoted to red panda conservation planning for different populations in different range countries – Nepal (2010), China (2012), and India (2013) – with additional discussions for Bhutan and Myanmar. Together these PHVA workshops are designed as the first step in reversing the risk of extinction of this species in the wild.

The objective of this PHVA workshop was to create a vision for red panda conservation in China, to gather and analyze all available data on the status of and threats to red pandas, and to use this information to establish a conservation strategy and action plan for the red panda in China as a part of similar efforts throughout the full range of the species and subspecies. This workshop was organized by the Institute of Zoology of the Chinese Academy of Sciences in collaboration with the Rotterdam Zoo and the IUCN SSC Conservation Breeding and Small Carnivore Specialist Groups, and was facilitated by the Conservation Breeding Specialist Group. Participants included Chinese and international representatives from the State Forestry Administration, universities, zoos, and non-government organizations (NGOs).

Workshop Process

The workshop began with presentations on the status of and threats to red pandas in China and Myanmar as well as research and conservation efforts for these populations. This was followed by an overview of the previous Red Panda PHVA workshop conducted in Nepal in 2010 and relevant population viability modeling results for red panda populations. Workshop participants then participated in a plenary discussion to articulate important aspects of a collective vision for the future of red pandas in China; these perspectives were drafted into the following consensus vision statement:

> *VISION:*
> *Secure, viable populations of the three gene pools (representing the two subspecies) of red pandas that are distributed across appropriate eco-regions, which are not limited by provincial or national borders, and preserve the associated ecosystem services, thereby ensuring harmonious co-existence of red pandas and people.*
>
> **中国小熊猫保护愿景：**
> 建立跨省跨国界的小熊猫保护网络，确保小熊猫两个亚种的三个不同遗传种群在不同生态区域长期可持续生存，实现小熊猫与人类的和谐共存。

A threat analysis was conducted in a plenary brainstorming session to identify key factors or threats affecting red panda population viability and conservation. Related factors were grouped to form seven clusters or topics. The participants began the process of expanding each topic into causal chains, considering additional factors and conditions that lead to each threat and also the impacts of each threat on wild red panda populations.

Participants then divided into two concurrent working groups: the *Population Status Working Grou*p focused on issues related to red panda population and habitat assessment and connectivity, while the *Threats to Red Pandas Working Group* expanded the threats analysis and discussed potential actions to reduce these threats and/or their impact on red pandas. These groups periodically reconvened in plenary sessions to present their analyses and recommendations for discussion and consensus by all participants. The workshop concluded with a plenary discussion to identify priority action steps for conservation.

Summary Recommendations and Next Steps

The *Population Status Working Group* compiled the best available information on red panda populations and habitat for China. Based upon this information as well as population modeling results, the group identified the following three long-term conservation goals for red pandas.

By 2050:

- Loss of populations, habitat, and genetic diversity has been halted in the high density core areas in China;
- Trans-boundary connectivity of habitats and populations between China and neighboring populations has been ensured; and
- Loss of habitat and the decline of populations in the current red panda range in Myanmar has been halted.

The group identified short-term objectives to support these goals (see Section 5).

To achieve these goals, it is important to have sufficient knowledge of current red panda population status, demographic rates and connectivity as well as good understanding of the nature, distribution and severity of threats to these populations. Such information will support the assessment and implementation of effective management strategies to promote population viability and minimize the negative impacts of human activities on red pandas. This is particularly true for *A.f. styani*, for which China carries the sole responsibility for its survival.

The *Threats to Red Pandas Working Group* explored threats to red pandas using the best available information to begin this process of identification and evaluation of alternative management actions to promote effective conservation. This group identified the following general goals, which complement those of the *Population Status Working Group*:

- Stabilize and restore wild red panda habitat;
- Develop and maintain a large and viable wild red panda population; and
- Increase awareness and action by the public for red panda protection.

Several strategies were recommended to support these goals, including actions related to policy, law enforcement, habitat restoration, education, and exploration of alternative options for energy, building materials, and development of sustainable livelihoods for local people (see Section 6 for details).

At the end of the PHVA workshop, the participants considered all of these goals and objectives, and developed the following list of recommended actions as priority next steps:

Priorities for China (by 2015)

1) **Formal report to the Chinese government** (SFA) to make sure they understand the situation, urgency and the required high level activities for conservation for red pandas.
2) **Rapid survey** on the distribution and population of red pandas; on the distribution, type and extent of threats; and development of long-term monitoring.
3) **Education, community development and sustainable livelihoods**, and other recommended activities that can be initiated while the survey is conducted.
4) **Fund raising plan** to secure funding for: survey and long-term monitoring; education; and community development and sustainable livelihoods.

Priorities for Myanmar (by 2015)

1) **Biological monitoring** (red panda populations, fecal collection);
2) **Transboundary collaboration**;
3) **Invite** a delegation from **Myanmar to the Indian PHVA** to do more planning for Myanmar [*note: the PHVA in India has since taken place and unfortunately it was not possible to have representation from Myanmar, necessitating the need for an alternative strategy for red panda conservation planning for Myanmar*];
4) **Sustainable agricultural activities** as an alternative to shifting cultivation; and
5) **Ranger training** for law enforcement staff and community rangers to carry out law enforcement, and community-based monitoring and awareness.

This PHVA report and the recommendations within it are considered advisory to the local and regional wildlife and forestry management authorities and their collaborators to help guide actions thought to be beneficial to the long-term survival of the red panda in China and Myanmar.

Special thanks go to Ms. Yan Li for her efforts in workshop preparation and organization, and to the numerous participants and students who provided oral and written translations of workshop materials and discussions.

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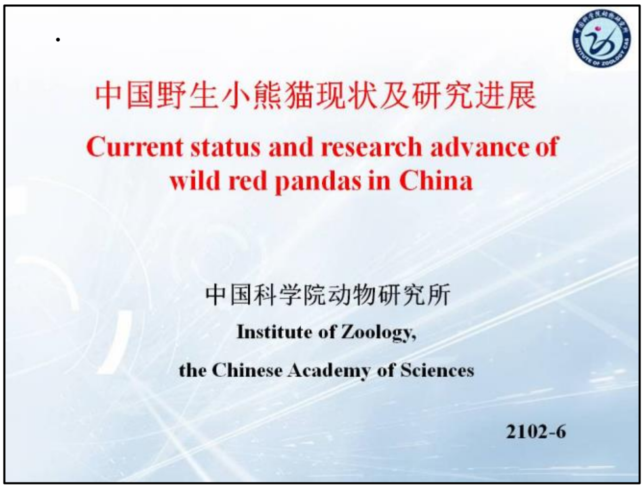
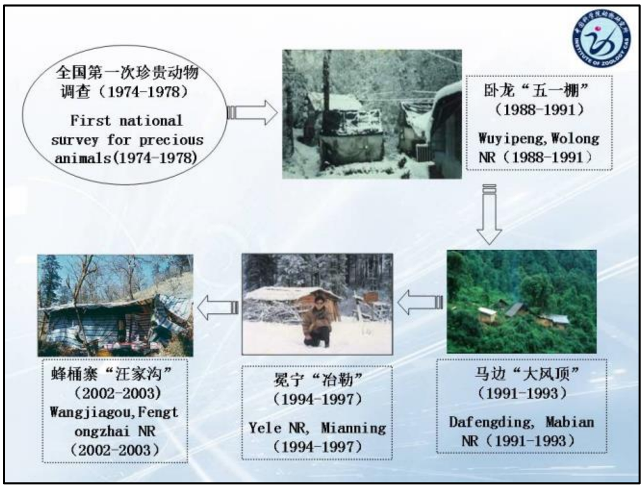
SECTION 2

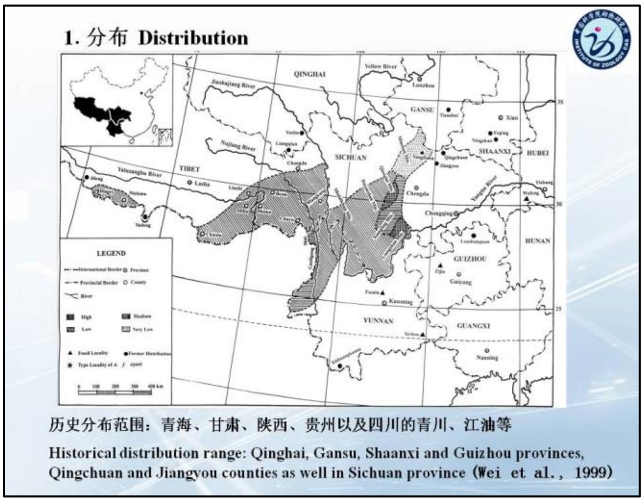
Status Review for China

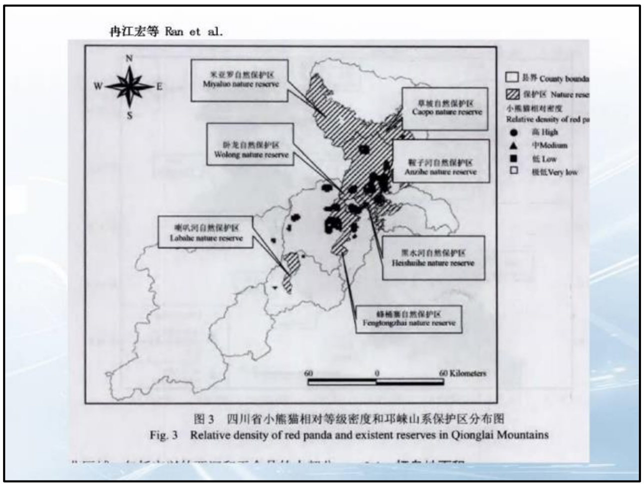
Red Pandas in China: Status Review

The following presentation was given by Wei Fuwen at the PHVA workshop, summarizing the current status and research activities for wild red panda populations in China. Further assessment of the status of red pandas in China was conducted by the *Population Status Working Group* during the PHVA workshop (see Section 5 of this report).









冉江宏等 Ran et al.

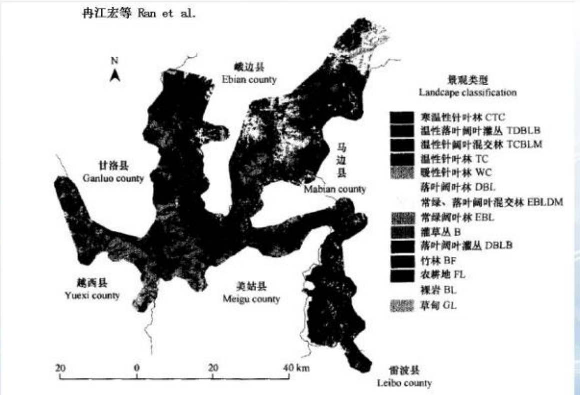


图2 凉山山系小熊猫生境景观类型分布图

Fig. 2 The distribution map of landscape types in study area

胡刚等 Hu Gang et al.

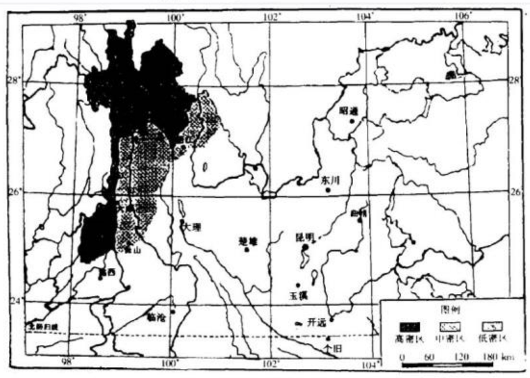


图1 云南省小熊猫分布示意图

Fig. 1 The current distribution and relative density of red panda in Yunnan

2. 栖息地与种群数量
Habitat and population size

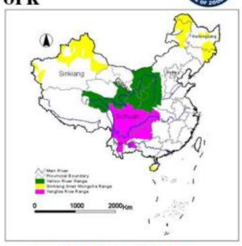
Province	Mountains	Forest (km²)	Habitat (km²)	Reserves	
				Number	Area (km²)
Sichuan	Minshan	7596.8	3730.0	9	2780.2
	Qionglai	7681.3	3771.5	5	2943.9
	Xiangling	4736.9	2325.8	2	407.0
	Liangshan	7734.9	3797.8	2	430.0
	Daxueshan	2845.8	1397.3	0	
	Shaluishan	4492.6	2205.9	0	
Yunnan		21 658.1	10634.1	7	6946.3
Tibet		19 499.1	9574.1	6	2357.5
Total		76 245.5	37436.5	31	15 864.9

(Wei et al., 1999)

3.保护网络 Conservation network

法律法规 Laws or regulations

Constitution of the People's Republic of China	1949
Criminal Law of the Peoples Republic of China	1979
Forest Law of the People's Republic of China	1984
Management Methods for Natural reserves of Forest and Wild Animals	1985
Environment Protection Law of the People's Republic of China	1989
Wild Animal Protection Law of the People's Republic of China	1989
Regulations of the People's Republic of China on the Implementation of Terrestrial Wildlife Protection	1992
Regulations of Natural Reserves of the People's Republic of China	1994
Regulations of the People's Republic of China on Administration of Import and Export of Endangered Wild Animals and Plants	2006



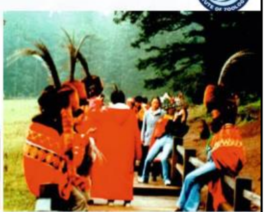
天然林保护工程NFPP

相关的自然保护区 Relative nature reserves

省份 Provinces	自然保护区总数Total of NR	总面积Total area (km²)
四川 Sichuan	32	16121.52
云南 Yunnan	8	7189.3
贵州 Guizhou	6	2357.54

4.威胁 Main Threats

- 生境丧失 Habitat loss
- 生境破碎 Habitat fragmentation
- 大型工程 (road, hydropower station, mining)
- 猎杀Poaching
- 展出Exhibition
- ……

三、研究进展

Part III: Research advance

1. 形态与功能适应

Morphology and functional adaptation

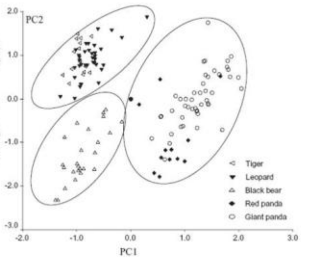
Its skull is dense and massive with broad zygomatic arches associated for the attachment of the muscles required for chewing.

The teeth are heavily cusped and have elaborate crown patterns that facilitate the effective mastication of bamboo.

The forepaw has an elongated radial sesamoid, adapted for grasping bamboo stems while feeding.

The resulting level of mastication increases the amount of plant nutrients, particularly of cellular contents, available to the animal.

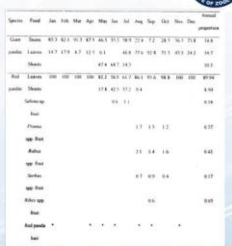
(Wei et al., 1999a)



(Zhang et al., 2007)

2. 食性与觅食对策 Diet and foraging strategy

- Bamboo leaves are the most important food item in their diet, almost being the only food in winter and usually the most common across all seasons
- Bamboo shoots and some fruits, especially those of *Sorbus* spp., are two important food sources. The former primarily occurs in their diet in spring, and the latter primarily in late summer and autumn
- Depending on availability, they can occasionally ingest some small mammals, birds, eggs, blossoms and acorns, and other parts of their range
- Some items in their diet perhaps are ingested by way of parenthesis, for example, moss and hair.



Yele NR

(Wei et al., 1999b)

Food item	April	May	June	July	August	September	October	November	December–March
Bashania faberi leaf	95.8	7.1	25.09	95.1	96.3	78.7	70.4	95.0	99.9
Bashania feberi shoot	4.2	92.8	74.89	4.9					
Sorbus					0.8	20.9	29.5	5.0	
Rubus					0.9				
Ribes					0.1	0.3			
Hair		0.1	0.01		1.7	0.01			0.1
Moss					0.2	0.04			
Others			0.01			0.05	0.1		
Sample size of droppings	34	31	30	30	33	31	30	31	30. 5 (average)

Fengtongzhai NR

(Zhang et al., 2009)

觅食对策 Foraging strategy

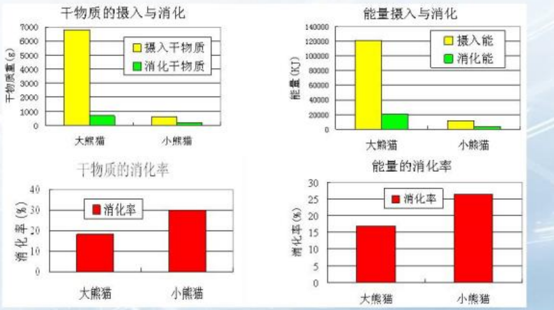
- 选择环境中营养质量最丰富的竹种 To select the most nutritious species of bamboos in the habitat
- 喜食竹叶 To prefer for leaves, the most nutritious part on bamboo stem
- 春季喜食竹笋，秋季喜食浆果类食物 To prefer for bamboo shoots in spring, and berries or fruits in autumn, which are nutritious and easily digestible

(Wei et al., 1999b; Zhang et al., 2009)

营养和能量 Nutrition and energy

To fulfill their daily energy requirements, red pandas ingested a large amount of energy from bamboo leaves, which varied from 10,145.8 kJ in the spring, 12,045.1 kJ in the summer-autumn, and 12,276.9 kJ in the winter to maximize the rate of energy intake. Zoo Biol 19:27–33, 2000. © 2000 Wiley-Liss, Inc.

(Wei et al., 2000)



3. 移动与空间利用

Movement and space use

移动Movement

Month	Percentage of total home range used		Daily movement distance (m)	
	Female	Male	Female	Male
2002				
April	26.7	15.6	457	458
May	16.9	20.4	389	488
June	43.4	41.9	503	301
July	48.1	26.3	534	484
August	22.5	30.8	414	468
September	17.6	19.7	327	399
October	24.3	35.0	359	609
November	22.7	41.5	319	545
December	37.8	38.4	540	599
2003				
January	38.6	18.0	486	244
February	24.7	15.6	565	477
March	37.5	21.9	468	486
Mean ± SD	30.1 ± 16.2	27.1 ± 14.8	447 ± 84	463 ± 107

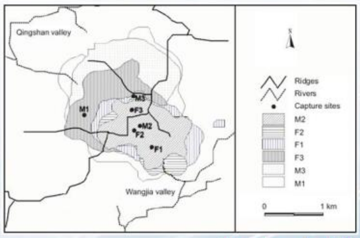
- 雄性日均移动距离较雌性为高
- 月份对日均移动距离有影响

The daily movement distance averaged 455 m across all individuals, 463 m for the males, marginally significantly higher than that for the females (447 m) (two-way ANOVA: $F_1 = 3.74, p = 0.053$). Month affected daily movement distance significantly ($F_{11} = 2.14, p = 0.016$). The daily movement distance is shortest (365 ± 296 m) in January and longest (573 ± 382 m) in December.

(Zhang et al., 2009)

巢域 Home range

Collared red pandas



Fengtongzhai NR

Individual	Sex	Age class	Body mass (kg)	Number of locations	Area of home range (km^2)*	Monitoring duration (month)
M1	M	adult	5.5	197	3.8	12
M2	M	adult	5.9	196	1.2	12
M3	M	adult	5.9	201	3.0	12
F1	F	adult	5.7	201	1.7	12
F2	F	adult	6.0	209	1.3	12
F3	F	adult	–	211	2.2	12

(Zhang et al., 2009)

生境利用Habitat use

red panda plots suggested preferences for microhabitats containing higher densities of fallen logs and tree stumps, whereas giant panda plots did not.

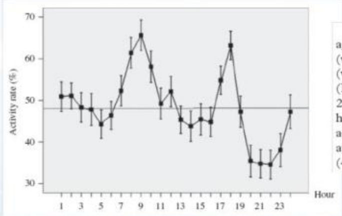
(Zhang et al., 2006)

Table 3. One-way ANOVA for the 8 variables with significant differences in Table 2 ($\bar{x}_1$ represents means of variables for giant panda group, $\bar{x}_2$ represents that for red panda group and $\bar{x}_3$ represents that for the control group).

Variables	$\bar{x}_1-\bar{x}_2$	ANOVA F	ANOVA P	$\bar{x}_1-\bar{x}_3$	ANOVA F	ANOVA P	$\bar{x}_2-\bar{x}_3$	ANOVA F	ANOVA P
Slope	−1.30	28.61	0.00	−1.80	44.29	0.00	−0.50	2.82	0.10
Bamboo density	6.61	1.68	0.20	18.39	7.81	0.01	11.78	2.69	0.10
Old shoot proportion	2.16	2.74	0.10	6.17	30.89	0.00	4.01	11.49	0.00
Bamboo height	11.75	9.63	0.00	20.76	21.07	0.00	9.01	3.86	0.05
Tree size	7.84	6.55	0.01	10.48	10.52	0.00	2.64	0.86	0.34
Tree stump density	−0.24	10.23	0.00	−0.08	1.47	0.23	0.16	4.00	0.05
Fallen log density	−0.74	21.39	0.00	−0.20	1.96	0.16	0.54	9.74	0.00
Fallen log dispersion	1.28	12.02	0.00	0.87	5.14	0.03	−0.41	1.01	0.32

4. 活动模式与昼夜节律

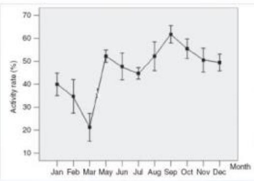
Activity pattern and daily rhythm



The circadian activity rate of red pandas averaged 48.6% (±12.4), with two peaks at 700–1000 h (with 60.3% activity rate per hour) and 1700–1800 h (with 58.4% activity rate per hour), respectively (Figure 2). The lowest active period occurred from 2000 to 2300 h with the activity rate of 35.7% per hour (Figure 2). On average, red pandas were more active in the daytime (53.3%±8.18), intermediate at dawn and dusk (48.6%±8.86) and less at night (44.2%±7.34).

(Zhang et al., 2011)

活动节律



Activity varied with season (F=7.58, df=2, *P*=0.001) and was lower in winter (42.2%±13.9) and higher in spring (51.9% ± 7.90, *P*=0.047) and summer–autumn (54.3%±8.83, *P*≤0.01). Red pandas were most active in September (maximum activity rate was 61.7%) and least active in March (minimum was 21.0%).

(Zhang et al., 2011)

休息频次

On average, red pandas rested 4.96±0.9 times per day, including 2.23±0.69, 1.42±0.80 and 1.31±0.81 times for long rests (mean duration: 4.02±1.24 h), medium rests (mean duration: 1.59±0.45 h) and short rests (mean duration: 0.79±0.21 h), respectively. Long rests constituted 73.2% of the total duration.

(Zhang et al., 2011)

Table II. Frequencies (Mean ± SD) and duration (in h) of long (>2 h), medium (1–2 h) and short rests (≤1 h) for six red pandas.

Seasons	Long rests Frequency	Long rests Duration	Medium rests Frequency	Medium rests Duration	Short rests Frequency	Short rests Duration
Spring	1.94±0.69	3.85±0.77	1.86±0.64	1.52±0.13	1.64±1.06	0.82±0.11
Summer–autumn	2.07±0.81	3.86±1.27	1.43±0.87	1.60±0.50	1.43±0.80	0.82±0.13
Winter	2.51±0.44	4.22±1.40	1.17±0.72	1.54±0.50	1.02±0.60	0.69±0.27

5.保护遗传学 Conservation genetics

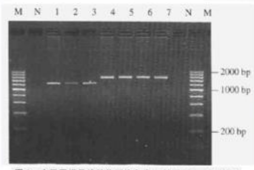


图 2 小熊猫样品线粒体细胞色素 b 基因（1－3）以及大熊猫的线粒体控制区（4－7）扩增产物的电泳结果

Fecal DNA extraction

（张保卫等，2004）

Isolation of microsatellite for red panda individual identification

（Wu et al.， 2009）

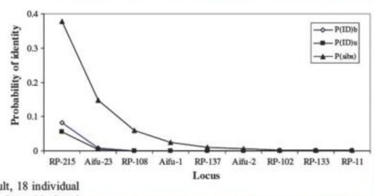
Locus	Primer sequence (5′-3′) (F, forward; R, reverse)	Repeat motif	Labeling dye	T_a (°C)	A	Size range (bp)	H_o	H_e	GenBank Accession no.
[illegible]	[illegible]	[illegible]	TAMRA	52	14	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	52	3	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	FAM	46	8	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	50	7	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	HEX	52	5	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	50	12	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	HEX	52	6	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	52	8	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	FAM	50	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	50	8	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	TAMRA	50	9	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	HEX	50	14	[illegible]	[illegible]	[illegible]	[illegible]

Genotyping faeces of red pandas (*Ailurus fulgens*): implications for population estimation

Yu Guo · Yibo Hu · Dunwu Qi · Xiangjiang Zhan · Michael W. Bruford · Fuwen Wei

粪便个体识别

Fig. 1 Probabilities of identity for pairs of individuals and full siblings, P(ID) and P(sibs), in the order of increasing probability of identity of nine microsatellite loci, based on 18 unique genotypes of faecal samples from the wild. *P(ID)b* biased estimation of P(ID), *P(ID)u* unbiased estimation of P(ID) corrected for sample size



amplification and data checking. As a result, 18 individual red pandas were identified successfully from 33 faecal samples collected in the field using nine red panda-specific microsatellite loci with a low probability of identity of 1.249×10^{-3} for full siblings. Multiple methods of tracking genotyping error showed that the faecal genetic profiles possessed very few genotyping errors, with an overall error rate of 1.12×10^{-5}. Our findings demonstrate the feasibility and reliability of using faeces as an effective source of DNA for estimating and monitoring wild red panda populations.

Eur J Wildl Res (2011) 57:1231–1235
DOI 10.1007/s10344-011-0556-4

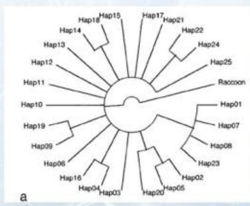
Phylogeography and genetic structure

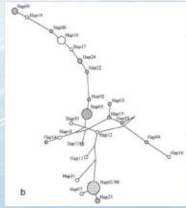
系统地理格局及遗传结构

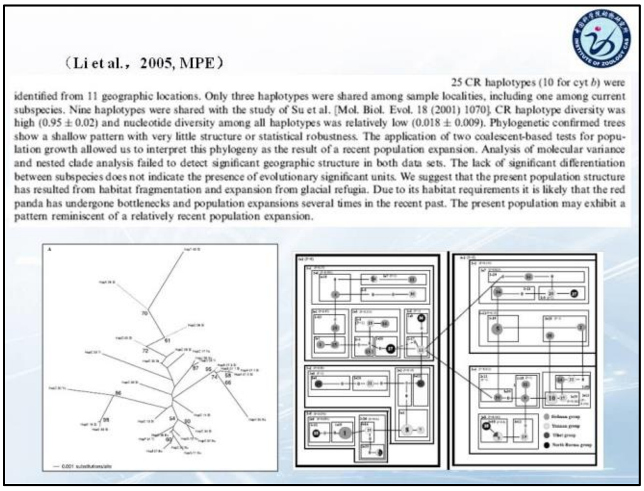
（Su et al.，2001， MBE）

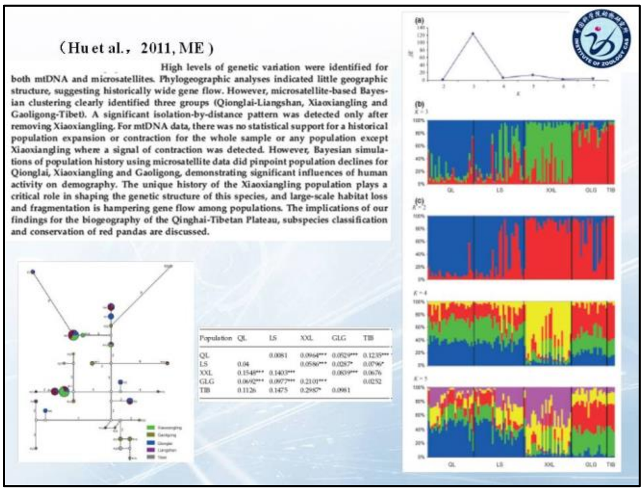
Seventeen polymorphic sites were found, together with a total of 25 haplotypes, indicating a high level of genetic diversity in the red panda. However, no obvious genetic divergence was detected between the Sichuan and Yunnan populations.

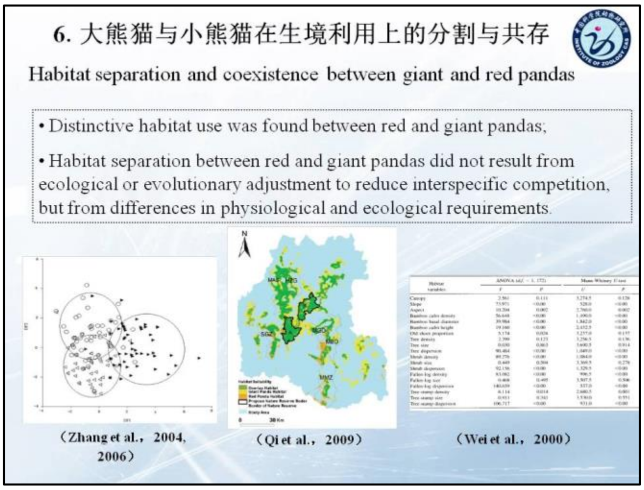
The pairwise mismatch distribution fitted into a pattern of populations undergoing expansion. Furthermore, Fu's F_S test of neutrality was significant for the total population which also suggests a recent population expansion. Interestingly, the effective population size in the Sichuan population was both larger and more stable than that in the Yunnan population, implying a southward expansion from Sichuan to Yunnan.

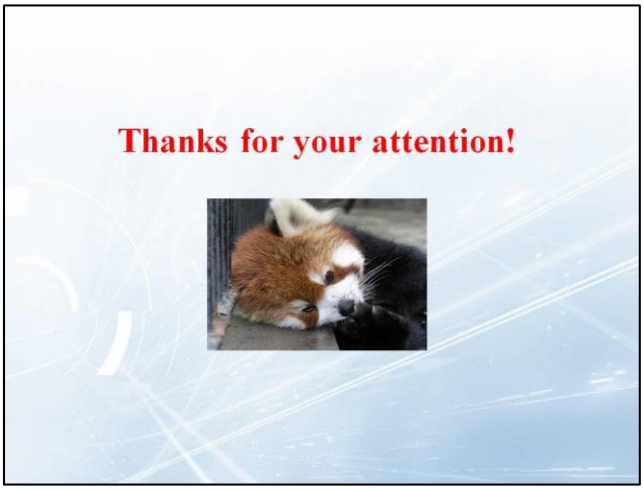





(Li et al., 2005, MPE)
25 CR haplotypes (10 for cyt b) were identified from 11 geographic locations. Only three haplotypes were shared among sample localities, including one among current subspecies. Nine haplotypes were shared with the study of Su et al. [Mol. Biol. Evol. 18 (2001) 1070]. CR haplotype diversity was high (0.95 ± 0.02) and nucleotide diversity among all haplotypes was relatively low (0.018 ± 0.009). Phylogenetic confirmed trees show a shallow pattern with very little structure or statistical robustness. The application of two coalescent-based tests for population growth allowed us to interpret this phylogeny as the result of a recent population expansion. Analysis of molecular variance and nested clade analysis failed to detect significant geographic structure in both data sets. The lack of significant differentiation between subspecies does not indicate the presence of evolutionary significant units. We suggest that the present population structure has resulted from habitat fragmentation and expansion from glacial refugia. Due to its habitat requirements it is likely that the red panda has undergone bottlenecks and population expansions several times in the recent past. The present population may exhibit a pattern reminiscent of a relatively recent population expansion.


(Hu et al., 2011, ME)
High levels of genetic variation were identified for both mtDNA and microsatellites. Phylogeographic analyses indicated little geographic structure, suggesting historically wide gene flow. However, microsatellite-based Bayesian clustering clearly identified three groups (Qionglai-Liangshan, Xiaoxiangling and Gaoligong-Tibet). A significant isolation-by-distance pattern was detected only after removing Xiaoxiangling. For mtDNA data, there was no statistical support for a historical population expansion or contraction for the whole sample or any population except Xiaoxiangling where a signal of contraction was detected. However, Bayesian simulations of population history using microsatellite data did pinpoint population declines for Qionglai, Xiaoxiangling and Gaoligong, demonstrating significant influences of human activity on demography. The unique history of the Xiaoxiangling population plays a critical role in shaping the genetic structure of this species, and large-scale habitat loss and fragmentation is hampering gene flow among populations. The implications of our findings for the biogeography of the Qinghai-Tibetan Plateau, subspecies classification and conservation of red pandas are discussed.
Population QL LS XXL GLG TIB
QL 0.0081 0.0964*** 0.0529*** 0.1235***
LS 0.04 0.0586*** 0.0287* 0.0796*
XXL 0.1548*** 0.1403*** 0.0839*** 0.0676
GLG 0.0692*** 0.0977*** 0.2101*** 0.0252
TIB 0.1126 0.1475 0.2987* 0.0981
(a)
(b)
(c)
QL LS XXL GLG TIB


6. 大熊猫与小熊猫在生境利用上的分割与共存
Habitat separation and coexistence between giant and red pandas
• Distinctive habitat use was found between red and giant pandas;
• Habitat separation between red and giant pandas did not result from ecological or evolutionary adjustment to reduce interspecific competition, but from differences in physiological and ecological requirements.
N
(Zhang et al., 2004, 2006)
(Qi et al., 2009)
(Wei et al., 2000)


Thanks for your attention!

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SECTION 3

Status Review for Myanmar

Red Pandas in Myanmar: Status Review

To date there has been no Population and Habitat Viability Assessment (PHVA) undertaken for red pandas in Myanmar. However, Than Zaw, Project Manager at the Hkakaborazi National Park Project of the Wildlife Conservation Society, Myanmar Program, attended the PHVA workshop in Beijing and provide some baseline information from Myanmar. His presentation was based on a report published in *Small Carnivore Conservation* and later republished in *Red Panda – Biology and Conservation of the First Panda*. This publication and his presentation are summarized below.

Geographical Distribution

Recent Observations

Red pandas are found in northern Myanmar in the following areas:

1. Hkakaborazi National Park;
2. Hponkanrazi Wildlife Sanctuary; and
3. Emaw Bum

A survey in 2003 indicated there were red pandas in Hkakaborazi National Park and Hponkanrazi Wildlife Sanctuary based on the presence of feces. However, no animals were observed on camera-traps, despite high effort at Hkakaborazi. Feces were confidently assigned to species by experienced local hunters and largely comprised bamboo leaves; in appearance they were identical to feces produced by a red panda caught at Zalahtu (3,390m) by staff of the Nature and Wildlife Conservation Division (NWCD), Hkakaborazi National Park. This animal was sent to Yangon Zoological Gardens. Staff of the same unit caught three other red pandas in 2002–2003. These animals were sent to the head office of Hkakaborazi National Park, in Putao, but died in transit (see Table 1 for more details).

Table 1. Records of red pandas captured in Myanmar.

Survey area	Site	Latitude (N)	Longitude	Capture date State
Hkakaborazi	Zalahtu, near Madein	28°08′	97°24′	March 2003 Live
Hkakaborazi	near Tahundam	28°11′	97°38′	Jan 2002 Live
Hkakaborazi	near Tahundam	28°14′	97°37′	Feb 2003 Live
Hkakaborazi	Tahundam	28°10′	97°40′	13 Feb 2004 Dead
Hkakaborazi	Tazundam	28°02′	97°34′	2 Nov 2003 Dead
Hkakaborazi	Gushin-1	27°38′	98°13′	Apr 2004 Dead
Hponkanrazi	Ziadam	27°34′	97°06′	9 Feb 2002 Skin

More recently, in February 2010, two live red pandas were seen on a branch of an oak tree in Hkakaborazi within dwarf bamboo–pine forest (28°03′ N, 97°36′ E, 2,575 m). Red panda tracks were observed in the snow within Rhododendron-pine forest (27°07′ N, 97°25′ E, 2,890 m) in 9 Mar 2010.

In northeast Kachin state, four different individuals were seen during a bird surveying visit to Mount Majed in early 2005 (Eames 2005), and a freshly-hunted animal was seen on Emaw Bum in early 2007 (Eames 2007).

A red panda was recently observed on a camera-trap by a gibbon survey team in Emaw Bum, Sawlaw Township within dwarf bamboo–pine forest (26°30′N, 98°22′E) 2,720 m in 06 Feb 2011.

Historical Reports
There are previous records from this area of northern Myanmar. Dollman (1932) and Pocock (1941) recorded red pandas 150 miles north of Myitkyina, near the Yunnan border; two sites on the Nam Tamai (one at 27˚50′N, 97˚55′E); and the Taron Valley. These specimens were found at altitudes ranging between 2,000-3,000m (1,070–2,130 m, Nam Tamai Valley; and at 2,740 m, Taron Valley). Subsequently, in February 1962, two specimens were collected on Janraung Bum at 2,488m (Tun Yin 1967).

Red pandas were also reported in northeast Kachin state: two skins reputedly from Sakkauk, on the north flank of Emaw Bum were reported by Anthony (1941).

The location of all records, both historical and current, are shown in Figure 1.

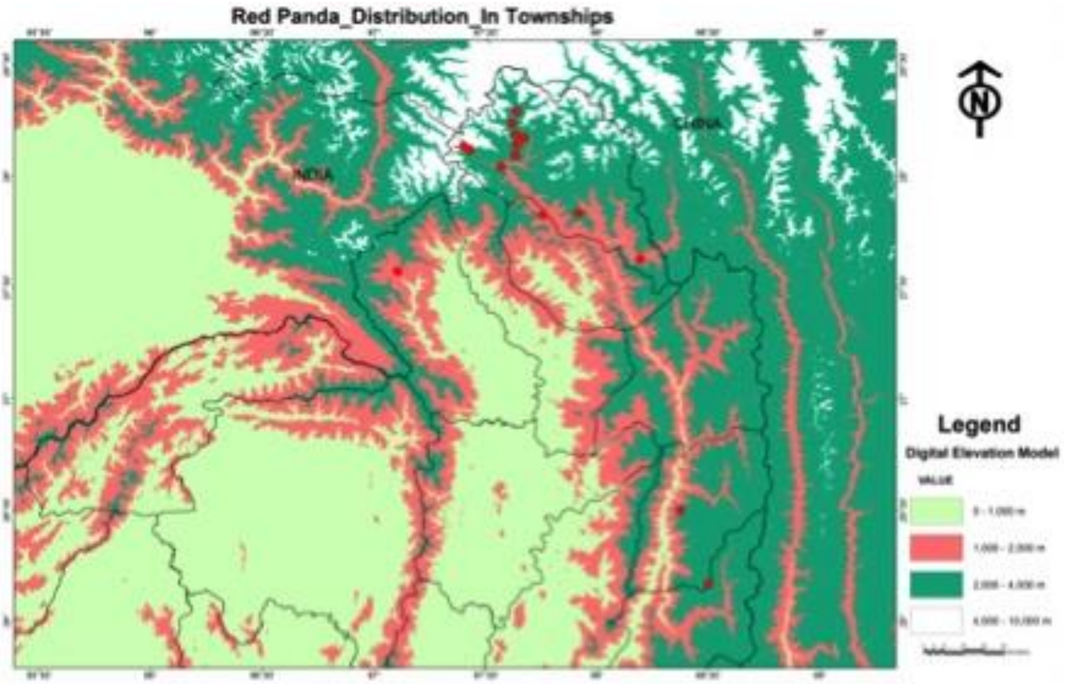


Figure 1. Locations of all red panda records in Myanmar.

Habitat and Altitude
Red pandas in Hkakaborazi in 2003 were found in dwarf bamboo–pine forest. Signs of red pandas were recorded only at high altitudes (over 3,000 m), above the timber line, among dwarf bamboo (1.5-2.4m tall). Local people reported that red pandas in Hkakaborazi move downslope in winter (Rabinowitz and Saw Tun Khaing 1998).

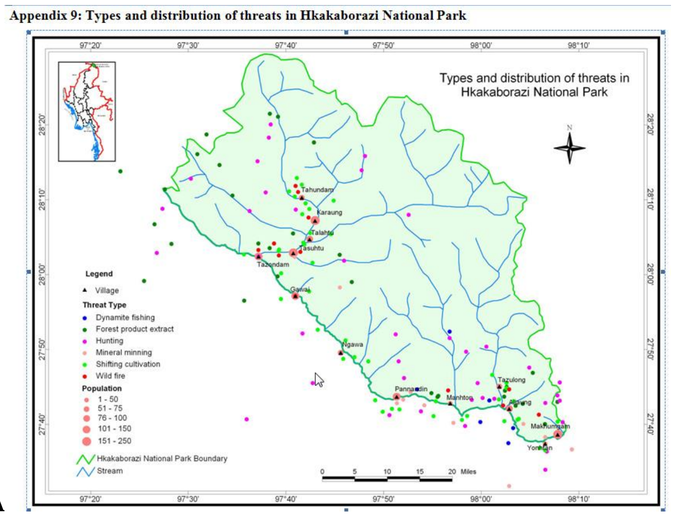
Threats in Myanmar

Timber Extraction

The villagers usually extract timber for local use from the forest around the villages. For the past three years Chinese timber companies have been extracting timber commercially from around the Maw River. This timber is exported to China. Timber to the north and east of the present production area is reportedly earmarked for extraction. A few villagers also cut some timber in the same area for export to China.

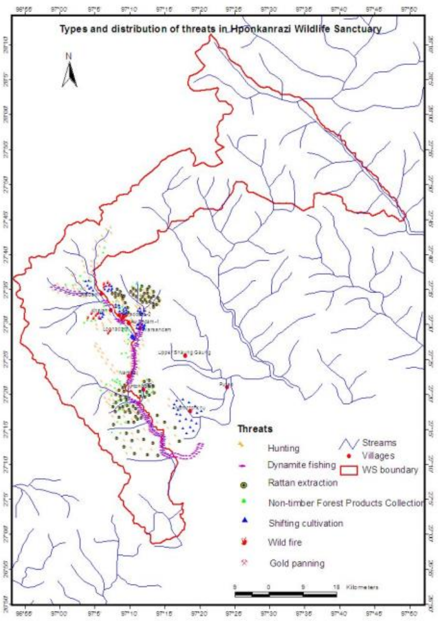
Wildlife Extraction

Hunting of wildlife is practiced both for subsistence consumption and trade. Although they hunt some species for meat for themselves, meat is sometimes sold to Chinese people staying in the survey area for road construction, either as part of the logging operations or related to dams that are under development in the area (particularly the ‘Wusut dam’). Bones of serow and takin can be sold for use in making traditional medicine. The target species are reportedly still common in this area even though the villagers have been hunting wildlife for many years. Figure 2 shows the distribution of threats.



A

Figure 2. Location of threats in Hkakaborazi (A) and Hponkanrazi (B).



B

Conservation Status

The lack of camera trap records suggests that red pandas might be scarce in Hkakaborazi, because there was significant survey effort over 3,000m (nine camera positions totaling about 340 trap-nights) and effort was high within 2,000–3,000m. However, it could simply be that by chance none was photographed. However, red pandas, which forage primarily on the ground (Roberts and Gittleman 1984), are surely vulnerable to snaring (e.g., for musk deer *Moschus*), which is widespread in the area. Rabinowitz and Saw Tun Khaing (1998) found that, in Hkakaborazi, local people did not actively target red pandas, but did kill or collect them opportunistically and sold the skins. Red panda skins were seen for sale in markets on the Thai–Myanmar border at Tachilek in 1998, an area far from likely wild red pandas and a known trading point (e.g., Davidson 1999). The threat of harvest for the international captive animal trade is difficult to assess: there is ample opportunity through the markets along the Hkakaborazi–China border. Choudhury (2001) identified habitat degradation as the chief threat in India to red pandas. Hence, it is noteworthy that habitat in Hkakaborazi and Hponkanrazi, especially at mid and high altitudes, is relatively stable (Renner *et al*. 2007). In some other areas (e.g., Emaw Bum) forests are much degraded (Eames, 2007), and some populations within the species' small Myanmar range are no doubt in decline.

Conservation Needs of Red Pandas in Myanmar

Consolidation of the Hkakaborazi National Park is important in conserving biodiversity through effective management to secure the population of red pandas (global interest). Although red pandas were recorded in two protected areas, Hkakaborazi National Park and Hponkanrazi Wildlife Sanctuary, and outside of protected area Emaw Bum, Hkakaborazi is the only protected area with conservation staff and well maintained by law enforcement and education activities since 2005.

Baseline Trade Surveys

There is huge trade in small carnivores to Chinese markets from Vietnam (e.g,. Bell *et al*. 2004), but little information on the magnitude of such trade from Myanmar (e.g., Davidson 1999; Martin and Redford 2000; Shepherd 200; Shepherd and Nijman 2007).

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SECTION 4

Vision and Threat Analysis
Plenary Discussion

Plenary Discussion: Vision Statement and Threats Analysis

Vision Statement

A vision statement is a short statement that outlines the desired future state of the species and is long term and ambitious. There may be several different components to a vision statement, including the scope (i.e., geographic range, time scale) and representation, functionality, and desired degree of management intervention.

The PHVA workshop participants engaged in a plenary discussion of the desired future for red pandas in China and generated a list of components that were integrated to form the following vision:

VISION:
Secure, viable populations of the three gene pools (representing the two subspecies) of red pandas that are distributed across appropriate eco-regions, which are not limited by provincial or national borders, and preserve the associated ecosystem services, thereby ensuring harmonious co-existence of red pandas and people.

中国小熊猫保护愿景：

建立跨省跨国界的小熊猫保护网络，确保小熊猫两个亚种的三个不同遗传种群在不同生态区域长期可持续生存，实现小熊猫与人类的和谐共存。

Development of this vision helped to define a common understanding among the workshop participants on the ultimate goal for the species in China and to guide the development of objectives and actions to help achieve this vision.

Threats Analysis

A thorough understanding of factors that impact the viability of red panda populations in China is important to identify and evaluate management strategies to address threats and promote population and species viability.

Workshop participants were asked to brainstorm and contribute threats or challenges to red panda conservation in China. They wrote each threat or challenge on a card (in both Chinese and English) and placed it on the wall. Clusters of related factors were identified to form the basis of more detailed working group discussions.

Threats or potential threats identified by participants through this exercise were:

- Dam construction
- Road construction
- Power lines
- Mining
- Industry
- Conversion of forests to plantations
- Timber extraction
- Grazing
- Agriculture land use
- Shifting cultivation
- Urbanization
- Human settlement
- Tenure reform
- Western Initiative

- Mass tourism
- Earthquake
- Forest fires
- Fuelwood collection
- Bamboo collection
- Bamboo flowering
- Bamboo disease
- Disease in red pandas
- Poaching
- Wild capture
- Traditional lifestyle of minorities
- Unsustainable Traditional Chinese Medicine
- Wildlife trade
- Lack of law enforcement
- Lack of education
- Lack of awareness of red panda population losses/decline
- Lack of baseline information on red panda demography and population dynamics across range
- Political conflict
- Restricted access
- Human population growth
- Climate change

These threats may impact red panda populations in one or more ways. Some threats reduce populations through removal of animals or by leading to higher mortality and/or lower reproduction in wild red pandas. Other threats reduce population through loss of adequate habitat or food supply and thus lowering the number of animals that can be supported by the habitat. Habitat fragmentation and lack of adequate protection of animals moving between habitat patches leads to population fragmentation, resulting in genetic isolation and possible increased risk of decline due to stochastic processes affecting small isolated populations. A few overriding challenges affect many aspects of both wildlife and human populations as well as the environment, such as human population expansion and climate change.

Further discussion and prioritization of these threats, including root causes and resulting impacts on red panda populations, were undertaken by the *Threats to Red Pandas Working Group* (see Section 6 of this report).

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SECTION 5

Population Status Working Group Report

Working Group Report: Population Status

Members: Angela Glatston, Gu Xiaodong, Dirk Kloss, Kristin Leus, Long Yongcheng, Qi Dunwu, Ran Jianghong, Tang Weihong, Wei Fuwen, Wu Ruidong, Yang Xuyu, Yang Zisong, Than Zaw, Zao Lianjun

Status Assessment in China

The Population Status working group collected the current available information on the distribution of red pandas and their habitat in China, through reviewing published literature as well as expert knowledge of the participants at the workshop.

Methods

The habitat distribution for red pandas in China was mapped through three steps.

First, the county-level distribution was identified, based on the information derived from various publications (e.g., Hu and Wei 1992; Hu 1998a; Hu 1998b; Wei *et al.* 1999; Hu and Du 2002; Han and Hu 2004; Hu *et al.* 2011) and the expert knowledge of those who attended the PHVA workshop. Each of the counties where red pandas are/were (potentially) present was classified according to three categories: confirmed presence, historical presence, and possible presence. For the confirmed presence counties, the anticipated density of red pandas in the county was classified according to three general categories (based on expert opinion): high, medium and low density. Participants also identified the county-level distributions of two subspecies (i.e., *A.f. fulgens* and *A.f.styani*) and three genetic groups.

Second, the county-level distribution data were overlapped with habitat types. Due to a lack of good data on land cover or vegetation types, the suitable habitat types for red pandas were preliminarily identified as forested lands with > 10% canopy and shrub lands, which were derived from the national 1:1 000 000 land use dataset (Figure 3).

Third, the distribution data that combined county and habitat types were again overlaid with the suitable elevation range (for the red panda) between 2000 and 4000 m. The data on elevation range were derived from the SRTM 90 meter resolution DEM (Digital Elevation Model; USGS 2004; Figure 4).

Using the habitat distribution data that combined the information on counties, habitat types and elevation range, the characteristics of the landscape patterns of the red panda habitat were analyzed. The landscape fragmentation was calculated with the formula: FM = (Np-1)/Na, where FM is the fragmentation index value, Np is the total patch number, and Na is the total area.

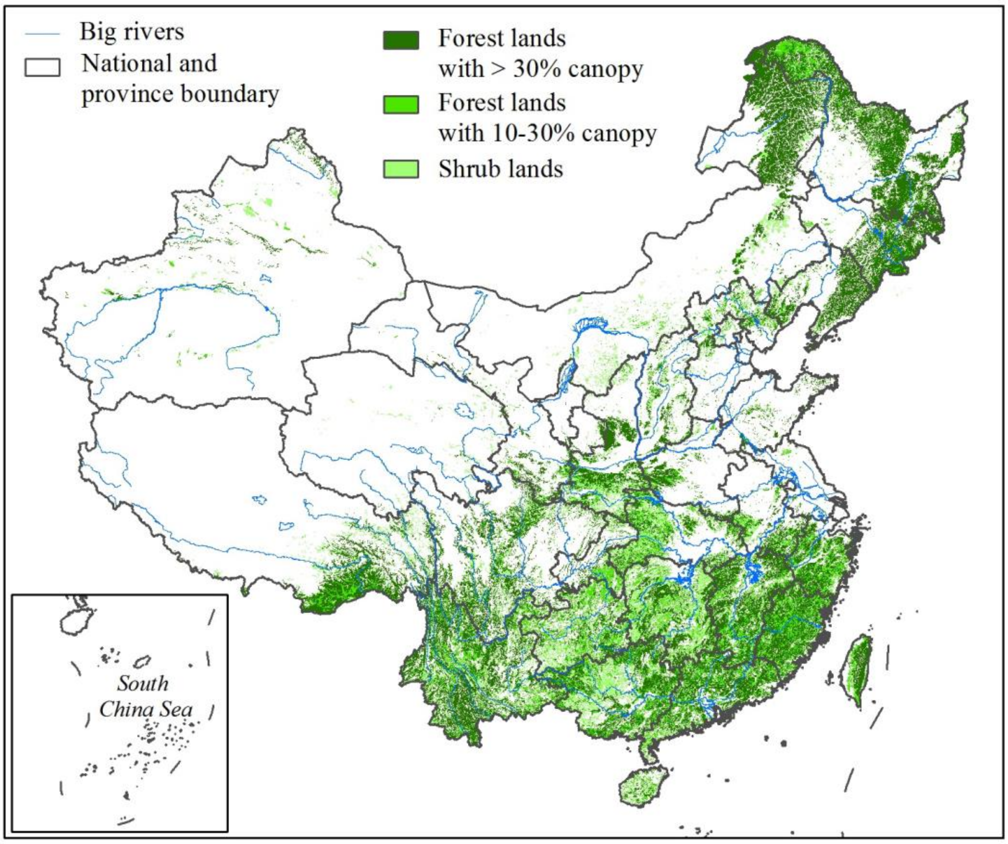

Figure 3. Distribution of forest lands and shrub lands in China.

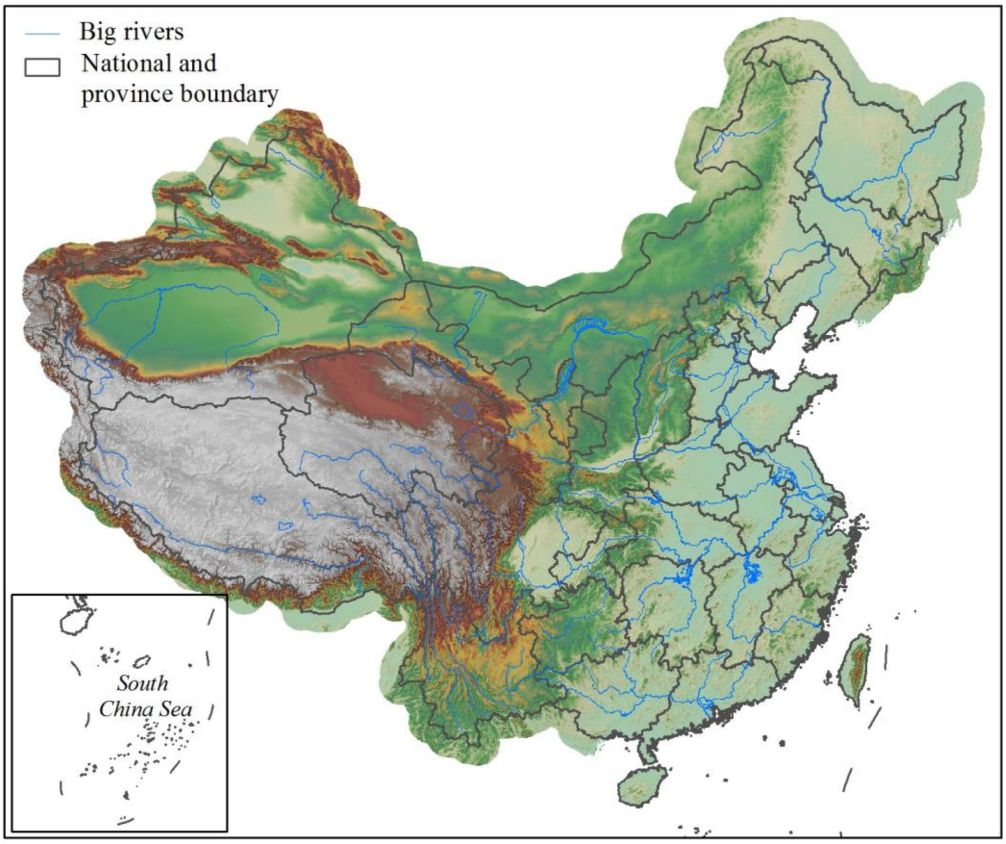

Figure 4. SRTM 90 meter resolution DEM in China.

Results

The habitat distribution of red pandas involves 88 counties in five provinces: Sichuan, Yunnan, Tibet, Qinghai, and Gansu. Most of these counties (55 in total) are situated in Sichuan, while 17 are located in Yunnan, 14 in Tibet, one in Qinghai and one in Gansu. Of the 88 counties, 58 counties have confirmed red panda presence, 28 counties have potential presence, and two counties have historical presence. For the 58 confirmed presence counties, 18 are recognized as containing high density habitat, 28 as medium density, and 12 as low density (Figure 5). These confirmed presence counties are all distributed in Sichuan, Yunnan and Tibet, and the 18 high density counties are only located in Sichuan and Yunnan (see Table 2). Qinghai and Gansu are at the marginal area of the distribution range for red pandas, and each of them has only one possible presence county.

Table 2. Distribution of red pandas at county level by provinces.

		No. confirmed presence counties				
Provinces	No. of counties	High density	Medium density	Low density	No. of possible presence counties	No. of historical presence counties
Sichuan	55	13	13	8	19	2
Yunnan	17	5	4	4	4	
Tibet	14		11		3	
Qinghai	1				1	
Gansu	1				1	

A. f. fulgens is distributed in 20 counties in Yunnan and Tibet (Figure 6), 17 of which with confirmed presence and 3 with potential presence. *A.f. styani* is distributed in 68 counties in Sichuan, Yunnan, Qinghai, and Gansu (Figure 6), with 41 with confirmed presence, 25 with potential presence, and 2 with historical presence. Of the three genetic groups, the Qionglai-Liangshan (QL-LS) group is distributed in 66 counties (39 confirmed presence, 25 potential presence, and 2 historical presence); Gaoligong-Tibet (GLG-TIB) group is distributed in 20 counties (17 confirmed presence and 3 potential presence); and Xiaoxiangling (XXL) group is distributed in 2 counties of being confirmed presence (Figure 6).

Red panda habitat covers a series of geographical regions, including the Minshan Mountains (Mts), Qionglai Mts, Liangshan Mts, Daxiangling Mts, Xiaoxiangling Mts, Shaluli Mts, and Daxueshan Mts in Sichuan; the Gaoligong Mts, Meilixueshan Mts, Jiawuxueshan Mts, Biluoxueshan Mts, Habaxueshan Mts, and Yulongxueshan Mts in Yunnan; and the south Tibet area. These regions have been recognized as priority areas for biodiversity conservation by the Chinese government and many international conservation organizations and priority setting schemes, such as the biodiversity hotspots, global 200 priority ecoregions, endemic bird areas, and the national priority conservation areas (Stattersfield *et al*. 1998; Myers *et al*. 2000; Olson and Dinerstein 2002; MEP 2011).

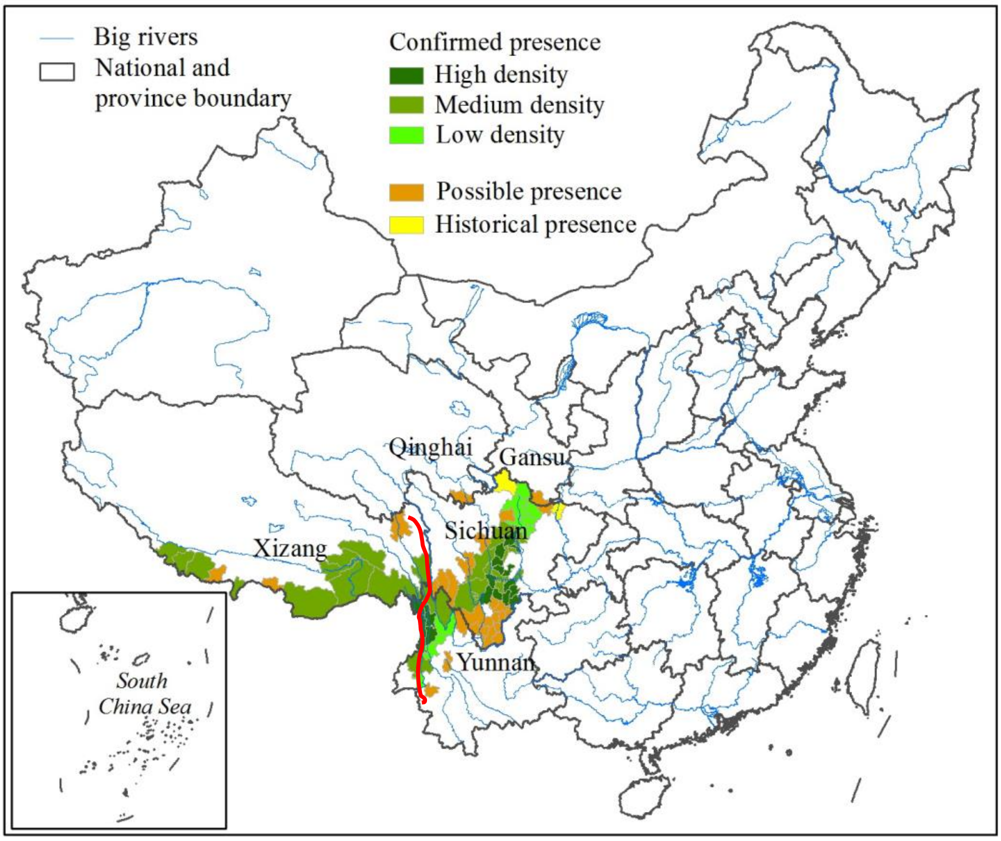

Figure 5. Habitat distribution of red pandas at county level (left of the red line = *A.f. fulgens*; right = *A.f. styani;* according to Li *et al*. 2005).

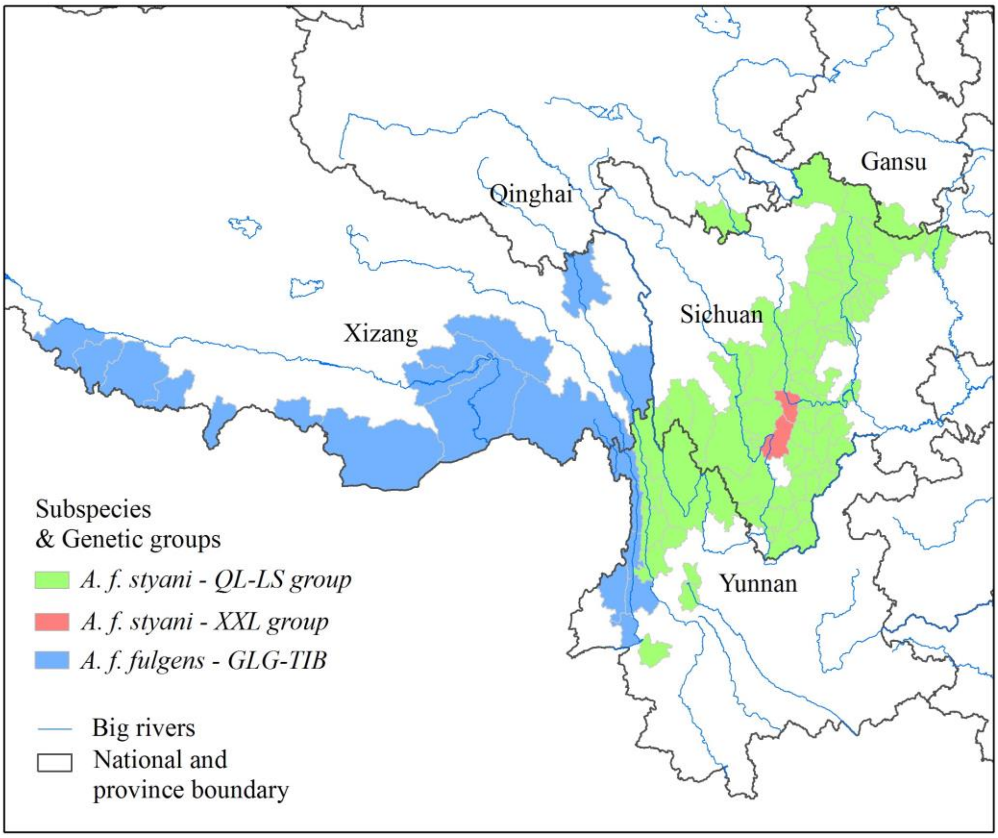

Figure 6. Distribution of subspecies and generic groups at county level.

After combining the information on counties, habitat types and elevation range, the total area of red panda habitat is around 156,000 km^2 (Figure 7). The areas for confirmed, possible, and historical presence habitat are about 121.1, 33.8 and 1.1 thousand km^2, respectively. For the confirmed presence habitat, the area for high, medium and low density is about 25.3, 74.4 and 21.4 thousand km^2, respectively. The habitat area distributed in Sichuan, Yunnan, Tibet, Qinghai and Gansu accounts for about 43.8%, 27.0%, 27.9%, 0.4% and 0.9% of the total, respectively. In terms of the confirmed presence habitat, Sichuan, Yunnan and Tibet contain 36.2%, 29.6% and 34.5%, respectively (Table 3).

Table 3. Habitat area of red panda by provinces after combining the information on counties, habitat types, and elevation range (area unit: 1000 km^2).

Provinces	Total habitat area	Area of confirmed presence habitat				Area of possible presence habitat	Area of historical presence habitat
		High density	Medium density	Low density	Total all densities		
Sichuan	68.5	13.4	19.2	11.2	43.8	23.6	1.1
Yunnan	42.1	11.9	13.5	10.4	35.8	6.3	
Tibet	43.6		41.8		41.8	1.8	
Qinghai	0.6					0.6	
Gansu	1.4					1.4	

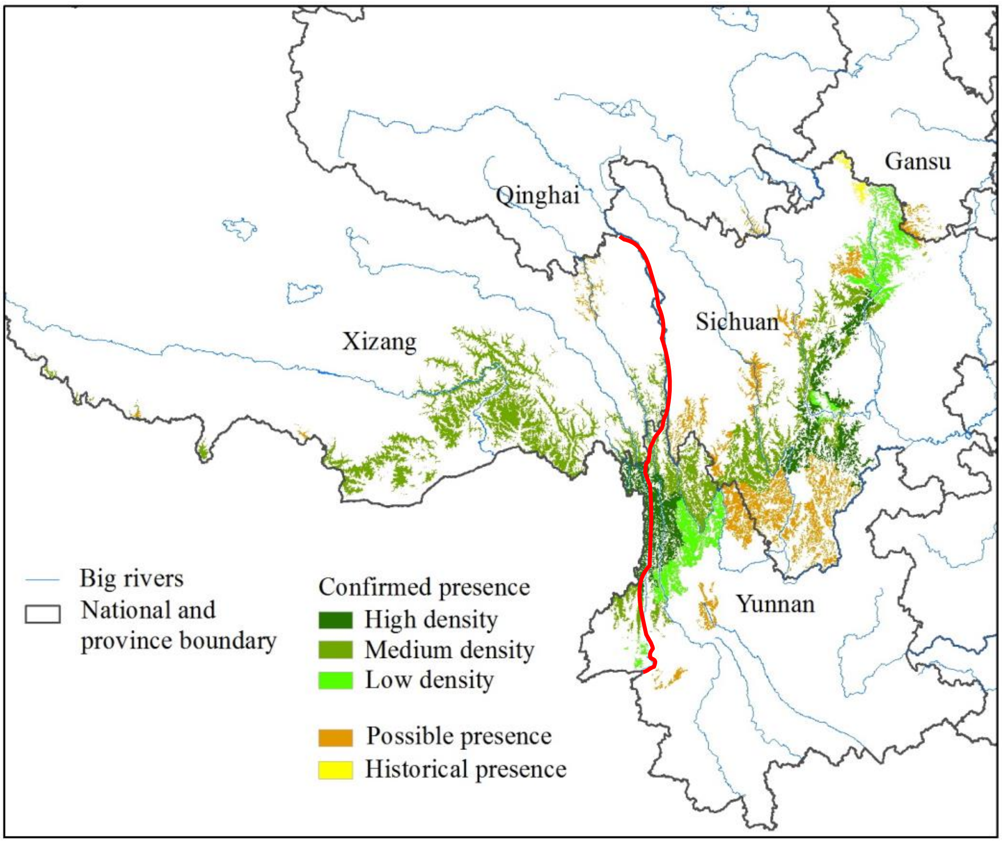

Figure 7. Habitat distribution of red pandas after combining information on counties, habitat types, and elevation range (left of the red line = *A. f. fulgens*; right = *A. f. styani;* according to Li *et al*. 2005).

The habitat area is 53,300 km^2 for *A. f. fulgens*, with 18.5% in Yunnan and the other 81.5% in Tibet, and 102,700 km^2 for *A. f. styani*, with 66.7% in Sichuan, 31.4% in Yunnan, 0.6% in Qinghai and 1.3% in Gansu. The habitat area for QL-LS group is 98,900 km^2, with 65.3% in Sichuan, 32.6% in Yunnan, 0.6% in Qinghai and 1.5% in Gansu. The GLG-TIB group has a total habitat area of 53,300 km^2, with 18.5% in Yunnan and 81.5% in Tibet. The XXL group occupies 3,800 km^2 in Sichuan.

Due to the rough definition of "red panda habitat" (necessitated by the lack of good data on land cover or vegetation types) and the fact that even within good habitat, red pandas do not use all aspects of the landscape equally (e.g. slope orientation preferences), the above presented values are likely considerably overestimates of the occupied red panda habitat. For example, it should be noted that the above methodology differs from that presented in Wei *et al.* (1999), where red panda habitat was defined as 49.1% of total forest, leading to areas of confirmed presence red panda habitat in Sichuan, Yunnan and Tibet of respectively 17,228.3 km^2, 10,634.1 km^2 and 9,574.1 km^2. This methodology was based on the reasoning that in those locations where red panda and giant panda are sympatric, they have different micro-habitats but similar macro-habitats and that giant pandas only used 49.1% of their total available forest area (Wang 1989).

The overall fragmentation index of the red panda habitat is relatively low. The core habitat areas in Sichuan, Yunnan and Tibet have similar fragmentation degrees, while the marginal distribution regions in Qinghai and Gansu have higher fragmentation indices (Table 4).

Table 4. Landscape characteristics of red panda habitat (area unit: km^2).

	Patch number	Maximum area	Minimum area	Mean area	Fragmentation index
Overall	6587	23700	0.01	23.71	0.042
Sichuan	2555	18071	0.01	26.80	0.037
Yunnan	1502	21877	0.01	28.06	0.036
Tibet	2317	10864	0.01	18.80	0.053
Qinghai	76	312	0.01	7.84	0.126
Gansu	211	738	0.01	6.74	0.148

The Xiaoxiangling population appears relatively isolated from the other *A.f. styani* population(s). It is a smaller population and represents a different genetic type. Based on the habitat work for giant pandas and the overlap of habitat between red pandas and giant pandas, this area appears relatively fragmented. Genetic study showed three genetic groups, largely following the mountain range origins: Gaoligong and Tibet (GLG and TIB), Qionglai and Liangshan mountains (QL and LS), and Xiaoxiangling mountains (XXL) (Hu *et al*. 2001).

Goals and Objectives

Based on the above status assessment and the vision statement developed at the PHVA workshop for the red panda in China, the Population Status working group developed the following goals and objectives:

Goals

By 2050:

- Loss of populations, habitat, and genetic diversity has been halted in the high density core areas in China;
- Trans-boundary connectivity of habitats and populations between China and neighboring populations has been ensured; and
- Loss of habitat and the decline of populations in the current red panda range in Myanmar has been halted.

Objectives

1. By 2015, perform surveys on red panda populations and habitats range-wide in China, and initiate research on red panda ecology in the different ecoregions within the three gene pools involved.
2. Based on the survey results, perform a conservation gap analysis so as to ensure that all main red panda habitat types are covered by protected areas with good connectivity.
3. By 2025, ensure that red pandas are effectively protected in relevant areas throughout their range, by means of capacity building in Protected Area management.
4. Establish effective trans-boundary (Sino-Myanmar-India-Nepal-Bhutan) cooperation mechanisms.

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Red Pandas in China Population and Habitat Viability Assessment Workshop

Beijing, China
11 – 14 June 2012

Final Report

SECTION 6

Threats to Red Pandas Working Group Report

Working Group Report: Threats to Red Pandas

Members: Sarah Bexell, Chang Youde, Chen Youping, Fan Zhiyong, Hu Yibo, Nie Yonggang, Tara Stephens, Kathy Traylor-Holzer, Wang Xiao, Xie Zhong, Yang Benqing, Zhang Chenlin, Zhou Zhixing

Working Group Process

This working group reviewed the potential threats outlined in the plenary session (see Section 4 of this report), consolidated them when appropriate, and prioritized issues to identify the main threats to red pandas. The group members were given the following tasks:

1. For each threat, identify and diagram how this affects red panda populations (using as many steps as needed). Then work in the other direction to diagram the factors that lead to or cause this threat.
   对每个威胁因素，确定并图解它如何影响小熊猫种群。然后**反向**图解导致这个威胁因素的原因。
2. For each relationship between two factors on the diagram, indicate whether this information is known (fact based on data) or it is a hypothesis (assumption based on expert opinion).
   对于图解中的两个相关因素之间的联系，标明这是已知的（数据**支**持）或只是猜测（经验假设）。
3. Write a brief descriptive statement of each diagram that explains these relationships, including the direction of the relationships.
   给每个图解写个简要总结，解释这些因素之间的联系及影响方向。
4. Prioritize the main threats (the ones at the center of each diagram), based on the relative impact of this threat on the viability of the species in China.
   主要威胁的优先顺序（每个图解的中心），取决于这个威胁因素对中**国**此亚种的有效种群影响的严重性。
5. Set Goals: Taking into account the vision and the current threats to red panda populations, describe in more detail what you would like the situation to be with respect to these threats when the vision is achieved.
   目标：**考**虑小熊猫保护愿景与当前受胁状况，详尽描述在保护愿景中小熊猫种群相对于当前的威胁因素所期望达到的状况。
6. Set Objectives: Given the vision, current status (with possible data gaps) and the goals, what needs to be done to achieve the goals and vision? When setting Objectives:
   任务：考虑到保护愿景、当前小熊猫现状(包含可能的数据空缺)与保护的目标，确定达成目标与保护愿景所需要完成的任务。**在**设定任务时：
7. For each threat chain, identify those relationships (arrows) that can be influenced in some way that may break the chain. These points become potential points for setting objectives.
   针对每个威胁链，甄别其中可以被影响或打破威胁链的关联(**箭**头)。这些节点即是可以设定任务的节点。
8. For each point of influence, identify the potential objective (action) that could be taken.
   针对每个有效应的节点，确立可以采取的措施与任务。

9. For each potential objective, briefly assess its:
   - Conservation benefit level
   - Cost level
   - Likelihood of success

   对于每一个潜在的任务，忠实的评估它的：
   - 保护的有益程度
   - 开销水平
   - 成功的可能性
10. Choose one or more objectives per chain based on your evaluation.
    基于大家在中的评价，针对每一个威胁链选出1个或多个任务。

The following information is the result of these discussions.

Results of Threats Evaluation

Within China, red pandas live in the Southwestern provinces of Sichuan and Yunnan and in Tibet with a declining population. In recent years, the threats to red pandas and their habitat have become serious due to socio-economic development and increase of human activities in their habitat. Therefore, the *Threats to Red Panda Working Group* focused on the threats to red panda and their habitat in China and Myanmar. After detailed discussions we think the main threats red pandas now face in China include timber extraction, bamboo shoot collection, poaching, grazing, collection of Chinese medicinals, road construction, mass tourism, mining and dam construction. Our group members conducted a detailed analysis on each threat factor to begin to delineate possible solutions as explained below.

Refer to Table 5 for a listing of all identified potential actions and their assessment with respect to benefits, costs, and likelihood of success.

小熊猫在中国主要分布在四川、云南等地，种群数量相对稳定；但近些年，由于社会经济的发展与人类活动的加剧，对小熊猫及其栖息地所产生的威胁也越来越大。因此，威胁因素分析小组主要分析小熊猫目前在中国所受到的威胁因素。经过认真的分析讨论，我们认为野生小熊猫面临的威胁因素主要包括森林采伐、采笋割竹、盗猎、放牧、中草药采集、道路建设与大规模旅游以及采矿和水坝建设等。小组成员对每一个威胁因素进行了仔细的分析讨论，得出每一个威胁因素的可能的解决方案，如下。

General Overall Goals

After reviewing all potential threats, the working group developed the following goals:

- Stabilize and restore wild red panda habitat;
- Develop and maintain a large and viable wild red panda population; and
- Increase awareness and action by the public for red panda protection.

The following recommended actions under each threat were identified to help to achieve these main goals.

Poaching 盗猎

Purpose 盗猎的目的：

- For fur & skins and for meat 对毛皮的需求和食肉;
- Use of red panda body parts for socio-cultural purpose (making hats) 用于制作帽子;
- Red panda body parts trading 贸易的需求; and
- Red panda as pets and zoo specimens 作为宠物饲养.

Suggested Actions 建议的解决方法：

1. Captive management **圈养种群管理**:
   Enhance captive population reproductive management and general welfare to reduce the demand for wild individuals. Captive animals should be managed legally and humanely.
   加强圈养种群的繁殖管理，减少对野生个体的需求。

2. Law enforcement 加强执法:
   In some places, especially in some unprotected areas, law enforcement is inadequate. So enforcing the protective laws and punishing poaching behaviors is needed.
   在一些地方，对盗猎等活动的执法力度不够，特别是一些非保护的区域。因此,需要加强保护执法力度，严惩盗猎行为。

3. Educate 宣传教育：
   Educating the public to enhance the awareness of wildlife protection to reduce the demand for red panda products.
   教育人们对野生动物的保护意识，减少对野生小熊猫的需求。

4. Create more Nature Reserves 建立保护区：
   Establish more nature reserves in red panda habitat and potential habitat.
   把那些有小熊猫活动的地方建立成保护区。

5. Population supplementation 种群补充：
   Conduct scientifically well planned reintroduction and translocation projects in some potential red panda habitat if this measure becomes necessary. Ensure the area can be protected.
   在一些潜在的小熊猫栖息地进行重引入和迁地保护工程。

6. Alternative livelihoods 替代生计(livelioods)：
   Develop sustainable economic sources for local residents to reduce poaching.
   发展当地居民的其它经济来源，减少盗猎。

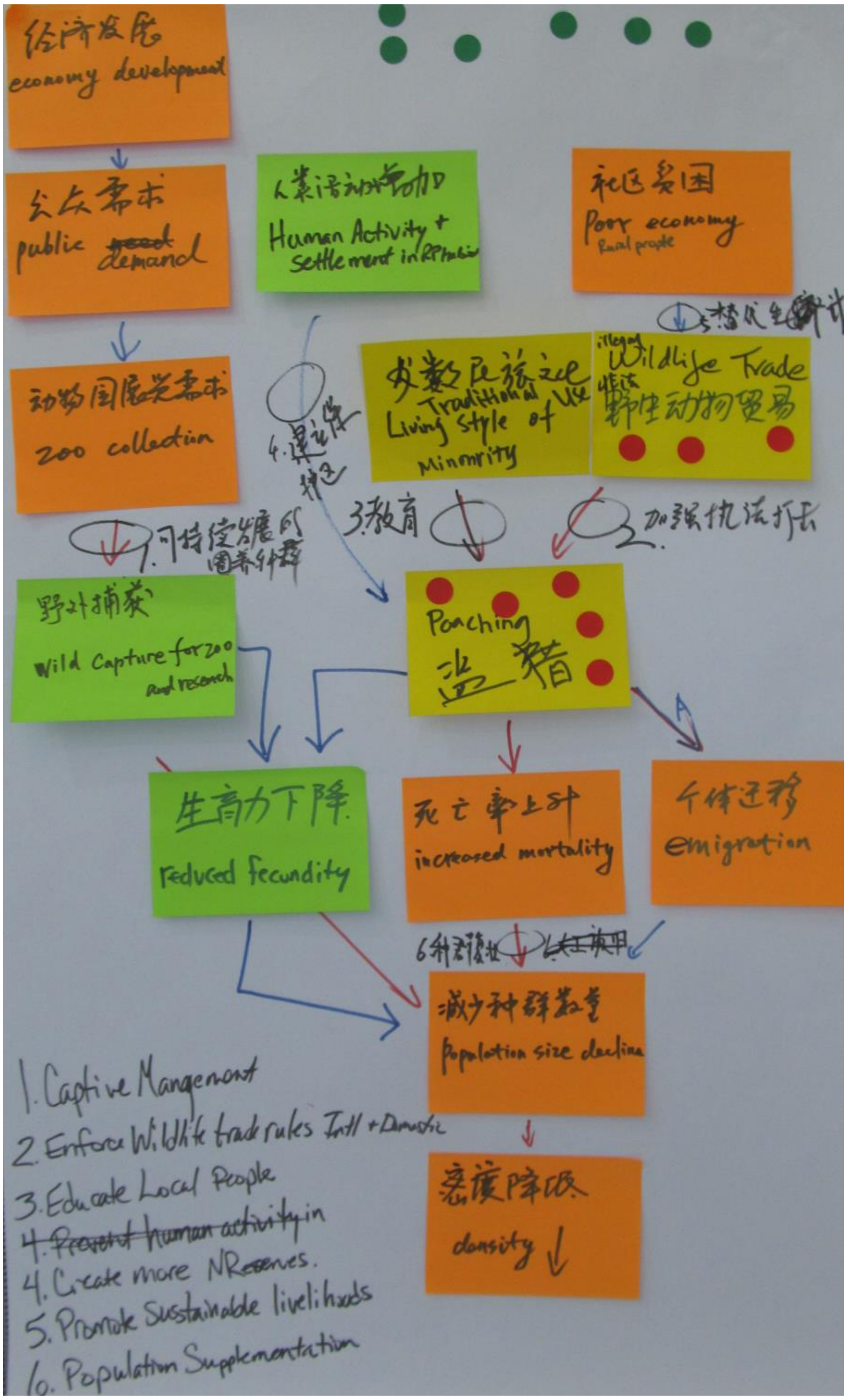


Figure 8. Poaching diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Mining and Dam Construction Ⅶ.采矿，水坝建设

Suggested Actions *建议的解决方法：*：

1. Establish more Nature Reserves 建立更多保护区：
   This is a good way to protect red pandas and their habitat. But this is slow because of the strict examination and approval process of the government.
   可有效保护，但较慢，一般需要通过严格的审批。
2. Rational Planning Policy Consultation 合理规划：
   Conducting environmental impact assessment before building.
   建设前对环境进行评估。
3. Habitat restoration 恢复栖息地：
   Habitat restoration: It is hard to restore habitat after mining or dam construction because the destructive impact on red panda habitat of this kind is usually serious and thorough.
   开矿，水坝建设等对栖息地破坏基本是彻底的，很难恢复。
4. Education 教育:
   Let people know how seriously dam construction and mining destroys the environment. Reduce use and waste of energy. Encourage the reduction of interference to the environment and wildlife during mining and dam construction.
   宣传开矿和水坝建设对环境的破坏的严重性，较少人们在开矿和水坝建设过程中对环境及野生动物的干扰。
5. Enforce laws 加强执法：
   Enforce the law of protection and punish poaching behavior heavily by construction workers and miners who come to the region to work.
   加强执法力度，严惩盗猎等违法行为。

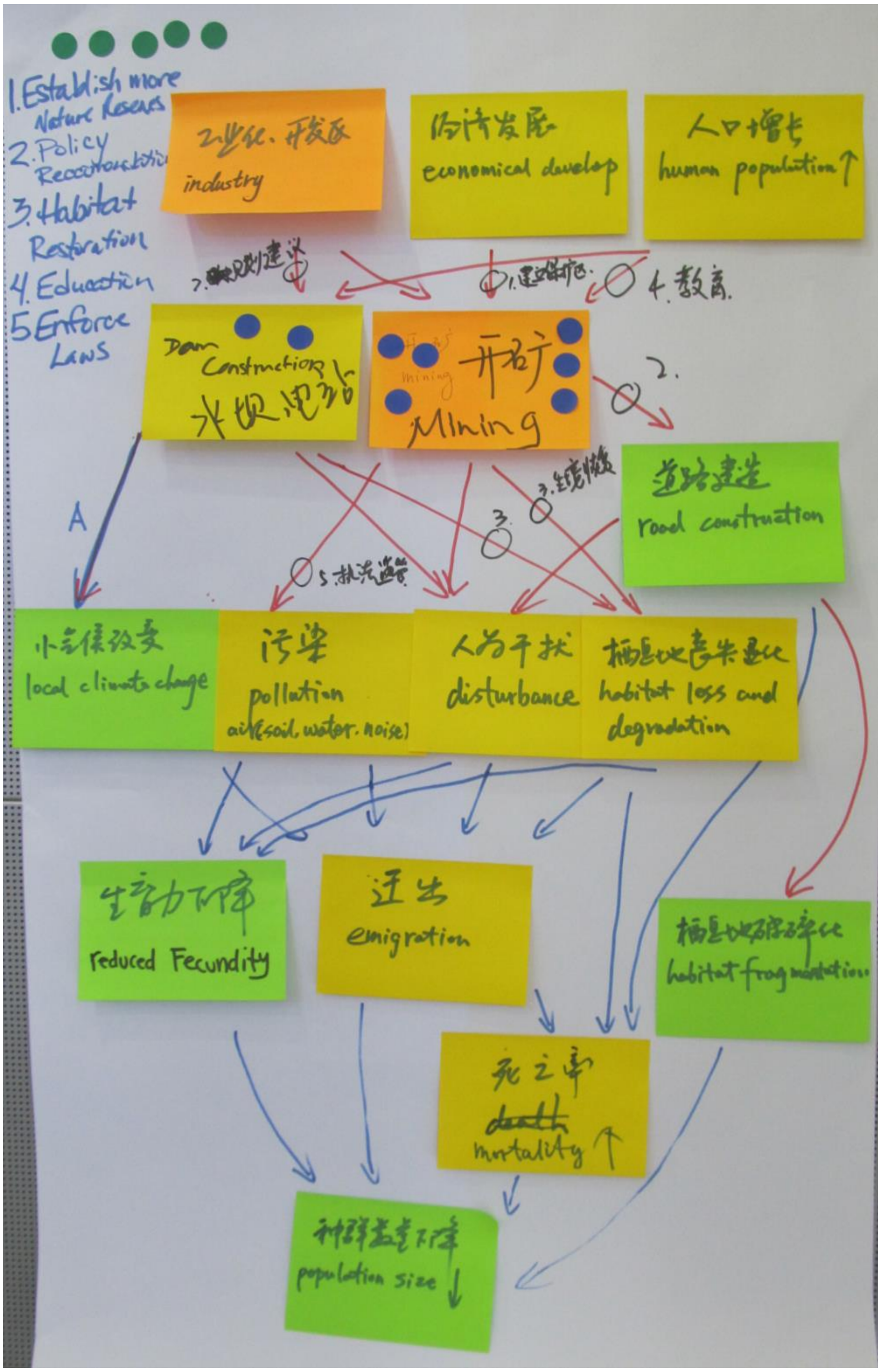


Figure 9. Mining and Dam Construction diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Road Construction and Mass Tourism 道路建设，大规模旅游

Suggested Actions 建议的解决方法：

1. Policy consultation on road planning 道路规划政策建议：
   Recover the connection between fragile habitats by the building of ecological corridors.
   通过建立生态廊道等方式来恢复栖息地间的连接。

2. Educate tourists 教育游客：
   Tell people the negative impact of tourism on wildlife and its habitat to reduce the interference on the environment and animals, and guide people to refuse to consume wildlife products during travels.
   减少旅游过程中对环境的破坏，不干扰动物活动，不消费野生动物制品。

3. Ecotourism 生态旅游：
   Change the traditional travel style to ecotourism.
   改变传统的旅游方式，进行生态旅游。

4. Habitat restoration 恢复栖息地：
   Restore destroyed habitat through the planting of native trees, shrubs, bamboo, etc.
   使受到破坏的生境得到恢复，比如种植林木等。

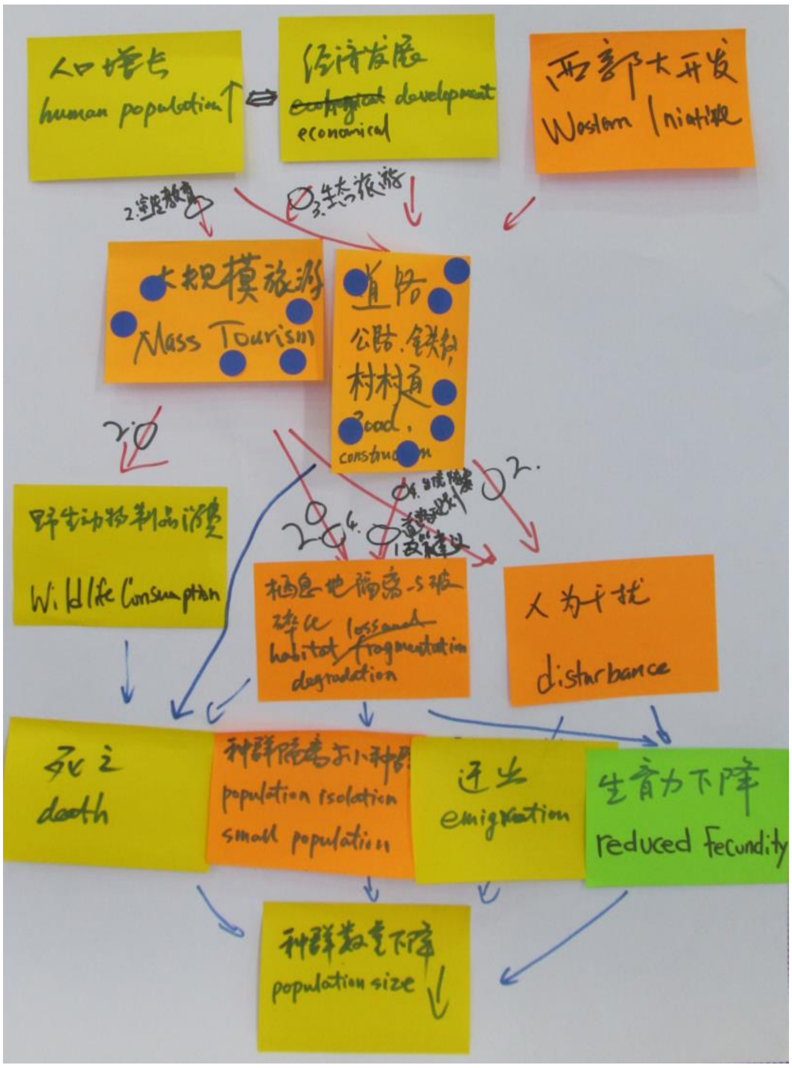


Figure 10. Road Construction and Mass Tourism diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Timber Extraction 森林采伐

Purpose 盗猎的目的：

- Energy – for cooking and heating in local people’s homes 能源需求; and
- Building materials 建筑用材

Suggested Actions 建议的解决方法：

1. Alternative energy 能源替代:
   Introduce new energy sources such as solar and methane instead of traditional wood energy. This could be supported by the government or a non-government organization (NGO).
   通过新能源（沼气、电力等）替代传统的烧柴，可获得NGO 的支持。

2. Tree planting 植树：
   Implement community forestry programs to decrease the wood extraction from red panda habitat. This program could be supported by a non-government organization (NGO).
   通过社区植树造林的方式，减少人类对小熊猫栖息地内木材的需求，可获得NGO 的支持。

3. Alternative building materials 替代建材：
   Use new house-building materials (especially recycled fibers) to decrease the wood consumption for buildings needed by local people. This could be supported the government or by a non-government organization (NGO).
   转变传统的建筑用材方式，减少建房对木材的需求，可获得NGO 的支持。

4. Policy consultation 政策建议：
   Suggest to policy-makers that the policy associated with logging and forest shifting should consider the conservation of red pandas, and accordingly, to revise or improve related policies.
   建议政策制定符合小熊猫保护实际，修改相关森林改造政策。

5. Education 宣传教育：
   Educate city dwellers to buy furniture and other wood products more responsibly. Tell the local people the adverse effects of logging on the red panda and its habitat, as well as to human health to decrease the wood consumption.
   向当地居民宣传木材砍伐对小熊猫等保护动物的影响的严重性，从而减少对木材的使用。

6. Habitat restoration 生境恢复：
   Restore the destroyed habitats by planting native trees, shrubs and bamboo in the areas that have been logged excessively.
   在采伐严重的区域进行针对性的栽种树木，使破坏的生境得以恢复。

Figure 11. Timber Extraction diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Grazing 放牧

Purpose 盗猎的目的：

- Economic source of local people 当地人的经济收入来源；and
- For meat 食物需要.

Suggested Actions 建议的解决方法：

1. Alternative livelihoods 替代生计：
   Develop sustainable economic sources of the local residents to reduce grazing.
   发展当地居民的其它经济来源，减少放牧。
2. Educate local people 对当地居民教育宣传：
   Educate the public to enhance the awareness of wildlife protection to reduce grazing behavior in red panda habitat.
   教育人们对野生动物的保护意识，减少在野生小熊猫生境内放牧。
3. Educate city people 对市民进行教育宣传：
   Educate city dwellers about their impact on red pandas (and giant pandas) from consuming meat raised in rural areas adjacent to red panda habitat. Educate the public, especially city people to increase their awareness of wildlife protection to reduce the demands for products of grazing in red panda habitat.
   教育人们对野生动物的保护意识，减少食用小熊猫生境内野生散养动物制品。
4. Set boundaries 圈养：
   Set boundaries of grazing sites to prevent livestock entering red panda habitat.
   设立放牧围栏，避免牲畜进入小熊猫生境。
5. Disease prevention 疾病防控：
   Vaccinate livestock and other domestic animals for disease and administer parasite control to avoid cross infection between livestock, domestic animals and red pandas.
   对牲畜与其他动物进行病虫害免疫，避免动物间疾病的交叉感染。

Figure 12. Grazing diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Bamboo Shoot Collection 采笋割竹

***Purpose** 盗猎的目的：*

- For food 食物，制作生活工具如篮子; and
- For making baskets, bar bar, etc. 圍等

***Suggested Actions** 建议的解决方法：*

1. Education 教育宣传:
   1. Design an education campaign for city people explaining the link between wild bamboo shoot consumption and the decline of red pandas and giant pandas and asking them to stop eating bamboo shoots and travelling to remote areas. 2. Tell the local people the adverse effects of bamboo shoot collection on the red panda and its habitat to avoid heavy shoot collection and consumption (it was noted that this would necessitate providing an alternative income strategy for them.)
   教育人们采集竹笋对小熊猫会产生严重的影响，避免大量的采集与食用。

2. Bamboo planting 竹子种植：
   Plant bamboo outside of the habitat of red pandas to meet the demand for bamboo or shoots, and finally decrease bamboo consumption.
   在非小熊猫生活环境内种植竹子，满足人类对竹笋及竹子的需求，减少对小熊猫栖息地竹子的利用。

3. Set collection quotas 合理采集:
   Set reasonable collection time (seasonal) and collection sites. These quotas will need to be monitored.
   设定合理的采集时间和地点。

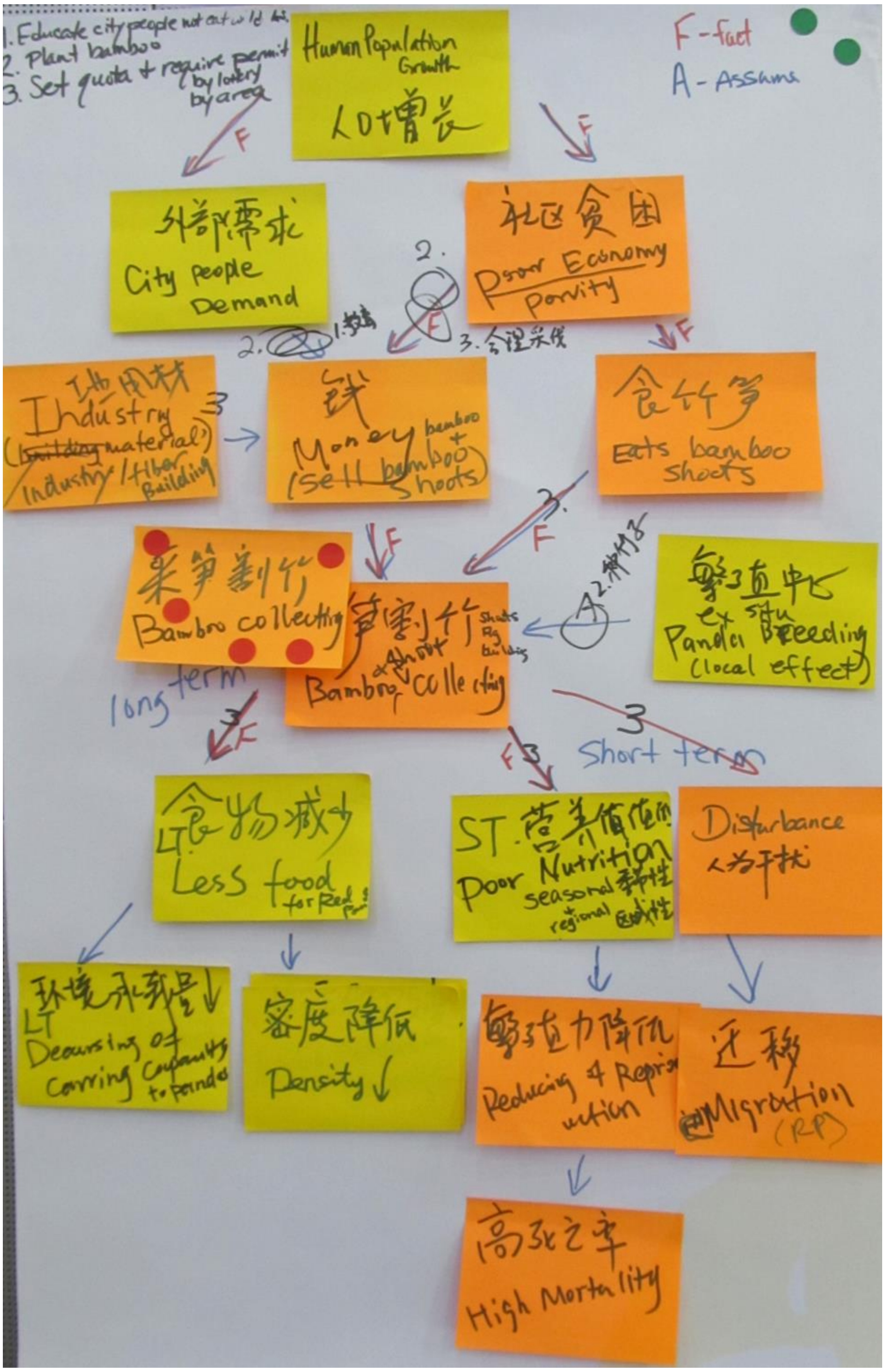


Figure 13. Bamboo Collection diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Chinese Medicine Collection 中草药采集

Purpose 盗猎的目的：

- Economic resource 经济来源；and
- Individual medical needs or desires 个人需求.

Suggested Actions 建议的解决方法：

1. Planting TCMs 人工种植养殖：
   Propagate TCM plants, herbs, fungus to meet the demands of people instead of getting them from the wild. Wild items are usually desired but educate people on the threats to wildlife from consuming items taken from the wild.
   人工种植植物药，而不需要从野外人工挖采。

2. Developing alternative medicine 开发替代品：
   Develop sustainable and humane new medicines with similar functions to meet the demand.
   开发具有类似功能的新药物。

3. Set collection quota 合理采集：
   Limit the amount, the time (season) and the site of collection.
   限制采集量，以及规定采集的时间和地点。

4. Education 宣传教育:
   Let the local people know TCM collection activities have heavy impacts on wild animals.
   告诉当地中草药采集对环境及动物造成的影响。

5. Enforce laws 加强执法：
   Enforce laws to make sure illegal TCM-collection will be seriously punished.
   加强执法力度，严惩采药行为。

6. Habitat restoration 恢复栖息地：
   Restore destroyed habitat through the planting of native trees, shrubs, bamboo, etc.
   使受到破坏的生境得到恢复，比如种植林木等。

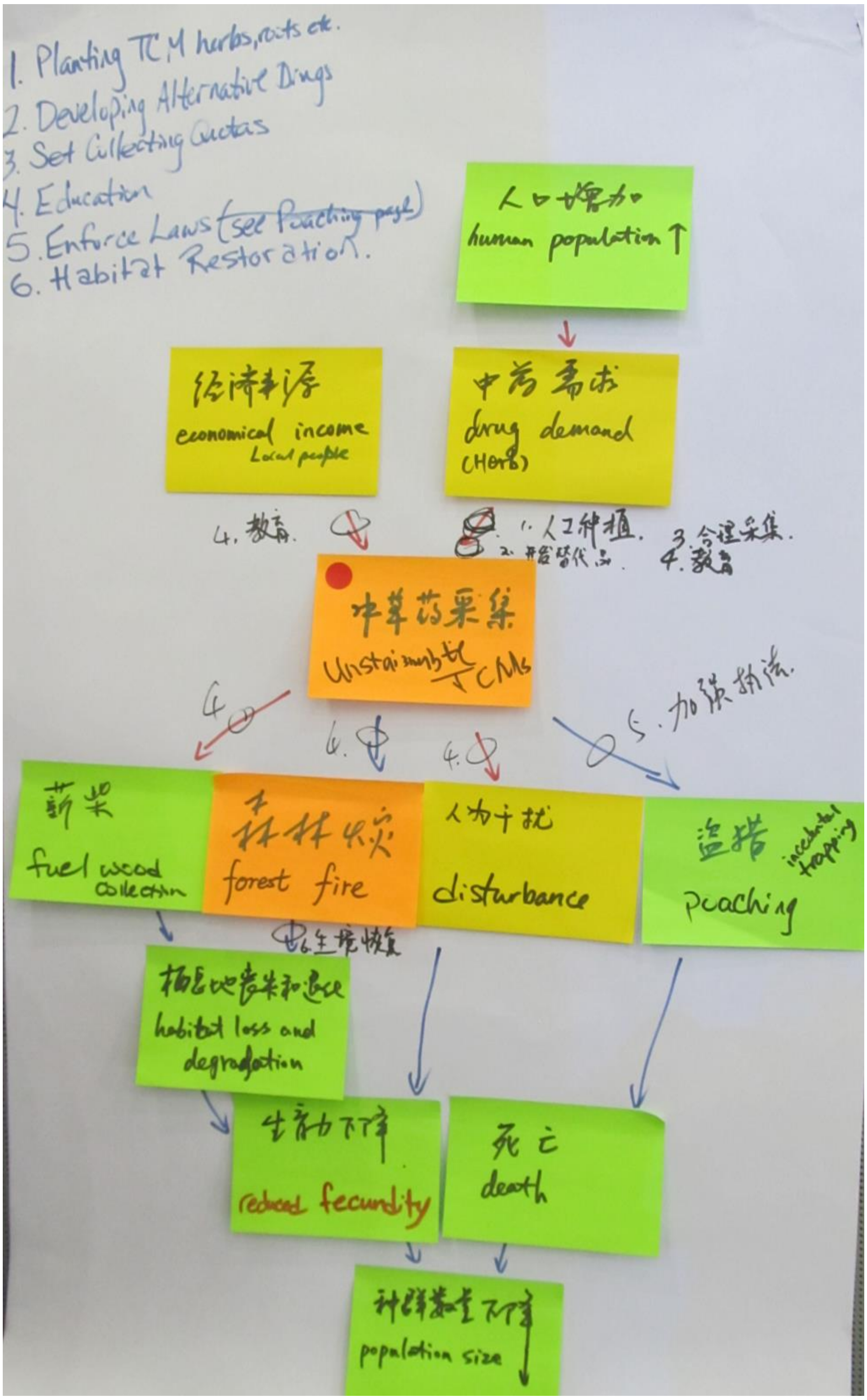


Figure 14. Chinese Medicine Collection diagram: causes and impacts. Red arrows indicate relationships based on facts; blue arrows indicate relationships based on assumptions.

Table 5. List of primary threats to red pandas, potential actions to address these threats, and the relative conservation benefit, costs, and likelihood of success of each.

	THREATS & Potential Actions		益处 **Benefits**	代价 **Costs**	成功可能性 **Likelihood of success**
Poaching 盗猎					
1	Captive management	圈养种群管理	H	M	H
2	Enforce laws	加强执法	H	H	M
3	Educate local people	教育宣传	H	M	H (LT 长期)
4	Create more NP	建立保护区	H	H	L
5	Population supplementation	种群补充	M	H	L
6	Sustainable livelihoods	替代生计	H	H	H
Grazing 放牧					
1	Sustainable livelihoods	替代生计	H	H	H
2	Educate local people	教育宣传	H	M	H (LT 长期)
3	Educate city people	对市民教育宣传	M	L	M
4	Set boundaries	圈养	H	H	L
5	Disease prevention program	疫病防控	H	M	H
6	Habitat restoration	恢复栖息地	H	H	L
Bamboo Shoot Collection 采笋割竹					
1	Educate city people	教育宣传	H	L	M
2	Plant bamboo	人工种植	H	M	H
3	Set collection quotas	合理采集	H	M	M
Timber Extraction 采伐					
1	Alternative energy service (NGO)	替代能源	H	H	H
2	Community forestry program (planting)(NGO)	植树	H	M	H
3	Alternative building materials (NGO)	替代建材	M	M	M
4	Policy consultation	政策建议	H	L	M
5	Education	教育宣传	H	L	M
6	Habitat restoration	恢复 栖息地	H	H	L
Dam Construction & Mining 水坝建设和开矿					
1	Establish more nature reserve	建立更多保护区	H	H	L
2	Policy consultation	合理规划	H	L	M
3	Habitat restoration	恢复栖息地	H	H	L
4	Education	教育	H	L	H (LT 长期)
5	Enforce laws	加强执法	H	H	M

H = High; M = Moderate; L = Low; (LT) = long-term

Actions highlighted in yellow indicate recommendation actions based on the working group's overall assessment.

Red Pandas in China
Population and Habitat Viability Assessment Workshop

Beijing, China
11 – 14 June 2012

Final Report

SECTION 7

Vortex Modelling Report

Red Panda Modeling Report

Members: Kristin Leus, Yang Zhisong, Zhang Zejun, Than Zaw

Vortex Simulation Model

Computer modelling is a valuable and versatile tool for quantitatively assessing risk of decline and extinction of wildlife populations, both free ranging and managed. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA).

The simulation software program *Vortex* (v9.99) was used to examine the viability of the red panda population in Nepal. *Vortex* is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. *Vortex* models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by either creating individuals to form the starting population or importing individuals from a studbook database and then stepping through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate both demographic stochasticity and annual environmental variation. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of *Vortex* and its use in population viability analysis, see Lacy (1993, 2000), Brook *et al*. (2000) and Miller and Lacy (2005).

Introduction

As was the case in Nepal, hardly any reliable life history parameters, population sizes and quantitative population trends required for entry into the Vortex model are known for wild red panda populations in China. The Beijing modelling working group therefore based the input parameters for the vortex model largely on those used during the Nepal PHVA (with a few exceptions – see baseline model parameters below).

The aim of the baseline model was to simulate a “best case scenario”: a red panda population free from anthropogenic threats. While precise data on frequency of occurrence and severity of impact of catastrophes were lacking, it was felt that bamboo flowering, earthquakes and forest fires, all occurring in red panda habitat, did constitute catastrophic threats to the populations and the effect of conservative versions of such catastrophes was simulated. Because of the large uncertainty in data entry values, the model will not be able to investigate the viability of specific red panda subpopulations in China, under specific threat conditions or management scenarios. However it can help to illustrate the extreme vulnerability of small red panda subpopulations, even without human caused threats acting upon them and it can help to illustrate relative effects of different types of threats as well as the urgency to precisely define the occurrence and severity of various threats in different areas. Modelling also helps to illustrate a few basic principles in population biology for conservation.

Baseline Model Parameters

A baseline model was constructed with the aim to represent red panda populations free of human caused threats. With the exception of the reproductive strategy, a higher number of lethal equivalents, differing starting population sizes and corresponding carrying capacities and the inclusion of three catastrophes, the input parameters were derived from the vortex model used for the Nepal red Panda PHVA (Jnawali *et al.* 2012), themselves derived from previously published literature and reports and from discussions with the PHVA workshop participants, incorporating recently gathered unpublished information as well as general personal experience.

General Model Parameters

Number of iterations: *500*
Number of years: *100 (or more than 20 generations)*
Extinction definition: *Only one sex remains*
Number of populations: *Single population*

Reproductive Parameters

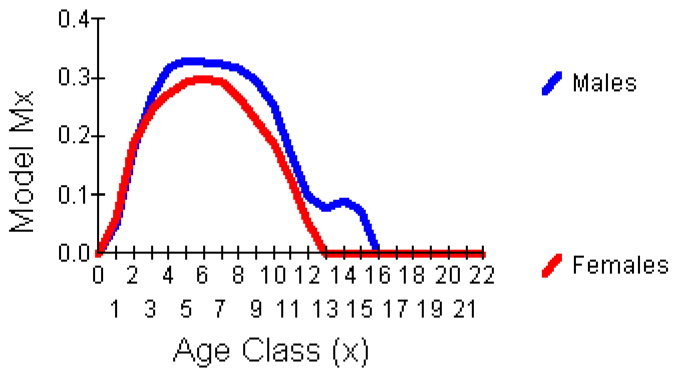
Mating system: *Monogamy*
In contrast to the participants of the Nepal Red Panda PHVA, the Beijing participants elected to model the mating system of the red panda as "Monogamy" based on the observation that the male and female look after the cubs/den together. It was therefore thought unlikely that males had more than one partner per year. Pairings will change from year to year. Also in zoos it can be seen that males play with the cubs once they are a bit older.

Reproductive lifespan: *10 years*

Data from captive populations:
The European and North American subpopulations of *A.f. fulgens* in the *International Studbook for Red Panda* (Glatston 2006) have large enough sample sizes for reliable life table calculations and yielded the following information:

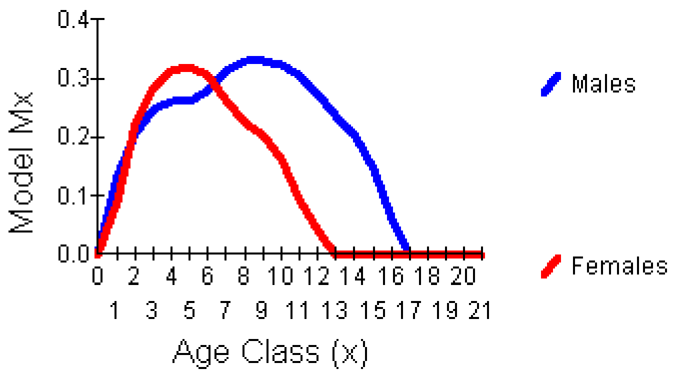
European captive subpopulation of *Af.fulgens* from 01/01/1984 – 31/12/2006:
Reproductive life span: Males: 1-15 years; Females: 1-12 years
Age at first reproduction Females: median 2Y 11M 29D
Age at first reproduction Males: median 3Y 1M 20D

Graph of age specific fecundity (Mx = average number of same sex offspring born to a parent of a specific age class):



North American captive subpopulation of *A.f.fulgens* from 01/01/1984 – 31/12/2006:
Reproductive lifespan: Males: 1- 16 years, Females: 1-12 years
Age at first reproduction Females: median 2Y 11M 12D
Age at first reproduction Males: median 2Y 7M 27D

Graph of age specific fecundity (Mx = average number of same sex offspring born to a parent of a specific age class):



Data from literature:
Young are said to attain adult size at approximately 12 months and to be sexually mature at approximately 18 months (Roberts 1975, 1980, 1981) [quoted in Roberts and Gittleman 1984].

Summary:
In captivity, the first age of reproduction is 1, but the median age of first reproduction is 2-3 years. Based on available information workshop participants felt that in the wild first age of reproduction is likely 2 years of age for both males and females. Both sexes have territories but there are no reports of active fighting between animals for territories. For this reason, the first age of reproduction was thought to be as young as 2 and there was felt to be no reason to think this is later for males than for females, because there is at yet no evidence for intra-male fighting for territories. The last age of reproduction for females in captivity appears to be about 12 years. It is thought that pandas in the wild do not live beyond their reproductive lifespan and that the latter is probably a bit shorter than in captivity – workshop participants agreed on 10 years.

Maximum number of young per year and litter size distribution: *3 (1: 40%, 2: 55%, 3: 5%)*
In captivity, pandas have 1-4 cubs but a litter size of 4 is a very seldom occurrence (Glatston 2006). It is thought that in the wild they will have 1-3 cubs and the frequency of these was based on results from the captive population in Europe and North America.

Captivity: *A.f. fulgens* populations in the period 1 Jan 1984 to 31 Dec 1996.

Europe:

Litter size	%	N
1	39%	197
2	55%	274
3	5%	26
4	1%	3

N. America

Litter size	%	N
1	32%	101
2	56%	177
3	11%	34
4	1%	2

Sex ratio at birth (in % males): 50%
In captivity the sex ratio at birth appears to be 50/50 (Glatston 2006) and there is currently no reason to assume this might be different in the wild.

Births in captivity: 1 Jan 1984 till 31 Dec 1996:

Region	Males.Females.Unknown Sex
Europe:	303.285.89
N.America:	189.208.55
India:	27. 27. 0

Percentage of adult females breeding per year: 80%
In captivity, during the period 1 Jan 1984 to 31 Dec 1996, the shortest inter-birth intervals were (Glatston 2006):

Europe:	335 days
N. America:	340 days
India:	347 days

From the literature we learn that:
- In the wild, births occur in spring and summer, but mainly in June (Hodgson 1847; Pocock 1941; Wall 1908) [quoted in Roberts and Gittleman 1984].
- Females that lose litters do not undergo a postpartum estrus. [captivity] [Roberts and Gittleman 1984]
- Red pandas seek mates from December to February, and the female gives birth to up to four cubs around four months later. The cubs stay with their mother until she gives birth again the following year, when they venture out on their own (Holtcamp 2009)

The workshop participants therefore felt it is likely that females generally breed once a year. The percentage of females breeding per year was felt to be relatively high; there are no field data to support this but the workshop participants agreed on 80%.

Percentage males in the breeding pool: 95%
It was felt that in principle by far the majority of adult males of breeding age would be in the breeding pool every year.

Mortality Parameters

Age specific mortality rates:
There are no reliable age specific mortality data for wild red pandas. Based on experience in captivity combined with literature data from species that were felt to be possible model species (see below) the following mortality parameters were agreed upon:

Females:	0-1:	45(±5)
	1-2:	20(±5)
	2+:	15(±3)
Males:	0-1:	45(±5)
	1-2	20(±5)
	2+:	15(±3)

Data from captive populations:
Age specific mortality rates (Qx = proportion of animals dying in a specific age class before being able to reach the next age) for captive *A.f. fulgens* in Europe (EEP) and N. America (SSP) (Glatston 2006) *[Data smoothed once, tails adjusted and sample size effects in higher age classes manually adjusted]*:

	Mortality Males		Females	
Age	**Qx EEP**	**Qx SSP**	**Qx EEP**	**Qx SSP**
0	0.42	0.5	0.33	0.48
1	0.05	0.04	0.05	0.03
2	0.05	0.04	0.05	0.038
3	0.05	0.043	0.053	0.055
4	0.053	0.048	0.058	0.068
5	0.065	0.058	0.063	0.07
6	0.082	0.072	0.068	0.07
7	0.09	0.08	0.075	0.07
8	0.103	0.082	0.105	0.075
9	0.133	0.087	0.153	0.095
10	0.17	0.092	0.188	0.125
11	0.208	0.098	0.228	0.145
12	0.228	0.133	0.29	0.163
13	0.233	0.198	0.343	0.193
14	0.273	0.23	0.42	0.24
15	0.345	0.32	0.64	0.34
16	0.285	0.41	0.9	0.53
17	0.36	0.6	1	0.85
18	0.43	0.88	1	1
19	0.62	1	1	1
20	0.88	1	1	1
21	1	1	1	1

Data from literature:
Yonzon and Hunter (1991) report some mortality rates for a limited number of red pandas in a heavily human disturbed area with a high level of predation by dogs, and these rates are therefore not suitable for a baseline model free of anthropogenic threats: “Their fecundity is also limited (usually one cub/female/year and mortality of both cubs and adults is high: of 12-13 cubs born during the course of the field study, only three survived beyond six months of age and four of nine known adults died during the project (Yonzon and Hunter, in press). Most of the deaths from known causes (57%) were human-related; thus the presence of chauri, their herders and dogs was clearly detrimental to the pandas.”

Data from other species:
It was felt that in terms of body size, lifespan and reproductive characteristics a small felid or raccoon could perhaps function as a model.

From: Miller *et al.* 2005 (based on new analyses by Aaron Haines; see also Haines *et al.* 2005, 2006): Preliminary Population Viability Assessment for the Ocelot (*Leopardus pardalis*) in South Texas and Northern Tamaulipas.

Age Class	% Mortality (SD) (Road mortality excluded)	
	Females	Males
0 – 1	30.0 (6.0)	30.0 (6.0)
1 – 2	15.0 (3.0)	15.0 (3.0)
2 – 3	16.0 (4.0)	30.0 (6.0)
3 – 4	8.0 (2.0)	13.0 (3.0)
4+	8.0 (2.0)	8.0 (2.0)

From: Rees *et al.* 2008: Raccoon ecology database: A resource for population dynamics modelling and meta-analysis.
"Ontaria Rabies Model" (ORM) default values from Ontaria field data and range of values found for rural raccoons in the Racoon Ecology Database (REDB):

Parameter	ORM Default value	REDB
Year 0 male(female) mortality rate	0.5	Sub-adult: 0.4-0.51
Year 1 male(female) mortality rate	0.4	Adult: 0.3-0.9
Year 2 male(female) mortality rate	0.3	
Year 3 male(female) mortality rate	0.3	
Year 4 male(female) mortality rate	0.3	
Year 5 male(female) mortality rate	0.6	
Year 6 male(female) mortality rate	0.6	
Year 7 male(female) mortality rate	0.6	

Catastrophes:

Most wild populations will undergo catastrophes, defined as short lived events that have a large influence on survival and/or reproduction. In fact, in a study examining population data of 88 vertebrate species, Reed *et al.* (2003) detected a probability of catastrophic die offs (defined as a one year decrease in population of 50% or more) of about 14% per generation. The workshop participants felt that bamboo flowering, earthquakes and forest fires potentially constituted catastrophic events for red panda populations in China. There are areas/valleys where only one species of bamboo grows so that if this flowers this event can have a significant effect on pandas that live in that area. Earthquakes can cause landslides which can cause localised habitat destruction. Forest fires equally can cause habitat degradation, fragmentation and destruction.

Data on the frequency of these catastrophes, their precise effects on the red panda and the severity of these effects is lacking. However, it was felt that it would be more realistic to include three catastrophes with a conservative effect on survival and reproduction into the model, than to include no catastrophes at all.

The three catastrophes were modelled as following:

	Bamboo flowering	Earthquake	Forest Fire
Frequency	=100*((Y%60)=CEIL((60*SRAND(R)))) (meaning there will be a flowering event every 60 years with a different start year for each run)	2 (or on average twice in 100 years)	1 (or on average once in 100 years)
Severity Reproduction	0.8 (or a 20% reduction in reproduction)	1 (no effect on reproduction)	1 (no effect on reproduction)
Severity Survival	0.8 (or a 20% reduction in survival)	0.9 (or a 10% reduction in survival)	0.7 (or a 30% reduction in survival)

Initial population size (N) and carrying capacity (K):
The baseline model was run three times, for three different separate populations:

Population	**N**	**K**
Xiaoxiangling *A.f. styani* population (XXL)	400	600
Rest of *A.f. styani* population (RSt)	3000	4000
A.f. fulgens population (Fulg)	2000	4000

The Xiaoxiangling population is a smaller population, it is relatively isolated from the remainder of the *styani* population and it represents a different genetic type. It was thus modelled separately.

Inbreeding depression:
Because no information is available on the presence or absence or the way of manifestation of inbreeding depression in the red panda populations, and on how many lethal equivalents are present per diploid individual, inbreeding depression was included in the Vortex model with the following settings:

- Inbreeding depression is modelled as reduction in the first year survival of inbred individuals.
- The number of lethal equivalents (LE) sets the severity of the inbreeding depression. The default value in *Vortex* is 3.14 LE per diploid individual, based on a survey of 40 captive mammal populations (Miller and Lacy 2005). While this default number was used in the Nepal red panda Vortex model, a cumulating amount of research suggests a higher impact of inbreeding depression in many wild populations (O'Grady *et al*. 2006). The number of lethal equivalents for this red panda model was therefore set at the higher level of 6.
- The percentage of the genetic load due to recessive lethal alleles was set at the default level of 50%.

Model Results

The Vortex red panda model was used to address five modelling questions outlined below. In Tables 6-12 giving the results for stochastic model simulations, the following abbreviations are used for various model outputs relevant to population viability:

Init N = Initial population size; K = carrying capacity; stoc-r = stochastic growth rate r; SD(r) = standard deviation for stochastic r; PE = probability of extinction; N = mean population size; SD(N) = standard deviation for mean population size; GD = gene diversity; SD(GD) = standard deviation for gene diversity)

1. What are the deterministic projections for the Xiaoxiangling population?

The deterministic projection assumes no stochastic fluctuations, no inbreeding depression, no limitation of mates, no harvest, and no supplementation. Catastrophes are included but because deterministic projections cannot cope with random numbers, for the deterministic calculations the bamboo flowering catastrophe was set with a frequency of =100*[(Y%60) = 30] which means if occurs in years 30 and 90 of the 100 year simulation.

The baseline model results in a population growth rate of 7.9% per year (r= 0.079), a generation growth rate (R0) of 1.451 and a generation time of 4.70 years for both males and females. This appears to be within a range that is feasible for a red panda population without anthropogenic threats.

The stable age distribution associated with the model is as follows:

Stable age distribution:

Age class	Females	Males
0	0.166	0.166
1	0.084	0.084
2	0.062	0.062
3	0.048	0.048
4	0.038	0.038
5	0.029	0.029
6	0.023	0.023
7	0.018	0.018
8	0.014	0.014
9	0.011	0.011
10	0.009	0.009

Ratio of adult (>= 2) males to adult (>= 2) females: 1.000

2. What are the stochastic projections for the baseline model for the three populations investigated?

All three baseline populations modelled showed a positive growth rate, obtained population sizes at carrying capacity and had a zero probability of extinction in the absence of anthropogenic threats (Table 6). **HOWEVER,** one should remember that the conditions of the baseline scenario (no human-caused threats) exist nowhere in the distribution area of the red panda in China. Every known locality has a combination of several human caused threats acting on the populations.

Even under these idealized conditions, the XXL population maintained an average gene diversity of 96.8% after 100 years. Many conservation projects recommend to strive to retain in the order of 100-98% of gene diversity (and thus 100-98% of the evolutionary potential), which this population would thus just fail to achieve on its own. The two other populations, which reached their carrying capacity of 4000 individuals, were able to maintain 99.5% of gene diversity. For more on maintaining gene diversity, see question 4 below.

Table 6. Stochastic model results for the three baseline populations modelled in the absence of human-caused threats.

Population	Init N	K	stoc-r	SD(r)	PE	N	SD(N)	GD	SD(GD)
Xiaoxiangling *A.f. styani* population (XXL)	400	600	0.062	0.096	0	575.57	46.96	0.9678	0.0047
Rest of *A.f. styani* population (RSt)	3000	4000	0.072	0.094	0	3882.75	275.36	0.9951	0
***A.f. fulgens* population (Fulg)**	2000	4000	0.071	0.095	0	3893.83	260.23	0.9949	0.0003

3. What level of habit destruction or degradation, modelled as a reduction in carrying capacity, would result in an unacceptable risk of extinction or a negative average population growth?

When habitat becomes degraded or disappears, the carrying capacity of a particular region will decrease. In order to investigate at what carrying capacity a population would have an unacceptably high risk of extinction, we started from the smallest baseline population (XXL) and reduced carrying capacity in consecutive scenarios (Table 7). In the first scenario the carrying capacity (K=500) was higher than the initial population size (N=400). In the consecutive scenarios the initial population size and carrying capacity were the same. The results in Table 7 indicate that a carrying capacity of only 100 individuals resulted in 11% probability of extinction. A population with a carrying capacity of only 50 individuals had a 89% probability of going extinct in the course of 100 years and had a negative average growth rate (r = -0.017). From a purely demographic perspective and in the absence of further habitat degradation or other human caused threats, a carrying capacity of at least about 200 individuals would be necessary to avoid a high risk of probability of extinction.

Table 7. Stochastic model results for populations with different carrying capacities.

Scenario	stoc-r	SD(r)	PE	N-all	SD(N-all)	GD	SD(GD)
N400/K500	0.060	0.096	0	478.91	4.,74	0.9614	0.0061
N&K 400	0.058	0.096	0	380.58	37.42	0.9528	0.0084
N&K 300	0.053	0.097	0	281.98	29.42	0.9366	0.0124
N&K 200	0.044	0.100	0	178.47	30.08	0.9062	0.0253
N&K 100	0.017	0.118	0.11	53.52	33.43	0.7923	0.0895
N&K 50	-0.017	0.159	0.896	1.4	4.96	0.5572	0.1948

However, since the baseline model for XXL already failed to maintain what is generally accepted as a sufficiently high level of gene diversity for wild populations (98-100%), reducing the carrying capacity further only increased the level of gene diversity that was lost over the course of 100 years. In fact, a population with 100 individuals only maintained 79% of gene diversity after 100 years. This would equate to an average level of inbreeding of 21% which is slightly lower than the equivalent level of full-sib matings (25%).

Apart from causing a reduction in heterozygosity, inbreeding may cause decreased fitness in inbred individuals of naturally outbreeding species, a phenomenon which is called inbreeding depression (Frankham *et al*. 2002). The latter may express itself in many forms, some of which may not be immediately obvious unless one consciously sets out to investigate them, e.g., reduced juvenile survival, reduced adult survival, less successful mate acquisition, lower social dominance ranking of inbred individuals, reduced fertility, increased bilateral asymmetry, increased disease susceptibility etc. Inbreeding depression occurs more often than not and numerous wild populations have now been shown to suffer from inbreeding depression (Crnokrak and Roff 1999; Frankham *et al*. 2002; Frankham 2010). Inbred populations that appear to have healthy growth rates are not necessarily free from inbreeding depression, and inbred populations experiencing inbreeding depression are not guaranteed to go extinct. Furthermore, at low to moderate levels of inbreeding, inbreeding depression is usually low to moderate as well. However, there appears to be a threshold effect whereby there is a marked and incremental increase in risk of extinction due to inbreeding depression from intermediate levels of inbreeding onwards (Frankham 1995). Inbreeding effects also tend to be more severe in harsher environments. Populations that appeared fine may therefore start to struggle in times of increased stress from whatever source (Frankham 1995). Replicate populations of the same species, inbred to the same degree will show different degrees of inbreeding depression, possibly including no inbreeding depression or even increased fitness with inbreeding (e.g. Lacy *et al*. 1996), but the probability that inbreeding reduces fitness is higher than that it does not. Inbreeding depression therefore increases the probability of extinction, especially when populations remain small and moderate levels of inbreeding have been reached. Current scientific evidence suggests that, certainly when we deal with highly threatened populations, it would be foolish not to take the possible existence and effects of inbreeding depression into account (Frankham and Ralls 1998).

Ideally, for wild populations, one would strive for the retention of something in the order of 100-98% of gene diversity – so that 100-98% of the evolutionary potential can be retained. It will therefore be necessary to ensure that small populations (even those with about 200 individuals) have connectivity to other populations so that the gene diversity in each subpopulation, and certainly at the level of the meta-population can be kept sufficiently high.

4. In the absence of human caused threats, which population size is necessary to maintain the level of gene diversity at its current level?

When an extra model was run with a starting population size of 2000 and a carrying capacity of 4500, the population was able to maintain 100% of gene diversity for 100 years (Table 8). A population with a starting size and carrying capacity of 1000 individuals was able to maintain 98% of gene diversity.

Table 8. Stochastic model results for populations with different initial population sizes and carrying capacities.

Scenario	stoc-r	SD(r)	PE	N	SD(N)	GD	SD(GD)
N1000/K1000	0.074	0.082	0	983.66	34.87	0.9810	0.0021
N2000/K4500	0.079	0.082	0	4450.43	126.77	0.9950	0

5. *What would be the effect in increased mortality, for example because of poaching?*

Poaching was identified as a threat to red pandas in China. In the absence of data on the frequency and severity of poaching, poaching was modelled through increasing levels of mortality. Table 4 shows the results of an additional 5% mortality for both sexes and all age classes in the three populations (the Xiaoxiangling *A.f. styani* population (XXL); the rest of *A.f. styani* population (RSt) and the *A.f. fulgens* population (Fulg)):

Females:	0-1:	50(±5)
	1-2:	25(±5)
	2+:	20(±3)
Males:	0-1:	50(±5)
	1-2	25(±5)
	2+:	20(±3)

It was thought unlikely that poachers would select individuals of particular sexes or ages, and poaching of adult females can also decrease the survival of dependant juveniles. This level of increased mortality has an important effect on the Xiaoxiangling population, resulting in a negative average growth rate and a probability of extinction of 21.6%. A similar increase in mortality did not result in a significant probability of extinction for the two other populations, in comparison to the baseline scenario, but it did reduce the average growth rate to zero growth (Table 9) rather than a positive growth rate of 7% (Table 6) – suggesting that an additional 5% mortality is about the maximal level these larger populations can sustain.

Table 9. Stochastic model results for the three populations (Xiaoxiangling *A f. styani* population (XXL); the rest of *A f. styani* population (RSt); and *A.f. fulgens* population (Fulg)), with an additional 5% mortality for all ages and sexes.

Scenario	stoc-r	SD(r)	PE	N-all	SD(Nall)	GD	SD(GD)
XXL Mincr5	-0.022	0.116	0.216	108.99	136.57	0.8882	0.1046
RSt Mincr5	0.001	0.098	0	2273.06	1134.61	0.9908	0.0060
Fulg Mincr5	0	0.098	0.004	1978.09	1145.35	0.9870	0.0141

If we concentrate further on the smaller Xiaoxiangling population, Table 10 demonstrates that an additional 4% mortality overall is about the maximum such a population can sustain, in the sense that it results in a zero population growth and a minor probability of extinction of 3%.

Table 10. Stochastic model results for the Xiaoxiangling *A.f. styani* population (XXL) with respectively an additional 1, 2, 3, 4 or 5% mortality for all ages and sexes.

Scenario	stoc-r	SD(r)	PE	N-all	SD(Nall)	GD	SD(GD)
XXL Mincr5	-0.022	0.116	0.216	108.99	136.57	0.8882	0.1046
XXL Mincr4	0.002	0.103	0.032	316.04	179.48	0.9423	0.0495
XXL Mincr3	0.019	0.099	0.002	469.43	141.24	0.9594	0.0182
XXL Mincr2	0.035	0.097	0	535.26	91.42	0.9649	0.0065
XXL Mincr1	0.048	0.096	0	563.75	61.47	0.9670	0.0054

Applying an additional 5% mortality to all age classes has a much more negative effect on the population than only increasing either the juvenile or the adult age class mortality by this amount (Table 11). There was less difference between those last two scenarios.

Table 11. Stochastic model results for the Xiaoxiangling *A. f. styani* population (XXL) with an additional 5% mortality for both sexes and for respectively all ages, only juveniles and only adults.

Scenario	stoc-r	SD(r)	PE	N-all	SD(Nall)	GD	SD(GD)
XXL Mincr5	-0.022	0.116	0.216	108.99	136.57	0.8882	0.1046
XXL JMincr5	0.042	0.095	0	556.69	67.06	0.9675	0.0048
XXL AMincr5	0.009	0.102	0.012	388.39	177.35	0.9468	0.0491

Applying an additional 5% adult mortality to both sexes, versus only one sex, did not have a very large effect (Table 12). There is only a hint that the scenario for increased adult male mortality does slightly better than the other two scenarios in terms of average growth rate and genetic diversity retained.

Table 12. Stochastic model results for the Xiaoxiangling *A. f. styani* population (XXL) with an additional 5% mortality for adults of respectively both sexes, only males and only females.

Scenario	stoc-r	SD(r)	PE	N-all	SD(Nall)	GD	SD(GD)
XXL AMincr5	0.009	0.102	0.012	388.39	177.35	0.9468	0.049
XXL AMMincr5	0.046	0.087	0	569.41	56.86	0.9670	0.005
XXL AFMincr5	0.013	0.099	0.004	425.87	162.63	0.9546	0.027

General Conclusions

With the current model parameters:

- Very small populations, <200 red pandas, have a high probability of extinction EVEN WITHOUT additional, human-caused, threats.
- From a purely demographic perspective and in the absence of further habitat degradation or other human-caused threats, a carrying capacity of at least about 200 individuals would be necessary to avoid a high risk of probability of extinction. However, a population of 200 individuals would only maintain 90% of the original gene diversity after 100 years, which would equate to an average level of inbreeding of 10%, which is slightly lower than the equivalent level of half-sib matings (12.5%). Ideally, for wild populations, one would strive to retain in the order of 98-100% of gene diversity – so that 98-100% of the evolutionary potential can be maintained.
- Even under the unrealistically optimal scenario of the absence of human-caused threats, a population in the region of 4500 individuals is likely necessary to completely maintain the current level of gene diversity (100%). A population of about 1000 individuals was able to maintain 98% of gene diversity after 100 years.
- Even larger populations will eventually become extinct if human threats, such has timber extraction, bamboo shoot collection, poaching, grazing, traditional medicine collection, infrastructure development, mining, etc. are not urgently addressed.
- An additional 5% mortality across ages and sexes, due to poaching or other reasons, appears to be about the maximal level that a population of 4000 individuals can demographically sustain. For a population of 600 individuals, this limit appears to be at about 4% additional mortality.
- The three populations modelled here were each modelled as one large panmictic population. In reality it is likely that there is some degree of fragmentation within these large populations, making them more vulnerable than the model results suggest.

Recommendations

1. To refine the projection of future trends for red panda populations in China and evaluate the impact of alternative management strategies, it is vital that basic data on:
   - population sizes and distribution
   - fertility and mortality
   - the nature, distribution and severity of threats and catastrophes

   of wild red panda are urgently collected.

2. Even in the absence of more data, it is evident that only relatively large populations of a few thousand individuals are genetically viable. To avoid significant losses of genetic diversity of red pandas in China, it is vital that:
   - The sizes and locations of subpopulations are identified and mapped;
   - The potential for dispersal (and thus gene flow) between these subpopulations is determined and where necessary and appropriate restored or improved; and
   - Human caused threats are immediately addressed.

3. Items 1 and 2 above are particularly true for *A.f. styani*, for which China carries the sole responsibility for its survival.

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SECTION 8

Next Priority Action Steps

Priority Action Steps

At the end of the PHVA workshop, the participants considered the goals and objectives, and developed the following list of recommended actions as the most urgent 'next steps':

Priorities for China (for next three years – by 2015)

1) **Formal report to the Chinese government** (SFA) to make sure they understand the situation and urgency and the required high level activities for conservation for red panda (in Chinese and English)

   Coordinator: Wei Fuwen
   Timeline: One month

2) **Rapid survey** on the distribution and population of red pandas; on the distribution, type and extent of threats; and development of long-term monitoring.

   Coordinator: Wei Fuwen
   Collaborators:
   - Institute of Zoology, Chinese Academy of sciences
   - Yunnan University
   - China West Normal University
   - Sichuan University
   - Chengdu Research Base
   - Red Panda Network
   - SFA in range counties
   - Beijing Zoo (Zhang Cheng Lin)
   - Chinese Association of Zoological Gardens (CAZG)
   - SFA *ex situ* facilities

   Intermediary goals:
   - Identify survey sites.
   - Define and develop survey and monitoring methodology. Circulate existing methodology among survey group.
     - *Angela Glatston to send the pre-PHVA survey design to Wei Fuwen*
     - *Red Panda Network (RPN) to send RPN methodology*
     - *Institute of Zoology (IOZ) to send IOZ methodology*

3) **Other areas of activity** that can be initiated while the survey is conducted, such as:

   - Education
     Follow up team: Sarah Bexell, Red Panda Network

   - Community development and sustainable livelihoods
     Follow up team: Sarah Bexell, Chen Youping, Red Panda Network, The Nature Conservancy, possibly World Wildlife Fund

4) **Fund raising plan** to secure funding for: survey and long-term monitoring; education; and community development and sustainable livelihoods. Potential funds from:

   - Chinese government (*Coordinator:* Wei Fuwen as point person)
   - International organizations (*Coordinators:* Angela Glatston, Red Panda Network)

Priorities involving Myanmar

1) **Biological monitoring** (red panda populations, fecal collection for subspecies determination/genetic typing)
2) **Transboundary collaboration** (e.g., regarding Chinese consumption of wildlife and non-timber forest products)
   - Talk to TRAFFIC about this (*Angela Glatston to follow up)*
   - Incorporate in awareness activities where relevant (see above)
3) **Invite** a larger delegation from **Myanmar to the Indian PHVA** to do more planning for Myanmar [*note: the PHVA in India has since taken place and unfortunately it was not possible to have representation from Myanmar, necessitating the need for an alternative strategy for red panda conservation planning for Myanmar*];
4) **Sustainable agricultural activities** as an alternative to shifting cultivation
5) **Ranger training** for law enforcement staff and community rangers to carry out law enforcement, and community-based monitoring and awareness

All recommendations made by the PHVA workshop participants are considered advisory to the local and regional wildlife and forestry management authorities and their collaborators to help guide actions thought to be beneficial to the long-term survival of the red panda in China and Myanmar.

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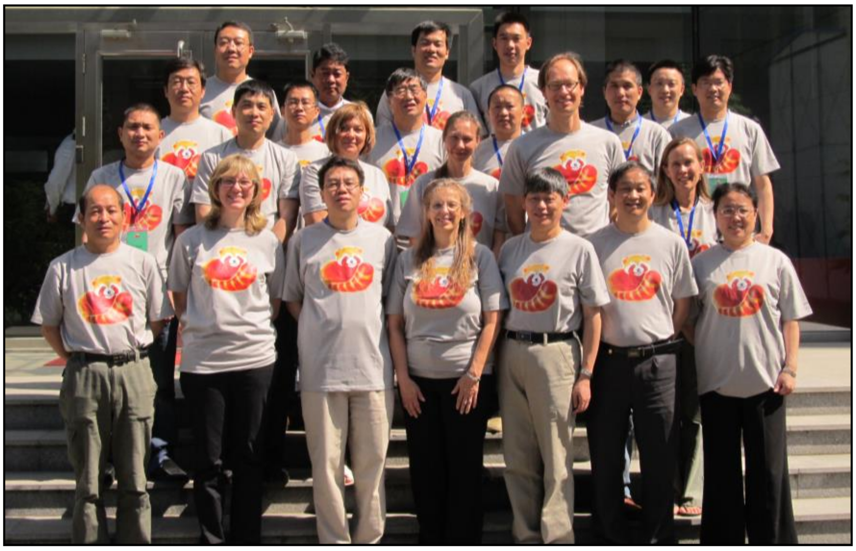

APPENDIX I

Workshop Participants

Workshop Participant List

Participant	Institution	Email
Wang Weisheng	State Forestry Administration	
Wang Zhengyu	Bureau of Foreign Affairs, Chinese Academy of Sciences	
Wei Fuwen	Institute of Zoology, Chinese Academy of Sciences	weifw@ioz.ac.cn
Hu Yibo	Institute of Zoology, Chinese Academy of Sciences	ybhu@ioz.ac.cn
Nie Yonggang	Institute of Zoology, Chinese Academy of Sciences	nieyg@ioz.ac.cn
Yang Zisong	China West Normal University	yangzhisong@126.com
Wu Ruidong	Yunnan University	rdwu@ynu.edu.cn
Ran Jianghong	Sichuan University	rjhong-01@163.com
Yang Xuyu	Forestry Department of Sichuan	yangxuyu@263.net
Gu Xiaodong	Forestry Department of Sichuan	sc-panda@263.net
Tang Weihong	Gaoligongshan Natural Reserve, Yunan	
Yang Benqing	Fengtongzai Natural Reserve, Sichuan	20088777@163.com
Chen Youping	Pingwu Forestry Bureau	
Zhao Lianjun	Pingwu Forestry Bureau	
Xie Zhong	Chinese Association of Zoological Gardens	xiezhong@126.com
Zhang Chenlin	Beijing Zoo	zhch6465@263.net
Angela Glatston	Rotterdam Zoo	a.glatston@rotterdamzoo.nl
Tara Stephens	Calgary Zoo, Canada (sponsor)	TaraS@calgaryzoo.ab.ca
Sarah Bexell	Chengdu Research Base of Giant Panda Breeding	sarah.bexell@du.edu
Qi Dunwu	Chengdu Research Base of Giant Panda Breeding	qidunwu@163.com
Fan Zhiyong	World Wildlife Fund (WWF)	zhyfan@wwfchina.org
Chang Youde	World Wildlife Fund (WWF)	
Long Yongcheng	TNC	ylong@tnc.org
Than Zaw	WCS Myanmar Program	thanzaw.wcsmp@gmail.com wcsadmin@myanmar.com.mm wcsmp@myanmar.com.mm
Dirk Kloss	Red Panda Network (sponsor)	dirk@redpandanetwork.org
Kristin Leus	CBSG Europe	kristin@cbsgeurope.eu
Kathy Traylor-Holzer	CBSG USA	kathy@cbsg.org

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Meeting Agenda

<u>11 June 2012 (Monday)</u> – DAY 1

AM Welcome and opening remarks
Group photo
Participant introductions
Introduction to workshop and PHVA process (Kathy Traylor-Holzer)
Overview of Red Panda PHVA workshop in Nepal (Kristin Leus)
Status of red pandas in China (Wei Fuwen)
Status of red pandas in Myanmar (Than Zaw)

PM Overview of small population biology and the Vortex red panda model (Kristin Leus)
Development of a vision for red pandas in China
Generation of threats and issues related to red panda conservation

<u>12 June 2012 (Tuesday)</u> – DAY 2

AM Formation of working groups and instructions
Working groups: Issue generation
- Issue descriptions, causes and consequences, prioritization
- Data assembly and data gaps

PM Working groups (continued)
Plenary session: Working group reports and discussion

<u>13 June 2012 (Wednesday)</u> – DAY 3

AM Working groups: Goals and objectives
- Generation of long- term goals to address issues
- Identification of short-term objectives to achieve goals

PM Working groups: Actions
- Identification and evaluation of potential actions and model scenarios

Plenary session: Working group reports and discussion

<u>14 June 2012 (Thursday)</u> – DAY 4

AM Working groups: Development of recommended actions

PM Plenary session: Final working group reports
Next steps forward – beyond the PHVA workshop
Closing of workshop

Working Group Tasks: Population Status Working Group 群现状评估工作小组

1. **Map red panda populations and habitat (and specify which subspecies). For example, map areas with:**
   绘制小熊猫种群和栖息地分布图（标明亚种）。例如：
   - **Confirmed red panda presence 确定有小熊猫分布**
   - **Potential red panda presence 可能有小熊猫分布**
   - **Previously present but now gone 以前有小熊猫分布**现在没有的
   - **Unknown situation 情况不明**

If helpful, use mapping of <u>potential red panda habitat in suitable altitudinal range</u> (mark different habitat types where relevant)
如果需要，可以使用在适宜高度范围内小熊猫可能栖息地地图（标记相关的不同类型栖息地）

2. **Mark protected areas on the map 将**图上的保护区域标出来。

3. **Identify different populations/areas that may be isolated from each other.**
   标出可能与其他种群或地区隔离的区块。

4. **Determine a population size for each population, e.g. based on (average – or min/max) densities and area of occupied/ potential habitat.**
   为每个种群确定种群大小，例如，基于（平均或最大**/最小）种群密度及栖息地占地面**积的种群大小。

5. **Map areas where each main threat occurs. Indicate the relative severity of the threat (e.g., low, moderate, high).**
   在图上标出每个主要威胁因素作用区域。标明威胁因素相对严重性（例如，**低，中，高）**

6. **If possible, determine the population trend for each population:**
   如果可能的话，确定每个种群的变化趋势：
   - **Increasing 增**长
   - **Stable** 稳定
   - **Decreasing 下降**
   - **Unknown 不明**

7. **In the written report, record for all of the above what is based on:**
   在书面报告中，记录下基于下面两点的所有结论：
   - **Fact (and indicate the source, e.g. literature, observation)**
     实际（写明来源，例如，文献，观测）
   - **Assumption (record your reasoning) 假**设（写下推论依据）

8. **Set goals** 设立目标：
   Taking into account the vision and current population status, describe in more detail what you would like the population situation to be when vision is achieved.
   考虑小熊猫保护愿景与当前种群现状，详细描述在保护愿景中小熊猫种群所应达到的状况

9. **Set Objectives 确定任**务：
   Given the vision, current status (with possible data gaps) and the goals, what needs to be done to achieve the goals and vision.
   考虑到设定的保护愿景、当前小熊猫现状**(包含可能的数据空缺)与保**护的目标，确定达成目标与保护愿景所需要完成的任务。

Working Group Tasks: Threats to Red Pandas Working Group

威胁因素分析工作小组:

1. **For each threat, identify and diagram how this affects red panda populations (using as many steps as needed). Then work in the other direction to diagram the factors that lead to or cause this threat.**
   对每个威胁因素，确定并图解它如何影响小熊猫种群。然后反**向**图解导致这个威胁因素的原因。

2. **For each relationship between two factors on the diagram, indicate whether this information is known (fact based on data) or it is a hypothesis (assumption based on expert opinion). Document your source (fact) or reasoning (assumption).**
   对于图解中的两个相关因素之间的联系，标明这是已知的（数据支**持）或只是猜**测（经验假设）。记下来源（实际）或推论（假设）。

3. **Write a brief descriptive statement of each diagram that explains these relationships, including the direction of the relationships. The description and diagrams should be clear so that people who did not attend the workshop will understand.**
   给每个图解写个简要总结，解释这些因素之间的联系及影响方向。确**保未参加**讨论的人员能清楚明白这些图解和描述。

4. **Prioritize the main threats (the ones at the center of each diagram), based on the relative impact of this threat on the viability of the subspecies in China.**
   主要威胁的优先顺序（每个图解的中心），取决于这个威胁因素对中国**此**亚种的有效种群影响的严重性。

5. **Set goals 目**标**:**
   Taking into account the vision and the current threats to red panda populations, describe in more detail what you would like the situation to be with respect to these threats when the vision is achieved. You can have one goal for all chains, or one goal for several chains, or one goal per chain, as appropriate.
   考虑小熊猫保护愿景与当前受胁状况，详尽描述在保护愿景中小熊猫种群相对于当前的威胁因素所期望达到的状况。可针对不同的威胁因素设定不同数量的目标。

6. **Set Objectives 任**务**:**
   Given the vision, current status (with possible data gaps) and the goals, what needs to be done to achieve the goals and vision.
   考虑到保护愿景、当前小熊猫现状**(包含可能的数据空缺)与保**护的目标，确定达成目标与保护愿景所需要完成的任务。

When setting Objectives 在设定任务时：

1. **For each threat chain, identify those relationships (arrows) that can be influenced in some way that may break the chain. These points become potential points for setting objectives.**
   针对每个威胁链，甄别其中可以被影响或打破威胁链的关联**(箭**头**)。**这些节点即是可以设定任务的节点。

2. **For each point of influence, identify the potential objective (action) that could be taken.**
   针对每个有效应的节点，确立可以采取的措施与任务。

3. **For each potential objective, briefly assess its:**
   - **Conservation benefit level**
   - **Cost level**
   - **Likelihood of success**

   对于每一个潜在的任务，忠实的评估它的：
   - **保**护的有益程度
   - **开**销水平
   - **成功的可能性**
   -

4. **Choose one or more objectives per chain based on your evaluation in #3.**
   基于大家在#3中的评价，针对每一个威胁链选出**1个或多个任**务

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APPENDIX II

Key Reference Literature

Key References (workshop briefing materials)

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