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Author(s): Jianguo Liu, Zhiyun Ouyang, Yingchun Tan, Jian Yang and Heming Zhang
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Changes in Human Population Structure: Implications for Biodiversity Conservation

Jianguo Liu
Michigan State University

Zhiyun Ouyang
Chinese Academy of Sciences
Beijing, China

Yingchun Tan
Jian Yang
Heming Zhang
Wolong Giant Panda Research Center
Sichuan, China

Human population size and growth have been recognized as important factors affecting biodiversity, but the impacts of population structural changes on biodiversity are not clear. In this paper, we made the first attempt to link human population structural changes with implications for biodiveristy, using Wolong Nature Reserve (southwestern China) for the endangered giant panda as a case study. From 1982 to 1996, the labor force (20–59 years of age) in the reserve jumped by 59.76 percent, although the total population size increased by only 14.65 percent. During the same time period, the sex ratio (males:females) of small children (0–4 years of age) changed from 0.98:1 to 1.20:1, and the percentage of children receiving education beyond the elementary school level increased from 14.04 to 27.47. The increase in labor force and the number of male-biased children could have more negative impacts on the panda habitat, whereas improving school education could help more young people move out of the reserve by going to college and finding jobs elsewhere and thus reduce destruction to the panda habitat.

Please address all correspondence to Jianguo Liu, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824; e-mail: jliu@perm3.fw.msu.edu.

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INTRODUCTION

Human impacts on the environment and biodiversity have been recognized for a long time (Ehrlich & Holdren, 1971; Ehrlich, 1988; Wilson, 1988; Lubchenco et al., 1991; Vitousek et al., 1997). Previous studies on population-environment and population-biodiversity interactions often used human population size, density, or growth rates as independent variables in descriptive or correlational analyses (e.g., Holdren & Ehrlich, 1974; Norman, 1994; Lutz, 1996; Waak, 1996; Cheever, 1997; Thompson & Jones, 1999). Although demographers have done extensive research on temporal changes in population structure (e.g., sex ratio and age composition), we have not found any studies that linked population structural changes and their possible impacts on biodiversity. Efforts are urgently needed to explore such an unexplored field, because identifying the linkages between changes in human population structure and biodiversity could be helpful (1) to understand the underlying mechanisms behind the human impacts, and (2) to develop effective socioeconomic policies for biodiversity conservation.

A conventional approach to preserve biodiversity has been to establish "protected areas" (e.g., nature reserves and national parks). The major purpose of protected areas is to avoid or minimize human impacts on biodiversity, but in reality, human encroachments are very common in a large number of protected areas around the world (Dompka, 1996). As a result of extensive human activities, biodiversity in protected areas continues to decline. Here, we list just a few examples. In India's Periyar Tiger Reserve, Great Himalayan National Park, and Gir National Park, there are a variety of population pressures arising from migration, herb collection, cattle and sheep grazing, and tourists (Singh, 1996). Maldonado (1996) reported that biodiversity in the Sierra Nevada de Santa Marta Biosphere Reserve of Colombia has suffered from migration, increased tourism, marijuana-related violence, and conflicts among indigenous groups. The unique biodiversity of the Lake Nakuru National Park in Kenya is threatened by extensive waste and land erosion due to the rapidly growing local population and tourists (Thampy, 1996). Increased tourism, a growing demand for fish products, and introduced animal and plant species had tremendous impacts on the marine biodiversity of the Ecuador-Galapágos Islands National Park (MacFarland & Cifuentes, 1996). Despite the extensive protection efforts for the Everglades National Park of the United States, rapid human population growth and economic development in South Florida has reduced the population of wading birds nesting in the Everglades by more than 90 percent (Bancroft, 1989; Ogden, 1994). Furthermore, 51 animal species and 54 plant species have been listed or designated as candidates for listing under the U.S. federal Endangered Species Act (Bancroft, 1996).

In this study, we make the first attempt to analyze population structural changes and discuss the implications of these changes for biodiversity conservation in protected areas, using Wolong Nature Reserve (southwestern China) as an example. Like many other protected areas in China and other countries, local residents in Wolong depend on the forest and land inside the reserve for energy and food. Wolong is the first reserve designated for conserving the well-known endangered giant pandas and other endangered/threatened species (Schaller et al., 1985). However, annual fuelwood consumption in this reserve continued to increase from approximately 4,000 M^3 to 10,000 M^3 during the past two decades (Liu et al., 1999). Under human influences (e.g., fuelwood collection, timber harvest, agriculture), the panda habitat has been reduced by more than 20,000 ha. Furthermore, much of the remaining habitat has become highly fragmented and degraded in quality (Liu et al., 1999). Although it is known that the human population size in Wolong increased by about 15 percent in the past 15 years (Liu et al., 1999), it is not clear whether the human population structure changed. Therefore, in this paper we hope to answer two major questions: Did the human population structure (sex ratio, age composition, and level of education received) in Wolong change during the last 15 years? If so, what are the implications of these changes for the giant panda habitat?

METHODS

Most of the approximately 1,000 giant pandas in the wild inhabit the designated nature reserves (Giant Panda Expedition, 1974; China's Ministry of Forestry & WWF, 1989). Our study site, Wolong Nature Reserve, is the largest among the 25 nature reserves for giant panda conservation (MacKinnon & De Wulf, 1994; Wang, 1997). This reserve was established in 1962 with an area of 20,000 ha, and expanded to its current size of 200,000 ha in 1975 (He et al., 1996). Approximately 110 giant pandas, representing 10 percent of the total wild population, inhabit the Wolong reserve (Giant Panda Expedition, 1974; China's Ministry of Forestry & WWF, 1989; Zhang et al., 1997).

Wolong Nature Reserve is located in Wenchuan County, Sichuan Province, Southwestern China (102°52′–103°24′ East, 30°45′–31°25′

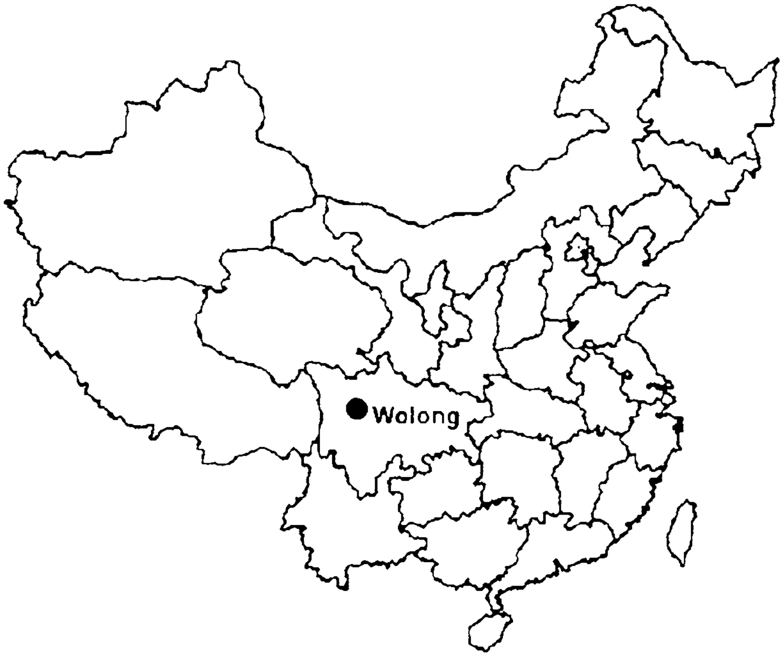

FIGURE 1. Location of the Wolong Nature Reserve.

North) (Figure 1). It is situated between the Sichuan Basin and the Qinghai-Tibet Plateau, and is characterized by high mountains and deep valleys, with elevations ranging from 1,200 to 6,525 m. It encompasses several climatic zones and has high habitat diversity (Schaller et al., 1985), with more than 2,200 animal and insect species and nearly 4,000 plant species (Tan et al., 1995). In addition to the giant pandas, 12 other animal species and 47 plant species in the reserve also appear on China's national protection list.

The reserve is part of the international Man and Biosphere Reserve Network (He et al., 1996) and is managed by the Wolong Administration Bureau. The Bureau reports to both China's Ministry of Forestry and the Sichuan Province government. In Wolong, there are more than 4,000 local residents, belonging to three minority ethnic groups and the Han majority ethnic group. Although the Han ethnic group accounts for the vast majority of the population in China, the three minority ethnic groups comprised approximately 70 percent of the total population in the reserve in 1996 (Tibetan—66.46%, Chang—3.03%, and Hui—0.21%) (Wolong Nature Reserve, 1996). Between 1982 and 1996, the human population in the reserve increased from 3,782 to 4,336 (an increase of 14.65%) (Wenchuan County, 1983; Wolong Nature Reserve, 1996). The current birth rate is about 2.5 children per woman (Liu et al., 1999). This high birth rate is due to the fact that minority ethnic groups are exempt from China's well-known policy of "one-child per couple," because of the Chinese government's political consideration. The vast majority of the local residents are farmers, but there are diverse economic activities in the reserve, including agriculture (maize and vegetables are the major crops), fuelwood collection, timber harvesting, house building, transportation, collection of Chinese herbal medicine, and tourism. Other types of employment include road construction and maintenance, and construction of small hydropower stations over the two main rivers in the reserve.

Data regarding the human population structure in the Wolong Nature Reserve were obtained from the 1982 population census (Wenchuan County, 1983) and the 1996 farmer household survey (Wolong Nature Reserve, 1996).

RESULTS

Age composition. The pyramid base (age groups with greater than 8% of the total population) in 1996 was higher but narrower than that found in 1982 (Figure 2). It consisted of seven age groups (0–34 years old) in 1996 and only four age groups (0–19 years old) in 1982. On average, each age group at the pyramid base accounted for 13.85 percent and 10.09 percent of the total population in 1982 and 1996, respectively.

The number of children (0–19 years old) was reduced 16.90 percent from 1982 to 1996 (Figure 3), whereas the number of young adults (20–34 years old) almost doubled (with an increase of 97.61%) during the same time period. People in the age groups from 20 to 59 years old (the main labor force) increased by 59.67 percent from 1982 to 1996. The number of old people (60+ years of age) increased by 24.47 percent.

Sex ratio. There were two notable changes in the sex ratio (Figure 2 and Table 1). First, the sex ratio of small children (0–4 years of age) changed from 0.98:1 in 1982 to 1.20:1 in 1996. In number terms, there were 5 fewer small male children (196) than small female children (201) in 1982. However, there were 35 more small male children (213) than small female children (178) in 1996.

Second, the sex ratio of the oldest people (70+ years of age) was 0.57:1 in 1982, but increased to 0.98:1 in 1996. In number terms, there

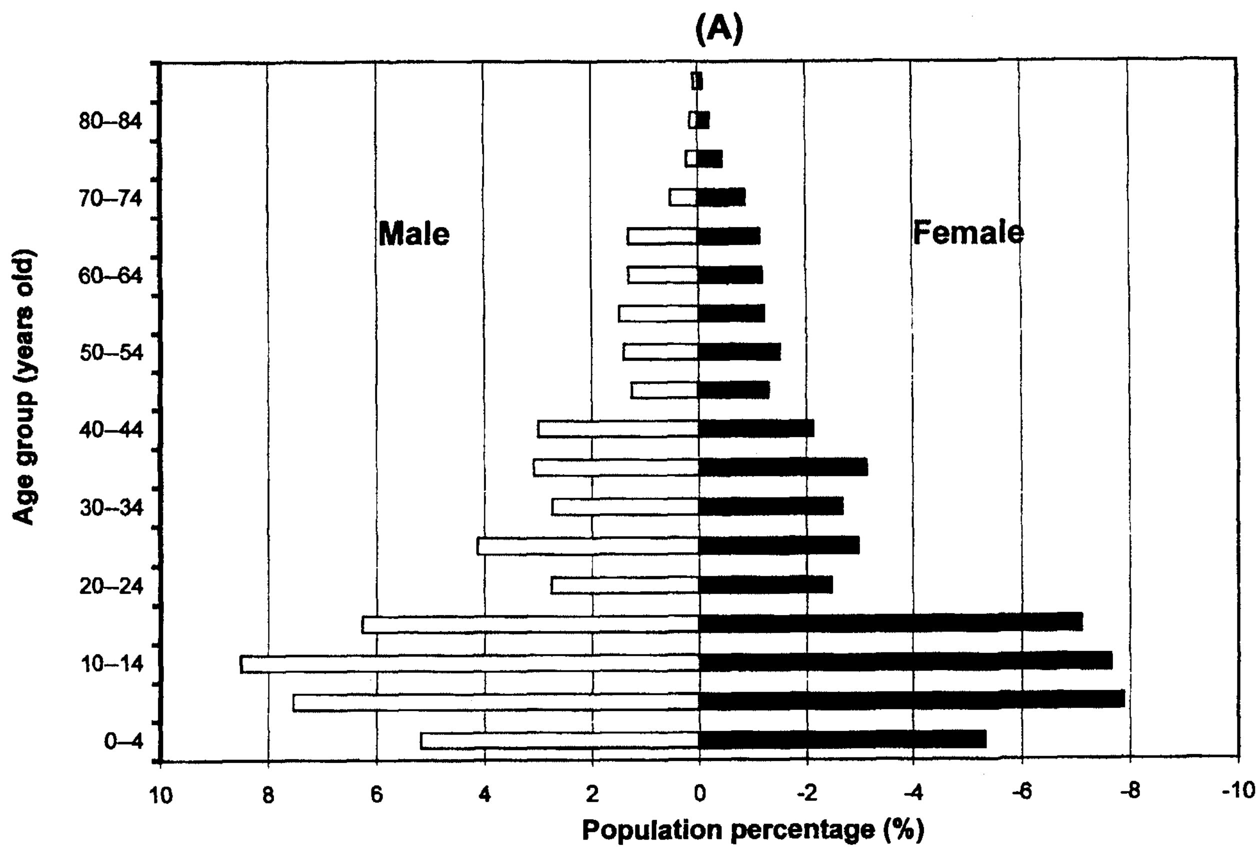

FIGURE 2. Age and sex structures at the Wolong Nature Reserve in 1982 (A) and in 1996 (B).

(B)

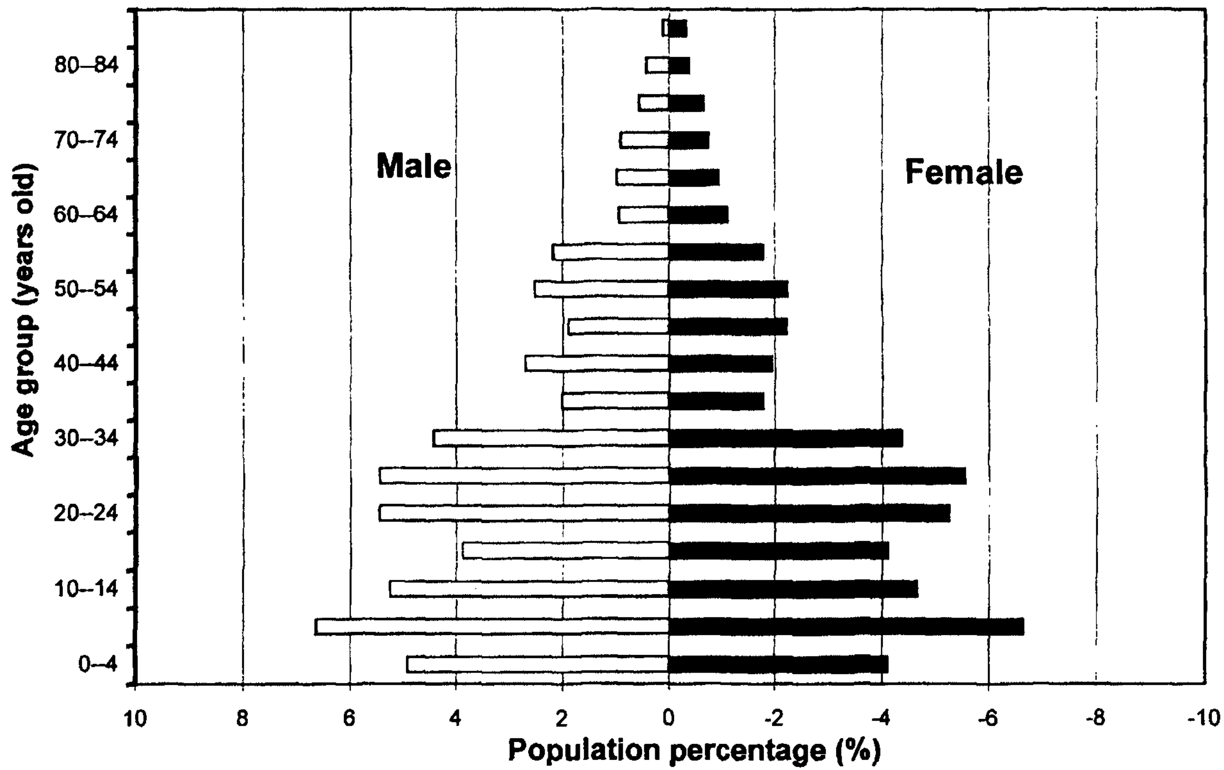

FIGURE 2. (*Continued*)

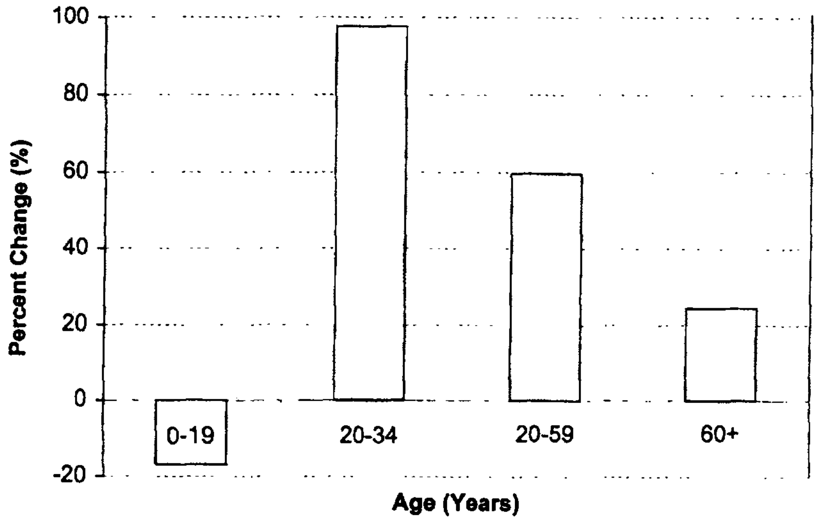

FIGURE 3. Percent changes in human population at different age groups between 1982 and 1996.

were 26 more females (61) than males (35) in 1982, but the numbers of males (89) and females (90) were almost the same in 1996. This means that more males lived longer in 1996 than in 1982. In other age groups (5–69 years of age), the average sex ratio remained basically unchanged in 1982 (1.06:1) and 1996 (1.04:1).

Education. From 1982 to 1996, the illiteracy percentage dropped from 30.85 percent to 24.60 percent, and the percentage of people who attended only elementary school was reduced from 55.10 percent to 47.94 percent (Figure 4). Percentages of people who received middle school, high school, and college education increased from 14.01, 0.00, and 0.03 percent in 1982 to 22.73, 4.21, and 0.53 percent in 1996, respectively (Figure 4). Overall, the percentage of people who received an education beyond the elementary school level doubled from 1982 (14.04%) to 1996 (27.47%).

DISCUSSION AND CONCLUSIONS

Although the total population increased by only 14.65 percent from 1982 to 1996, the labor force (those 20–59 years of age) jumped by 59.76 percent (Figure 3). In other words, the rate of change in the labor force was

TABLE 1

Changes in Sex Ratio (Males: Females) at Wolong Nature Reserve

	Year	
Age group (years old)	1982	1996
0–4	0.98:1	1.20:1
5–69	1.06:1	1.04:1
70+	0.57:1	0.98:1

three times higher than the rate of change in the total population. This sharp increase in the labor force is exceptionally significant with regard to human impacts on the panda habitat because it is the labor force that does most of the damage to the panda habitat through activities such as harvesting timber trees, collecting fuelwood, and constructing roads.

The male-biased youngest age group has two important implications for future population dynamics and the panda habitat. First, the extra boys inside the reserve would have to marry girls from outside the reserve because there would not be enough girls in the reserve. Marrying girls from outside the reserve will further increase both the population size and the labor force inside the reserve. Second, men are more influential than women in terms of the amount and extent of the impacts on the giant panda habitat, because men typically perform heavier jobs (e.g., cutting fuelwood, harvesting timber trees, constructing roads) than women. This is in contrast to some other parts of the world in which mainly women are responsible for collecting fuelwood (e.g., Cruz, 1996) and managing natural resources (Waak, 1996).

Many of the previous efforts regarding conservation education focused on enhancing public awareness and participation. However, it is unclear what school education can do for conservation. For example, are people with higher levels of school education more willing to move out of the reserve to conserve the panda habitat? To answer this question, we did a survey regarding local residents' attitudes toward relocation (Liu et al., 1999). We found that most of the young people were willing to settle outside of the reserve before they got married, especially if they could receive a higher education or more job opportunities in the cities. Although older people preferred not to move out, they often supported and encouraged their children and grandchildren to obtain a college education and then work outside the reserve. These findings suggest that a higher level of school education could help young people move out of the reserve, and

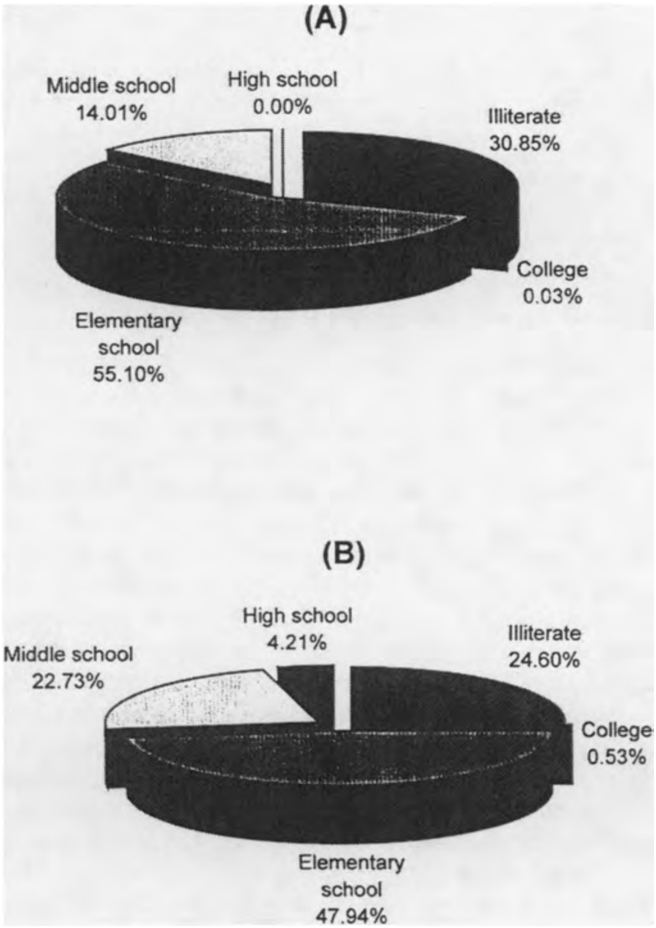

FIGURE 4. Levels of education that the local residents received in 1982 (A) and in 1996 (B).

thus reduce the humans' future impacts on the panda habitat. It is encouraging that the education levels in the reserve have improved over the last 15 years (Figure 4), but the percentage of people who had a higher education is still incredibly low.

In the past, the Chinese government and some international organizations tried to relocate local residents using a household approach, which attempted to relocate the local people household by household—both young and old. However, this is very difficult to do, because older people are accustomed to their local life and usually do not want to relocate. For example, in the early 1980s, to encourage local residents to move away from the core zones of the giant panda habitat, the World Food Program and the Chinese government built a large apartment complex in an area within the reserve that was unsuitable for giant pandas. However, not a single household moved to the complex.

Liu et al.'s (1999) simulation results show that moving young people out of the reserve would be more feasible and effective than the household approach. First, young people are more willing to relocate. Since they possess more technical skills, they do not need to depend on the land and can find professional jobs relatively easily. Second, moving one young person out of the reserve is equivalent to relocating a number of people, because the young person will not have children and grandchildren living inside the reserve. A key for stimulating more young people to relocate is to provide them with quality education in elementary, middle, and high schools. Enhancing education from the elementary to the high school levels will better prepare young people to compete for college education in the cities, and consequently reduce the total population and labor force in the reserve. Of course, we cannot expect 100 percent of the young people go to college. In our computer simulations (Liu et al. 1999), even if only 22 percent of the young people relocated (through attending college, marriage, and other job opportunities), the human population size in the reserve would be reduced from 4,300 at present to about 700 in the year 2047, and the giant panda habitat would recover and then increase by 7 percent. Under the status quo, however, the human population size in the reserve would increase to approximately 6,000 and the giant panda habitat would be further reduced by about 40 percent.

Our study demonstrates that there have been dramatic changes in the human population structure at the Wolong Nature Reserve. In fact, the rates of population structural changes, such as the labor force and the percentage of young people, were much higher than the rate of change in the total population size. These structural changes, especially the significant increase in the size of the labor force, could have a profound impact on the panda habitat in Wolong. Thus, studying population structural changes is essential in order to identify the underlying mechanisms of human impacts on the giant panda habitat and to develop effective socioeconomic policies for conserving giant pandas.

In conclusion, on the one hand, population structural changes are a common phenomenon (e.g., Shryock & Siegel, 1976), and biodiversity loss is becoming increasingly severe. On the other hand, research on the link-age between population structural changes and biodiversity conservation is lacking. It is our hope that our study will stimulate other researchers to quantitatively link population structural changes with biodiversity, because insights into the linkages between these changes (especially the size of the labor force) and biodiversity can be helpful to understand and predict the roles and mechanisms of human beings in altering biodiversity around the world.

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