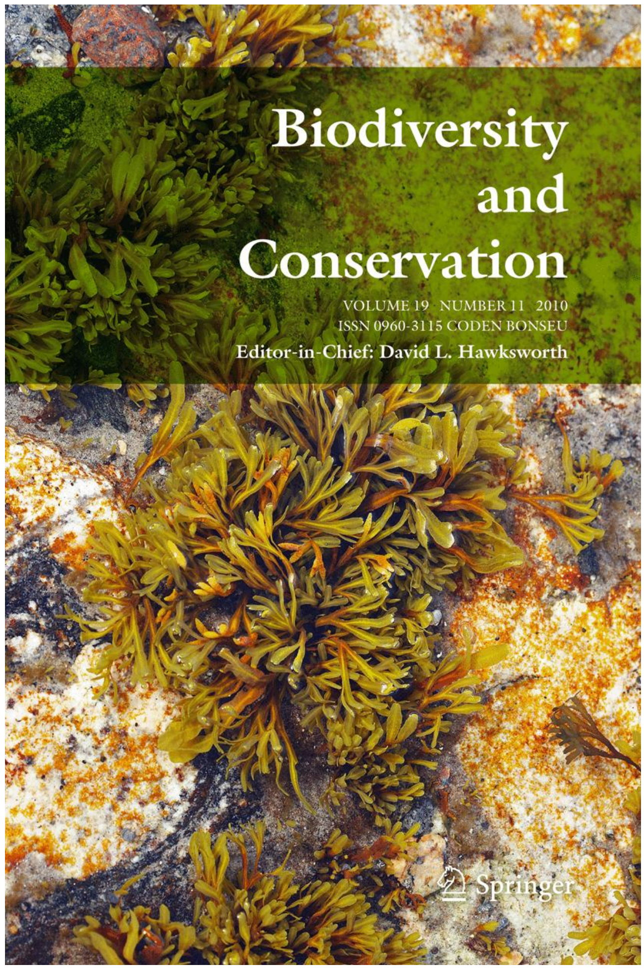
ISSN 0960-3115, Volume 19, Number 11



Biodivers Conserv (2010) 19:3195–3206
DOI 10.1007/s10531-010-9886-x

ORIGINAL PAPER

Beyond pandas, the need for a standardized monitoring protocol for large mammals in Chinese nature reserves

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Received: 28 April 2009 / Accepted: 23 June 2010 / Published online: 3 July 2010

Abstract Monitoring programs are important for effective conservation and management programs. However, most of these programs rely on indirect sign surveys of elusive animals that often leave cryptic signs of their presence. In Sichuan Province, China, sign surveys are oriented mainly toward giant panda (*Ailuropoda melanoleuca*) populations but also are used to track other nationally listed species. We have developed and tested a monitoring system based on camera-trapping that can detect a wide range of large, terrestrial mammal and bird species within the reserves of Sichuan. This system is embedded within current protected area patrolling activities and relies on a partnership of management agencies, universities and international organizations. The international organizations and national universities primarily provide the training and assist with study design and data analysis. Data management and access is controlled at the regional level by the appropriate state agencies. Limitations to this system include the need for additional training and support to less developed reserves and the long-term availability of funds to support field staff. However, the potential return on investment is a consistent tracking of multiple species across diverse set of reserves, facilitating comparative analysis of results that will assist in adaptive management throughout the region.

Keywords Giant panda · Monitoring · Camera-trapping · Large mammals · China

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Background

Large mammals play critical roles within ecosystems and are vulnerable to human impact and extinction (Morrison et al. 2007). The minimum knowledge needed for effective management of mammals within protected areas includes knowing what species are present, their distribution within the area, and their relative abundance across different habitat types. Well-designed monitoring programs with standardized protocol can provide robust data to wildlife managers to obtain such information and monitor the long-term population or biodiversity trends (Pereira and Cooper 2006; Marsh and Trenham 2008). However, monitoring is often poorly targeted, or not conducted, due to the difficulties and expense involved (Sheil 2001). Monitoring activities that are conducted are frequently targeted on specific species and ignore sympatric species which are also of conservation concern. The challenge for conservation managers becomes one of selecting the monitoring approach that optimizes information needed for multiple objectives.

Giant panda (*Ailuropoda melanoleuca*) is one of the world's flagship mammal species and has attracted immense financial and manpower resources, as well as international attention, devoted to the conservation of this single species (Schaller 1994; Loucks et al. 2001). The central distribution of giant panda is within Sichuan Province (485,000 km^2) in southwest China and the Sichuan Forest Department (SFD) currently manages 117 nature reserves, which set aside 15.4% of the province for conservation and contain many globally unique species, such as giant panda, takin (*Budorcas taxicolor*), golden monkey (*Rhinopithecus roxellarae*), and Chinese monal (*Lophophorus lhuysii*). The majority of the reserves focus on conserving habitat for the giant panda and, based on the 2001 survey, these reserves encompass 46.2% of the known range and 56.7% of the known populations of the species (Sichuan Forestry Department 2002). Since 1996, several Sichuan reserves (e.g., Wanglang Nature Reserve and Wolong Nature Reserve, hereafter we use NR to refer to Nature Reserve) have monitored giant panda populations within their boundaries, including data on their distribution and evidence of human disturbance. In an effort to broaden the scope of this monitoring program, the monitoring activities were expanded in 2003 to include all giant panda reserves in Sichuan using a standard protocol (Sichuan Forestry Department 2003), and reserve staff were encouraged to collect sign and sighting information for all species along their patrolling routes (Gu et al. 2004, 2005). The efforts devoted to panda conservation appear to be successful, as both the recent country-wide survey and recent reserve-specific studies indicate giant panda populations are at least stable and may be increasing (State Forestry Administration 2006). Success with giant panda conservation, however, does not always translate into effective management of other large mammal species. Besides the giant panda, few of the sympatric mammal species are currently managed within the reserves, the assumption being that giant panda is an umbrella species (Caro and O'Doherty 1999; Lu et al. 2000), whose management will benefit all species through virtue of similar habitat and protection needs. A recent series of conservation courses sponsored by the Smithsonian's National Zoological Park (NZP) involved staff from 22 reserves throughout Sichuan and found 70% experiencing significant black bear/human conflicts along their boundaries, yet none monitored their bear populations for either population trends or distribution, and none of these reserves currently have programs to mitigate these conflicts. In Sichuan there is a real and imminent need to broaden management and conservation activities beyond giant panda.

The standard methodology used by reserves, a direct count and indirect sign survey along their patrolling routes, is relatively effective for giant panda monitoring because the giant panda's feces and feeding signs are abundant, easy to find and identify, and almost always confined to a single forest type (i.e. coniferous forest with bamboo in the understory) (Schaller et al. 1985; Schaller 1994). However, sighting of nocturnal species are rare, and sign records are always confined to a few large mammal species. For example, 1871 records of 41 wildlife species (i.e. 28 mammal and 9 pheasant species) were documented during the monitoring activities of 17 giant panda reserves of Min Shan region of Sichuan in 2003, but 63% of these sign were from only five species (i.e. giant panda, takin, golden monkey, goral (*Naemorhedus goral*) and wild boar (*Sus scrofa*)) (Gu et al. 2005). Signs of many species, such as small carnivores or medium-sized ungulates, are difficult to discriminate between, and beyond the abilities of most patrolling staff. Meanwhile, the current mammal lists for many reserves in Sichuan are based on limited surveys conducted decades previously, or conceptual models that predict the presence of species based on the range of elevations found within the reserve (Wanglang Nature Reserve Administration 1998). With the Chinese government investing significantly in conservation (Sichuan Forestry Department 2001; Xie 2004), there is an opportunity to set a new standard of monitoring and management within these critical reserves. The establishment of an accurate baseline data is the only means to obtain a reliable assessment of adaptive management practices within and between the reserves.

There is an additional bureaucratic element important to this discussion: with the reluctance of the Chinese government to allow international agencies access to and control of sensitive data (Schaller 1994), there is a need for a monitoring system that can be conducted at the local or regional level, with minimal control by international scientific organizations. The goal is an effective monitoring system that can be conducted by reserve staff, with coordination and organization at a regional level by the government.

Use of remote-triggered, infrared sensor camera units (hereafter referred to as camera-trapping) offers one of the best current techniques to reduce sampling discrepancies between reserves, habitats, and field teams (Cutler and Swann 1999; Silveira et al. 2003; Swann et al. 2004). Camera-trapping have been used across a board range of mammals and birds (Cutler and Swann 1999), and to address specific research questions including presence/absence (Foster and Humphrey 1995; Whitefield 1998), abundance (Carbone et al. 2001; O'Brien et al. 2003; Rowcliffe et al. 2008), population parameter (Karanth 1995; Karanth and Nichols 1998), and daily activity pattern (Foster and Humphrey 1995; Pei 1998; Azlan and Sharma 2006). Camera-trapping was not introduced to China until the late 1990s, and since its introduction has been used for various endangered species (Wildlife Conservation Society 2002; Dahmer et al. 2004; Tilson et al. 2004; Lu et al. 2005; Ma et al. 2006), and to assess the effectiveness of conservation activities (Wang et al. 2006). Beyond a research tool, we believe cameras-trapping can provide a reliable, standardized means for reserve staff to document the presence of large- and medium-sized mammals and, if systematically placed, estimate certain population parameters of species across habitat types and reserves, and monitor the trends of these population parameters over years.

To develop the full potential of camera-trapping, however, there needs to be standardized protocols for set-up and movement of cameras across a reserve, and a centralized data organization. We are reporting on such a system in Sichuan Province, China. NZP, China Wildlife Conservation Association (CWCA), SFD, and Peking University (PKU) have conducted courses for reserve staff since 2002 on survey techniques using camera-trapping within giant panda reserves. These courses led to pilot surveys being conducted in several reserves and a standardized monitoring program, which obligates the partners to train reserve staff, supply equipment and support, provide standardized formats for geo-referenced data collection, and centralized management of the information. Our initial goals were to: (1) demonstrate and develop a field camera-trapping protocol for large mammal monitoring in panda reserves; (2) train reserve staff on use of camera-trapping, as well as evaluate the progress of each reserve after training; and (3) collaborate with local participants to establish a province-wide large mammal monitoring system that integrates camera-trapping across reserves. Our findings are applicable to many country or region-wide wildlife monitoring efforts that rely on local staff for compliance and effectiveness.

Pilot study

To examine the utility of our camera-trapping protocol, we conducted the first pilot study in Tangjiahe NR, from March 2002 to November 2003 (see Wang et al. 2006 for details). The Tangjiahe NR is an approximately 300 km^2 reserve in northern Sichuan (104°36′–104°53′ longitude and 32°32′–32°41′ latitude) and was established in 1978 (Fig. 1). The entire reserve was divided into 71 4-km^2 blocks for sampling. Tangjiahe NR has four patrolling teams, each responsible for a specific region within the reserve. Patrolling staff placed camera units in the selected block during their regular patrolling routes, and on their subsequent patrol (2 weeks later) checked batteries and film, and moved the camera units to the next block. They planned to visit all blocks, but steep terrain resulted in only 56 of 71 blocks being surveyed, with five CamTrakker camera units (Camtrak South Inc., Watkinsville, Georgia, US) placed in each block. Within the survey block, camera units

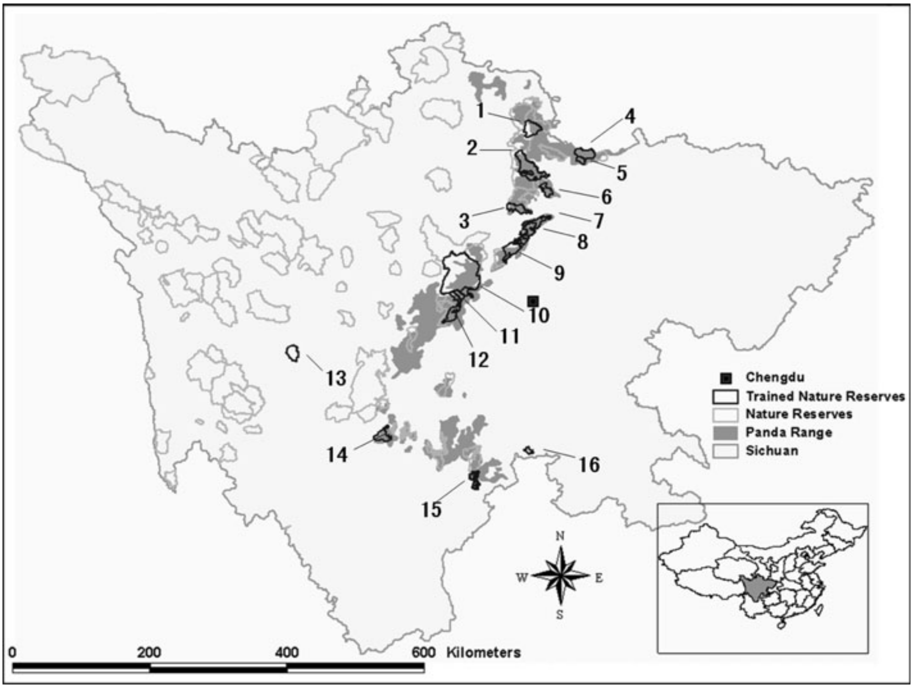

Fig. 1 Nature reserves involved in camera-trapping monitoring in western Sichuan Province, China. 1: Wanglang NR; 2: Xuebaoding NR; 3: Baodinggou NR; 4: Tangjiahe NR; 5: Laohegou Timber Area; 6: Piankou NR; 7: Qianfoshan NR; 8: Jiudingshan NR; 9: Baishuihe NR; 10: Wolong NR; 11: Anzihe NR; 12: Heishuihe NR; 13: Gexigou NR; 14: Yele NR; 15: Mamize NR; 16: Laojunshan NR

were placed along animal trails according to the UTM coordinates selected via GIS, and placed a minimum of 300 m apart. Even at a 300 m distance, we can not assume independence between sample points because of the magnitude of difference in home range size between species such as small herbivores and large carnivores. As the reserve treated these data as an index and not a density estimates, the selection of a minimum distance was a compromise between the variation in ranging behaviour and the need to adequately sample each survey block. All blocks were surveyed during non-winter months: March–December 2002 and March–October 2003, over an elevation range of 1,100–3,200 m. After the two field seasons, staff had surveyed 329 locations, for a sampling effort of 4,515 camera-days, with 509 pictures of 19 identified species (16 mammal and 3 pheasant species).

Three conclusions of that pilot study were:

(1) Camera-trapping was popular with the reserve staff, which could now "see" the animals, many for the first time. Staff felt they avoided misidentifications that occurred during sign surveys and increased their knowledge of animal signs by comparing the pictures with signs near the camera location. The wildlife photographs were also used for public education programs in local villages and schools, which is an important role of the reserves, and were presented to their superiors within the reserve and region.
(2) Two wildlife groups were appropriate target species for monitoring using camera units: terrestrial mammals > 0.5 kg and phasianid species (e.g., grouse, pheasant, partridge, and monal). Adult individuals of both groups had adequate body size to be detected by the camera units, and could be unambiguously identified to species from the photographs. Though small mammals (<0.5 kg) and birds were frequently photographed, it was difficult to differentiate among similar species. Aerial and arboreal mammals were not photographed in sufficient quantities to be appropriate for monitoring with this technique.
(3) The protocol needed modification: The 2-week sampling interval was insufficient to record elusive and solitary carnivores with large home ranges. Second, although the protocol specified the camera units be separated by >300 m, subsequent examination of locations within a GIS found some points separated by <150 m. These sample points could be eliminated prior to analysis, but represented a wasted effort by field staff. The problem was due to different patrolling teams setting out camera units in adjoining blocks and the difficulty in estimating distance in the steep terrain. We dealt with these issues by increasing the sample period to 1 month, creating smaller (1 km^2) block sizes for placement of a single camera, and placing all blocks within a valley under the control of a single patrolling team.

Training courses

For the first 5-day course in October 2003, we compiled a training course manual in Mandarin Chinese, and instructed 22 staff from five reserves, with four instructors. A second (Tangjiahe NR, May 2004) and third (Tangjiahe NR, July 2005) course trained 30 staff from eight new reserves and a timber company, with staff from the four original reserves returning to share their experiences. Most of the trainees were patrolling staff with high school level education (38 of 51), the remaining trainees possessed an associate degree from a forestry college (9 of 51), or a college degree (4 of 51). Some students had experience in previous regional surveys, such as the giant panda survey and national vertebrate survey, and about half the trainees (27 of 51) had attended other courses organized by international organizations in the past 8 years.

Each reserve left the training with a written monitoring protocol that would answer their management questions, and was allocated camera units and supplies (batteries and films) based on their planned level of activity. Each reserve was visited at least once by course instructors to consult with reserve directors and encourage activity.

Initial survey results

We tracked the progress of all reserves, some of which did an effective job (Table 1). An example of an effective reserve was Wanglang NR, which completed a large mammal and phasianid survey of all forested areas below 3,400 m elevation within 1.5 years after training. With the revised protocols they sampled 132 locations (3,793 camera days), and detected 20 mammal and 6 phasianid species. Staff from Wolong NR were trained in May 2005, and recorded 26 mammal and 6 phasianid species at 51 locations during the subsequent 8-month field season. Their camera-trapping was integrated into their regular monitoring activity, which was based on sign surveys along patrolling routes. Their

Table 1 Nature reserves which attended training courses in 2002–2007 and the progress after training

Nature reserve[a]	Training year	Area (km^2)	No. camera	Camera-days[c]	No. wildlife photograph	No. mammal species[e]	No. phasianid species[e]	Relative progress
Tangjiahe	2002	400	25	4697[d]	757	19/39	4/10	High
Baodinggou	2003	195	22	156	20	9/37	2/11	Low
Piankou	2003	91	15	13	7	3/31	0/8	Low
Qianfoshan	2003	177	10	72	30	8/35	1/7	Low
Wanglang	2003	323	23	3793	569	20/30	6/9	High
Baishuihe	2004	302	11	n/a	10	2/37	1/7	Low
Jiudingshan	2004	615	10	170	15	5/40	1/10	Low
Xuebaoding	2004	636	15	526	182	17/42	5/12	Medium
Gexigou	2005	229	10	n/a	50	6/34	2/9	Low
Heishuihe	2005	398	5	n/a	n/a	n/a	n/a	Low
Laohegou[b]	2005	73	10	974	180	15/31	2/9	Medium
Mamize	2005	388	4	n/a	15	2/40	0/4	Low
Wolong	2005	2000	30	1115	595	26/44	6/12	High
Yele	2005	243	5	73	2	1/44	1/9	Low
Laojunshan	2007	35	6	n/a	6	1/21	1/4	–
Anzihe	2007	101	6	n/a	0	0/26	0/8	–
Total			207	~13000	~2500	32	12	

[a] Listed in the order of year trained

[b] Timber area

[c] As of October 2007

[d] As of June 2006

[e] Number of species detected in the monitoring/number of species previously listed by the reserve; for only mammal species, we only count the species whose body weight > 0.5 kg

supervisors considered the new monitoring reports, using camera-trapping data and photographs, as significantly improved (Shi XG, Department of Resource Management, Wolong NR, pers. comm., 14 June 2006).

Timber companies also benefited from the training. After the national logging ban in 1998, many timber companies have attempted to transition to nature protection in order to maintain government income for their staff. However, prior to conversion there must be a demonstrated abundance of important focal species (Regulations of the People's Republic of China on Nature Reserves 1994). Without trained staff or access to university personnel, it is difficult for timber companies to meet these requirements. Laohegou Timber Company received training in 2005 and subsequently initiated a monitoring program with the help of Wanglang NR. As of April 2007, they had surveyed more than half of their 73 km^2 area and recorded 15 mammal and two phasianid species, including two List I and five List II species (i.e. the two highest protection categories under Chinese legislation), which fulfilled the requirement of a baseline survey for upgrading to nature reserve status.

Protocol limitations

The encouraging progress of some protected forests (e.g., Wanglang, Wolong, and Tangjiahe NR, and Laohegou Timber Area) was dampened by finding that most reserves did not progress beyond obtaining photographs of rare wildlife for display (Table 1). There was a significant positive correlation between sampling effort and the number of photographs (Pearson Correlation, $r_p = 0.94$, $P = 0.001$, $n = 10$), but a weaker correlation of sampling effort with number of mammal ($r_p = 0.788$, $P = 0.055$, $n = 10$) or phasianid species ($r_p = 0.784$, $P = 0.058$, $n = 10$) photographed. In June 2006, we hosted a workshop in Wolong NR for staff from all trained reserves to share their experiences. Three categories of issues emerged from these discussions: (1) equipment limitations (i.e. camera units not reliable, difficult to repair once broken, camera units lost or damaged by wildlife, and not enough camera units); (2) staff limitations (i.e. lack of manpower, training, organization, or trapping perceived as low priority by higher-level staff); and (3) funding limitations (i.e. limited funds for film, developing, or support of field work). These problems were overcome by the better organized reserves, but were impediments to the smaller, more poorly-funded reserves. We also asked each reserve if they wanted to continue using the camera units and every reserve answered, "Yes, no matter how many difficulties we have".

Institutional support by reserve directors and associate directors was a critical limitation to the success of the camera units for both surveys and monitoring efforts. Enthusiasm at the patrolling level cannot compensate for different priorities at higher administrative levels. SFD has agreed to take a more active role in promoting and encouraging use of camera units within the reserves. As the government agency responsible for managing all wildlife at the province level, SFD has the legislative role to set monitoring and survey guidelines for the reserves within the province (Regulations of the People's Republic of China on Nature Reserves, 1994), and are the logical recipient of survey and monitoring data. Universities and scientific organization can help in two aspects of the process: training of reserve staff in standardized protocols, and assisting SFD in data analysis. In our case, NZP agreed to provide training, while PKU assisted with data management and analysis, so that sensitive information stayed within its proper channels.

Going from a survey to a monitoring protocol

Our initial focus was to assist each reserve to survey its large mammal populations using camera units. However, once a survey was complete some reserves considered incorporating camera-trapping into their overall monitoring system. For example, the initial survey of large mammals in Tangjiahe NR concluded in 2003, but Tangjiahe added camera-trapping into its sign-based monitoring protocol in 2006. The Tangjiahe monitoring protocol was intended to record human activities, both legal (i.e. ecotourism, construction, staff housing, and honey production) and illegal (i.e. wildlife poaching, herb and mushroom collection, and timber harvest). Impacts from tourism most concerned the reserve staff, as they were under increasing pressure from the local government to boost tourism within the reserve.

For effective use of the camera-trapping at Tangjiahe NR, two considerations needed to be addressed: selection of target species and distribution of monitoring sites. Target species for the camera monitoring needed to meet three criteria: (1) easily detected by the camera units; (2) important to the reserve; and (3) sensitive to human activities. Target species selected by Tangjiahe staff were Reeve's muntjac (*Muntiacus reevesi*), tufted deer (*Elaphodus cephalophus*), Chinese serow (*Capricornis milneedwardsii*), wild boar, hog badger (*Arctonyx collaris*), and Malayan porcupine (*Hystrix brachyuran*). For each species, the number of photographs per 100 camera days will be used as an index of relative abundance, though the effectiveness of such index remains controversial (Jennelle et al. 2002).

In designing a monitoring program for Tangjiahe, we selected 120 monitoring sites based on four factors: existence of trails and access points for staff, elevation, and known areas of illegal and legal human activities. We stratified the sampling into three elevation bands (1,200–1,800; 1,801–2,400; and >2,400 m) due to elevation's significant impact on vegetation. For legal human activities we delineated a "high use" area around reserve structures, major roads, honey production areas, tourist hiking trails, and other known human activities. For illegal human activities, previous patrolling activities had identified perennial camp sites used by poachers, trails used to reach these areas, and points of entry into the reserve; all of which we considered areas of "high potential" for illegal activity.

Twenty cameras were distributed among the staff of three field stations. The protocol estimated 6 month sampling for each year, every site is surveyed for 30 days, and patrolling staff moving camera units and checking batteries and film. Data are managed by the administration of the reserve (Department of Research and Education) and transferred to PKU and SFD at the end of the season for analysis and an annual monitoring report.

Monitoring expenses

The financial support needed for a monitoring program that incorporated camera-trapping, can be estimated based on our experience. For a 5-year monitoring project in a 300 km^2 reserve; we assume the annual sampling season will be 8 months (April–November), with 80 sites sampled using 10 camera units (1 month at each site), approximately 20% of camera units will be either lost or damaged, and 20% of sampling sites will be invalid due to these camera failures and other accidents during the 5-year period. Thus a reserve could sample 320 sites with an initial 10 camera units, and expect five camera units to be replaced and another five repaired during the 5 years. The annual budget for a reserve to conduct a stand-alone monitoring program with camera units is US$ 6,210 (Table 2),

Table 2 Estimated expenses (in US$) for supporting camera-trapping monitoring activities within a 300 km^2 nature reserve for 5 years based on 2001–2007 activities in Sichuan Province

Item	Quantity	Unit price	Note	Total ($)
Camera units	10	400	Passive infrared digital model	4000
Camera replacement	5	400		2000
Camera repair	5	50	Does not include shipping	250
Camera accessories	10	40	Spare memory card and rechargeable batteries	400
Allowance for field staff	1600 Person days	10/person/day	Food included	16000
Field supplies			Datasheets, wire, string, other batteries	800
Vehicle use	2000 miles	8/10 miles	50 miles/month	1600
Data management			Administration	1500
Project management			Administration	1500
Other expense			Travel by SFD and university coordinators	3000
Total				31050

We assume a stand-alone program and not as part of current patrolling. A program incorporated into an on-going activity would be substantially less expansive due to reduced staff and vehicle expenses

which is minimal compared to the immense financial resources devoted to giant panda breeding and conservation. At Wanglang NR (323 km^2), annual costs for current giant panda monitoring and patrolling are US$ 9,000–12,000 (Jiang SW, vice-director of Wanglang, pers. comm., January 25, 2008). If camera-units are added to the current patrolling routes and schedules, we estimate an additional annual expense of US$ 3,010 (Table 2).

Potential

Both Chinese government and international organizations recently moved conservation attention and resource toward measures of biodiversity and ecosystem function instead of a single species such as the giant panda (Loucks et al. 2001; Xie 2004). The nature reserves network played a principal role of biodiversity monitoring and conservation in China (Xie 2004). More effective and standardized monitoring programs, encompassing a range of taxa, need to be developed and relevant practice encouraged. Over the last 5 years of training and monitoring activity, we have found camera-trapping to be an effective tool for survey and monitoring of large terrestrial animals in nature reserves, and an effective data management and supporting framework has been established. Species accumulation curves derived from camera-trapping data are helpful to determine the minimal sampling effort needed while setting up the monitoring plan. One interesting aspect is the potential of this technique to remove species from the current mammal lists of most reserves. For example, a recent mammal list for Tangjiahe NR (Hu 2005) contained 22 large-bodied carnivore species (body weight > 0.5 kg), yet we detected only 6 of theses species carnivore species (e.g., Asiatic black bear (*Ursus tibetanus*), Asian golden cat (*Catopuma temminckii*), leopard cat (*Prionailurus bengalensis*), hog badger, yellow-throated marten (*Martes flavigula*), Himalayan palm civet (*Paguma larvata*)) during almost 4,700 camera days.

Four of the listed species have not been reported since the reserve was established in 1978, the remaining 12 species are still of unknown abundance. Though the minimal sampling effort needed to detect species, especially for solitary carnivores with large home range, might vary broadly (Carbone et al. 2001; Datta et al. 2008), a monitoring program that includes camera-trapping will provide a baseline detection rate for the 6 detectable species. The continued non-detection of the other species may permit revision of the species list. This process alone would bring reserves closer to reality in making management decisions.

Although we face difficulties in scaling up this program, there is a critical need and willingness to employ camera monitoring at more reserves in Sichuan. Our focus has been on reserves established for giant panda conservation, yet these reserves comprise only 18% of the total reserves within the province. The challenge is to effectively fund those reserves outside the relatively wealthy reserves involved in giant panda conservation. One possibility lies in recruiting international organizations that have identified other regions of Sichuan Province (i.e. Tibetan Plateau and Hengduan Mountains) as important conservation zones, such as Conservation International and World Wildlife Fund.

Recent advances in data analysis will greatly improve the utility of camera-trapping data (MacKenzie et al. 2006; Rowcliffe et al. 2008; Tobler et al. 2008; McShea et al. 2009; O'Brien et al. 2010). With consideration of imperfect detection probability, likelihood-based models have been developed to estimate the site occupancy rates of target species related to various sampling and detection variables by repeating sampling (MacKenzie et al. 2002, 2003). Camera-trapping data are ideal for generating detection matrices for each detected species and for analysis using occupancy models such as those proposed by MacKenzie et al. (2006) and Hines (2006). Occupancy rates can be estimated for species of interest and subsequently used as an index for long-term changes of the population. A Wildlife Picture Index (WPI) using camera-trapping data to calculate the geometric mean of occupancy estimates (O'Brien et al. 2010) would be an easy and effective indicator for reserves in incorporate in their monitoring efforts.

Only when comparable data are generated by similarly trained and equipped reserves will managers be able to compare biodiversity between reserves, habitats, and management plans. The current sign-based survey is not adequate to expand beyond the monitoring of giant pandas. We believe a higher initial outlay of funds and training for a camera-based monitoring system will provide the framework needed for reserves in Sichuan Province to move forward.

Acknowledgments This project was supported by Smithsonian's National Zoological Park, Friends of the National Zoo, Peking University, Sichuan Forestry Department, China Wildlife Conservation Association, and World Wildlife Fund China. We thank Tangjiahe NR and Wolong NR for hosting the training courses and workshops, and all the reserve staffs that assisted with program management, data collection and logistic support. We also thank George B. Schaller and Colby Loucks for reviewing our manuscript and providing valuable comments. We had fruitful discussions with Lu Zhi, Wang Hongjia, Gu Haijun and Dai Bo on this project and the manuscript.

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