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Comparative habitat use by giant panda, *Ailuropoda melanoleuca* in selectively logged forests and timber plantations

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A b s t r a c t. We compared the habitat use by giant panda (*Ailuropoda melanoleuca*) in selectively logged forests and timber plantations in the Changqing National Nature Reserve, Shaanxi, China. The results indicated that giant pandas preferred selectively logged forests to abandoned timber plantations. Habitat use of the giant panda was strongly influenced by the over storey canopy cover. Dense over storey canopy in abandoned timber plantations appeared to impede bamboo growth and then resulted in low food availability for the giant pandas. Thus, the abandoned timber plantations were not suitable habitats for giant panda.

Key words: vegetation, deforestation, conservation, Changqing Nature Reserve, China

Introduction

Giant panda (*Ailuropoda melanoleuca*) is an endangered species endemic in mountainous regions of central and southern China. Habitat fragmentation and degradation by deforestation is one of the primary threats to the preservation of the giant panda (S c h a l l e r et al. 1985, P a n et al. 1988, 2001, H u 2001, P e n g et al. 2001, L o u c k s et al. 2001). Before the 21st century, more than 42,000 km^2 of the subalpine temperate forests inhabited by giant pandas were logged (H u 2001). Although a logging ban has been instituted in natural forests across the range of pandas in China until 2010, deforestation and silvicultural activity significantly altered the giant panda habitat (P a n et al. 1988, H u 2001).

The giant panda is an obligate bamboo feeder that selects habitats primarily according to available food resources (S c h a l l e r et al. 1985, R e i d & H u 1991). Primary forests proved to be of principal importance for protecting giant pandas (S c h a l l e r et al. 1985, H u 2001), whereas long-term research in logged areas reflected adaptable habitat use by giant pandas (P a n et al. 2001).Although selective logging could result in intensive disturbance for giant pandas, selectively logged forests could be naturally restored as habitats for giant pandas compared with clearcuts, uncut forests, and even old-growth forests in the short term (P a n et al. 1988, T a y l o r & Q i n 1989, R e i d et al. 1991).

Sizeable timber plantations still exist in logged areas throughout the ranges of giant panda, though those timber plantations are abandoned and set aside for natural succession when most of forest farms and forest companies in the range of giant panda were designated as nature reserves (H u 2001, P a n et al. 2001). Are these abandoned timber plantations in nature reserves suitable habitats for giant pandas? If not, what should the nature reserve management authority do to improve its suitability as habitat of giant panda? Studies on use of the abandoned timber plantations by giant panda are limited. We conducted the study

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to: (1) compare habitat use by the giant pandas between selectively logged forests and abandoned timber plantations; (2) examine environmental variables potentially influencing habitat use of giant panda; and (3) evaluate the implications for conservation of giant panda.

Study Area

This study was conducted in the Changqing National Nature Reserve (33° 19′ N – 33° 44′ N, 107° 17′ E – 107° 55′ E), established in 1995 in Qinling Mountains, Shaanxi, China (Fig. 1). The reserve is 299 km^2 in area and 800–3,071 m above sea level. The reserve is located on the southern slope of Qinling Mountains, at the boundary of Oriental and Paleoarctic Realms. Being affected by high mountains, climate in the reserves falls in the semi temperate humid zone with short cool summers and long cold winters.

The Changqing Nature Reserve was transformed from the once state-owned Changqing Forestry Company in 1995, following over two decades of commercial logging in the area. From 1972–1989, the Changqing Forestry Company practiced selective logging: some large trees were left uncut in the logged areas to regenerate seedlings. Considerable under storey vegetation also remained untouched (mean of canopy coverage after selectively logging $\geq$40%) (Pan et al. 1988).

From 1990–1994, the company clear-cut and then planted trees on the logged sites. to establish tree plantations. When the Changqing Forestry Company was transformed from a

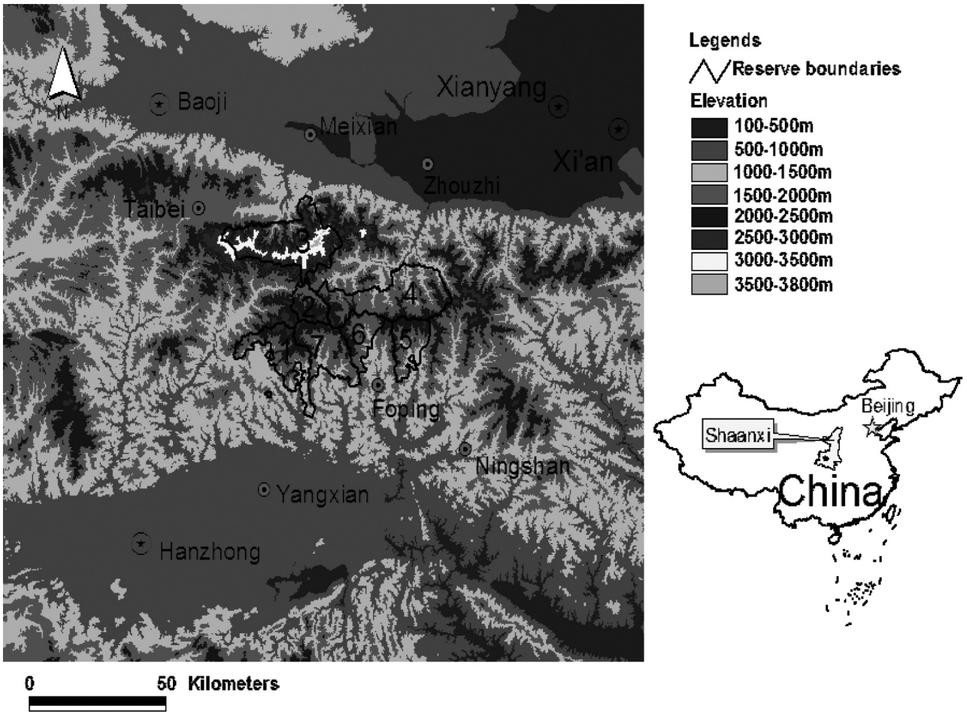

Fig. 1. Locations of the Changqing Nature Reserve and other reserves in the Qinling Mountains, Shaanxi, China. 1 Changqing Nature Reserve (NR); 2 Laoxiancheng NR; 3 Taibei NR; 4 Zhouzhi NR; 5 Tianhuashan NR; 6 Guanyinshan NR; 7 Foping NR.

forestry company to a nature reserve, these timber plantations were abandoned and set aside for natural succession. All areas in the reserve have been strictly protected since designation as a nature reserve.

There are mosaics of timber plantations (about 24 km^2) and selective logged forests (about 203 km^2) in the present landscape of the nature reserve. About 84% of the timber plantations are located in the core protected zone, and are dominated by Japanese larch (*Larix kaempferi*), Prince Rupprecht Dahurian larch (*Larix principis-rupprechtii*), and Chinese hard pine (*Pinus tabulaeformis*) re-planted by the forestry company. Prince Rupprecht Dahurian larch and Chinese hard pine are native trees of the Qinling Mountains, but Japanese larch, an exotic species in the Qinling Mountains, also was planted for timber production in 70 percent of the plantation area in the nature reserve, when primary and secondary natural forests were clear-cut. The selectively logged forests are dominated by Farges fir (*Abies fargesii*), Armand pine (*Pinus armandi*), Chinese hard pine, Chinese red birch (*Betula albo-sinensis*), oriental white oak (*Quercus aliena*), evergreen oak (*Quercus spinosa*), and oriental oak (*Quercus variabilis*). Songhua bamboo (*Fargesia qinlingensis*) and Bashania bamboo (*Bashania fargesii*) are main food resources of giant pandas in the reserve (P a n et al. 1988). These bamboo species were naturally found throughout the entire study areas before the forests were logged. Qinling Mountians are the northern limit of the distribution range of giant panda. From 1989 to the end of the 20^{th} century, the habitat of giant panda expanded and population size of giant panda increased from 240 to 270 giant pandas in the Qinling Mountains, fifty-two giant pandas were found in the Changqing Natural Reserve according to the Third National Giant Panda Survey (Management Station of Nature Reserve and Wildlife in Shaanxi Province 2003).

Materials and Methods

During March–April 2004 and May–June 2005, ninety-six 100 m by 10 m sample transects (48 in the selectively logged forests and 48 in the abundant timber plantations) were surveyed. The minimum distance between the two sections was 200 m. Each sample transect was located in a forest patch of at least 0.5 ha and no less than 10 m from the edge of the forest patch. Habitat type of the patch was identified by referring to the historical forestry inventories in the study area. Habitat use by the giant panda was quantified by counting fecal groups (R e i d & H u 1991, W e i et al. 2000), which were defined as containing less than 10 individual droppings (R e i d & H u 1991). All giant panda fecal groups were counted by the same two researchers and fecal group density (groups/ha) was calculated as a relative index of habitat use by giant pandas.

The Vanderploeg and Scavia's index (E_i*) (L e c h o w i c z 1982) was used to identify habitat use in the selectively logged forests and abandoned timber plantations by the giant pandas:

$$E_i^* = [W_i-(1/n)]/[W_i+(1/n)]$$

Where: W_i is the selectivity coefficient (C h e s s o n 1978), and n is the number of habitat types. The index W_i was calculated:

$$W_i = (r_i/p_i)/\Sigma\,(r_i/p_i)$$

Where: p_i is the proportion of sample units in the ith class, and r_i is the proportion of fecal groups in the ith class. E_i* is scaled between –1 and +1. When $E_i^* < 0$ giant panda avoided this habitat, when $E_i^*=0$, giant panda used this habitat randomly, and $E_i^*>0$ indicates preference. Based on the X^2 test, the statistical significance of E_{ij} was tested by comparing the actual use of a habitat type to its expected use based on random choice amongst all classes available (Reid & Hu 1991).

A 20 m by 20 m quadrat was placed at the midpoint of each transect to quantify forest patch characteristics. Five environmental variables (altitude, slope gradient, slope aspect, canopy cover, and bamboo cover) were recorded in each quadrat for analysing the relationship between habitat use by pandas and local environment. Altitude was recorded with a Geographical Positioning System Receiver (12XLC, Garmin); slope aspect and gradient were measured with a compass (DQL-4, Harbin Optical Instrument Factory), and those two variables were ranked and assigned an integer value. Slope aspects were: (1) North; (2) Northeast; (3) East; (4) Southeast; (5) South; (6) Southwest; (7) West; and (8) Northwest. Slope gradients were classified: (1) 0–5°; (2) 6–20°; (3) 21–30°; (4) 31–40°; and (5) >40° (Dong et al. 1996). The over-storey canopy cover and bamboo cover were estimated by using Braun-Blanquet's cover classes (Braun-Blanquet 1964): (1) <1%; (2) 1–5%; (3) 6–15%; (4) 16–25%; (5) 26–50%; (6) 51–75%; (7) 76–100%. The height of the over-storey canopy was not less than 5 m.

The fecal group densities of the giant pandas were not normally distributed (Kolmogorov–Smirnov test: $Z=3.69$, $P<0.05$). The data were transformed with either power or log transformation but still not normally distributed. Therefore, non-parametric tests were used.

To test whether habitat use by giant pandas was correlated with particular habitat features, Kendall rank correlation coefficients (tau-*b*) and Kendall partial rank correlation coefficients between fecal group densities and environmental variables were calculated (Reid & Hu 1991). The same tests were used to examine the possible relationships between environmental variables (Reid et al. 1991). A significance level of all tests was set at $P\leq 0.05$. Except for Kendall partial rank correlation coefficients that were calculated by hand, all other conventional analyses were performed using the statistical software package SPSS 13.00.

Results

Habitat use by giant panda and environmental variables

The fecal group density in the selectively logged forests was significantly higher than that in the abandoned timber plantations (Table 1).

Table 1. Differences of fecal group density (mean±SE) of giant panda and environmental variables between selectively logged forests (SLF) and timber plantations (TP) in the study areas.

	Fecal group density (group/ha)	Altitude (m)	Rank values of four environmental variables			
			Canopy cover	Bamboo cover	Slope gradient	Slope aspect
SLF	24±6.854	1865±49.79	5±0.136	3±0.263	3±0.144	5±0.327
TP	4±1.443	1865±25.43	6±0.119	2±0.226	3±0.107	5±0.326
Mann-Whitney U	880	1026	561	756	900	897
P (2-tailed)	0.011*	0.670	0.000*	0.004*	0.052	0.059

*Difference is significant at the 0.05 level (2-tailed).

Over-storey canopy cover was significantly lower in selectively logged forests than abandoned timber plantations, whereas bamboo cover was significantly higher in selectively logged forests than abandoned timber plantations (Table 1). The similarities of selective logged forests and abandoned timber plantations were found respectively in altitude, slope gradient, and slope aspect in the study areas (Table 1). Vanderploeg and Scavia's selectivity index showed that giant pandas did exhibit significant preference for selectively logged forests and avoidance of abandoned timber plantations (Table 2).

Table 2. Use of selectively logged forests (SLF) and timber plantations (TP) by giant panda.

Habitat types	Actual fecal groups	Expected fecal groups	χ^2 test		Proportion of fecal groups (r_i)	Proportion of sample units (p_i)	Selectivity coefficient (Wi)	Vanderploeg and Scavia's index (E_i*)
			χ^2	P				
SLF	113	66	11.756	0.001*	0.850	0.500	0.850	0.259
TP	20	66	25.391	0.000*	0.150	0.500	0.150	-0.538

*Significantly preferred or avoided at $P < 0.05$ based on the χ^2 test.

Correlations between habitat use by giant panda and environmental variables

Fecal group density decreased as over-storey cover increased, and this relationship remained strong with the effect of bamboo cover held constant (Table 3, Table 4). Fecal group density increased as bamboo cover increased (Table 3), however, the relationship was substantially influenced by over-storey canopy cover (Kendall partial rank correlation: partial tau = 0.07, P>0.05). Except over-storey canopy cover and bamboo cover, no other environmental variables were strongly associated with fecal group density (Table 3).

Table 3. Matrix of Kendall correlation coefficients (tau-b) between fecal group density (groups/ha) and environmental variables.

	Altitude (m)	Slope aspect	Slope gradient	Canopy cover	Bamboo cover
Fecal group density	0.114	0.065	-0.015	-0.279*	0.181*
Canopy cover	-0.298*	0.050	0.008	1.000	-0.416*
Bamboo cover	0.080	-0.095	0.061	-0.416*	1.000

*Correlation is significant at the 0.05 level (2-tailed).

Correlations between environmental variables

There was a significant negative correlation between over-storey canopy cover and bamboo cover (Table 3). The negative correlation was maintained when the altitude held constant (Table 4). Over-storey canopy cover decreased with increasing altitude (Table 3). There was still significant correlation between over-storey canopy cover and altitude with the effect of bamboo cover held constant (Table 4). Except bamboo cover and altitude, no other environmental variables were significantly correlated with over-storey canopy cover (Table 3). Bamboo cover was significantly correlated only with over-storey canopy cover, and tended to decrease with increasing over-storey canopy cover (Tables 3 and 4).

Table 4. Kendall partial rank correlation coefficients (tau-b) for associations of paired variables with the effect of a third intervening variable held constant.

Pairs of variables	Original tau	Variable held constant	Partial tau	*t* value
Fecal group density and canopy cover	-0.279	Bamboo cover	-0.228	-2.219*
Canopy cover and bamboo cover	-0.416	Altitude	-0.412	-4.288*
Canopy cover and Altitude	-0.298	Bamboo cover	-0.292	-2.892*

*Correlation is significant at the 0.05 level (2-tailed).

Discussion

Giant pandas preferred selectively logged forests over abandoned timber plantations. Over-storey canopy cover was an important factor affecting habitat use. Selective logging creates forest windows in the over-storey canopy. Precipitation and light through those forest windows help the growth of bamboo. The forest windows have high food availability for giant pandas. In addition, in order to reduce energy expenditures, the giant pandas frequently use these openings (Reid et al. 1991, Wei et al. 2000, Yu et al. 2003). Previous studies also showed that the selectively logged forests were preferred by giant pandas (Reid et al. 1991, Wei et al. 1996, Hu 2001, Zhang et al. 2002).

Compared to selectively logged forests, timber plantations typically had dense canopies, while the under-storey bamboo had been clearly cut to establish timber plantations. Bamboo resources inside the timber plantation are scarce, specially in Japanese larch plantations. The sole forest management goal of those plantations is timber production, the tree species formed a dense over-storey canopy which prevents sunlight to penetrate and thus retards growth of bamboo. Dense canopies still predominate the timber plantations, thus it is difficult for the bamboo forest to develop. Consequently, timber plantations lack of food resources and giant pandas reduce their activities. Studies indicated in range of the giant panda, clear-cutting and afforestation for timber production often resulted in change of vegetation structure, flora composition, microclimate, habitat loss and degradation (Taylor & Qin 1993, Ouyang et al. 2002).

In the long term, panda habitat in China will need to be expanded to accommodate panda population increases (Loucks et al. 2003). Selectively logged forests are preferable to timber plantations when restoring disturbed areas for conservation. Forest management in areas with the giant pandas should adopt selective cutting rather than monoculture timber plantations, in order to maintain a balance between timber production and panda conservation. In other words, selective logging would be a potential "win-win" forest management strategy. When improving existing monoculture Janpaness larch plantations for conservation of the giant pandas, we proposed to thin out the understorey or otherwise open gaps in the over-storey canopy in the Janpaness larch forests in Qinling Mountains to allow bamboo to grow.

The study has implications to the *Green-for-Grain Policy* which the Chinese government is implementing for converting agricultural areas on steep mountain slopes back to forest through planting of seedlings and seeds in many parts of the habitats of giant panda. The national policy has deep impacts on the forest vegetation in the country. It is often mentioned that this policy also will benefit giant pandas by expanding available habitat and linking the fragmented existing habitats. However, just by planting seedlings to reforest an area with monoculture forests will not guarantee the area regenerate vegetation as suitable habitats for panda. Our study demonstrates that the *Green-for-Grain Policy* may be of limited value to giant panda protection unless further forest management such as periodic selective logging is implemented in the reforested area. In the range of giant pandas, vegetation structure and bamboo resources in giant panda habitat should be sufficiently considered when implementing the *Green-for-Grain Policy*.

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