PATTERNS AND IMPACTS OF TOURISM DEVELOPMENT IN A COUPLED HUMAN AND NATURAL SYSTEM

by

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ABSTRACT

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The human-nature relationship is entering a new period of intense and accelerating changes at local, regional, and global scales. To sustain and improve human well-being without impairing the ecosystems on which it depends, it is needed to holistically view and manage the human society and the natural environment as a coupled system. Tourism is one of the world's largest and fastest growing industry and has great potential to contribute to the United Nation's Millennium Development Goals, especially on enhancing global biodiversity conservation and fighting poverty. Although it has been widely practiced in protected areas in less developed countries, few have been successful in balancing the needs of both conservation and development and achieve sustainability in the long run. To harness the great potential of tourism for sustainability, there is an urgent need for long-term research of tourism development in protected areas that takes a holistic perspective and integrates both the socioeconomic and ecological dimensions of this globally emergent phenomenon.

In this dissertation I studied the evolution of tourism in Wolong Nature Reserve, a flagship reserve in China, across three decades. I investigated both the patterns and drivers of tourism development and also its socioeconomic and ecological consequences. The Tourism Area Life Cycle model was employed to classify and interpret the dynamic drivers and changes associated with tourism through its different development stages. Through a longitudinal analysis on the income sources of over 200 local households, I showed that the local community

benefited economically from tourism in various direct and indirect ways. However, most households who benefited more from tourism are those used to possess more livelihood assets than the others; thus the poorer was marginalized during tourism development. To assess the ecological impacts of tourism development, I used a novel habitat-based approach to assess giant panda population capacity and viability to investigate how tourism, as an emerging land use type, affects panda habitat use and its consequences at population level. I found that past human disturbance has depleted more than half of the Reserve's capacity for giant pandas. Although recent forest restoration is likely to help provide more habitat for panda population recovery, over 60% of the potential gain in panda population capacity could be lost if the current expansion of tourism, especially through the use of the multiple trails traversing the Reserve, continues in the future.

This interdisciplinary study provided a solid example of how the complexity of coupled human and natural system can be studied using a mixed quantitative and qualitative methods. It makes substantial contributions to the conservation of giant pandas as tourism has become a major threat to their long-term survival in the remaining habitats. It also provides useful tools and essential information for a better management of tourism in protected areas. The findings from this dissertation also have broad implications for sustainable rural development, tourism development, wild land management, and biodiversity conservation.

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To those who care and strive to help

the people and wildlife in Wolong.

To see a world in a grain of sand,
And a heaven in a wild flower,
Hold infinity in the palm of your hand,
And eternity in an hour.

William Blake - Auguries of Innocence

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CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 Tourism and biodiversity conservation

Human population has exceeded seven billion (UNFPA 2011), placing ever-increasing pressure on biodiversity around the world (Secretariat of the Convention on Biological Diversity 2010). To protect biodiversity and maintain representative ecological processes, genetic potential, and ecosystem services, 134,000 formal protected areas (e.g., nature reserves) have been designated worldwide as of 2009 (United Nations 2010). Protected areas are believed to be the cornerstone of biodiversity conservation (McNeely & Miller 1983), and are generally perceived as the safest strongholds of wild nature (Armesto et al. 1998). However, pressures from growing human populations both inside and outside protected areas boundaries can compromise their intended functioning as wild places (Dompka 1996; Hansen et al. 2002; Liu et al. 2001; Park & Harcourt 2002).

In recognition of the increasing importance of socioeconomic factors to conservation success, and also partly as a reaction to the failures of fortress conservation, a "neo-populist" conservation approach, such as integrated conservation and development projects (ICDP), emerged (Blaikie & Jeanrenaud 1997). ICDP approaches are motivated by identifying common interests for both conservation and development to achieve both goals simultaneously. However, in practice ICDP have not met expectations, either because of improper implementation or an inability to generate economic profit due to mixed objectives (Berkes 2004; Hughes & Flintan 2001). This has led conservationists to search for more profitable approaches (Daily & Ellison 2002), or a neo-liberal economic approach (Blaikie & Jeanrenaud 1997), such as tourism.

With recent advances in transportation and information technology, tourism is becoming one of the largest industry in the world (World Travel and Tourism Council 2012). Tourism and its related economic activities generate 9.2% of Global Domestic Product, employ over 100 million people, and transport nearly one billion international travelers per year (World Travel and Tourism Council 2012). Nature-based tourism (often called ecotourism, although this term actually refers to a subset of nature-based tourism activities (Weaver & Lawton 2007)), refers to "forms of tourism in which the main motivation of the tourist is the observation and appreciation of nature" (UN World Tourism Organization 2002). It has been the fastest growing section of tourism since the 1980's (Newsome et al. 2002a).

Nature-based tourism has great potential to improve biodiversity conservation and reduce poverty (Coria & Calfucura 2012; Millennium Ecosystem Assessment 2005; UN World Toruism Organization 2010). Nature-based tourism can provide income opportunities to local residents, especially traditionally marginalized groups, including women and ethnic minorities. It is widely perceived to be clean, non-consumptive, and inexpensive to develop because it relies on existing natural, cultural, and historical resources. The revenue generated from nature-based tourism can be used to fund the maintenance and improvement of protected areas and reduce local poverty (Balmford et al. 2009; Buckley 2011). Thus, nature-based tourism has been widely implemented in developing countries for biodiversity conservation (e.g., Costa Rica and Kenya (Honey & Gilpin 2009); Rwanda (Gossling 1999); Ecuador (Wunder 2000); Nepal (Bookbinder et al. 1998); and Belize (Lindberg et al. 1996)).

In spite of the potential to support conservation, nature-based tourism in practice is often used to boost profits for external investors or local elites, with little regard for the well-being of the environment or local community (Acott et al. 1998). In many cases nature-based tourism causes ecological degradation in protected areas (Farrell & Marion 2001; Grossberg et al. 2003; Klein et al. 1995; Yu et al. 1997) with little or no benefit to the majority and the poor of the local community (Bookbinder et al. 1998; Carrier & Macleod 2005 ; Kruger 2005b). By creating economic disparities between tourist destinations and poorer economies in the surrounding landscape, tourism can cause population growth within and in proximity to protected areas as people migrate to fill jobs linked to tourism (Taylor et al. 2003), which may create more pressure on the resources that nature-based tourism relies on.

1.1.2 Tourism in China's protected areas

China has the world's largest human population and second largest economy (Liu & Raven 2010). With the fourth largest land territory in the world, China accounts for more than 10 percent of the world's vascular plants species (over 35,000) and terrestrial vertebrate species (6,347), among which 667 are endemic to China, such as the famous Giant Panda (*Ailuropoda melanoleuca*) (Ministry of Environmental Protection of the People's Republic of China 2008). Despite the richness of species, almost all of China's biodiversity is under stress with an estimation of 15-20% of all species endangered (World Bank 2001). To conserve biodiversity and protect endangered species, a total of 2,640 nature reserves have been established as of 2012, covering 14.93% of China's territory (China News 2012). About 14% (363) of the Reserves are

at the national level. Historically most of the nature reserves have been underfunded. For example, only three national nature reserves, namely Wolong, Foping, and Baishuijiang Nature Reserves, were directly funded by central government (i.e., State Forestry Administration) (Ouyang et al. 2002).

China is the leader in Asian tourism in both international arrivals and receipts (World Travel and Tourism Council 2012). World Tourism Organization (WTO) forecasts indicate that by 2020, China will become the world's leading tourism destination (UN World Tourism Organization 2001). Over the last 30 years, both inbound and domestic tourism in China has boomed (Lew 2003). By 2010, China had the world's largest domestic tourism market with 2.1 billion domestic travelers and 1.3 trillion (about US$200 billion) Yuan of tourism revenue. China is also the third most popular tourist destination in the world, with 56 million overnight visitors in 2010 (Chiang 2010).

To diversify sources of financial supports and meet the increasing demands for visiting nature areas, many nature reserves in China has been practicing nature-based tourism for years. In the late 1990s approximately 80% of nature reserves in China had developed ecotourism, and nearly 16% of the nature reserves hosted more than 100,000 visitors annually (China National Committee on Man and Biosphere 1998; Li & Han 2001). Several provinces in west China, including Sichuan and Yunnan, where the Southwestern China Mountains global biodiversity hotspot area is located (Conservation International 2005), have designated nature-based tourism as their major source of economic growth in the next decade.

Besides nature reserves, there are also over 3,000 protected areas of other types, including forest parks, wetland parks, geo-parks. Tourism has also been widely developed in these protected areas (Wang et al. 2012). Unnecessary damage and unwise development has led to degradation of local ecological, economic, and social systems in many protected areas (Wang et al. 2012; Zhong et al. 2011). Lindberg et al. (Lindberg et al. 2003) identified confusion over land ownership and a strong desire for generating economic opportunities as challenging issues to current ecotourism development in China and pointed out that "… the recent evaluation of reserve management, which includes but goes well beyond ecotourism, illustrates the role of researchers in understanding and informing policy and practice. Nonetheless, continued research is important, not only topics within the broad policy arena, but also with respect to more focused topics such as the economic and ecological impacts of ecotourism …".

1.1.3 Study tourism destination as a complex system

Tourism researchers are usually trained in "a tradition of linear, specialized, predictable, deterministic, cause-and-effect science" with a reductionist background (Farrell & Twining-Ward 2004). The conventional linear methods may be valuable in studying tourism system within a short time span. But tourism is an open, dynamic and complex system, consisting of many interacting components, involving different stakeholders with different objectives, and driven by many internal and external forces (Butler 1999; Gunn 2002). The processes and impacts associated with tourism are highly susceptible to changes. Linear thinking and methods are insufficient in understanding and interpreting the complex behavior of the tourism system, such

as the emergence of unexpected events. Therefore, tourism is often managed with markedly incomplete knowledge, especially on the behavior and dynamics of the whole system. Farrell and Twining-Ward (2004) concluded that traditional tourism research has become "an impairment to integration, unity, and sustainability" and thus does not help preserve the resources that tourism depend on.

The recent advances in sustainability science (Clark & Dickson 2003; Kates et al. 2001) provide new scopes for tourism research and management. Sustainability science examines the dynamic and complex interactions and behaviors of coupled human and natural systems (Berkes et al. 2003; Liu et al. 2007a; Liu et al. 2007b) through synthesizing research on biological, socioeconomic, geophysical, and technology systems. Sustainability in tourism cannot be achieved by focusing on key elements of the traditional "tourism industry", instead sustainable tourism development is only possible through substantially shifting toward integrated and adaptive management and research of the complex adaptive tourism system as a whole (Farrell & Twining-Ward 2004). As sustainability is multifaceted, a transdisciplinary approach that seeks understanding of complexity through linking and integrating diverse types and sources of knowledge on both the human (e.g., social, economic) and natural (e.g., ecological, hydrologic, geophysical) components of the system and also their interactions is needed.

In order to better understand the complex tourism system (e.g., thresholds, feedbacks, legacy effects), greater attention needs to be given to long-term place-based studies (Farrell & Twining-Ward 2004). These studies would allow researchers to explore how the complex interactions within and between the human society, ecosystem, and the biophysical environment

take place, shape the evolutionary trajectory of the system, and be shaped by the system. As these interactions and the resulted changes usually occur at different organizational levels and temporal scales, three different perspectives - the systems perspective, the agent-based (or individual-based) perspective, and the narrative perspective (Lambin et al. 2003), are needed to understand them. The systems perspective explains the major trend of changes at the scale of destination or community at medium temporal scale; the agent-based perspective is about individual (e.g., households, people, animals) decision making within a small temporal scale; and the narrative perspective deals with a much larger time scale and focuses on nonlinearities that cannot be predicted from normal trend analysis. It is essential, though quite challenging, to integrate knowledge from multiple disciplines in such studies (McConnell et al. 2011). This requires researchers to move out of disciplinary boundaries and go beyond the existing approaches to develop more comprehensive portfolios of tools to study and manage tourism for long-term sustainability.

1.2 Study area

Wolong Nature Reserve (Fig. 1, 102°52′ to 103°24′ E, 30°45′ to 31°25′ N) is home to the largest wild population (ca. 140) of Giant Pandas (*Ailuropoda melanoleuca*), a global conservation icon (Schaller et al. 1985; Wolong Administration Bureau 2004). The Reserve was established in 1963 and expanded to its current size of 2,000 km^2 in 1975 (Liu et al. 1999). Climbing from 1,150 m to 6,250 m in elevation (Fig. 1.1), the Reserve hosts hundreds of

mammal and avian species and thousands of higher plant species (Wolong Nature Reserve Administration Bureau et al. 1987), making it part of the Southwestern China Mountains biodiversity hotspot at the global level (Liu et al. 2003b; Myers et al. 2000). The Reserve is an important headwater area for the Minjiang River, a major branch of the Yangtze River. Forests in the Reserve grow in several elevation zones, from evergreen and deciduous broadleaf forests at lower elevations (approximately 1,500 m above sea level), to subalpine coniferous forests at higher elevations (approximately 2,700 m above sea level) (Schaller et al. 1985) with an average forest canopy cover of 56% (Linderman et al. 2004).

Giant pandas in the Reserve spend most of the year in forests of elevations between 2,600 and 3,000 m (Schaller et al. 1985) and their staple food consists of two bamboo species, arrow bamboo (*Bashania fangiana*), distributed within the range of 2,500 to 3,400 m, and umbrella bamboo (*Fargesia robusta*), distributed throughout areas 1,600 to 2,650 m in elevation. Almost 99% of the panda diet consists of bamboo, and in Wolong they consume these two bamboo species in a seasonal pattern: in the winter season the young stems of arrow bamboo are eaten; in spring and summer seasons the young *Fargesia robusta* shoots are consumed; and in the fall season pandas mainly subsist on the leaves of arrow bamboo (Hu 2001; Schaller et al. 1985). Giant Panda habitat includes areas that provide bamboo and shelter for daily activities and reproduction (Schaller et al. 1985). Suitability of panda habitat depends on many abiotic (e.g., slope and elevation) and biotic (e.g., bamboo and forest cover) conditions, as well as on the degree of human impacts (Liu et al. 1999). Currently panda populations in Wolong are separated into several sub-populations with low genetic exchange and face a high risk of extinction within

this century (Hu 2001; Loucks et al. 2001; Loucks et al. 2003; Schaller et al. 1985; Yan & IUCN/SSC Conservation Breeding Specialist Group 1999).

The Reserve is managed by the Wolong Administration Bureau, reporting to both China's State Forestry Administration and Sichuan Province. The bureau is hierarchically structured with two townships under its governance - Wolong Township and Gengda Township. In each township there are three villages, each of which is composed of a number of villager groups. Between 1975 and 2008 the human population in Wolong and Gengda townships increased by about 85% to around 4,600 and the number of households tripled to about 1,250 (Liu et al. 1999; Wolong Administration Bureau Department of Social and Economic Development 2006). Most local people belong to Tibetan and Qiang ethnic minorities but can speak fluent Mandarin Chinese in a local dialect.

Throughout the twentieth century, local people in this area survived primarily on a subsistence-based agricultural economy that was highly dependent on the natural resources in the Reserve. Crop production, livestock-raising, and herbal medicinal plant collection were the most important livelihood strategies of local households (Ghimire 1994). Local people also actively harvested wood, bamboo, and fodder from the forests for daily use. By the mid-1990s, local communities annually consumed around 10,000 m^3 of wood for cooking food and pig fodder, and for heating houses and consumed over 1,000 m^3 for house construction (Liu et al. 1999). At the same time the lack of alternative income also led some local people to pursue poaching and illegal logging (Schaller 1994). By the end of the century natural resources extraction activities of

local community resulted in severe destruction of wildlife populations and habitat in the Reserve, including the giant pandas (An et al. 2002; Li et al. 1992b; Liu et al. 2001; Liu et al. 1999).

In 1979 the Reserve became one of China's first three UNESCO biosphere reserves (Li & Zhao 1989). Since then conservation issues in the Reserve started to receive extensive attention both domestically and internationally. In 1983 the Chinese central government designated the Reserve as the nation's first special district for nature conservation, where conservation and development are practiced and managed by the same administrative unit. The Wolong Special District Administration Bureau received direct financial support from the central government and reported to both China's Ministry of Forestry and the Sichuan provincial government.

Although it has been 50 years since the Reserve was established as one of China's first reserves for giant panda conservation, the loss and fragmentation of panda habitat still remains as a primary threat to the panda population. Panda habitat in the Reserve continuously deteriorated due to pressure from increasing human population and household proliferation (Liu et al. 2001; Liu et al. 1999).

A variety of human activities occur in the Reserve, such as farming, collection of fuelwood and collection of Chinese herbal medicinal plants. Before 1975, much of the loss and fragmentation of panda habitat in Wolong was due to authorized timber harvest (banned in 1975). Since then, fuelwood collection has been the most important proximate factor of deforestation. Fuelwood was needed daily for cooking human food and pig fodder and for heating in the winter (Liu et al. 1999). As population and household number grew in the Reserve, the impact of fuelwood collection became increasingly extensive and intensive.

To stem the ecological degradation in the Reserve, various local and national conservation programs were implemented. From the mid-1980s to early 2000s, about 550 ha (> 70%) of local croplands were reclaimed into tree plantations under local and national payment for ecosystem services programs. Other similar programs were implemented to pay local households to stop logging, to monitor the forests, and to plant trees in previously logged areas (Liu et al. 2008; Wolong Administration Bureau 2004). As a result, by 2007 a clear trend of forest transition has been observed (Viña et al. 2011).

On May 12th 2008 a devastating (7.9 Mw) earthquake struck the Reserve and the surrounding area in Sichuan province. The earthquake and its associated landslides caused extensive damage to forests and infrastructure, including the main road and many tourism facilities (Viña et al. 2011). A series of reconstruction programs were implemented to restore the ecological, social and economic systems. Tourism has been identified as the primary means for future economic growth in the Reserve and over 200 million US dollars will be spent by Wolong Administration Bureau on tourism infrastructure reconstruction by 2015 (Wolong Administration Bureau 2009b).

1.3 Conceptual framework and research objectives

This dissertation arises from my interest in understanding trade-offs and synergies between biodiversity conservation and economic growth and exploring the potential of tourism as a tool to alleviate poverty and conserve endangered species in China. Wolong Nature Reserve is

an ideal site for this topic. The Reserve is rich in biodiversity and well-known both domestically and internationally and tourism development history in the Reserve is one of the longest in protected areas in China. More importantly, Wolong Nature Reserve is one of the most well studied protected areas in China. The research described in this dissertation is built on a long-term research project conducted by an international team of scientists from Michigan State University, Chinese Academy of Sciences, and Wolong Nature Reserve since mid-1990s. The project takes a systems perspective and focus on the interactions and feedbacks among human population, forest, panda habitat, and government policies (Liu et al. 1999). In this dissertation I try to expand the general framework in Liu et al. (1999) to including new components such as panda population, tourists, and tourism development policies and new interactions (e.g., tourism-induced impact on panda habitat and population) among the components (Fig. 1.2).

The main goals of this dissertation are to investigate the evolution of the tourism system in Wolong Nature Reserve, China, to understand the pattern and driving forces of change associated with tourism growth, and to assess the socioeconomic and ecological impacts of tourism development.

My specific objectives are to (1) apply the tourism area life cycle model to investigate the evolution of tourism development in Wolong Nature Reserve, China; (2) investigate the determinants and impacts of tourism participation at the local household level; (3) develop a habitat-based panda population mapping procedure to investigate the spatio-temporal dynamics of panda population changes under different land use situations; and (4) assess the ecological

impacts of trail uses on plant biodiversity and use the procedures developed in objective 3 to evaluate the potential impacts of trail use on panda population distribution and viability.

The following four chapters (i.e., Chapter 2 to Chapter 5) address each of the above objectives, respectively, while the final chapter synthesizes the findings of the previous chapters. In Chapter 2, I examined the applicability of the Tourism Area Life Cycle model to tourism development in the Reserve. The economic, social, environmental, and governance changes associated with tourism development in the Reserve were assessed and the external and internal factors that affected the Reserve's tourism development were investigated. In Chapter 3, I investigated the diverse benefits that local households received from tourism development, identified the factors that led to household-level participation in tourism, and assessed how tourism participation affected local residents' perception on the social benefit and environmental impacts of tourism development in the Reserve. In Chapter 4, I implemented a habitat-based approach with knowledge on panda habitat suitability and panda territorial behavior to assess panda population potential and distribution in the Reserve. In Chapter 5, I investigated the ecological impacts of emerging trail use from two different aspects. Using ordinary least square models, I estimated the effects of biophysical, vegetative, and human disturbance factors on the floristic similarity between a series of trailside and forest interior quadrats at different vegetation layers. Using the procedures established in Chapter 4, I assessed the potential impacts of extensive trail use across the Reserve on panda population potential. Finally in Chapter 6, I summarize the findings and discuss their implications for studying and managing nature-based tourism destination as a coupled human and natural system.

Figure 1.1 Location of Wolong Nature Reserve (bottom) in China (top) with indication of elevation. For interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this dissertation.

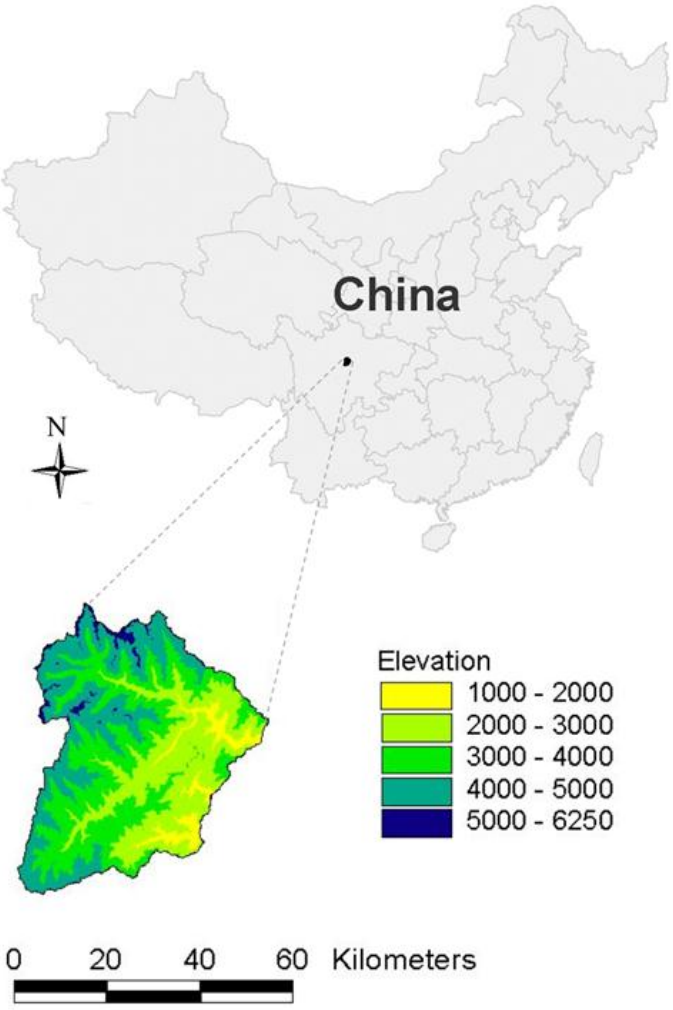
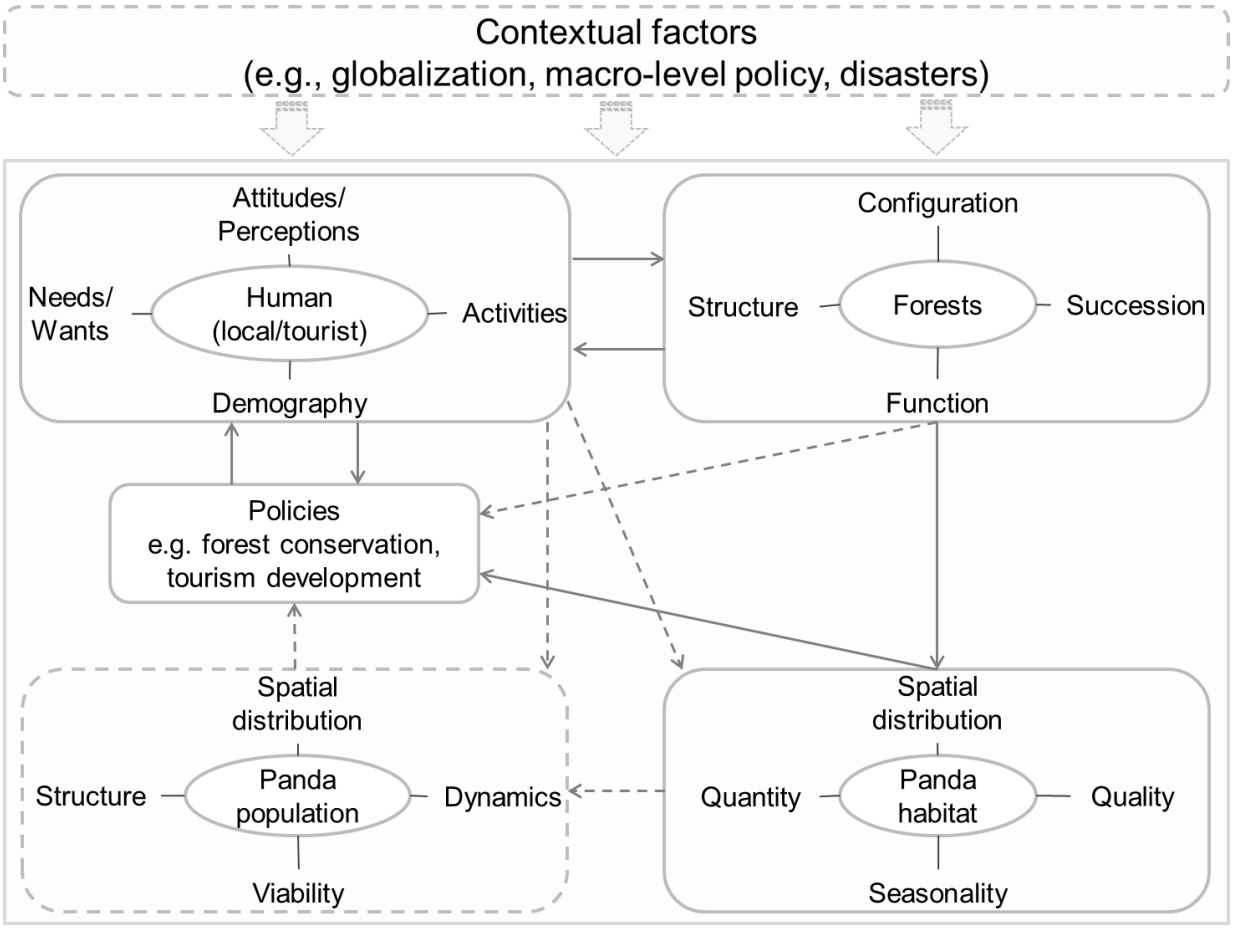


Figure 1.2. Conceptual framework of the research, showing the interrelationship among human, forests, and pandas in Wolong Nature Reserve. The diagram is modified from Liu et al. (1999), with new component and relationship introduced shown in dashed box and arrows.



CHAPTER 2

EVOLUTION OF TOURISM IN WOLONG NATURE RESERVE

2.1 Introduction

Tourism is one of the world's largest and fastest growing industries (World Travel and Tourism Council 2012) and has the potential to make significant contributions to the achievement of several Millennium Development Goals (MDGs), such as eradication of poverty and environmental sustainability (UN World Tourism Organization 2006). The dynamic nature of tourism and the fact that the processes and impacts associated with tourism are highly susceptible to changes makes it difficult to harness the power of tourism for sustainable development of destinations (Butler 1999). Thus understanding the evolution of a tourism destination is a critical first step toward sustainable tourism development.

Tourism area life cycle (TALC) (Butler 1980) is a useful model and one of the best known theories on the evolution of tourism destinations. This model represents the relationship between an increasing rate of tourist visitation and the development of a tourist destination over time, as a life cycle, and offers a relevant framework in terms of identifying development milestones for monitoring changes resulting from tourism development. The cycle includes several stages: exploration, involvement, development, consolidation, stagnation and post-stagnation (Butler 1980).

A tourism destination in the exploration stage is characterized by a small number of tourists, an irregular pattern of visitations, and a lack of specific tourism facilities. As visitation increases and follows some regularity, the local community starts to develop specific tourism facilities and the destination enters the involvement stage. In the development stage tourist volume continues to increase and the destination becomes fully developed. In this stage local

control of tourism development may start to weaken rapidly and new facilities provided by outside organizations looking for high-volume businesses, gradually dominate. When the increasing rate of visitation starts to decline and tourist volume reaches a peak, the consolidation stage is reached. Following the consolidation stage the number of visitors hits the capacity and stagnates. After that is either a decline stage, a stabilization stage, or a rejuvenation stage, in which new attractions are developed and visitation goes up again.

Over the last 30 years, dozens of studies have been conducted to apply the TALC model in various locations and the findings have been compared and contrasted with Butler's original postulations (Lagiewski 2006). In some cases inconsistencies between observed tourism destination's development and the TALC model were found. For example, Hovinen (1981, 1982) found that tourism development in Lancaster County, Pennsylvania deviated significantly from the TALC model in the later stages, while Bao (1995) found that some karst caves in China had no obvious exploration and involvement stages, and visitation declined sharply after development stage. But overall, it is generally accepted that TALC model is a useful descriptive tool for analyzing the evolution of tourism destinations (Johnston 2001; Lagiewski 2006).

Despite its wide applicability, only a small number of studies have applied the TALC model to tourism in protected areas. The International Union for Conservation of Nature (IUCN), the world's oldest and largest global environmental organization, defines a protected area as "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008). Effective management of protected areas is critical

for conservation of the world's natural environment and biodiversity (Dudley 2008). IUCN provides a system for categorizing protected areas based on management objectives of the wide variety of protected areas worldwide. Seven categories of protected areas are defined, recorded and classified under this most widely recognized and globally used system– Ia. strict nature reserve; Ib. wilderness area; II. national park; III. natural monument or feature; IV. habitat/species management area; V. protected landscape/seascape; and VI. protected area with sustainable use of natural resources. Tourism and recreation are primary management objectives for category II, III, and V protected areas and secondary management objectives for category Ib and VI protected areas (Dudley 2008).

Visitation to protected areas has been the fastest growing segment in the tourism industry, especially in developing countries (Balmford et al. 2009; Newsome et al. 2002b). Tourism may generate critical financial support for conservation in protected areas, but it may also lead to unwanted ecological changes (Balmford et al. 2009). It may help alleviate poverty in and around protected areas and change people's perceptions and attitudes toward the environment, but may also lead to local cultural loss (Kruger 2005a; Stone & Wall 2004). Planning, developing, and managing tourism in protected areas for long-term sustainability is still a daunting challenge and necessitates comprehensive understanding of the evolution of tourism in various types of protected areas.

The TALC model has been applied to a few IUCN categories II and V protected areas (Boyd 2006; Johnson & Snepenger 1993; Zhong et al. 2008). Johnson & Snepenger (1993) found that tourism in Yellowstone was more intricate than the TALC model predicted, as different

sources of information did not reach an agreement on whether the park was at development or consolidation stages. Boyd (2006) applied the TALC model to national parks in Canada, including the Banff National Park, and concluded that the model can serve a useful guide to trace park development, evaluate impacts, and avoid overuse. Zhong et al. (2008) showed that the TALC model was also applicable to tourism development in the first forest park in China, and the government and private sectors played important roles in triggering stage changes.

Although tourism development in these protected areas generally conforms to the TALC model, it was also found that tourism development in protected areas is generally subjected to more regulations than other tourism destination types (Weizenegger 2006). So far, no one has applied the model to study tourism development in more strictly managed protected areas, where regulation is strong and the conservation goals usually outcompete economic goals (Dudley 2008). Understanding the pattern and processes of the evolution of tourism in these protected areas could provide important insights on how tourism in these and other critical ecosystems can be sustainably managed and thus have important implications for global biodiversity conservation. New issues identified in these cases may help broaden the applicability of the TALC model.

To address this gap we studied the evolution of tourism in Wolong Nature Reserve for Giant Pandas in Sichuan, China (Fig. 2.1) from its emergence in 1980s to the present time. Tourism in China's protected areas has emerged and grown fast during the past three decades. By late 1990s, over 80% of China's nature reserves were developing tourism (China National Committee on Man and Biosphere 1998; Han & Ren 2001). In 2002, the first national nature reserve ecotourism master plan was approved by the State Forestry Administration to guide

tourism development in Wolong Nature Reserve. This signaled a new round of tourism development into the most restrictive and also ecologically most important protected areas of China. Over the last ten years, similar ecotourism master plans have been approved for at least another 30 national nature reserves (Peng & Zhang 2011).

The objectives of this study were to: a) examine the applicability of the TALC framework in Wolong Nature Reserve, China; b) describe the economic, social, environmental, and governance changes associated with the evolution of tourism in the Reserve; c) identify the drivers and processes of changes behind the observed growth of tourism.

2.2 Methods

Past studies on the application of the TALC model usually involved qualitative analyses to relate information in specific destination (e.g., changes in tourist arrivals (Butler 1980), accommodation capacities (Johnston 2001), local community's attitudes toward tourism development (Akis et al. 1996), and environmental conditions (Johnson & Snepenger 1993)) to different TALC stages to portray the historical progression of tourism development. These efforts have been more descriptive than normative (Lagiewski 2006).

A few attempts have been made to examine the TALC model quantitatively. For example, Lundtorp and Wanhill (2006) used a mathematical process to model the increasing tourist visitation of the destination (Lundtorp & Wanhill 2006). They tested the expected tourism volumes change using long-term data sets from the Isle of Man in Britain and the Danish Island

of Bornholm and found that the life cycle curve fit better to destinations where all visitors are 'repeaters' than others where "non-repeaters" comprises a significant proportion of the tourist body (Lundtorp & Wanhill 2006). A major problem in quantitatively testing and modeling the TALC curve is the lack of long-term data on visitors to tourism area, especially data that date back to the onset of tourist visit (Butler 2006). In fact, even long-term data may not be sufficient to help specify mechanisms of stage progression and identify cutoff time for stage changes during destination development. This is because both demand and supply sides of tourism development are amalgam of various activities and subjected to different regulations (Lagiewski 2006). Alternatively, Johnson (2001) proposed to specify mechanisms through finding "critical events" and "blurry transitions" that can be used to interpret stage or sub-stages changes. The former refers to key events that significantly affect the development of the institution of tourism. The latter focuses on a series of more subtle events that also drive stage changes. Cutoff dates of stage or sub-stage changes identified in this way are thus less arbitrary (Johnston 2001).

In this study the TALC model was examined against the observed tourism development in Wolong Nature Reserve. Data used here were collected through in-depth interviews and surveys with various local stakeholders, questionnaire surveys of tourists, field surveys, and secondary data sources, such as government documents, as listed in Table 2.1.

The local rural households survey results reported here are part of a long-term comprehensive study on the Reserve (Liu 1999, 2001). Details about the household survey will be described in detail in Chapter Two.

During the summers of 2005 I conducted semi-structured interviews on 68 local tourism-related small businesses in the Reserve, including 40 hotel/restaurant owners or managers, nine leisure farm owners, eight souvenir shop owners, five retail shop owners, and six street vendors who sold barbecue to tourists. This sample covered >80% of the small businesses in each of the categories, except the leisure farm owners (~45%). The other small businesses were either not reachable during the survey season or refused to be interviewed. The information collected included business conditions (investment, purchases, employment, income, revenue, and energy consumption), perceptions on tourism development, and knowledge of tourists activities inside the Reserve.

Fifteen government officials and reserve managers were surveyed in 2005 about the history of tourism development in the Reserve and their perceptions on it. While the individuals were not randomly selected, they cover a good range of age (23 to 52 years old), education levels (primary education to college education), and working experience in the Reserve (3 years to >20 years). In 2007 a focus group on tourism development issues in the Reserve was organized with the participation of 12 reserve managers. These managers were specifically selected from the tourism-related government segments, such as tourism, natural resource management, and socioeconomic development departments. A series of semi-structured interviews were also conducted with the director (three times) and two vice directors (once each) of the Reserve in 2007, 2008 and 2009.

A survey of tourists was conducted at the most visited attraction in the Reserve, the China Conservation and Research Centre for the Giant Pandas (CCRCGP), where the world's largest in-

captive panda population and most successful panda breeding program are located. This is also the only place in the Reserve where official tourist counts had been recorded since the early 2000s. Random interception surveys were conducted at the exit of CCRCGP during July and August of 2006 (54 days total) and June to October of 2007 (62 days total). The first tourist leaving the center every 15 minutes during the day time was stopped and surveyed. The structured survey questionnaire covers basic information about the tourist's trip characteristics, trip motivation, and main activities in the Reserve. A total of 1090 tourists from over 20 countries were surveyed.

A tourism infrastructure survey was conducted in the summers of 2006 and 2007 to record the locations of main tourism attractions, hotels/restaurants, and frequently used trails in the Reserve using a Global Positioning System receiver. Details about the trail survey will be described in Chapter Five.

Secondary data used here include local government's annual statistical reports about visitor arrivals, annual tourism receipts and other tourism-related information, publications (i.e. in peer-reviewed journals, books, news articles, etc.) about the Reserve, road maps and zoning maps of Wolong Administration Bureau. Habitat ratings were taken from a A four-category giant panda habitat suitability map (Viña et al. 2007).

Based on annual visitor volumes, annual tourism receipt (Fig. 2.2) and change in accommodation capacity (Fig. 2.3), past tourism development in Wolong Nature Reserve was divided into five stages. Key tourism development indicators and their ecological, social, and

economic impacts were summarized and compared among stages. Major changes in tourism planning and governance through the stages were investigated.

2.3. Results

2.3.1. Tourism development stages and driving forces

In 1979 the Reserve became one of China's first three UNESCO biosphere reserves (Li & Zhao 1989), which started to bring the Reserve some international attention. It was not until 1980s that visitation to the Reserve was allowed. The following sections provide a summary of five stages of tourism development in the Reserve over the past three decades. Key events that are critical in defining stages changes are listed in Table 2.2.

2.3.1.1 Exploration stage (1980-1990)

Late 1970s and early 1980s mark the initiation of China's recent economic reform and implementation of the "open-door" policy. This time period coincides with China's tourism boom in the last three decades (Zhang 2003). In 1980 an internationally collaborative giant panda research project was initiated in Wolong Nature Reserve by the Chinese Ministry of Forestry and the World Wildlife Fund (WWF). This event attracted global attention as it was the first ever scientific collaboration on conservation between Chinese researchers and their Western peers, led by the prominent scientist and conservationist George Schaller. The collaboration led to fruitful research findings on giant panda biology and ecology in the wild, which was published

in both academic journals and books and public magazines such as National Geographic. It also resulted in the establishment of the world's first giant panda breeding center in the Reserve. Later the center was officially named the China Center for the Research and Conservation of the Giant Pandas (CCRCGP) (Schaller 1994; Wolong Administration Bureau 2004).

In 1983 a mass flowering and die-off of arrow bamboo (*Bashania fabri Yi*), a major staple food species for wild pandas, swept across the Reserve. Although field research showed that giant pandas did not change their daily and seasonal behavioral patterns despite the significant decline of their food base (Johnson et al. 1988), it was widely (by mistake) believed by the public and the government that the bamboo flowering would lead to panda starvation and mortalities (Pan et al. 2001; Schaller 1994). News about the pandas and the Reserve made headlines on both domestic and international media and soon brought to the Reserve donations and aid from around the world. This also attracted thousands of visitors every year, mostly "foreign scientists and delegates and domestic and international panda fans" (Wolong Administration Bureau 2004), even though at the time all foreigners were required to get a special entry permission from the Minister of Forestry (now State Forestry Administration) (Sichuan Province Committee on Annal Compilation 1996).

Throughout the 1980s, CCRCGP's efforts to breed pandas in captivity were largely unsuccessful. The first and only surviving (for three years) panda bred in1980s was born in 1986 (Schaller 1994). Britain's Prince Phillip visited the Reserve as the president of WWF and named the panda "Blue Sky"(Wolong Administration Bureau 2004). With the increasing media exposure, Wolong Nature Reserve started to establish its fame as the "Hometown of the Giant

Pandas" both internationally and domestically (Wolong Administration Bureau 2004). During this period, annual tourist arrivals in the Sichuan province increased at a rate of almost 25% (Sichuan Province Committee on Annal Compilation 1996), but the annual tourist arrivals to the Reserved only fluctuated between 10,000 and 20,000 (Fig. 2.2). This was partly due to the poor road condition and the lack of tourism infrastructure in the Reserve. For example, it was recorded that over 3000 tourists from the Chengdu city, including 200 foreigners, visited the Reserve during the Labor Day holiday (May 1st) of 1983. Only a small proportion of the visitors were able to stay in the Reserve's government guesthouse with a total of 120 beds, and many others had to stay in reserve staff' dorms (Wolong Administration Bureau 2004).

The lack of tourism development in 1980s was ultimately due to the cautiousness of the Reserve administration at the time. The first preliminary plan to develop tourism was prepared in as early as 1982 (Li et al. 1992a). The discussions on whether and how to develop tourism in the Reserve continued throughout the decade. The Reserve authorities thought there was not enough knowledge to support making a tourism development plan with minimal potential negative impacts on the ecosystem and the endangered panda population. During this period, while all visitors to the Reserve were welcomed, there was not a specific department of the Reserve administration to manage tourism-related issues and local people had little involvement in tourism.

2.3.1.2 Involvement stage (1991-1997)

In 1990s China's economic reform and "open-door" policy entered a new era and the country started to receive more international visitors (Yu 1992; Zhang 2003). In Sichuan province giant panda habitat was identified as its top "special tourism resource" (Sichuan Province Committee on Annal Compilation 1996) and the previous restrictions on tourist visitation (requirement of entry permission) to Wolong Nature Reserve were lifted. Further discussions on developing tourism in the Reserve led the managers to believe that carefully planned and managed tourism might bring multiple benefits (Li et al. 1992a). The perceived benefits included a) using tourism income to supplement support from the central government and improve the financial status of the Reserve administration and their employees, b) diversifying the income sources of local residents to help reduce their extraction and consumption of natural resources (e.g., through fuelwood harvest and illegal logging) so that habitats of wildlife, such as the giant pandas, could be better protected; c) providing job opportunities for family members of the Reserve administration officials; d) enhancing communication and information exchange with outside parties for obtaining more external support (Li et al. 1992a).

The Wolong Tourism Development Inc., a government-owned company, was formed in 1991 to organize and regulate the increasing visitation to the Reserve. This marked a major change in the government's role in tourism development from reactive to active tourism management. In 1997 the company was turned into the Department of Tourism, an official governmental section under the Wolong Administration Bureau, to take charge of all tourism planning and management issues. Potential attractions were carefully selected by the Reserve

administration, and all were distributed along the main road to avoid disturbing pandas in the remote forests (Li et al. 1992a). These attractions included CCRCGP, a wild animal and plant specimen museum at Wolong township, and short trails into two valleys starting from the roadside (Li et al. 1992a).

During this period, the CCRCGP achieved some ground-breaking successes with in-captive panda breeding. In 1991, twin pandas were born in CCRCGP with one cub surviving to adult age. Every year since then, at least one new panda cub has survived in CCRCGP. In 1996 the first captive born (in 1991) and surviving panda was relocated to San Diego Zoo in the United States as one of a pair of pandas in a new cooperative breeding and conservation program between the two countries. This panda, named Bai Yun, became the most productive female panda outside China and has so far given birth to five cubs in San Diego Zoo. These new-born pandas continued to put Wolong Nature Reserve in the global media.

While the successful panda breeding program further publicized the Reserve, the annual tourist arrivals doubled from the previous period to about 25,000 - 30,000 every year. The situation started to change since a multi-year road construction project was initiated in 1992. The project, funded by the provincial government with a budget of 35 million Yuan (1 Yuan = 0.1818 US Dollar in 1992), aimed to upgrade the road crossing the Reserve into part of the No. 303 provincial road. The main goal of this project was to strengthen the economic, social, and political linkage between the eastern urban regions of the Sichuan province and the mountainous regions in the west, where ethnic minorities, such as Tibetan and Qiang people, reside.

The improved road condition in the Reserve also made large-scale infrastructure construction possible and more efficient. In 1995, Wolong Hotel, the first of its kind in the Reserve with 126 beds, was built with partial financial support from the Sichuan Province government. In the next year, another hotel, namely Wolong Sitongyuan Hotel, was constructed with investments from the Sichuan Department of Transportation.

During this period some small businesses emerged to provide food and lodging to tourists, but these businesses were almost all owned and managed by the relatives of the Reserve officials. Also in this period, some rural residents started to sell local products, such as dried medicinal herbs, to tourists.

2.3.1.3 Development stage I (1998-2004)

By late 1990s, forest and panda habitat loss and degradation in the Reserve reached a historically high level, largely because the "fence and fine" type of conservation policies in the past failed to address local people's livelihood needs (Liu et al. 2001). To change this situation, a new conservation plan, the *Wolong National Nature Reserve Master Plan*, was compiled and approved by the State Forestry Administration in 1998. The plan for the first time officially adopted tourism as a new conservation strategy. It was hoped that tourism would generate funds for forest and panda habitat conservation and provide alternative income for local farmers. Second, a zoning management system, including experimental, buffer and core zones, was established as a guideline for regulating human activities and mitigating negative human impacts across the Reserve (Fig. 2.5).

Also in 1998 the Sichuan province government announced the first ever *Sichuan Province Tourism Development Master Plan* (Wu 2001), in which giant panda was branded the province's tourism image marker and panda tourism to Wolong was given special development priorities. In 2000 giant panda was further promoted as one of the top three tourism brands of the province. Two government agencies, the Sichuan Department of Tourism and the Sichuan Department of Forestry, were identified to work with Wolong Administration Bureau to make a giant panda tourism development master plan as part of an integrated provincial tourism plan. This plan later evolved into the *Wolong National Nature Reserve Ecotourism Development Master Plan* and was officially approved by the State Forestry Administration in 2002.

The completion of the provincial road in 1999 connected the Reserve to an important tourism destination cluster in western Sichuan, collectively called the Greater Jiuzhaigou Loop Touring Area (Fig. 2.1). Every year millions of domestic and international tourists came to visit this region with several National Scenic Areas and World Heritage Sites (Fig. 2.3). A significant rise in tourist visitations to the Reserve was observed in this period (Fig. 2.1). While the main tourist attractions in the Reserve did not change much, annual tourist arrivals almost tripled compared with the involvement stage (Table 2.3). But many tourists chose to stop by at CCRCGP to see the in-captive pandas and then continued to travel to the Siguniang Mountain National Scenic Area (Fig. 2.1) to stay overnight.

A new round of tourism infrastructure development was implemented in this period. The first was a new Panda Hotel constructed near CCRCGP in 1999. In 2002 the Reserve signed a contract with the Luneng Xinyi Ltd. Co., a subsidiary of a large state-owned enterprise from

Shandong province of China, to set up a new shareholding tourism corporation, with the Reserve receiving 45% of the total shares, and the Shandong side 55% (Su et al. 2007). The Luneng Company soon invested 42 million Yuan (1 Yuan = 0.1208 US Dollar as of 2002) to upgrade the Wolong Hotel to four-star level with 668 beds.

Another noted tourism development project in this period took place in the Zhonghe river area of the Reserve which administratively belongs to the Sanjiang township of Wenchuan county (Fig. 2.5). Limited by steep mountain ridges, the Reserve's capacity in monitoring human encroachment in the Zhonghe river area was low. Since late 1990s, the Wenchuan county government had been developing tourism infrastructure in the area (State Forestry Administration 2006). In 1999 the Reserve established an agreement on tourism development in this area with the Wenchuan county government under the supervision of Sichuan Department of Forestry. The existing tourism development in the buffer zone in Zhonghe area (Fig. 2.5) of the Reserve was kept. A new three-star hotel in the buffer zone and a series of tourism facilities that extended three kilometers into the core zone of the Reserve were constructed.

During this stage local participation in tourism also increased significantly. Over 30 household-owned hostels and restaurants, almost all distributed around the township centers and beside the main road, were constructed, together providing over 1000 beds. A significant number of micro-business also emerged, mainly selling local products and souvenirs to tourists. Souvenir demand also stimulated establishment of a family workshop factory in Wolong Township.

2.3.1.4 Development Stage II (2004-2007)

In 2004, the Reserve and the Luneng company decided to terminate their collaboration and all shares of Luneng company were transferred to Wolong Investment Co., Ltd., a newly established company owned by the Reserve administration. In 2005 collaboration was established between the Wolong Administration Bureau and the Jiuzhaigou Scenic Area Administration. Jiuzhaigou National Scenic Area was the first World Natural Heritage Site and one of the most popular tourism destinations in Sichuan province with over two million annual arrivals at the time (Lew 2003). A new Jiuzhaigou-Wolong Giant Panda Ltd. Co. was formed to supervise tourism development in the Reserve, in which Wolong had 20% of the total shares and Jiuzhaigou 80%. The basic plan was to intensify the tourism development with the brand of Wolong pandas, construct new tourism facilities and attractions to enrich visitor experiences, and enhance the underdeveloped services and transportation systems. Between 2005 and 2007, over 80 million Yuan were spent on infrastructure construction in the Reserve (Wolong Administration Bureau 2009a).

In 2006, the Reserve and its surrounding areas were officially designated a World Natural Heritage site, namely Sichuan Giant Panda Sanctuaries (IUCN 2006). A new ecotourism development plan was developed and approved to accommodate the World Natural Heritage requirements. Another round of construction was carried out to further widen and upgrade the provincial road to meet the increasing tourism needs.

Although the road construction and the related traffic restriction significantly reduced the visitation to the Reserve in 2007, the rise of tourist arrivals in the Reserve was apparent in this

period (Fig. 2.2), and the peak tourism season was usually from late spring to early fall (Fig. 2.4). These tourists came from around the country and the world. In our sample of 1,063 tourists at CCRCGP between 2006 and 2007, we recorded tourists from 26 foreign countries and from at least 30 provinces and cities of China. The top five origins of foreign tourists are Japan (13.3%), United States (7.9%), United Kingdom (5.0%), France (2.8), and Netherlands (2.6%). And the top five origins of domestic tourists were Sichuan (28.6%), Chongqing (15.8%), Guangdong (6.4%), Beijing (2.7%), and Shanghai (2.0%). Apparently except a large number of tourists from within the Sichuan province and the neighboring Chongqing city, most other tourists came from economically developed regions or countries. Wild pandas, natural forests and wildlife, and unspoiled air and water were the top three reasons that motivated the domestic tourists to come to the Reserve; for international tourists, the top three were natural forests and wildlife, wild pandas, and pandas in captivity (Table 2.4). Late spring to early fall marked the main tourism seasons for the Reserve, with two peaks in early May (the labor day holiday in China) and early Oct. (the national day holiday in China) (Fig. 2.4).

Besides the day-trippers who spent time at the conventional attractions (e.g., panda center, museum), several new tourist groups emerged and flourished in this period. One group was "*Nong Jia Le*" (or leisure farm, a special type of rural tourism that has become popular in China recently (Su 2011)) tourists, who came to the Reserve mainly for the cool weather and unspoiled air and water in the summer. These tourists were mainly city dwellers from around the Chengdu metropolitan area, where "*Nong Jia Le*" tourism originated in China in the early 1990s (He 2005). They usually spent weekends in private hostels or stayed a prolonged period of time in local

people's houses. During daytime, some rural tourists chose to walk the nearby trails. Another group was hikers, who came to the Reserve mainly for hiking, camping, birding, or enjoying the forest and alpine landscapes. The hikers frequented the trails across the Reserve, many of which used to be the main routes for local residents to go outside before the first road was paved into the Reserve in the 1960s (Wolong Administration Bureau 2004) but was later abandoned. These trails wind into the buffer and core zones of the Reserve, thus hikers conducted many activities in highly suitable panda habitat (Fig. 2.5). According to *Regulations of the People's Republic of China on Nature Reserves* (State Council of China 1994), tourists are banned from visiting areas outside the experimental zone in nature reserves. But the lack of monitoring staff and the low frequency (once a season before 2008 and twice a year after 2008) of field monitoring made it impossible to collect enough disturbance data to inform management. As a result, almost none of the tourists' activities along trails have been regulated or controlled in the Reserve (field observation).

2.3.1.5 Earthquake and post-quake reconstruction (2008 – present)

In 2008 the Olympic Games were held in Beijing, China, and it was expected to be a peak tourism year for the Reserve. The road upgrade work was completed in the Reserve in early spring. But two unexpected events struck this region and resulted in a complete stoppage of tourism. The Tibetan unrest (Yeh 2009) in spring 2008 led the government to enforce travel restrictions to western Sichuan. The Labor Day holiday of 2008 witnessed the lowest visitation to the Reserve in the last several years. Then on May 12th of 2008, a 7.9 Mw earthquake struck the

Reserve at its eastern boundary. The earthquake and its associated landslides led to ca. 148 causalities in the Reserve and also extensive damage to the infrastructure, including the road network and the tourism facilities (Viña et al. 2011). Many houses and other buildings collapsed or were damaged. All in-captive pandas raised in CCRCGP in Wolong township, except three that died during the earthquake, were relocated to a branch base of CCRCGP in Ya'an, Sichuan. A series of plans have been implemented to rebuild the infrastructure and restore the ecosystem in the Reserve.

Tourism is again being identified as the main tool of economic development after the main infrastructure reconstruction is completed (estimated by the end of 2012) and a newer version of the ecotourism development master plan has been proposed. A total of 1.382 billion Yuan (1 Yuan = 0.1464 US Dollar as of 2009) was to be spent in post-earthquake tourism development in the Reserve by 2015 (Wolong Administration Bureau 2009a). These plans call for the repair or replacement of damaged infrastructures, including roads and tourism facilities. To meet the new demand for lands to build tourism infrastructures, mainly the new panda breeding facilities of CCRCGP in the lower Gengda township, the zoning scheme was modified (Hull et al. 2011) and as a result an extra 102 ha of highly suitable habitat were allocated into the experimental zone. Also included in the reconstruction and tourism development plans was a new round of local household relocation from remote mountainous areas to roadside, with their cropland being reclaimed for tree and bamboo plantation as a way of ecological restoration. Tourism revenue is expected to be the main income source for both the local households and government after the reconstruction.

Post-earthquake tourism development in the Sanjiang township territory within the Reserve was also revitalized recently. The Sanjiang area was designated as a new national 4A scenic spot in 2009, the first of its kind in the Wenchuan Earthquake affected region (Xinhua News Agency 2012). Inside the Reserve, the construction of new CCRCGP facilities located in Gengda township was completed and functioning with 18 pandas returned from the Ya'an branch in October 2012 (Xinhuanet 2012a). Due to frequent landslides and debris flow after the 2008 earthquake, the newly reconstructed road was damaged twice and a third round of road reconstruction was recently started and is expected to be complete by 2015, when volumes of tourists are expected to come back to the Reserve (Xinhuanet 2012b).

2.3.2. Changes related to tourism development

2.3.2.1 Economic changes

When tourism started in the Reserve in early 1980s, the local economy was a typical subsistence-based agricultural economy. Over the last 20 years per capita annual net income of local residents increased steadily from only 1020 Yuan in 1990 to 2461 Yuan in 2006 (Table 2.3). Several factors contributed to the income increase: a) shifting crop type from corn and potato to cash crops, such as cabbage and turnip; b) taking temporary labor jobs inside the Reserve on road or other infrastructure construction projects; and c) participating in commercial businesses, mainly tourism-related activities. Based on a random sample of 220 local households, the number of households who participated in tourism increased from nine (~4%) in 1998 to sixty (27%) in 2006 (Liu et al. 2012). A longitudinal study based on the sample of local households

showed that households with greater financial (e.g., income), physical (e.g., access to key tourism sites), human (e.g., education), and social (e.g., kinship with local government officials) capital and less natural capital (e.g., cropland) were more likely to participate in tourism activities (Liu et al. 2012).

Overall, by 2006 service industry (mainly tourism) was still a small part of the rural economy in the Reserve, although its importance had been increasing since the 1980s (Table 2.3). Despite this growth, economic leakage (i.e., tourist expenditures flowing to outside investors or managers and not directly benefiting locals), was significant. While the annual service industry total income in the rural community more than tripled from 0.42 million Yuan per year in Development I stage to Development II stage, the total share of tourism receipt by the rural community declined from 8.5% to 4.7% (Table 2.3). This has also been confirmed by findings reported by He at al. (2008) and from the interviews with the tourist business participants in this study. In 2006, ~60% of the employees in the three government-owned hotels were from outside the Reserve. About half of the employees in private hotels and restaurants were from the outside, and they took most high-paid positions, such as managers and cooks. Almost all raw food products were purchased from outside. The family workshop souvenir factory stopped its production in 2005, after which all souvenirs sold in the Reserve were purchased from outside the Reserve.

2.3.2.2 Social changes

Few studies have investigated local residents' attitudes and perceptions toward tourism development and there are no data available to track the changes of their attitudes and perceptions through time. Our interviews in 2005 and 2007 indicated that most local residents had an overall positive attitude towards tourism development, despite the fact that they have various kinds of complaints on the biased distribution of the economic benefits from tourism (Chapter 4). It was also found that people from households participating in tourism tended to perceive more non-financial benefits in addition to more negative environmental impacts of tourism, compared with households not participating in tourism (Chapter 4).

Commercialization, such as tourism development, in rural communities may weaken the bonding social capital as community members have less time and incentive to cooperate with each other (Putnam 2000). This was confirmed in a recent study of fairness norms in the Reserve (Song et al. In press), which studied the variation of fairness norm among local residents and found that people having commercial experience with tourism tended to have weaker a norm of fairness.

2.3.2.3 Ecological changes

Forests and panda habitat had been experiencing severe destruction and degradation in the 20th century, mainly due to logging for timber, fuelwood, and construction materials (Liu et al. 2001). This declining trend has recently been reversed, due mainly to implementation of two national forest conservation and restoration programs since 2000 (Liu et al. 2008; Viña et al. 2011). Under these programs, logging in natural forests for any purpose was banned and over

three quarters of cropland on steep slopes in the Reserve were reclaimed into tree plantation. Subsidies were provided to local households through these two programs. A large amount of labor was released from fuelwood harvesting and cropping, and tourism became one option for some of this labor. In fact, results in Chapter 4 confirmed that households with less cropland by 2007 tended to have a higher likelihood of participating in tourism. Another study also showed that households operating a private hostel, restaurants, or Happy Farm House, tended to reduce fuelwood consumption more than those who did not (Liu et al. 2011). Tourism infrastructure construction in the Reserve, especially in the Development II stage, was mostly conducted with minimal impact on vegetation. All timber needs were imported from outside and tree felling only occurred when the road was widened. Thus overall tourism has at least positively supported the forest recovery in the Reserve.

However, visitation to key panda habitats of the Reserve had been increasing before the earthquake. The current zoning scheme only included less than half of the highly suitable panda habitat inside the core zone and 15.4% and 39.6% of the highly suitable panda habitats are inside the experimental and buffer zones, respectively (Fig. 2.5). And the core zone is not immune to tourists' disturbance either. Many trails extend well into the core zone through large patches of highly suitable panda habitat (Fig. 2.5). As shown in chapter 3, more than 95% of the panda presence locations found in the Reserve between 2005 and 2007 were at least 500 meters away from heavily used trails. Increasing road traffic of tourists may also discourage wildlife from visiting road side areas and thus further segregate wildlife populations on the two sides of the road. Model simulation results in Chapter 3 demonstrated that these activities, if expanded to all

major trails in the Reserve, may even cancel out the potentially positive effects of forest recovery on panda population.

These observed and modeled environmental impacts are consistent with the perceived impacts by local residents, especially those who had participated in tourism and had some knowledge of tourist activities in the Reserve (Chapter 4).

2.3.2.4 Changes in tourism governance

As tourism development in the Reserve evolved, its main driving force has been gradually changed from endogenous factors, such as financing conservation and poverty alleviation, to exogenous factors, such as promoting regional tourism development and economic growth. The tourism governance structure also changed. In the Exploration and Involvement stages tourism development in this period was 100% controlled and regulated by the Reserve administration with partial financial support from the provincial government. In the Development stages, the Reserve administration started to give up more control of tourism development to outside investors. On the one hand, this is a result of the regional and national authorities' increasing interests on tourism development in the Reserve; on the other hand, it was also due to the local community and government's lack of necessary financial capacity and human resources to meet the increasing demands for tourism infrastructure and facilities. More importantly, as the Reserve administration use authority over land and critical tourism resources to establish coalitions with outside investors and form state-affiliated firms, more revenue from tourism was channeled into government projects, while the local rural people became more marginalized.

2.4. Discussion

The TALC model has recently been used to study forest park tourism in China (Zhong et al. 2008), but the concept has not been applied to tourism in nature reserves, the largest part of the country's protected area system. In this study we examined the application of the TALC model to Wolong Nature Reserve – a flagship national nature reserve and one of the first biosphere reserves in China. Changes related to the evolution of tourism in the Reserve and the potential driving forces and impacts were also analyzed. Results indicate that the observed tourism development in the Reserve generally conform to the first three stages described in the TALC model – exploration, involvement, and development stages. Although the Reserve has not completed a full cycle or even reached the consolidation stage, the TALC model seems still to be useful in identifying some general patterns of changes and related processes in the tourism development in the Reserve. Annual tourist numbers, tourism receipts (Fig. 2.2) and the growth of tourism accommodation facilities (Fig. 2.3) generally increased as one would expect from a TALC model. The tourist numbers increased exponentially from stage to stage, so did the tourism receipt (Table 2.3).

The Reserve experienced prolonged exploration and involvement stages, and fast development did not take off till late 1990s. In 1980s and 1990s, the Reserve administration, as mainly a natural resource management agency, had willingness to develop tourism, but was limited by the lack of financial (e.g., investment), physical (e.g., road and other infrastructure), and human (e.g., tourism management expertise) capital. Since late 1990s, the pressure from the regional authorities started to become a dominant driver of tourism growth. The fame of the

Reserve as the "Hometown of the Giant Pandas" is one of the greatest tourism assets in this province of China. The strong influence from the provincial government gave the Reserve no choice but to open the door to tourists. In fact, many of the tourists entering the core zone of the reserve came from the Siguniang Mt. in the northwest and Sanjiang in the southeast, both of which are strongly supported by the Aba Tibetan Prefecture government.

Rises and falls in visitor numbers that occurred within stages (Fig. 2.2) seem also to be due to various endogenous and exogenous uncertainties. For example, the spike in tourist arrival in 1983 was triggered by the media report on potential panda starvation due to unexpected bamboo flowering and die-off; the reasons for the tourist number drops in 1989, 2003, and 2008 can be attributed to the Tianammen square protest (Yu 1992), the burst of SARS (Severe acute respiratory syndrome) (Liu 2003), and the earthquake (Fig. 2.2). These rises and falls remind us that tourism is an open and complex system with high levels of risk and uncertainty. For example, the Reserve and the surrounding areas in western Sichuan mountains are within a global hotspot for landslide and earthquake disasters (Arnold et al. 2005). Historically human population density in these regions is low as a result of low land fertility and high natural hazards (Wu 2001). In a commentary on the Sichuan province's tourism development master plan, Wu (2001) pointed out that a major flaw of the plan was the high level of investment in developing mass nature-based tourism in the disaster-prone region of western Sichuan. Before the 2008 earthquake, landslides and debris flow were common in Wolong Nature Reserve (Liu et al. 1999), and in less than one hour, a flood in summer 2007 damaged millions of Yuan of infrastructure construction in one valley of the Reserve. The 2008 earthquake is a vivid example showing how fragile the

infrastructure could be in the face of natural disasters. Landslides and debris flows induced by heavy rainfall events occurring every summer since 2008 had significantly impacted the local community's normal social and economic exchanges with the outside and limited potential tourists from visiting the Reserve, making the Reserve the only major tourism destination in the Sichuan province that has not yet recovered from the earthquake.

Obviously large scale financial investment into tourism development in this region could be risky and has to be carefully planned and implemented. But it is still favored by agencies like the Wolong Administration Bureau. Historically protected areas in China, including national nature reserves, were poorly funded, which significantly affected their functionality (Ouyang 2000; Ouyang et al. 2002). Tourism is regarded as an important way to help the management agency to achieve financial self-sufficiency. In fact, this was the first goal set by Wolong Administration Bureau in their preliminary tourism plan in the early stages. However, there is a significant difference between the protected area management agency's financial self-sufficiency and the economic self-sufficiency of the local community in and around the protected area. While it is clear that both are necessary to achieve effective biodiversity conservation, in practice local communities are often marginalized (China National Committee on Man and Biosphere 1998; Zinda 2012).

Although tourism in Wolong Nature Reserve has not reached the consolidation stage yet, some negative socioeconomic impacts, such as economic leakage and lack of local participation, have been detected. The situation worsened when regional authorities and outside investors joined the game. The Reserve administration used their authority over land and natural resources

to establish a government-affiliated corporation, in coalition with outside investors and regional authorities. The local community was never given a chance to participate in the planning and decision-making processes. As a result, even though the absolute amount of tourism revenue received by local community did increase from Development I to Development II stage, as a whole their share of the tourism revenue was almost halved (Table 2.3). Furthermore, opportunities to participate in tourism within the local community were also unevenly distributed (Chapter 4).

Signs of ecological degradation due to human disturbance have also been detected in the Reserve. This had a lot to do with the deficiency in the current monitoring program. Monitoring provides the bases for ecological change detection and future research. Wolong Administration Bureau has almost 500 staff (He et al. 2008), of which only around 30 were employed by the natural resource management department and directly participated in ecological monitoring (Yu 2005). Almost none of the tourist activities in the core zone of the Reserve were controlled.

The case of Wolong Nature Reserve is not unique in China. There are currently around 300 national nature reserves in China, covering over 8% of China's land (Wang et al. 2012). These national nature reserves are the most important cornerstone of biodiversity conservation in the country and also have extraordinary natural beauty with huge tourism potential. The land in nature reserves are disproportionally distributed in the economically underdeveloped western China. Tourism has been identified as a major non-consumptive development strategy in western China for over a decade (Yeung & Shen 2004). As demand for tourism resources increases in western China, these nature reserves inevitably become the targets. The approval of Wolong's

ecotourism master plan by the State Forestry Administration in 2002 was a strong top-down signal to other reserves and their regional authorities of the national government's positive attitude toward developing tourism in the country's most strictly managed protected areas, , although in practice over 80% of China's nature reserves had been conducting tourism development by late 1990s (China National Committee on Man and Biosphere 1998; Han & Ren 2001). By 2008 at least 30 national nature reserves have had their ecotourism development master plans approved (Luo & Wang 2010). According to a recent report in 2010, about 15% of the national nature reserve adjusted either the Reserve border or their zoning boundaries to accommodate recent infrastructure construction needs, mostly for tourism development (Peng & Zhang 2011).

There is an urgent need for actions to stem the trend of tourism-induced commercialization and ecological degradation in China's protected areas (China National Committee on Man and Biosphere 1998; Wang et al. 2012; Zhong et al. 2011). First, the current management system needs to be changed and the role of protected area management agencies in tourism development should be clarified. Protected area management agencies should not be both the referee and the player in the tourism game. Instead, the agencies need to step out of business operations and focus on their functions as a public sector, such as supervision, monitoring, and intervention when negative impacts occurred during tourism development. Second, full financial support is needed from the central or regional governments to build the capacity for the agencies. While it may be difficult to provide enough funding for all protected areas, the national nature reserves, the most important areas for biodiversity conservation in China (Wu et al. 2011),

should be given funding priority. The funds to national nature reserves should be from the central government instead of the regional government, so that the agencies' decision-making will not be influenced by the regional authorities. Third, tourism development plans should be screened with stricter criteria to minimize the potential ecological and socioeconomic impacts. Scientifically sound monitoring programs with capacity to effectively detect tourism-induced changes need to be part of the plans. Fourth, local communities should be empowered to participate through all stages of tourism development to develop a tourism co-management system.

To implement the above suggestions will be difficult, as it will involve some fundamental changes on the current management system of protected areas in China and needs to be secured through legislation (Ouyang et al. 2002). While the change will take time to happen, more in-depth studies on key protected area management issues, such as tourism development, can help provide valuable experiences and lessons to design a more effective management system for sustainable development in protected areas.

Figure 2.1 The location of Wolong Nature Reserve and surrounding townships in the Greater Jiuzhaigou Touring Area in western Sichuan province.

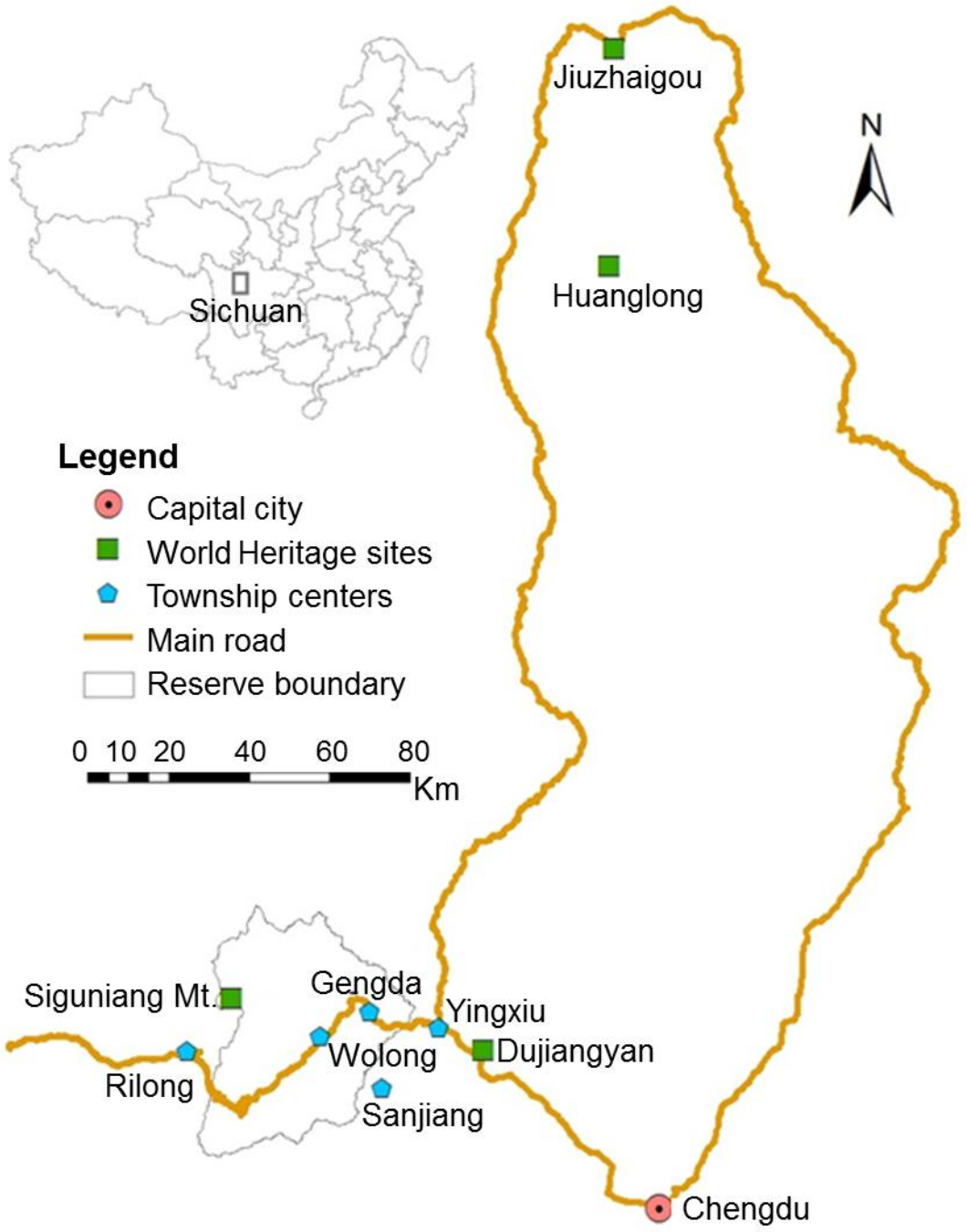


Figure 2.2 Trends of annual tourist arrivals and tourism receipt (only available since 1997, when the Department of Tourism was established) in Wolong Nature Reserve from 1980 to 2008.

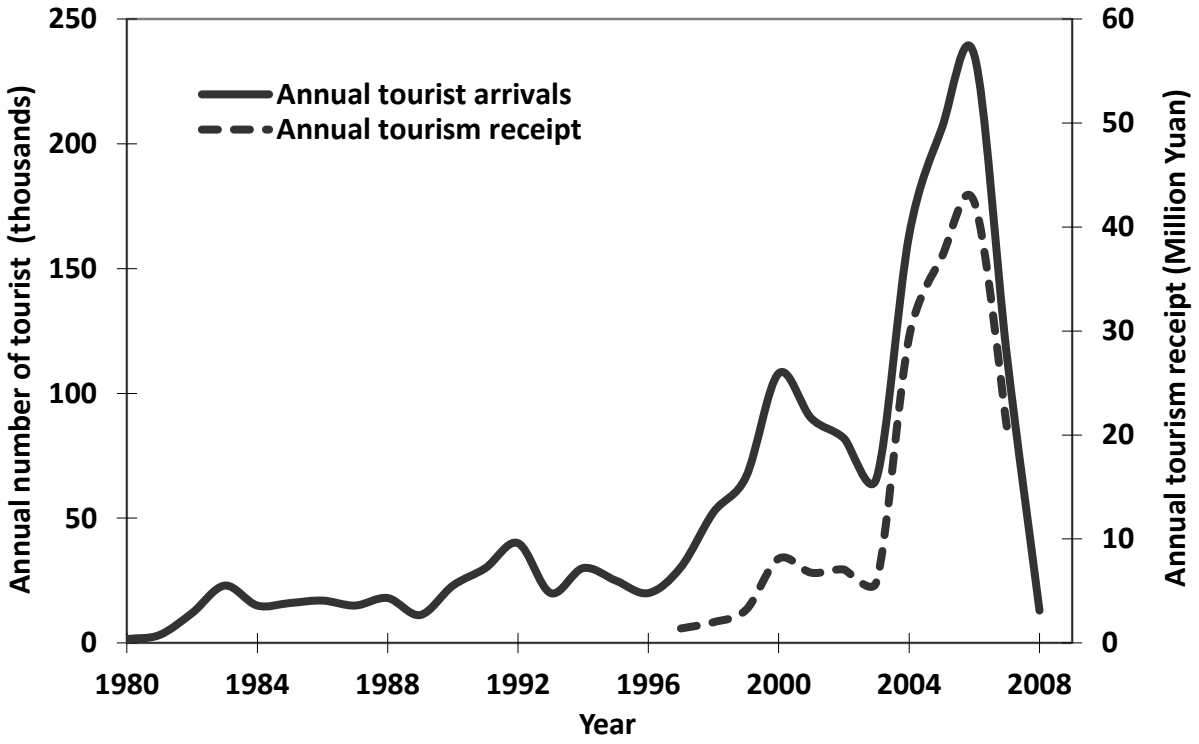


Figure 2.3 Numbers of hotels and beds in Wolong Nature Reserve (1993- 2007).

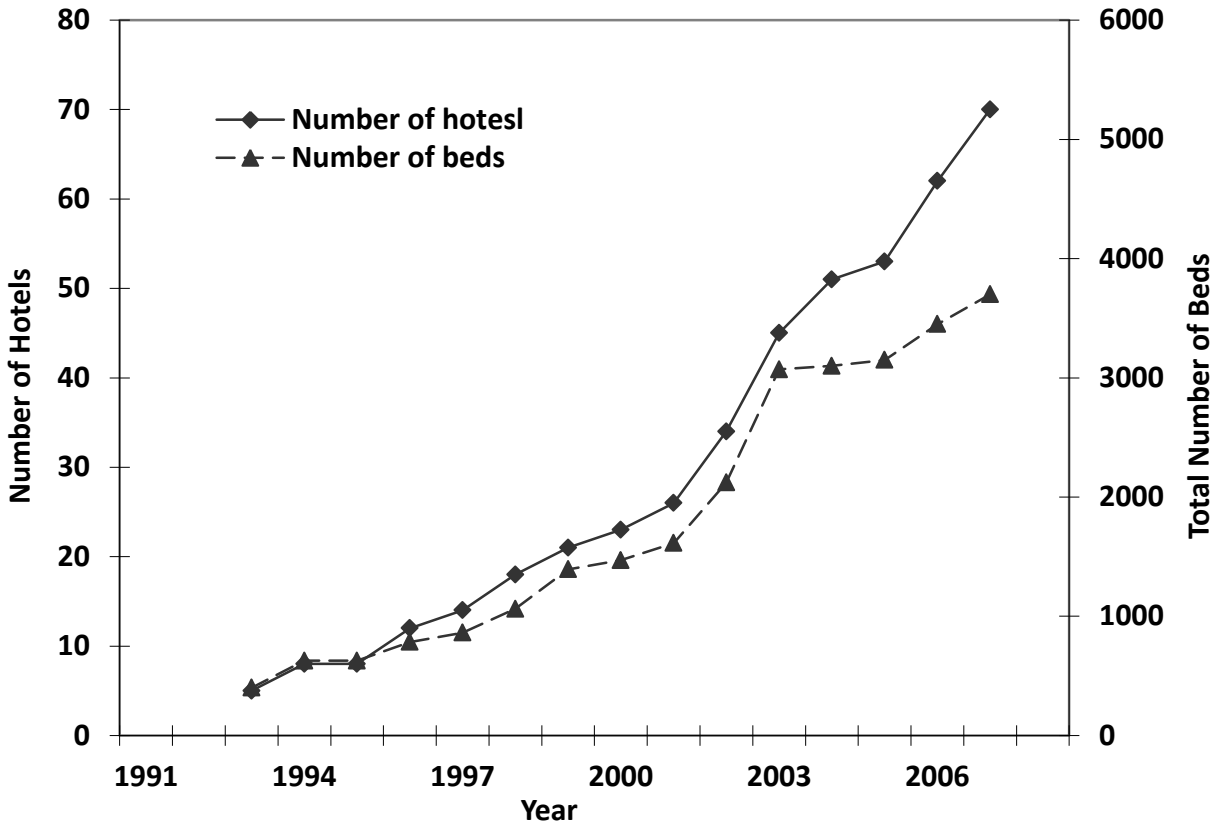


Figure 2.4 Seasonality of tourist visitation to the China Center for Research and Conservation of the Giant Pandas (CCRCGP) at Wolong Nature Reserve in Development II stage (2004-2006 data used). The peak tourism season started from May and ended in October. There were significantly more tourist arrivals in May and October than other summer months, mainly due to the Labor Day (May 1st) and National Day (Oct. 1st) holidays in China.

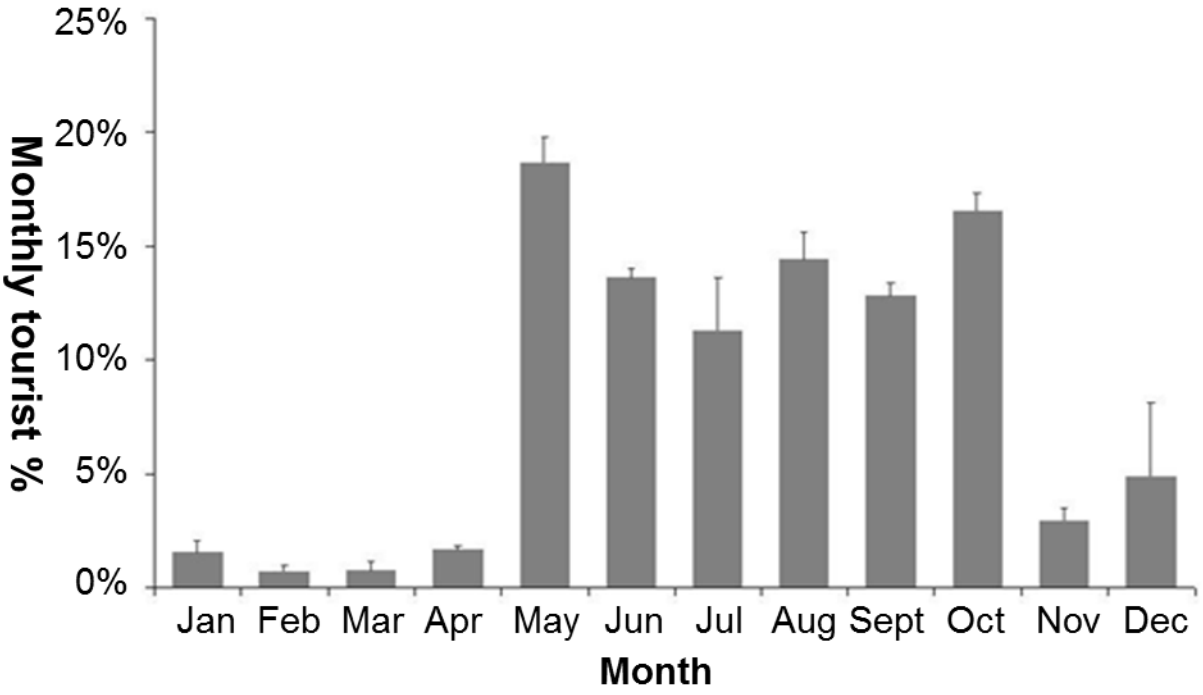


Figure 2.5 Distribution of trails and natural attractions with tourist activities across Wolong Nature Reserve in Development II stage. Full names of townships are shown with larger fonts.

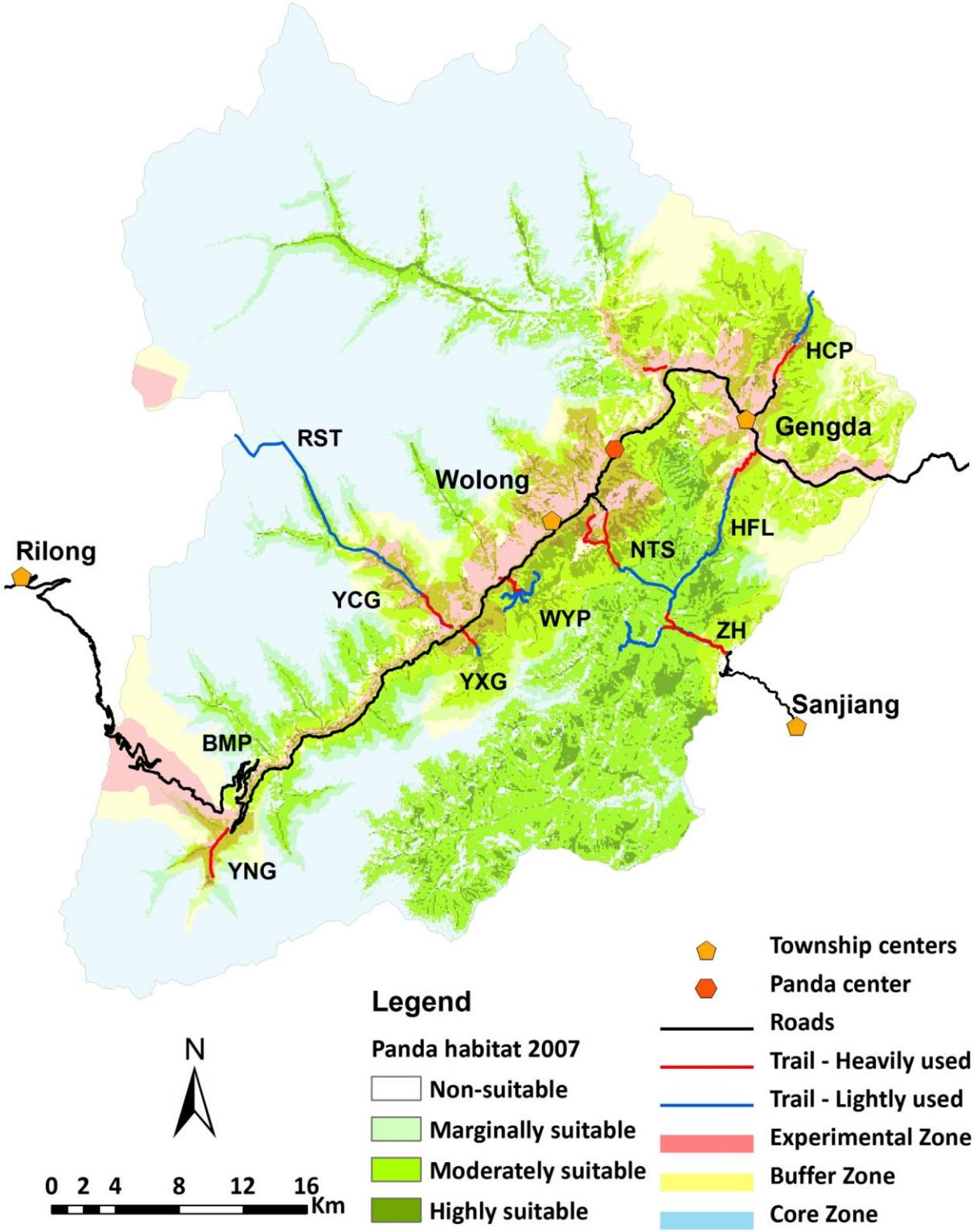


Table 2.1 A summary of the data used in this study.

Data	**Year**
Primary	
Local household survey	2005, 2007
Local business survey	2005
Tourist survey	2006 - 2007
Reserve official interviews	2005 - 2012
Reserve official focus group	2007
Tourism infrastructure survey	2005 - 2007
Secondary	
Annual tourist arrivals	1980 - 2007
Annual tourism receipt	1997 - 2007
Annual rural economic statistics	1980s - 2007
Reserve management master plan	1998
Reserve ecotourism development master plan	2001, 2007 and 2009
Local household survey	1999 (An et al. 2001)
Local business survey	2003 (He et al. 2008)

Table 2.2 Key events that related to stage changes in tourism area life cycle of Wolong Nature Reserve.

Year	Key events
1979	The Reserve was designated as a UNESCO Biosphere Reserve.
1980	An internationally collaborative giant panda research project was initiated in Wolong Nature Reserve by the Chinese Ministry of Forestry and the World Wildlife Fund (WWF).
1983	Mass flowering and die-off of bamboo in Wolong Nature Reserve attracted global media attention; the Chinese Conservation and Research Center of Giant Pandas (CCRCGP) was established.
1991	The Wolong Tourism Development Inc., a government-owned company, was formed to organize and regulate the increasing visitation to the Reserve.
1997	The Department of Tourism under the Wolong Administration Bureau was established to replace the Wolong Tourism Development Inc.
1998	The Wolong Nature Reserve Master Plan was approved.
1999	The provincial highway that connected the reserve to the capital city of Sichuan province was completed.
2000	The Wolong Nature Reserve Ecotourism Master Plan was approved by the Sichuan provincial government.
2002	The Wolong Nature Reserve Ecotourism Master Plan was approved by the State Forestry Administration of China.
2004	The construction of Wolong Hotel, the only four-star hotel in the reserve, was completed.
2006	The Sichuan Giant Panda Sanctuaries World heritage site was officially designated by United Nations Educational, Scientific and Cultural Organization (UNESCO), and a new round of road upgrade construction started.
2007	Establishment of a second giant panda breeding center in the reserve was approved by State Forestry Administration.
2008	The Wenchuan Earthquake (7.9 Mw) struck the reserve on May 12th.
2012	The construction of the new CCRCGP base in Gengda township of the Reserve was completed; the third round of road reconstruction was started.

Table 2.3 Major changes across the tourism area life cycle stages in Wolong Nature Reserve. Most relevant data were not available for Earthquake and post-earthquake reconstruction stage (2008-present), thus the stage was not listed.

Stage	**Exploration**	**Involvement**	**Development I**	**Development II**
Years	1980-1990	1991-1997	1998-2003	2004-2007
Mean Annual Tourists (thousand)	14.1	27.9	77.5	180.0
Mean Annual Tourism Receipt (million Yuan)	No Data	1.40	5.51	32.40
% International tourist	1.93%	2.15%	12.43%	6.72%
Total number of panda cubs born and survived at CCRCGP	1	14	38	51
Per capita annual net income of rural residents (Yuan*)	1020	1468	1975	2461
Rural community mean annual service industry income (million Yuan)	0.02	0.10	0.42	1.42
% Service industry income in rural economy	0.7%	1.9%	3.3%	7.1%
% tourism receipt to rural households	No Data	No Data	8.5%	4.7%

* Data from the years 1990, 1997, 2003, and 2006 (inflation adjusted to year 2006) were used to represent the end of each period. Year 2007 data was not available.

Table 2.4 Importance of different tourism resources in the Reserve as perceived by the tourists at the China Center for Conservation and Research of the Giant Pandas (CCRCGP) based on surveys in 2006 and 2007. The total number of tourists surveyed was 1090, including 656 from within China and 424 from outside China. Student's t-test was conducted for comparison between domestic and international tourists.

Tourism Resources	All tourists		Domestic		International		p-value
	Mean	SD	Mean	SD	Mean	SD	
Giant pandas in the wild	4.29*	0.97	4.39	0.89	4.14	1.06	<0.0001
Giant pandas in captivity	3.88	1.07	3.74	1.08	4.07	1.02	<0.0001
Unspoiled air and water	4.08	1.02	4.19	0.94	3.91	1.11	<0.0001
Natural forest and wildlife	4.25	0.93	4.27	0.91	4.21	0.95	0.13
Tibetan & Qiang culture	3.28	1.25	3.24	1.23	3.32	1.27	0.86

* Five-point Likert scale: 1. Not important; 2. Somewhat important; 3. Important; 4. Very important; 5. Extremely important

CHAPTER 3

DRIVERS AND SOCIOECONOMIC IMPACTS OF TOURISM PARTICIPATION IN WOLONG NATURE RESERVE

3.1 Introduction

Establishing protected areas is among the major strategies for stemming the rapid loss of global biodiversity. Over the last half century the total coverage of protected areas worldwide has increased by ten-fold whereas the trend in global biodiversity loss continues (IUCN & UNEP-WCMC 2011; Secretariat of the Convention on Biological Diversity 2010). While protected areas will continue to play an important role in conservation (Lovejoy 2006), the classic "fine and fence" method of management, which regards local people as a direct threat to biodiversity, has gradually given way to new approaches, such as the integrated conservation and development projects (ICDP) and payment for ecosystem service (PES) programs (Brown 2002; Ghimire et al. 1997; Kinzig et al. 2011; Wunder 2005). These new approaches recognize the trade-offs and linkages between human livelihood and biodiversity conservation. They focus on involving local communities in conservation, and use market tools to add economic value to biodiversity (Brown 2002; Ghimire et al. 1997; Salafsky & Wollenberg 2000; Spiteri & Nepal 2006). These approaches suggest that providing alternative sources of income to local communities through new livelihood opportunities or direct payments will help alleviate poverty and improve environmental awareness and conservation attitudes, which may eventually change the unsustainable resource extraction behaviors of local people and reduce human pressure on natural systems (Berkes 2004; Hughes & Flintan 2001; McShane & Wells 2004b).

Although the new approaches have gradually become mainstream concepts in conservation programs, there is still a lack of convincing empirical evidence that they are effective in achieving desired and balanced social, economic, and ecological goals (Brown 2002; McShane & Wells 2004a). For instance, many ICDPs fall short in creating enough incentives to discourage human activities that threaten biodiversity. In cases where desired economic benefits

were indeed generated, they were often enjoyed by a few local elites or siphoned to outside investors, whereas the poorest members of the community remain marginalized (Brown 2004; McShane & Newby 2004; Spiteri & Nepal 2006). These issues are at least partly due to over-simplified assumptions about targeted local communities in the management approach. Although there is always heterogeneity and complexity in communities, ICDPs often conceptualize them as small, homogenous, and static. Moreover, these communities are characterized as being unable or ill-equipped to succeed when new economic opportunities are offered (Brown 2002). To transform or evolve an entire targeted population, it is important to understand first how social and economic differentiation within a community, such as variation in the quantity and structure of livelihood assets owned by different households, affects community members' capacity to participate in an ICDP (Butler 1980, 2006).

Livelihood assets refer to the capital endowments owned by a household and include financial, human, natural, physical, and social capital (DFID 1999; Scoones 1998). Financial capital refers to savings, credit and income; human capital refers to the education, skills, knowledge, and the ability household members to work; natural capital refers to natural resources owned by a household such as land, forests and fisheries; physical capital refers to a household's access to basic infrastructure, such as roads and schools, and tools and equipment; and social capital refers to the social resources of the household, such as membership in organizations and "connections" to others in power.

Different assets are required to achieve different livelihood goals. Households with more assets tend to be more versatile in choosing livelihood strategies (DFID 1999). Diversifying livelihood and income sources has been common for rural households across the developing world (Ellis 2000; Haggblade et al. 2007). Livelihood diversification by households is

conceptualized as a process whereby labor supply and capital investment are distributed among farm, off-farm and non-farm activities within a local or regional economy. Households aim to maximize earnings subject to constraints imposed by limited capital resources in a trade-off with the desire to minimize risk (Reardon et al. 2007). We hypothesize that if an ICDP offers desired income-generating opportunities to a community, the choice by a household to participate in the project is largely affected by the family's livelihood assets.

Nature-based tourism is an important ecosystem service and one key activity in which rural households in developing countries can engage with and which has been used pervasively in ICDPs (Hughes & Flintan 2001; Kiss 2004; Millennium Ecosystem Assessment 2005). Tourism is arguably the world's largest industry, and nature-based tourism (also often called ecotourism, although this term actually refers to a subset of nature-based tourism activities (Weaver & Lawton 2007)) is the fastest growing segment of the tourism industry (Newsome et al. 2002b). Nature-based tourism has great potential to improve biodiversity conservation and reduce poverty (Coria & Calfucura 2012; Millennium Ecosystem Assessment 2005; UN World Toruism Organization 2010) compared to other economic development options in and around protected areas for the following reasons. First, tourism is a labor-intensive industry and has the potential to create more jobs per unit of investment than most other industries. In addition, tourism can be a useful source of employment for traditionally marginalized group, including women and ethnic minorities. Second, tourism is widely perceived to be "clean", "non-consumptive", and inexpensive to develop because of its use of existing natural, cultural, and historical resources. Third, tourism can attract outside investments in the development of the infrastructure, including roads and public services in the destination area, which can serve the needs of both local people and tourists. Fourth, nature-based tourism draws on local knowledge,

a form of human capital possessed by local households. When developing tourism activities, interactions between service providers (locals) and receivers (tourists) take place and leave important social impacts and potential benefits. Finally, specifically in developing countries, nature-based tourism should generate jobs and income opportunities for local communities, as well as help finance conservation, through government and non-government programs and the tourists themselves (Balmford et al. 2009; Buckley 2011).

Despite all the promises, in practice nature-based tourism sometimes results in significant negative environmental and socioeconomic impacts. The lack of local community involvement was found to be one of the top reasons behind such failures (Kruger 2005a). The long-term sustainability of nature-based tourism in and near protected areas is strongly dependent on its ability to improve the livelihood of local communities and to enhance local residents' attitudes and behaviors toward conservation. From a development perspective, tourism is successful only if the majority of the local community is involved and if it receives benefits equitably. From a conservation perspective, tourism is successful if the poor are preferentially targeted with jobs and poverty is reduced (Buckley 2010; Coria & Calfucura 2012; Scheyvens 1999; Wunder 2000). However, opportunities for local participation in tourism are not always equally accessible to all community members (Bookbinder et al. 1998; Coria & Calfucura 2012; Kiss 2004; Timothy 2002). The skill sets demanded by tourism jobs are typically not possessed by rural residents (Bookbinder et al. 1998). There are other barriers, such as the distance of residence to key tourism sites, hygiene, lack of social status and family connections, and lack of start-up capital, that prevent local residents from working in and owning businesses in the tourism industry (Timothy 2002). As a result, the benefits of tourism development often accrue to a few local elites and rarely reach the poor (Coria & Calfucura 2012; Kiss 2004; Timothy 2002).

To better understand the role that tourism plays in biodiversity conservation, systematic research with empirical data and quantitative analysis on the various direct and indirect financial and non-financial benefits and impacts that tourism brings to local communities in and near protected areas is needed (Kiss 2004; Stem et al. 2003). Ideally, such studies should follow communities during tourism development to collect baseline and subsequent monitoring data, so that longitudinal comparisons can be made. The tourism area life cycle theory, one of the best known theories on the evolution of tourism destinations (Butler 1980, 2006), offers a relevant framework in terms of identifying development milestones for monitoring changes resulting from tourism development. According to tourism area life cycle theory, development of a tourism destination follows a succession of phases from exploration and involvement stages to development and maturity stages. A tourism destination in the exploration stage is characterized by a small number of tourists, an irregular pattern of visitations, and a lack of specific tourism facilities. As visitation increases and follows some regularity, the local community starts to develop specific tourism facilities and the destination enters the involvement stage. In the development stage tourist volume continues to increase and the destination becomes fully developed. In this stage local control of tourism development may start to weaken rapidly and new facilities provided by outside organizations looking for high-volume businesses gradually dominate the market. When the increasing rate of visitation starts to decline and tourist volume reaches a peak, the maturity stage is reached. In other words, tourism stops growing. Following the maturity stage is either a decline stage, in which tourist volume goes down, or a rejuvenation stage, in which new attractions are developed and visitation goes up again (Butler 1980, 2006). Despite the popularity and the amount of funding invested in nature-based tourism development and conservation, nature-based tourism in protected areas of developing countries has rarely

been studied under a tourism area life cycle framework (Zhong et al. 2008) and the socioeconomic impacts of nature-based tourism through multiple stages have not been analyzed.

The aim of the study was to examine the nature, extent, and drivers of local households' participation in, and benefiting from, nature-based tourism in a biosphere reserve during a period of fast economic transition from agriculture and natural resources extraction to tourism. Applying the tourism area life theory, we identified various types of direct and indirect financial and non-financial benefits from tourism development over multiple life stages and modeled the determinants of household-level tourism participation. This study expands the understanding of the diverse socioeconomic impacts of tourism in protected areas.

The specific objectives of the study were to (1) enrich the conservation literature with longitudinal analysis of residents' participating and benefiting from tourism in protected areas, (2) demonstrate that livelihood assets can be a valid predictor of households' likelihood of tourism participation, (3) illustrate the relationship between tourism participation and local residents' environmental awareness and conservation attitudes, and (4) provide protected area managers with useful policy options that may encourage and facilitate more tourism participation at local levels to assist rural residents and to enhance biodiversity conservation. From these objectives, three research questions emerged:

1. What are the various ways that local residents participate in and benefit from tourism?

2. How do the quantity and structure of livelihood assets owned by local households affect their likelihood to participate in tourism?

3. Do people in tourism-participating households have particular perceptions of the socioeconomic and environmental impacts of tourism development?

3.2 Methods

3.2.1 Ethics statement

Permission from the Wolong Administration Bureau was sought and obtained before the individual subjects were contacted. Because many adult subjects were not literate, a verbal consent process was used. A verbal consent script was read to the subjects. Interviews proceeded only after the subjects gave their verbal consent. In case of non-consent, no further information was recorded. Because signed consent forms constitute a possible source of concern for the protection of respondents' confidentiality, signatures were collected during the verbal consent process. The study, including the verbal consent process and script, was reviewed and approved by the Institutional Review Board (IRB) of the Michigan State University (http://www.humanresearch.msu.edu/).

3.2.2 Data collection

As households are the basic units in which people organize activities such as food and energy consumption, and household members usually make joint or coordinated decisions regarding resource allocation, employment opportunities, and economic production (Ellis 1998; Singh et al. 1986; Wallace 2002; Wheelock & Oughton 1996), we collected data at the household level.

In 1999, we conducted an initial round of a questionnaire survey to collect baseline information on the socioeconomic status of local households. Because groups are the basic units of human organization in rural China, we conducted in-house personal interviews with a random sample of 220 households (ca. 20% of all households at the time) stratified on all groups in the reserve (An et al. 2002). Sample households were selected from each stratum (group) with equal probability. Over the past 17 years the research team has had a long-term collaborative

relationship with the local government and community. All researchers conducting interviews spoke fluent local dialect and all formal interviews were facilitated by a local assistant so that potential communication error during surveys was minimized. During the interviews we asked household heads or their spouses, who usually had the best knowledge about the household's affairs, about household demographics (e.g., household size, household members' ages, genders, education levels, occupations) and socioeconomic activities (e.g., major income sources, expenditures, energy consumption patterns) in the previous year.

We revisited the sampled households in 2005, 2006, and 2007, the peak tourism development period prior to the earthquake. Besides collecting similar demographic and socioeconomic data as in 1999, we paid special attention to the financial benefits local households received from tourism development. Data required for traditional economic impact analysis are often unavailable in under-developed rural areas because of the lack of reliable accounting/tax systems for small entrepreneurs (Walpole & Goodwin 2000). Thus, we focused on the type and magnitude of local employment generated directly and indirectly by tourism through recording the main income-generating activities of each member in the households. Direct tourism-related activities included managing (or renting to others to manage) private hotels and/or restaurants; opening Happy Farmer's Homes; working in government-owned tourism hotels or enterprises; driving taxis; and selling souvenirs, food, or other local products to visitors (Table 4.1). Local households might also earn labor income from temporary infrastructure construction projects or sell local products to hotels, restaurants, shops, or street vendors, and these indirect tourism-related activities were recorded as well (Table 4.1).

In 2005, we conducted an additional questionnaire survey (Supporting information S1) and asked the interviewees about their general knowledge of the history and status of tourism

development in the reserve and to give their personal opinions on a series of 16 questions in four categories: a) their experience of interacting with tourists; b) their perceptions of the socioeconomic benefits of tourism development; c) their perceptions of the various environmental impacts of tourism development; and d) their overall attitudes toward tourism development in the reserve. Interviewees from non-tourism households were also asked to describe specific barriers that prevented them from participating in tourism activities.

The locations of households and of key tourism sites inside the reserve, including two township centers and the entrances of two major tourism attractions (Figure 4.1), were obtained using a Global Positioning System receiver during the summer of 2006. As travelling inside the reserve is strongly influenced by the high-relief topography and under-developed road system, we chose to compute cost distances instead of Euclidean distances to estimate spatial accessibility of tourism resources to each household using the Path Distance function in ArcGIS 9.3 (ESRI 2009).

3.2.3 Measurements

In this study, a tourism household was defined as having at least one of its members working on activities directly related to the tourism sector between 2005 and 2007. All other households were classified as non-tourism households. Only tourism households received direct financial benefits from tourism, while both tourism and non-tourism households may have received indirect financial benefits from tourism. The non-financial benefits of tourism were measured based on the interviewees' perceptions of the social benefits of tourism.

We used existing information from the longitudinal survey data to construct household livelihood asset portfolios. Surrogates for all five types of capital were computed (Table 4.2): a)

financial capital - total household income and percentage of nonfarm income (income not from crop plantation or animal husbandry); b) human capital - household size, number of laborers aged between 18 and 49 (in the study area people older than 50 seldom participate in business-related activities), and education level (in years) of the most educated non-student adult in the household; c) natural capital – the amount of cropland owned by a household; d) physical capital – the travel cost distances between households and the nearest key tourism site; and e) social capital - a dummy variable indicating whether a household has kinship relationship (1=Yes; 0=No) with government officials and another dummy variable indicating whether a household has kinship relationship (1=Yes; 0=No) with village or group heads.

3.2.4 Data analysis

We used logistic regression procedures to estimate parameter values in multivariate models of household-level tourism participation. Logistic regression is an appropriate statistical technique for analyzing models of dichotomous dependent variables. We report parameters from the logistic regression equations in the form:

$$Ln(\frac{p}{1-p}) = \alpha + \sum(\beta k * Xk),$$

where p is the probability that a household participates directly in tourism activities, p/(1-p) is the odds of tourism participation, α is a constant term, β_k represents the effect parameter of the explanatory variables, and X_k represents the explanatory variables in the model, which include livelihood asset variables and township as a contextual factor. Coefficients in a logistic model give the change in the log-odds of tourism participation for a unit change in the explanatory variables. To facilitate interpretation of the coefficients, we report the odds ratios, which are interpreted as the amount by which the odds of tourism participation are multiplied for each unit

change in the explanatory variable. Odds ratios equal to 1 represent no effect; odds ratios greater than 1 represent positive effects; and odds ratios less than 1 represent negative effects.

To estimate the accuracy and reliability of the model we conducted a ten-fold cross validation (Refaeilzadeh et al. 2009). The samples were randomly divided into ten subsets (half composed of 21 households and the other half composed of 22 households). We iteratively (i.e., ten times) used nine subsets to train the model and the remaining to validate it. In each iteration we generated a receiver operating characteristic (ROC) curve and calculated the area under the ROC curve (AUC) as a measure of model accuracy.

We further examined how household-level tourism participation might affect local residents' perceptions and attitudes toward tourism development in the reserve. Because local households' choice of participating in tourism was not the result of a randomized or natural experiment, systematic differences between tourism and non-tourism households may constitute confounding effects, thus making it spurious to estimate the effects of household-level tourism participation on the interviewees' perceptions/attitudes. The self-selection nature of tourism participation creates a counterfactual question – "what would be the perception/attitude of a person in a tourism household if his/her household were not directly participating in tourism?" Ignoring this issue may lead to invalid inferences (Hirano & Imbens 2001; Rosenbaum & Rubin 1983).

We approached this issue with a propensity score weighting methodology (Hirano & Imbens 2001; Rosenbaum & Rubin 1983). A propensity score is the conditional probability of receiving the treatment given the observed covariates (Rosenbaum & Rubin 1983). The logic is that we may make causal inferences if we compare individuals in the treatment group (in our case, respondents from tourism households) to those in the control group (respondents from non-

tourism households) with similar propensity scores. The propensity score is defined as (Rosenbaum & Rubin 1983):

$$e(x) = \Pr(m = 1 \mid x),$$

where m is a dummy variable indicating the treatment (i.e., 1 for tourism household and 0 for non-tourism household); and e(x) is the propensity for receiving the treatment, which can be estimated from a logistic regression. We then used an inverse probability of treatment weighting method to estimate the average causal effect of household tourism participation on respondents' perceptions and attitudes (Hirano & Imbens 2001; Rosenbaum 1987). The weights are determined by:

$$\omega(m, x) = \frac{m}{e(x)} + \frac{1-m}{1-e(x)}.$$

Therefore, a tourism household is weighted by 1/e(x) and a non-tourism household is weighted by 1/(1-e(x)). In this way, more weight is assigned to a tourism household with a lower propensity score and to a non-tourism household with a higher propensity score, such that the estimation of the average causal effect focuses mainly on the strongest overlap in propensity between the two groups. The weight is then used in a series of weighted linear regressions (for Likert-type scale questions in categories b, c, and d) and weighted logistic regressions (for Yes/No questions in category a). In addition to the household-level participation in tourism, we controlled for the household's locations (township and travel cost distance to key tourism sites) and social ties and the respondent's age, education, gender, and occupation as covariates in these regression models (see detailed descriptive statistics of these control variables in Table 4.3).

All statistical modeling and analyses were conducted using PASW Statistics 18, Release Version 18.0.0 (SPSS, Inc., 2009, Chicago, IL, www.spss.com). Significance levels were set at 0.05, 0.01, and 0.001.

3.3 Results

3.3.1Direct and indirect financial benefits of tourism received by local households

In 1998, nine (4%) out of the 220 households sampled directly participated in tourism-related activities, with four owning private hotels and five selling souvenirs (Table 4.1). The number of tourism households increased to 60 (28%) in the peak tourism development period (2005-2007) before the earthquake. A total of 83 individuals from these 60 households worked in tourism-related jobs and 52 of them (62.7%) were females. In other words, by mid-2000s about 9.1% of the sampled population (896 individuals in 217 households) had worked in the tourism industry.

During the peak tourism development period (2005-2007) many local households also received indirect financial benefits from tourism development (Table 4.1). For instance, a total of 116 households claimed to have received some income from temporary labor jobs on infrastructure construction inside the reserve (primarily road construction), 87 of which were non-tourism households. A number of households also claimed to have earned income from selling medicinal herbs (14 tourism households and 25 non-tourism households), honey (6 tourism households and 19 non-tourism households), and smoked pork (10 tourism households and 12 non-tourism households) that were collected or made locally. Most of these local products were sold to local restaurants, shops, and street vendors, which eventually were purchased by outside visitors. Fifty-one (23.5%) households received neither direct nor indirect income during the peak tourism development stage.

Changes in the basic socioeconomic status of the randomly sampled households from the tourism involvement stage (late 1990s) to the peak development stage (2005-2007) are listed in

Table 4.4. In 1998, the 60 households who were later classified as tourism households had on average less cropland and more income per capita than the other households had. More than two-thirds of the reserve's croplands were reclaimed to tree plantation between 2000 and 2003. On a per capita basis, both types of households reclaimed about the same amount of cropland and received similar monetary subsidies from the two PES programs. By 2006, the mean per capita income of both groups increased significantly, and the net difference in per capita income (inflation adjusted) between the two types of households almost doubled to 1300 Yuan (~166 US dollars, 1 Yuan was equivalent to 0.1280 US dollars as of Dec. 2006). Non-tourism households generally earned more farm income by replacing subsistence crops (e.g., corn and potato) with cash crops (e.g., cabbage and turnips), while their mean non-farm income percentage remained at around 36 to 38% from the late 1990s to mid-2000s. Direct and indirect tourism income was most important to tourism households, and their mean non-farm income percentage increased from 40% to over 66% between the late 1990s and mid-2000s.

3.3.2 Determinants and barriers of household-level participation in tourism

A final sample of 215 households was included in the logistic regression model after excluding two households whose income data in the tourism involvement stage were incomplete and three households that were not present in 2005 (due to death or emigration). The binomial logistic regression model on household tourism participation includes 11 independent variables, the descriptive statistics of which are listed in Table 4.2. Ninety-four of the sampled households were located in Wolong township and the other 121 were Gengda residents. Then mean household size was about 4.1. The mean number of laborers was around 1.7. The most educated non-student adult in the household received on average 7.7 years of education. Each household

owned an average of 3.9 Mu (1 Mu = 0.067 ha) cropland. The mean annual household income in 1998 was 8,059 Yuan (~973 US dollars, 1 Yuan was equivalent to 0.1208 US dollars in 1998) and the mean non-farm income percentage in 1998 was 38%. The number of households with government- and village-level social ties was 24 (11.2%) and 39 (18.1%), respectively.

All five categories of capital seem to influence the likelihood of household-level participation in tourism. The annual household income in 1998 (financial capital) was a significant explanatory variable and higher income in tourism involvement stage increased the odds of tourism participation ($p<0.05$), but the non-agriculture income percentage in 1998, an indicator of the household's economic reliance on non-farm income opportunities before the tourism boom, was not significant. In terms of human capital, households with more laborers were significantly more likely ($p<0.05$) to be involved in tourism with each additional laborer increased the odds of household tourism participation by 2.06. Education had a positive effect on the likelihood of the household's participation in tourism ($p<0.01$), but household size did not. Households with more cropland (natural capital) tended not to participate in tourism ($p<0.001$). The more it cost physically to travel between a household and the closest key tourism site (physical capital), the less likely ($p<0.01$) the household would participate in tourism. A household's social capital has some influence on its likelihood to take part in tourism. Having a kinship relationship with government officials and village or group heads increased the odds of tourism participation by nine times ($p<0.01$) and three times ($p<0.05$), respectively. Township was also a significant predictor since households located in Wolong township, where the main tourism attractions were located, were significantly more likely ($p<0.05$) to participate in tourism than households in Gengda township.

In 2005, households were revisited and the heads or their spouses were asked a series of questions on their knowledge and perceptions of tourism development in the reserve. A total of 192 households answered the questions, including 55 tourism households and 137 non-tourism households. When the non-tourism household heads (or their spouses) were asked about what prevented their household members from participating in tourism, a variety of barriers were reported. Financial and physical limitations were mentioned most often, including lack of start-up funds (60.1%), household location being far from key tourism sites (57.5%), and lack of land and housing to start a tourism business (27.5%). Fifteen interviewees (10.1%) stated that the lack of transparent and supportive local tourism policies made them feel uncertain about the economic potential of tourism development. Other respondents referred to human and social capitals, such as the lack of social connections (9.4%), the lack of labor (6.5%), being too old to have a business (5.1%), and the lack of experience (4.3%). These responses are consistent with the logistic model results on determinants of household-level tourism participation.

3.3.3 Non-financial tourism benefits perceived by local households

We measured tourism's non-financial benefits on the basis of local people's perceptions in 2005. The interviewees were asked about how they interacted with tourists. Being in a tourism household increased the odds of communicating with tourists and receiving information about job opportunities from tourists by 7.17 ($p<0.001$) and 3.44 times ($p<0.001$), respectively (Table 4.5). In contrast, the odds ratios were 5.78 ($p<0.01$) and 2.82 ($p<0.01$), respectively, in the unweighted models. The respondents also reported other types of information exchange with tourists. For instance, from tourists they received information about tourism development and policies in other areas, about the tourists' experiences and impressions about the reserve, and

about the tourists' suggestions to improve tourism services. In return, they provided information to tourists on local wildlife distribution (especially pandas), culture, and conservation issues. Over one-third of the interviewees acknowledged there had been conflicts between locals and tourists (Table 4.5). They reported that conflicts usually took place during bargaining between local souvenir sellers and tourists or when some Happy Farmer's Homes (HFH) tourists filched vegetables from households' cropland.

Residents perceived socioeconomic benefits occurring to their households from tourism (Table 4.6). Almost everyone interviewed agreed that tourism development improved public services and living conditions, enhanced most families' quality of life, and built a good image of the reserve among outside people. Tourism household members tended to agree more ($p<0.05$) with the statement "tourism development has helped enhance my family's quality of life". They tended to agree less with two other statements "tourism development has helped enhance most families' quality of life across the reserve" ($p<0.05$ in the weighted model and $p>0.10$ in the unweighted model) and "tourism development has helped to build a good image of the area among outside people" ($p<0.01$ in weighted model and $p<0.05$ in unweighted model).

3.3.4 The influence of tourism participation on local residents' environmental awareness

Local people's perceptions of the environmental impacts of tourism development are listed in Table 4.7. In general, respondents from all households perceived almost no negative impact on the air and water quality, the soundscape (i.e., the natural acoustic environment), the mountain trails, and the natural forests in the reserve; the perceived a low level of negative impacts on wildlife including pandas (e.g., hikers disturbing wildlife) and the availability of medicinal herbs (e.g., tourists collecting some specific herbs in the reserve); and they perceived a

medium level of negative impact on road traffic (e.g., increasing traffic congestion and accidents). People from tourism households tended to perceive significantly higher levels of negative impacts on wildlife ($p<0.01$ in the weighted model and $p<0.05$ in the unweighted model) and road traffic ($p<0.05$ in the weighted model and $p>0.10$ in the unweighted model) than those from non-tourism households, and the influences of household-level tourism participation on other environmental impact perceptions were not significant. Overall, while almost all households acknowledged that tourism was good for the reserve, being in a tourism household seemed to make people disagree less with the statement that "there are conflicts between tourism development and conservation in the reserve" ($p<0.01$) (Table 4.8).

3.4. Discussions

Despite the high level of overall economic leakage reported in a previous study (He et al. 2008) and in this study, tourism development in Wolong Nature Reserve before the 2008 earthquake generated a broad range of economic and social benefits to the local community. First, over three-quarters of the sampled households received more or less financial benefit directly or indirectly from tourism. There are likely also other economic benefits not captured in our measurements, as tourism is a diverse industry with the potential to support other economic activities through creating income opportunities throughout a complex supply chain of goods and services. For example, while many tourism jobs were taken by outsiders (He et al. 2008), they consumed a significant amount of local produce and spent money in local restaurants and shops. Another interesting finding is that there were more female local residents than males working in the tourism industry. This confirmed tourism's potential to promote gender equity in developing countries (UNED-UK 1999). Second, tourism development improved the infrastructure and

living conditions of the community, especially through construction and upgrading of the main road. The road greatly facilitated the sales of cash crop (e.g., cabbage and turnip) to the outside market, which constituted a major income source for the majority of the rural households. This was well recognized by the interviewees. Moreover, tourism provided opportunities for local people to communicate with outsiders.

Nevertheless, the overall magnitude of economic benefit that local community received from tourism was yet limited and there was still disparity in the tourism-derived benefit distribution within the local community. Slightly over one-quarter of our sampled households earned some income directly from tourism. This direct tourism income was not the most important source of income for most households, except those who owned or managed a year-around hotel or restaurant (~5%). At a reserve level in 2006, income from the service sector represented only 7.4% of the total rural economic income in the two townships (Wolong Administration Bureau Department of Social and Economic Development 2006). Our binomial logistic regression model results revealed that the quantity and quality of the various capital possessed by a household determined whether it had the capability and motivation to pursue tourism as a new livelihood strategy. Households with less natural capital to earn on-farm income in this reserve tended to have more pressure to find income opportunities from tourism, which was one of the very limited non-farm alternatives in the reserve. Plentiful financial capital made a household capable of making necessary investments (e.g., builds a private hotel, purchase a car) to participate in tourism and the lack of such capital was mentioned by many non-tourism households as a major barrier to participating in tourism industry. Human capital was shown to matter. First, households with better-educated adults tended to benefit more from tourism, as they might possess better skills (e.g., the ability to communicate with outsiders,

knowledge of language beyond the local dialect) for participation in tourism or a better ability to acquire such skills. Second, households with more adult laborers have greater pressure to find non-farm income opportunities to make use of the surplus labor. Social capital, especially a household's kinship with government employees, was an important predictor of tourism participation. Households having close relationships with township- and reserve-level government officials were in a better position to acquire tourism-related information and critical resources (e.g., loan opportunities). This is consistent with previous findings in this reserve. Earlier evidence showed that almost all non-rural small tourism business managers were a relative of local government officials (He et al. 2008). Physical capital, measured as a household's proximity to the closest key tourism site, also influenced the likelihood of participation in tourism, because tourism income opportunities were found to be disproportionally distributed around those locations.

Our results showed households receiving more direct financial benefits tended to perceive more non-financial benefits. They tended to communicate more with tourists and exchange information with tourists; and they perceived more positive impacts of tourism on their standards of living. Despite some minor conflicts reported, the advantages of tourist-resident contact seem to outweigh the disadvantages, because such communications may help to break the feeling of isolation of rural minorities and visitors in the reserve, create mutual awareness of each group, and provide an opportunity to learn from each other. Such contact can be a starting point for more fundamental inter-cultural encounters, through which the educational potential of nature-based tourism can be realized. As these financial and non-financial benefits accrue faster to some tourism households than others, the existing disparity in the livelihood assets between

tourism and non-tourism households may increase. This may further augment social and economic differentiation within the community.

Besides the socioeconomic benefits to local residents, nature-based tourism also has the potential to enhance the environmental awareness and attitudes of local residents (Sekercioglu 2002; Spiteri & Nepal 2006; Stem et al. 2003). After several years of tourism development, we observed a high degree of agreement among respondents with regard to the positive socioeconomic impacts of tourism in the reserve. During the interviews, all interviewees acknowledged that pandas and forests are the top tourism attractions of the reserve. Thus those who participated in and benefited from tourism became more aware of the link between the economic value of natural ecosystems and conservation success. Despite their very favorable disposition towards tourism development, some respondents, especially those in tourism households, recognized that some types of negative environmental impacts may ensue. People from tourism households tended to be more knowledgeable about the intensities and the spatial distributions of tourists' activities through their interactions with tourists. Because they derived direct tourism benefits from the conservation of pandas and other wildlife, they were more likely to care about the ecosystem that harbored them. This increased awareness may help explain why more respondents from tourism households tended to think that there were conflicts between tourism development and conservation in the reserve. Overall, these are all signs that tourism development may positively influence the environmental awareness and attitudes of the local people, which in the long run may enhance local people's conservation behaviors.

From a policy perspective, the experience learned from past tourism development in Wolong Nature Reserve is of great value for making relevant interventions in the future. The 2008 earthquake, which reset the tourism development in the area, offers an opportunity for the

reserve to develop tourism that may better benefit the poor. The post-earthquake reconstruction plan includes a new round of local household relocations from remote mountainous areas to roadside areas, with their cropland being reclaimed for tree and bamboo plantation as one way to restore more habitats for the giant panda and other wildlife species. To construct new tourism facilities in the Gengda township, a significant amount of cropland was requisitioned with cash compensation to the affected households. While growing cash crop still constitutes an important and stable income source of many households, those who had to trade their cropland with cash compensation will inevitably be facing more limited livelihood options in the future. In the short run, many households may earn wage-labor income from the ongoing infrastructure reconstruction projects. But after the completion of reconstruction, as tourism has been identified as the major economic development tool in the reserve and the surrounding region, the importance of tourism-related income for the local households will be even greater in the future than before the earthquake. The Wolong Administration Bureau needs to design and implement policies to improve local households' capacities to pursue tourism as a major livelihood strategy. On the one hand, policies that specifically target the poor and help augment their livelihood assets (e.g., provide training to enhance human capital and making loan opportunities accessible to enhance financial capital) are needed. On the other hand, other regulations that encourage tourism operators to transfer significant amounts of benefits to the poor are also needed. For example, the government may require outside tourism operators or developers to preferentially provide job opportunities to people from the poorer households, rather than letting nepotism prevail as it has in the past (He et al. 2008).

Perhaps more importantly, involvement and integration of local communities into the entire tourism development process is critical for achieving ecological and socioeconomic

sustainability in protected areas (Liu et al. 2003a). Thus, local people, especially the poor, should be included in the policy design process from the very beginning. This is specifically relevant to countries like China, where conservation programs are usually implemented in a top-down manner with little input from the local stakeholders (Grumbine & Xu 2011; Liu & Diamond 2008). In the past, although there were two reserve-wide tourism stakeholder meetings organized by the Wolong Administration Bureau in 2001 and 2007, besides related government officials, only tourism business owners were invited (W. Liu, personal observation). The consequence was that most local people were only aware of the existence of tourism policies but not the details, which had prevented some capable households from participating in tourism, as reported by some respondents in our interviews. We suggest that local government first needs to expand their tourism stakeholder list to include all community members with willingness/interest to participate in tourism, carefully listen to their suggestions and understand their needs, and then design policies and regulations that will give poorer members priorities to participate in tourism and benefit from it. In the long run, to sustain a high-level of local participation in tourism, the current top-down decision-making, implementation, and management style in tourism development has to be changed to a multistakeholder-based, horizontal one.

Last but not least, our results highlight the strength of longitudinal data and quantitative analysis in understanding the impacts and effectiveness of nature-based tourism and ICDPs in general. While the need to conduct environmental monitoring of nature-based tourism is well recognized (Buckley 2011), the importance of monitoring socioeconomic changes is often overlooked, as is understanding the drivers behind the changes. By documenting the specific changes on the types and levels of tourism participation and the characteristics of community members, we may establish more precisely the contexts that give rise to the observed impacts.

Limited by time and monetary costs, after-the-fact analyses or simulation are more often used in impact assessment, but monitoring changes across time, particularly early to tourism growth stages, can accumulate data not possible to acquire by other methods and produce information with higher degrees of managerial utility and policy relevance. We suggest that socioeconomic impact measurement and change monitoring must be firmly incorporated into nature-based tourism planning and management in protected areas of developing countries from the early phases of development. Meaningful local involvement can then be ensured and positive impacts on poverty reduction and conservation can be effectively promoted.

Figure 3.1. Map of Wolong Nature Reserve, showing its location in China and the distribution of local households and key tourism sites inside the reserve.

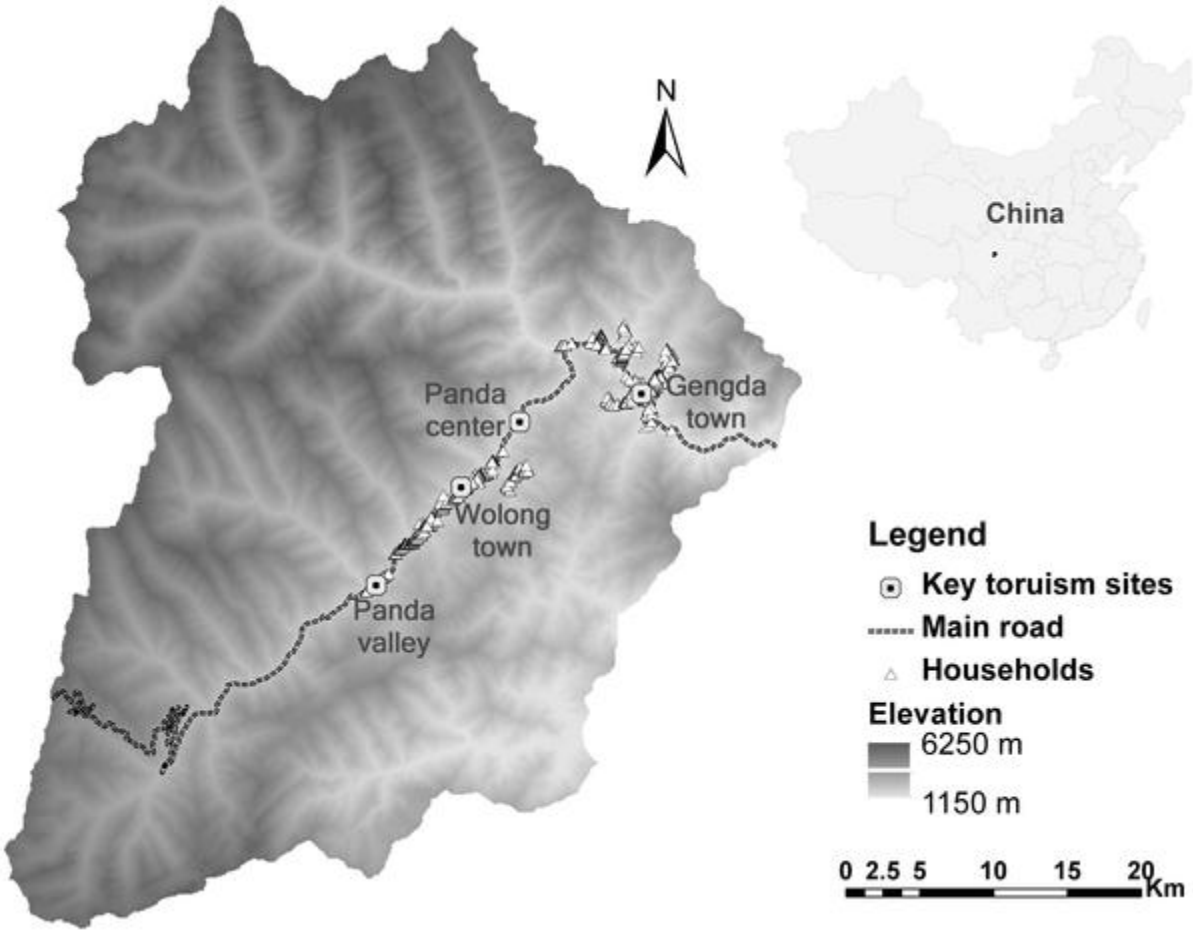


Table 3.1. Number of local rural households receiving different types of direct and indirect financial benefits in the tourism involvement and development stages in Wolong Nature Reserve.

Tourism-related activities	**Tourism involvement stage (1998, n=220)**	**Tourism development stage (2005-2007, n=217)**
Direct financial benefits		
Hotel/Restaurant owners and/or managers	4	11
Leisure farm owners	0	21
Street vendors and souvenir shop owners	5	20
Government-owned hotel employees	0	10
Taxi drivers	0	2
Sub-total	***9***	***60*** [a]
Indirect financial benefits		
Working as a temporary infrastructure construction laborer	No data	116
Selling locally collected medicinal herbs	No data	35
Selling locally made honey	No data	29
Selling locally made smoked pork	No data	22
Sub-total	***-***	***148*** [b]
TOTAL	***-***	***166***

a. Four households participated in more than one type of activity.
b. This includes 42 households that received both direct and indirect financial benefits and 106 households that received only indirect financial benefits.

Table 3.2. Results of the binary logistic regression model on household-level tourism participation (n=215).

Variable	Description	Mean (SD)	Parameter [a] (Robust SE)	Odds Ratio
Financial capital				
Log(Income 98)	Log transformed total household income in 1998 (in Yuan)	8.3319 (0.9171)	0.6799 * (0.3392)	1.9737
Nonfarm income%	Percentage of nonfarm income in total income in 1998	0.3756 (0.3164)	-0.9945 (0.8140)	0.3699
Human capital				
Household size	Number of people in each household	4.1302 (1.4115)	0.1748 (0.1732)	1.1910
Education	Education level (in years) of the most educated non-student adult in the household	7.7023 (3.289)	0.2161 ** (0.0836)	1.2413
Labor	Number of labors	1.6698 (1.0402)	0.7239 * (0.3264)	2.0625
Natural capital				
Cropland	Total cropland acreage of the household (in Mu)	3.8544 (2.4621)	-0.3943 *** (0.1101)	0.6742
Physical capital				
Log(Cost distance)	Log-transformed cost distance between the household and the nearest key tourism site	8.8583 (1.0088)	-0.8862 *** (0.2771)	0.4122
Social capital				
Tie_Government	Whether the household has a member or immediate relative working in local government: 1. Yes; 0. No	0.1116 (0.3156)	2.2067 ** (0.7792)	9.0855
Tie_Village	Whether the household has a member or immediate relative being a village or group head: 1. Yes; 0. No	0.1814 (0.3862)	1.0820 * (0.5015)	2.9507
Contextual factor				
Township	1. Wolong township; 0. Gengda township	0.4372 (0.4972)	0.8423 * (0.4200)	2.3216
Intercept			-2.1448 (3.9749)	0.1171
Wald χ-square			45.0600 ***	
Log-Likelihood			-76.6641	
Pseudo R-square (Nalgelkerke)			0.5410	
Ten-fold cross validation prediction accuracy			87.88%	
Ten-fold cross validation AUC			0.9338	

a. The signs *, **, and ***, represent significance at the 5%, 1%, and 0.1% levels, respectively.

Table 3.3. Descriptive statistics of the household and individual level variables in estimating the effects of household-level tourism participation on local residents' perceptions.

Variables	Description	Mean [a]	SD
Household-level			
Tourism household	1. Yes; 0. No	0.2865	0.4533
Township	1. Wolong township; 0. Gengda township	0.3979	0.4908
Log(Cost distance)	Log-transformed cost distance between the household and the nearest key tourism site	8.8535	1.0408
Tie_Government	Whether the household has a member or immediate relative working in local government - 1. Yes; 0. No	0.1146	0.3194
Tie_Village	Whether the household has a member or immediate relative being a village or group head - 1. Yes; 0. No	0.1875	0.3913
Individual-level			
Gender	1. Female; 0. Male	0.3229	0.4688
Education	Number of years of formal education that the respondent received	4.6927	3.6901
Age	Age of the respondent (in years)	47.4219	13.1585
Occupation	The main occupation of the respondent - 1. Farmer; 0. Others	0.8125	0.3913

a. n=192, one interviewee in each household, including 55 tourism households and 137 non-tourism households.

Table 3.4. Basic socioeconomic conditions of the 220 randomly sampled rural households in Wolong Nature Reserve in 1998 and 2006 [a].

Tourism stages	**Involvement stage (1998)**			**Development stage (2006)**		
Household type	Tourism	Non-tourism	t test [b]	Tourism	Non-tourism	t test
Per capita cropland area (in Mu [c])	1.97 (0.87) [d]	2.61 (1.56)	3.74 ***	0.63 (0.41)	1.25 (0.93)	6.73 ***
Per capita income (in Yuan)	1992 (1733)	1327 (1494)	2.03 **	6429 [e] (5068)	5157 (6323)	1.31 *
Nonfarm income %	40.7% (32.2%)	36.3% (31.4%)	1.03	66.2% (29.3%)	37.9% (29.6%)	4.27 ***
Poverty rate [f] %	35.00%	35.85%	NA	0	3.23%	NA

a. The overall response rates in 1998 for cropland and income questions were 95.5% and 99.1%, respectively, and those in 2006 were 87.6% and 84.8%, respectively.
b. Student's t test was used to compare cropland and income between tourism and non-tourism households. The signs *, ** and *** represent significance at 10%, 5%, and 1% levels respectively.
c. 1 Mu = 0.0667 Ha.
d. Standard deviation is shown in parentheses.
e. The income measurements in tourism development stage have been inflation-adjusted.
f. Standard rural poverty lines published by Chinese government in 1999 and 2006 (Rural Survey Department of National Bureau of Statistics 2000, 2007) are used.

Table 3.5. Estimated effects of household-level tourism participation on local residents' interactions with tourists.

	% agreed [a]		Coefficients [b] (SE) [Odds ratio]	
Household type	**Tourism**	**Non-tourism**	**Weighted**	**Unweighted**
1. I have had some communications with tourists.	73.6%	40.7%	1.0375 *** (0.2722) [7.1654]	1.2363 ** (0.4090) [5.7836]
2. I have received information about job opportunities from tourists.	19.2%	6.8%	1.7550 *** (0.5144) [3.4430]	1.9693 ** (0.6723) [2.8222]
3. There have been conflicts between local residents and tourists.	40.5%	32.6%	-0.5042 (0.3140) [0.8930]	-0.1132 (0.4370) [0.6040]

a. The sample sizes for tourism and non-tourism households are 53 and 135 (Q1-2) and 42 and 92 (Q3), respectively.
b. The signs ** and *** represent significance at the 1% and 0.1% levels, respectively.

Table 3.6. Estimated effects of household-level tourism participation on local residents' perceptions [a] on the socioeconomic benefits of tourism development.

	Mean score [a,b] (SD)		**Coefficients [c] (SE)**	
Household type	**Tourism**	**Non-tourism**	**Weighted**	**Unweighted**
1. Tourism development has helped improve public service and living environment.	1.74 (0.64)	1.70 (0.70)	-0.0904 (0.0857)	-0.0925 (0.1082)
2. Tourism development has helped enhance my family's quality of life.	0.64 (1.73)	-0.58 (1.73)	0.6956 * (0.2703)	0.8098 * (0.3143)
3. Tourism development has helped enhance most families' quality of life in the reserve.	1.56 (0.79)	1.69 (0.63)	-0.2522 * (0.1047)	-0.1565 (0.1094)
4. Tourism development has helped to build a good image of the area among outside people.	1.52 (0.72)	1.60 (0.72)	-0.2825 ** (0.0931)	-0.2644 * (0.1104)

a. Five-point Likert scale: -2. Strongly disagree; -1. Disagree; 0. Neutral; 1. Agree; 2. Strongly agree.

b. The sample sizes for tourism and non-tourism households are 55 and 136 (Q1-3) and 52 and 125 (Q4), respectively.

c. The signs * and ** represent significance at the 5% and 1% levels, respectively.

Table 3.7. Estimated effects of household-level tourism participation on local residents' perceptions [a] on the direct negative environmental impacts of tourism development.

	Mean score (SD)		**Coefficients [b] (SE)**	
Household type	**Tourism (n=55)**	**Non-tourism (n=137)**	**Weighted**	**Unweighted**
Air and water quality	0.02 (0.13)	0.01 (0.09)	0.0069 (0.0137)	0.0148 (0.0188)
Soundscape	0.11 (0.46)	0.04 (0.22)	0.0855 (0.0516)	0.0810 (0.0580)
Road traffic	1.67 (0.84)	1.56 (0.80)	0.2490 * (0.1208)	0.2193 (0.1346)
Mountain trail	0	0.01 (0.12)	-0.0056 (0.0133)	-0.0033 (0.0190)
Natural forest	0.05 (0.30)	0.04 (0.27)	0.0175 (0.0498)	0.0077 (0.0517)
Medicinal herbs	0.42 (0.79)	0.39 (0.70)	0.1959 (0.1320)	0.0206 (0.1480)
Wild pandas and other wildlife	0.31 (0.66)	0.03 (0.21)	0.1918 ** (0.0631)	0.1848 * (0.0750)

a. 0 = No impact, 1 = Low level, 2 = Medium level, 3 = High level. No positive impact was reported.
b. The signs * and ** represents significance at the 5% and 1% levels, respectively.

Table 3.8. Estimated effects of household-level tourism participation on local residents' overall attitudes toward tourism development.

	Mean score [a,b] (SD)		**Coefficients [c] (SE)**	
Household type	**Tourism**	**Non-tourism**	**Weighted**	**Unweighted**
1. There are conflicts between tourism development and conservation in the reserve.	-0.54 (1.66)	-1.37 (1.17)	-0.6143 ** (0.2271)	-0.6382 ** (0.2654)
2. Overall tourism development is good for the reserve.	1.85 (0.49)	1.95 (0.28)	-0.0819 (0.0508)	-0.0866 (0.0656)

a. Five-point Likert scale: -2. Strongly disagree; -1. Disagree; 0. Neutral; 1. Agree; 2. Strongly agree.
b. The sample sizes for tourism and non-tourism households are 46 and 114 (Q1) and 55 and 134 (Q2), respectively.
c. The signs ** represents significance at the 1% level.

CHAPTER 4

A HABITAT-BASED APPROACH TO ASSESS PANDA POPULATION POTENTIAL AND DISTRIBUTION

4.1 Introduction

Habitat loss and degradation and small isolated populations are two leading causes that threaten many endangered species around the world (Groom et al. 2006). Giant pandas (*Ailuropoda melanoleuca*) are endangered, with only about 1,600 wild individuals occurring in the temperate forests along the eastern edge of the Tibetan plateau in China. More than 60 nature reserves have been established for panda conservation since the 1960s. Various human activities, including deforestation, road and infrastructure construction, tourism, and livestock grazing, still exist at varying intensities throughout their geographic range, even inside nature reserves (State Forestry Administration 2006). Currently, wild pandas occur in <30 isolated areas, many of which are believed to be too small for supporting viable panda populations (Loucks et al. 2001).

Maintaining viable populations and reducing habitat destruction are the two top priorities for panda conservation (State Forestry Administration 2006). Population viability analyses (PVA) on giant pandas have been conducted (Li et al. 2003; Wang et al. 2002; Zhou & Pan 1997). Additionally, panda-habitat relationships have been studied for all major areas within panda range (Qi et al. 2011; Tuanmu et al. 2011; Viña et al. 2008). The importance of habitat to viable populations is well known, yet none of the existing panda PVAs incorporated habitat dynamics, making it difficult to explicitly integrate population viability goals into panda habitat management plans and decisions. The absence of quantitative empirical studies on panda habitat-population dynamics necessitates the use of process-based simulation models to evaluate the structure and composition of landscapes that support panda population viability.

Roloff and Haufler (1997, 2002) suggested that habitat quality, quantity, and spatial configuration can be used to index the potential size and distribution of populations. They

proposed a model that integrates habitat suitability index (HSI) modeling, allometrics to parameterize space use for varying habitat quality, and an agglomeration technique to delineate potential home range configurations (Roloff & Haufler 1997, 2002). Roloff and Haufler (2002) posit that the quality of these modeled home ranges relates to the likelihood of reproduction and survival, thereby, impacting viability. Roloff and Haufler (2002) recognized that the habitat-based approach to viability assessments may ignore important determinants of population performance (e.g. competition, disease, poaching), but nonetheless provides a useful framework for habitat monitoring and planning. This framework has been used to inform conservation planning for Canada lynx (*Lynx Canadensis*), Northern spotted owl (*Strix occidentalis caurina*), and Shiras moose (*Alces alces shirasi*) (Baigas et al. 2010; Linden 2006; Nylen-Nemetchek 1999; Roloff et al. 2012).

Throughout the 20th century, deforestation was the leading proximate cause of panda habitat loss and degradation across their distributional range (State Forestry Administration 2006), including Wolong Nature Reserve (Liu et al. 2001). While large-scale authorized logging was banned in 1975, selective logging for fuel and construction material still threatens panda habitat (An et al. 2006; Bearer et al. 2008; Liu et al. 2001; Liu et al. 1999). Selective logging impacts both forest and bamboo canopy structure, size, and spatial distribution, thereby directly causing panda habitat destruction and fragmentation (Liu et al. 2001; Liu et al. 1999). While the decline of forest cover and connectivity and resulting panda habitat loss and fragmentation has been quantified and modeled (Liu et al. 2001; Liu et al. 1999; Viña et al. 2007), the impact of deforestation on panda population potential and distribution is still unknown.

Liu et al. (Liu et al. 1999) suggested that wild pandas avoided areas with recent and concentrated human pressure. Disturbances do not necessarily directly alter forest cover but

functionally they may indirectly result in panda habitat degradation. Avoidance of human disturbance by pandas is one mechanism that leads to non-occupation of potential habitat (Pulliam 2000). Liu et al. (Liu et al. 1999) proposed a general framework to study the effect of human disturbances on potential panda habitat. The framework generally involves buffering an area around locations of human activities (i.e., sources of disturbances) to portray the magnitude and extent of the competitive exclusion effect. The indirect impacts of human disturbances on panda population potential and distribution are unknown.

The objectives of my study were to (1) implement the habitat-based approach of viability assessment on giant pandas in Wolong Nature Reserve, China, (2) validate the habitat-based viability output using information on known panda locations in the Reserve, and (3) portray the effects of historical human activities, both direct effects from deforestation and indirect effects from human presence, on panda population potential in the Reserve.

4.2 Methods

4.2.1 Modeling panda distribution

I modeled adult female panda home ranges using Roloff and Haufler's (1997, 2002) approach as implemented in the program HomeGrower Version 3 (Plume 2001, 2005). Survivorship and productivity of adult female pandas are most critical to population viability (Harris 2004). The number and spatial distribution of adult female pandas can provide a basis for estimating the overall panda distribution and environmental carrying capacity. Unlike adult male pandas, whose home ranges significantly overlap with each other, the home range overlap for adult female pandas is less and core areas almost never overlap (Hu 2001; Schaller et al.

1985). For instance, Schaller et al. (Schaller et al. 1985) used radio telemetry to study panda home range behavior in Wolong Nature Reserve. The two adult females in their study "… occupied opposite sides of a valley, 3.0 km apart, … were near each other only in spring when both descended to forage on new *Fargesia* shoots … No other adult females shared Zhen's range, ... even though 2 inhabited areas to the south and west of her". An important assumption of the HomeGrower program is that home ranges do not overlap; data on female panda space use suggest that this assumption is valid.

The HomeGrower requires two representations of panda habitat: 1) a habitat suitability map ranging from 0 (poor quality) to 100 (optimum quality), and 2) an additional map that portrays areas potentially serving as home range cores. Adult female panda habitat suitability was modeled using a multiplicative combination of three factors (forest cover, elevation and slope), consistent with Liu et al. (2001) and Viña et al. (2007). Based on research of wild pandas in the reserve, I designated habitat as highly suitable, moderately suitable, marginally suitable, and non-suitable, using a deterministic model. Accuracy of this deterministic model is comparable to other statistical models (e.g., Ecological Niche Factorial Analysis) for predicting panda habitat use (Viña et al. 2008). I designated the highly suitable habitat as potential core areas because the criteria of this habitat category corresponded to what is known about female panda core areas in Wolong Nature Reserve (Schaller et al. 1985). The core area map was portrayed as a binary map with highly suitable cells assigned the value 100 and all others assigned 0.

I used a roving window method to convert the categorical habitat suitability maps from my deterministic model into 90m resolution habitat maps where suitability was scaled continuously between 0 and 100. Each map cell was assigned a Habitat Suitability Index (HSI)

value based on the proportion of the highly suitable and moderately suitable cells within a square 288-ha window, approximating the allometric home range size of adult female giant pandas. Allometric home range describes the minimum area required by a mammal according to its body mass (Peters 1983). Given optimum habitat conditions, it is the theoretical scale of space use (Roloff & Haufler 1997). I used a general equation for herbivorous mammals to estimate the allometric home range size for female adult pandas (Peters 1983), assuming an average body mass of 90 kg (Zhu et al. 2001).

The HomeGrower model involves several steps to preferentially aggregate habitat units by a raster-based function into panda home ranges of varying size (Plume 2001; Roloff & Haufler 1997). The program first randomly distributes points (i.e., random seed; 10,000 were used in this study) on the landscape. The number of points depends on landscape and home range sizes, with the intent to saturate the study area so that all available habitat cells have opportunity to be included in a home range. The number of points is determined iteratively and corresponds to the value where home range counts stabilize. From each random seed, the program then aggregates neighboring core habitat cells into core home range areas. In this study, the core area goal, the minimal amount of continuous core habitat needed by an adult female panda, was 29 habitat units, corresponding to the observed minimal core area size for female pandas in the Reserve (Schaller et al. 1985). A habitat unit is the product of patch size and habitat quality (Roloff & Haufler 1997). Here I assume that if habitat quality was optional, pandas use a core area of 29 ha. Once core areas area identified, the program then aggregates habitat into the core area to define the home range. Here again, the program requires a habitat unit objective, the minimal amount of habitat units needed by an adult female panda; I used 288 habitat units, the allometric home range for female pandas. For both core and regular home ranges, the

HomeGrower program is responsive to habitat quality, recognizing that home ranges are larger as habitat quality declines.

Home ranges continue to grow until a maximum area is attained (1,000 ha in my study, about twice the size of the observed maximal female panda home range in Wolong (Schaller et al. 1985)). If the home range maximum is reached, the program aborts home range growth and the habitat is made available to other home range growth. The program stops when all the random seeds are exhausted. The model output includes a map of home ranges, a log of all the successes and failures in establishing home ranges, and a table recording the basic characteristics of each home range, such as random seed location, home range size, and mean habitat suitability across the home range. The number and spatial configuration of modeled home ranges provides insight into the habitat potential for pandas in the reserve.

The HomeGrower program includes some stochastic processes for home range aggregation, and it is advantageous to iterate the model. For each set of input core area and habitat suitability maps, I iterated the model run 100 times to generate 100 layers of potential home range maps. While each layer results from a common number of random seeds and home range growth criteria, the outputs differ among simulations in both the numbers and distributions of home ranges, because both seed location and home range growth are random processes. The program generates a frequency grid representing the spatial overlay of all home ranges. In my case the frequency values ranged from 0 to 100; a high value indicates that the map cell had a high probability of occurring inside a home range, suggesting that the cell was an important component of panda space use in the study area.

4.2.2 Validation with known panda occurrence data

China's third national panda survey in Wolong Nature Reserve was conducted during the summer of 2000 (State Forestry Administration 2006). I used observed panda occurrence information from the survey to validate the HomeGrower model output. The observed panda locations were overlaid with the panda home range frequency map generated by HomeGrower and the frequency values of each location were extracted. I then continuously binned the frequency range with a moving window of 10 and calculated the frequency of pixels with panda occurrence that fall in each of these shifting bins. This observed frequency was then divided by the frequency of pixels belonging to the same bin across the study area (i.e., expected frequency). This ratio of frequencies (observed/expected) is equal to one if the panda presence or individual locations occur at random. A Spearman-rank correlation coefficient was then calculated between the ratio of frequencies (observed/expected) in each bin and the bin rank. This coefficient, named continuous Boyce Index, is a reliable measure of presence-only based predictions (Hirzel et al. 2006). A model with high accuracy should have a high positive Spearman-rank correlation coefficient. Through this procedure, a continuous observed/expected frequency curve was obtained and a Spearman rank correlation coefficient was calculated using STATA 12.1 (StataCorp 2011)

4.2.3 Assessing impacts of deforestation on panda population potential and distribution

Three time periods, a hypothetical pre-human-settlement period, 1974, and 2001, were selected to study the changes of potential panda population distribution in response to forest cover changes in the Reserve. In the pre-settlement period, it was assumed that all areas under tree line were forested (Fig. 4.1). Information about forest cover for the other two periods was

obtained from Viña et al. (2007). Core area and habitat suitability maps were created for each time period and used as inputs in HomeGrower. The impact of deforestation on the panda population was estimated by comparing the quality, size, and distribution of adult female panda home ranges among the three periods.

4.2.4 Assessing impacts of human disturbance on panda population potential and distribution

A series of GIS analyses were conducted to delineate the spatial coverage of human disturbances around 1974 and 2001 in the reserve. Locations of households in the Reserve were obtained using field measurements with a Global Positioning System receiver with sub-meter accuracy (Trimble Pathfinder Pro XRS receiver with real-time differentiation function) and obtained from IKONOS 1-m resolution satellite imagery (see details in (An et al. 2005; Linderman et al. 2005)). The road and trail network map and road condition information in each period were acquired from the Department of Transportation at Wolong Administration Bureau. In the 1970s there was only one unpaved road along the main river of the reserve. New construction in the 1990s upgraded the main road into an asphalt-paved provincial road. Historical fuelwood harvest sites in the 1970s, 1980s, and 1990s were mapped based on intensive face-to-face household interviews of about 20% of the local households and confirmed in the field (Fig. 4.2, see details in (He et al. 2009)).

A Path Distance function in ArcGIS 10.0 (ESRI 2010) was used to calculate the cost for local people to travel to a specific location to harvest wood and to carry logs back home. While compensating for the actual surface distance traveled along slopes (longer than 2-dimensional surface distance), the Path Distance function also accounts for the horizontal (such as wind effect)

and vertical (considering uphill and downhill differences) factors influencing total locomotion cost.

To parameterize the factors needed to construct a cost surface that reflected the relative difficulty of traveling and carrying logs, a focus group interview was conducted to understand the rationale of how local people selected fuelwood harvest sites. Eight local hamlet heads or seniors with extensive knowledge on local culture, history and geography attended the focus group interview. Through discussion it was determined that the effect of slope (vertical factor in Path Distance function) on traveling and transportation can be best approximated by exponential relationships (Fig. 4.3). Generally it is more difficult to walk uphill than downhill, but walking downhill at >45 degrees angle is avoided. Carrying logs uphill is harder than walking without the weight, but transporting logs downhill was easier, as logs were usually slid on the ground. Vertical factors are relative values, and one unit of traveling cost is not equivalent to one unit of log transportation cost. It was also agreed that the much-improved road condition in the 1990s significantly reduced traveling and transportation costs. After the focus group interview a set of coefficients were assigned to different road conditions to approximate travel and transportation costs. Unpaved, small rock-paved and asphalt-paved roads were assigned with coefficients of 0.5, 0.2, and 0.05, respectively.

Combining the vertical factors, the road effects, and a DEM (90 m resolution; NASA's Shuttle Radar Topography Mission), cost surfaces for traveling and for log transportation in the 1970s and 1990s were created, and subsequently used as inputs for the Path Distance function with households in each township as the input source locations. The outputs were township-level travel cost grids and log transportation cost grids, on which the costs associated with known historical fuelwood harvest locations were extracted and ranked within each township at each

period. For each period the 95% highest traveling and log transportation cost values were chosen as the cost threshold for most households; above this threshold I assumed areas were rarely visited and cut, thus minimizing human disturbance effects on habitat. All map cells within the remaining cost values (i.e., ≤ 95%) were aggregated as potential travel and log transportation zones. Overlapping areas between the two zones in each period were defined as the historical logging focal areas, as they are most prone to be visited and logged. Logging at locations outside the focal area was considered physically irrational as it would not be justified by one or both of the traveling and log transportation costs.

Besides fuelwood harvest, other important daily activities of local residents, such as farming, animal husbandry, and collection of non-timber forest products also occur within logging focal areas, as these areas are readily accessible and are most familiar to local people. Therefore, logging focal areas also represent a zone with concentrated activities by local residents and thus potentially a major source of disturbances to pandas and other wildlife. To assess the marginal effects of these disturbances on panda population, new core area and habitat suitability layers were created by recoding habitat and core area cells in the logging focal area in the 1970s and 1990s into non-habitat. The same process to estimate panda population carrying capacity and distribution was performed with the new habitat maps and the results (1974' and 2001' in Figure 4.4 and 4.5) were contrasted with those from the original core area and habitat suitability maps (1974 and 2001 in Figure 4.4 and 4.5).

4.3 Results

4.3.1 Model validation

Information about panda presence from the third national panda survey in 2000 (Fig. 4.10) was used to validate HomeGrower model output in 2001. In 2000, the panda population size (all individuals beyond juvenile stage, above 1.5 years old) in Wolong Nature Reserve was estimated to be about 140-150 (State Forestry Administration 2006; Wolong Administration Bureau 2004). Based on past studies on the age structure of panda populations in the Reserve and other areas (Hou 2000; Huang et al. 1990; Wang et al. 2002; Wei et al. 1989; Xia & Hu 1990; Zhou & Pan 1997), the percentage of adult female pandas among all individuals above 1.5 years old ranges from 25.3% to 38.7%. The lowest estimate (25.3%) came from a study in Wolong Nature Reserve in 1980s after a large-scale bamboo die-off, during which adult panda mortality and emigration rates were believed to be significantly higher than normal (Huang et al. 1990; Reid et al. 1989). With this special case excluded, the percentage from all other studies ranges between 31.1% and 38.7%.

The adult female population carrying capacity of Wolong Nature Reserve in 2001 is about 56 (SD = 2.2), as estimated by 100 iterations of HomeGrower model runs. Based on the percentage range described above, the panda population carrying capacity in the Reserve as of early 2000s is between 145 (SD = 6) and 181 (SD = 7). The reported population size from the national survey falls at the lower end of this estimation; the estimated maximal panda population carrying capacity is about 25% higher than the reported number. Thus the HomeGrower model simulation suggests that the panda population in the Reserve may be at a level close to the environmental carrying capacity.

Output from the home range model for female pandas and the locations of panda occurrences (Spearman's $\rho=0.74$, $p<0.0001$) was positively correlated (Fig. 4.11). The frequency of documented panda occurrences increased with increasing likelihood of a habitat cell occurring in a modeled home range. This result suggests that the habitat-based home range estimator is useful for portraying the spatial distribution of pandas in the Reserve.

4.3.2 Historical logging focal areas and human disturbance zones

From 1970s to 1990s the size of the logging focal area in the Reserve doubled from 6,005 ha in the 1970s (Fig. 4.6) to 12,605 ha in the 1990s (Fig. 4.7). Within the focal area in the 1990s, the forest cover declined from 80.0% to 52.0%. Deforestation inside the focal area directly led to loss of potential panda habitat. During the same period, 799 ha of highly suitable panda habitat and 2,473 ha of moderately suitable panda habitat were lost inside the focal area. The habitat loss rate inside the logging focal area was 69% faster than outside and the highly suitable habitat loss rate was 233% faster inside than outside. Among the 449 panda signs found in the Reserve during the 2001 national panda survey, only 25 (~5.6%) were inside the logging focal area, and most of these were located close to the boundary (Fig. 4.7). The spatial distribution of panda occurrences confirmed the disturbance effects of human activities on panda distribution (Liu et al. 1999), although >6,000 ha of potential habitat still existed, including 1,525 ha of highly suitable habitat, in the logging focal area.

4.3.3 Habitat-based estimation of panda population size and distribution

The Reserve's carrying capacity for adult female pandas declined from an estimated 101 individuals during the pre-settlement period to 91 in 1974, and to 65 in 2001 (Fig. 4.4). The mean home range size increased from 303 ha in the pre-settlement period to311 and 348 in 1974 and 2001, respectively (Fig. 4.7).

When the historical disturbance zones were imposed on the 1974 and 2001 habitat maps, the estimated carrying capacity declined and the estimated mean home range size increased. In 1974, the indirect human disturbances caused the carrying capacity to decline by about 3.3% (Fig. 4.4) and the mean home range size to increase by 1.0% (Fig. 4.5). In 2001, the indirect human disturbances caused the carrying capacity to decline by about 14.1% (Fig. 4.4) and the mean home range size to increase by 1.1% (Fig. 4.5).

When examining the spatial distribution of the home ranges, connectivity of home ranges was higher in the pre-settlement period (Fig. 4.8) than in the other two periods (Fig. 4.9 and 2.10). In the pre-settlement period, most modeled adult female home ranges appeared physically connected into one single large population, with a few small home range patches distributed at the end of several narrow valleys (Fig. 4.8). By 1974, due to deforestation across the Reserve and disturbance in areas immediately around residential areas, the large population was divided into two subpopulations in the north and south of the Reserve, with more individuals distributed sporadically in several valleys to the north of the main river and road (Fig. 4.9). By 2001, the two sub-populations appeared to be more segregated and the smaller one in the north appeared more fragmented. The sporadic home ranges that used to exist in the north side of the main river seemed to be disappearing (Fig. 4.10). This modeled spatial configuration of the panda distribution in the Reserve corresponds with experts' knowledge in this area (Yan & IUCN/SSC

Conservation Breeding Specialist Group 1999). The genetic exchange between the two sub-populations was believed to be at a low level (Yan & IUCN/SSC Conservation Breeding Specialist Group 1999), and only three cases of panda crossing the main river/road have been observed in the past 15 years (Personal communication, Zhang Hemin).

4.4 Discussions

Using the best available knowledge on panda habitat suitability and panda territorial behavior (e.g., core area size and requirements), a habitat-based approach was implemented to assess panda population potential and distribution in Wolong Nature Reserve, China. The modeled panda population carrying capacity matches the estimated panda population based on the third national panda survey in 2000. The spatial correspondence between modeled adult female panda distribution and observed panda presences was significant. Techniques used in the national survey did not allow for differentiating presence of adult female pandas from those of other age and gender groups. Sex ratio in wild panda populations was estimated to be 1:1 (Wei & Hu 1994; Zhou & Pan 1997), thus more than half of the panda occurrence found during the 2001 census were probably from adult male pandas or sub-adult pandas, which may explain the observed omission errors (i.e., 30.9% of the observed panda occurrence were located in areas where the modeled home range frequency is 0). There are also a couple of areas showing commission errors, such as habitat patch located at the center and southwest corner of the Reserve (in light orange color in Fig. 4.10). The former area was not surveyed in 2000, but panda presence was later confirmed by field observations in 2006 and 2007. The latter area, despite being suitable for adult female pandas, was not occupied probably due to dispersal limitations (Pulliam 2000) for pandas from the south of the main river.

Assuming that the panda population consistently contains 31-39% adult females, the potential panda population size before human settlement is estimated between 260 and 320, and population carrying capacity in the 1970s is estimated between 230 and 280. The 1970s estimate is higher than the official reported number of 145, or 130-150 as estimated by Schaller et al. (1985), from the first national panda survey in 1970s. There could be several reasons for this discrepancy. First, technological and logistic limitations in 1970s potentially resulted in a higher number of undetected pandas (compared to the survey conducted in 2000). Second, the Chinese government in the 1970s intentionally under-reported the number of remaining wild pandas from an estimated 2400-2500 to approximately 1100, likely to increase panda value as diplomatic gifts (Hu 2001; Yu 2005). Thus there is a chance that the panda population size in Wolong Nature Reserve was also under-reported. Third, wildlife hunting and poaching was prevalent in and around the Reserve before the 1990s (Schaller 1987; Schaller 1994) and panda populations could have been existing at levels below the carrying capacity, just like most modern bear populations (Garshelis 2002).

One limitation of the panda habitat suitability model employed in this study was that the distribution and quantity of bamboo, the staple food species for giant pandas, was not included in the habitat assessment. As the bamboos are understory species, mapping bamboo distribution across a large landscape is more challenging than mapping forests. With the aid of high temporal resolution remote sensing imageries, such as those collected by Moderate Resolution Imaging Spectroradiometer (MODIS), the distribution of two major bamboo species in Wolong Nature Reserve have recently been mapped (Tuanmu et al. 2010). However, the limited temporal availability of MODIS data (from the 2000s to the present) prevented me from creating historical distributions of bamboo. However, missing the bamboo information may not drastically affect

my results. At least eight bamboo species exist in the Reserve, at least 90% of which are the two principle food species of pandas – arrow bamboo and umbrella bamboo. These bamboos are widely distributed in all major forest types (Schaller et al. 1985). Bamboo cover of 100% may not be a necessity for suitable panda habitat. For example Pan et al. (Pan et al. 2001) found in the Qinling mountains (the only other area with similar high density of wild pandas as Wolong), that pandas consumed only a negligible proportion of the annual bamboo growing stock. In fact, pandas may favor moderately patchy over large continuous bamboo distribution, because the patchy configuration allows them to move more freely. Johnson et al. (Johnson et al. 1988) found that pandas did not change their daily and seasonal activity patterns for at least three years after a massive bamboo die-off in Wolong Nature Reserve that reduced bamboo coverage from 55% to 13%. Bearer et al. (Bearer et al. 2008) also demonstrated that bamboo cover "did not need to be extremely high (>17%) in order to be panda habitat". Thus a moderate level of bamboo coverage, which is common in most forests in Wolong, may suffice for the needs of pandas. This may explain why the categorical habitat suitability model without bamboo information has been successful in predicting panda habitat use in the Reserve (Viña et al. 2008).

Another important finding from the modeling results was that panda habitat potential showed high sensitivity to historical habitat loss and degradation, even though these activities were relatively isolated around roads and human activity centers. From the pre-settlement scenario to 1974, the carrying capacity of the Reserve for adult female pandas declined from over 100 to about 88. This reduction (12.5%) is about twice that of absolute habitat lost during the same period (6.4%), which underscores the fact that logging and human disturbances were offsetting higher quality panda habitat. From 1974 to 2001, the Reserve lost 25.1% of its potential panda habitat and 20.9% of the highly suitable habitat, and the carrying capacity

declined 36.2%. The model results indicate that the impact of habitat loss, fragmentation, and degradation on panda populations may escalate as habitat potential is continually compromised, particularly if impacts are occurring in critical habitat areas. Herein lies one value of using a habitat-based approach to viability assessments, i.e., to identify critical habitat areas for conservation priority.

Loss and fragmentation of animal habitats has significant fitness consequences for both sexes. First, it is shown that as panda population carrying capacity in the Reserve declines, the mean adult female panda home range size increases (Fig. 4.5), indicating that mean habitat quality within home ranges declined and on average adult females need maintain a larger home range to attain the same habitat goal. Mean habitat quality within home ranges may be used as index to fitness (e.g., survival, pregnancy rate, newborn survival; see Roloff and Haufler 2002: Fig. 60.2). Home ranges with higher mean habitat quality would potentially support more consistent levels of reproduction than those with lower values (Roloff and Haufler 2002: Fig. 60.2). There may also exist a minimum quality threshold below which reproduction in a home range is not supported (Roloff & Haufler 1997). Second, as habitats become fragmented, mating cost for males may increase. Increasing distances among adult females may force adult male pandas to expand their home ranges and spend more energy monitoring potential mates. In the short mating season for pandas, usually 1-2 weeks in early April, males would need to travel longer distances for successful mating with multiple females. Therefore, the combination of a low daily energy budget and short mating season of giant pandas may reduce the fitness of adult males and their chances of successful mating, as the level of habitat fragmentation increases.

In conclusion, by coupling a novel modeling tool with rich data and knowledge about panda biology and past land use and land cover changes in Wolong Nature Reserve, we were

able to reconstruct the history of panda population decline and range shift, and established a clear association between modeled panda population changes and observed human-induced habitat loss and degradation. The cumulative impacts of selective logging across a long time period on panda populations was quantified, as was the marginal effect of disturbances that competitively excluded pandas from around human settlements.

As deforestation in the Reserve has been reduced in recent years (Viña et al. 2011), tourism and livestock grazing, which are increasing significantly in the Reserve have increased and may become important sources of disturbance for wild pandas. The approach used in this study can be easily adapted to evaluate potential impacts of these new threats on panda populations. Besides utility in predicting population potential and distribution, this habitat-based population mapping approach may also be used to compare the potential impacts of different conservation and development scenarios in terms of population viability goals. One of the greatest challenges facing reserve managers in Wolong and other parts of the world is the evaluation of the effects of individual land use options on endangered species population viability and biodiversity, especially over large and/or complex landscapes. The approach used here may provide a useful tool to assess the tradeoffs associated with alternative land management choices and make informed decisions to enhance the conservation of biological resources.

Figure 4.1 Panda habitat suitability map under the pre-human settlement scenario, in which all areas under the tree line are assumed forested. By early 2000s over 1000 local households occur in the reserve, mostly along the main river that traverses from northeast to southwest.

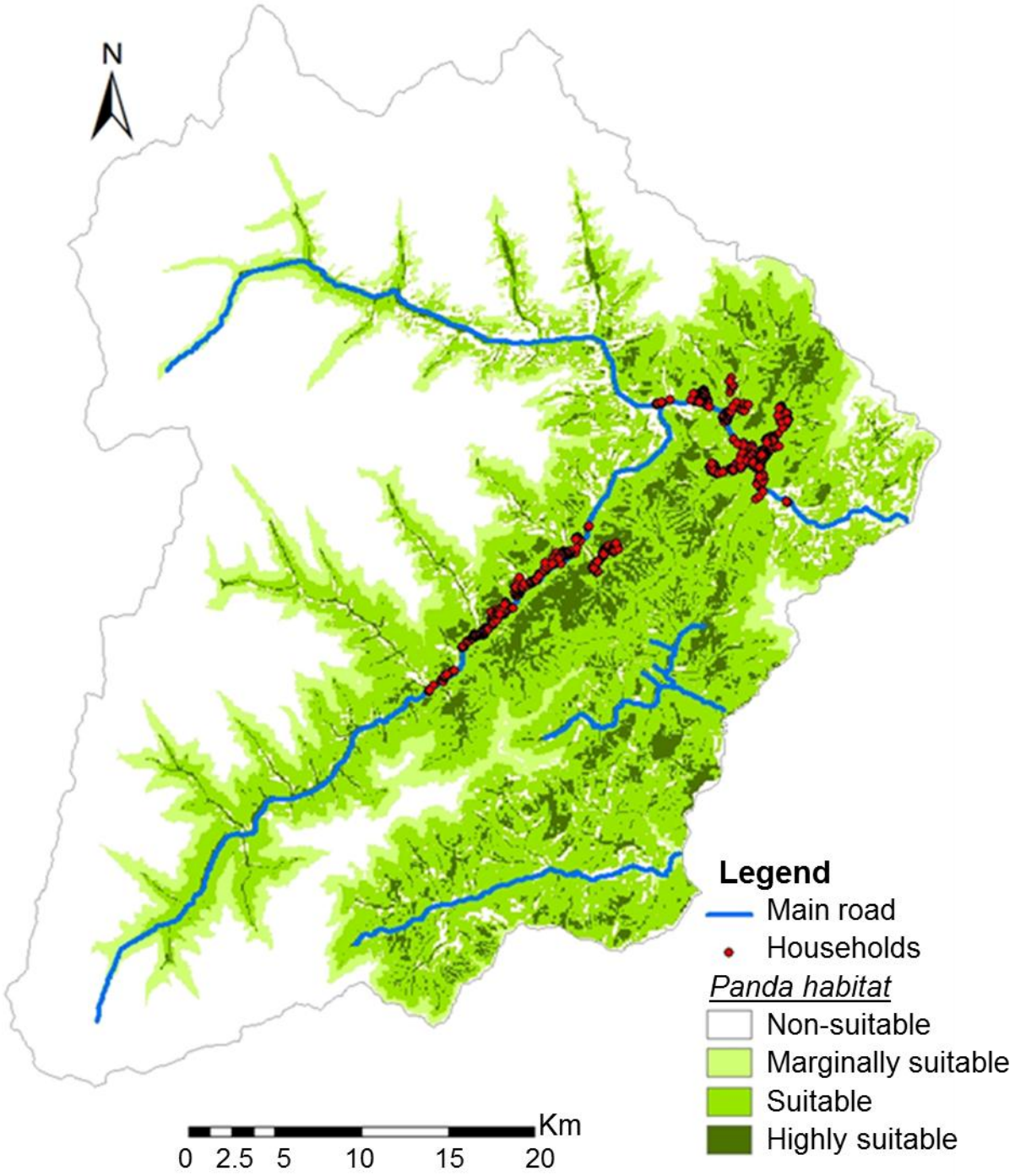


Figure 4.2 Examples of historical fuelwood harvest locations in Wolong and Gengda townships in Wolong Nature Reserve, 1970s to 1990s.

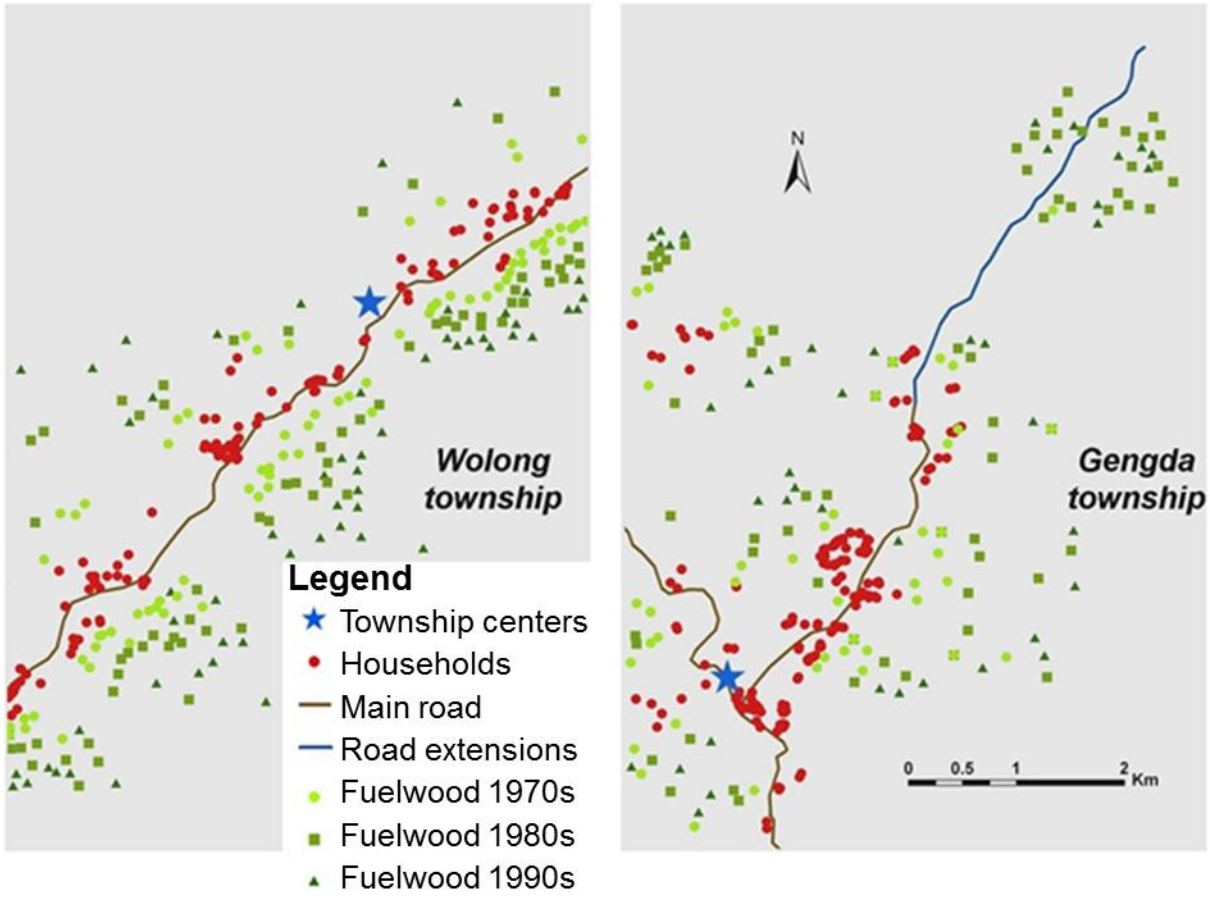


Figure 4.3 Vertical factors as derived from topographic slope for traveling and log transportation cost analyses. Relationships are based on focus group interviews with knowledgeable local people from Wolong Nature Reserve, 2007.

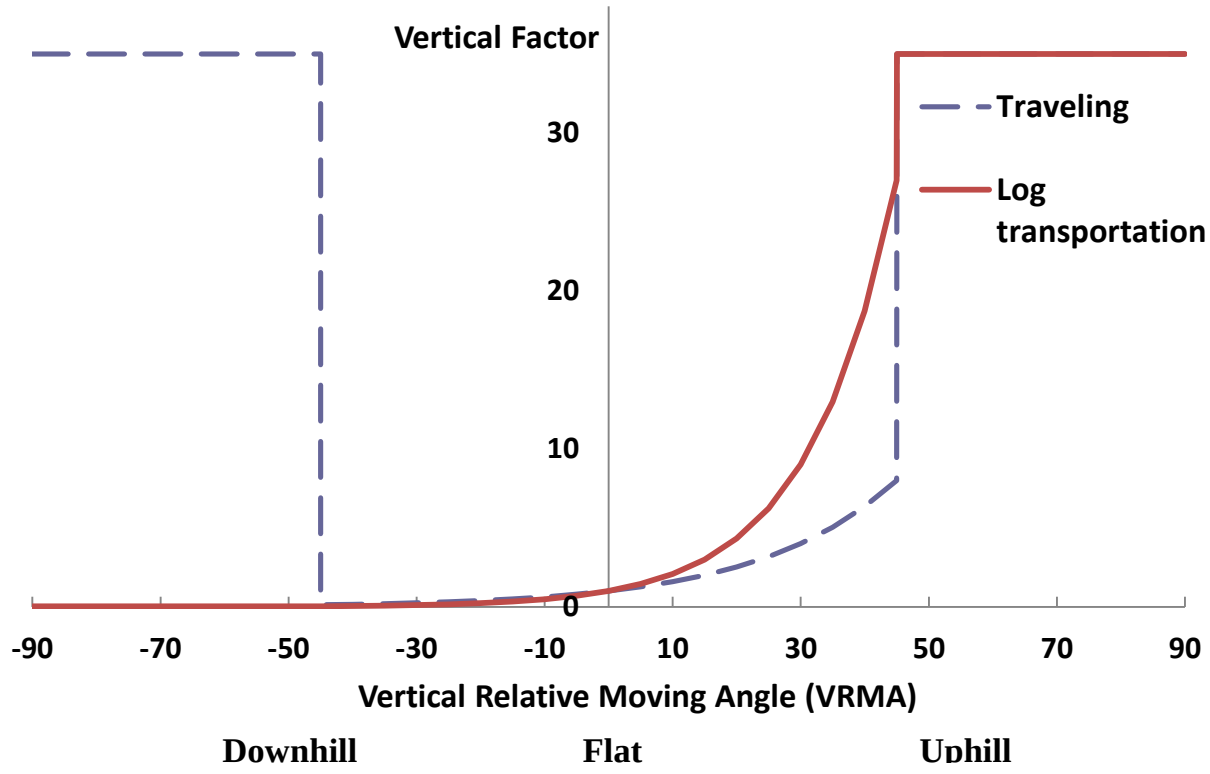


Figure 4.4 Mean model numbers of adult female panda home ranges in Wolong Nature Reserve based on habitat suitability maps in three time periods (standard deviations shown as error bars). The lighter grey bars show the mean modeled numbers when logging focal areas (Figures 4.4 and 4.5) are excluded from the panda habitat maps that were input into HomeGrower.

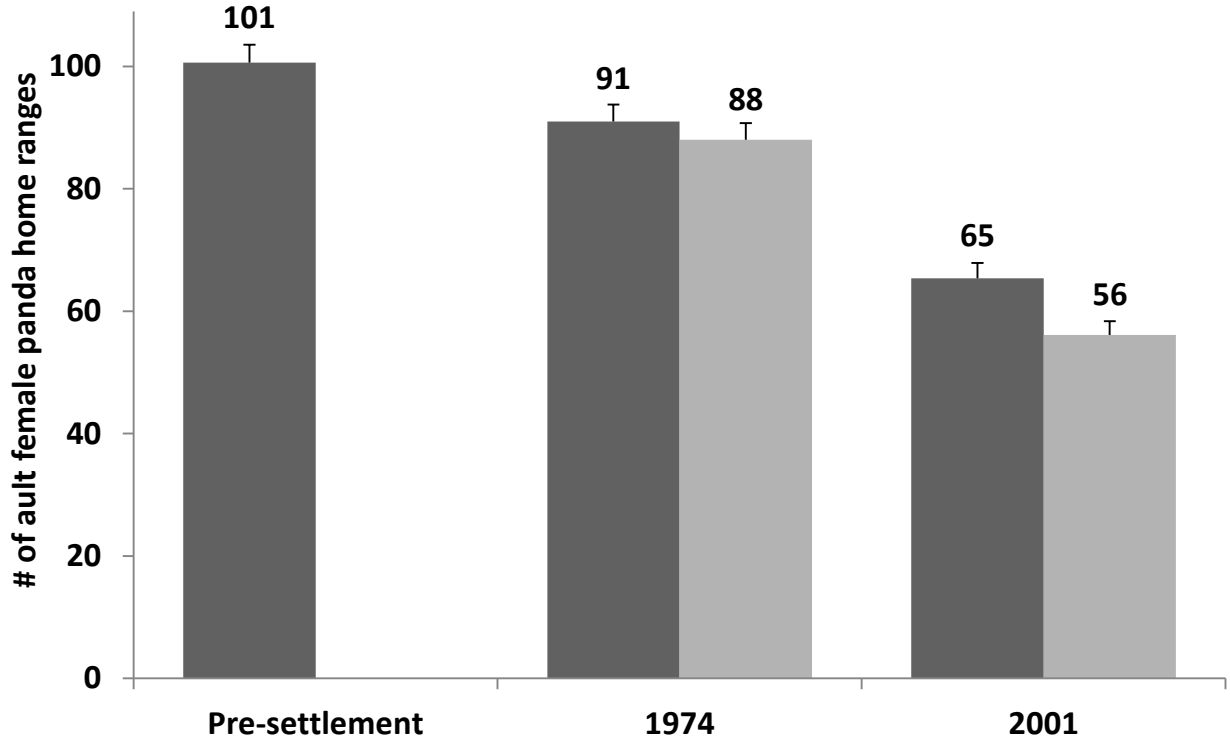


Figure 4.5 Mean modeled sizes of adult female panda home ranges in Wolong Nature Reserve based on habitat suitability maps in three time periods (standard deviations shown as error bars). The lighter grey bars show the mean modeled sizes when logging focal areas (Figures 4.4 and 4.5) are excluded from the panda habitat maps that were input into HomeGrower.

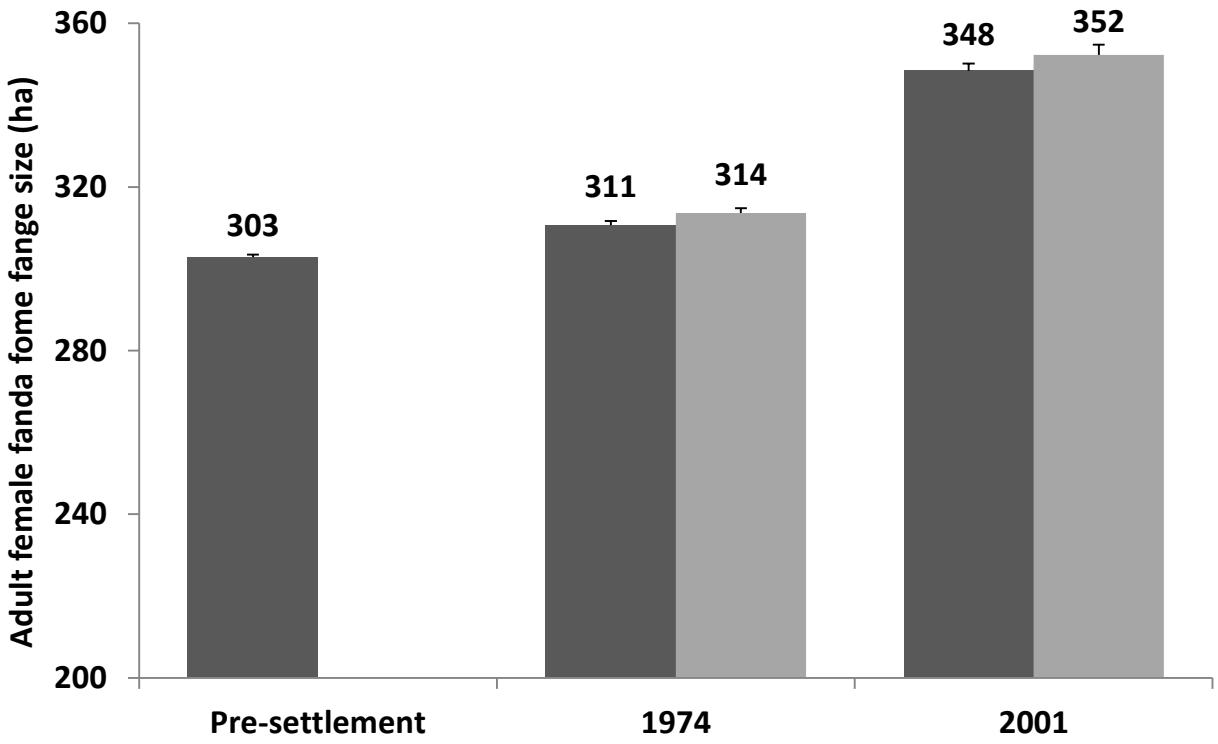


Figure 4.6 Logging focal areas (pink area) in 1970s and panda habitat suitability map in 1974 in Wolong Nature Reserve.

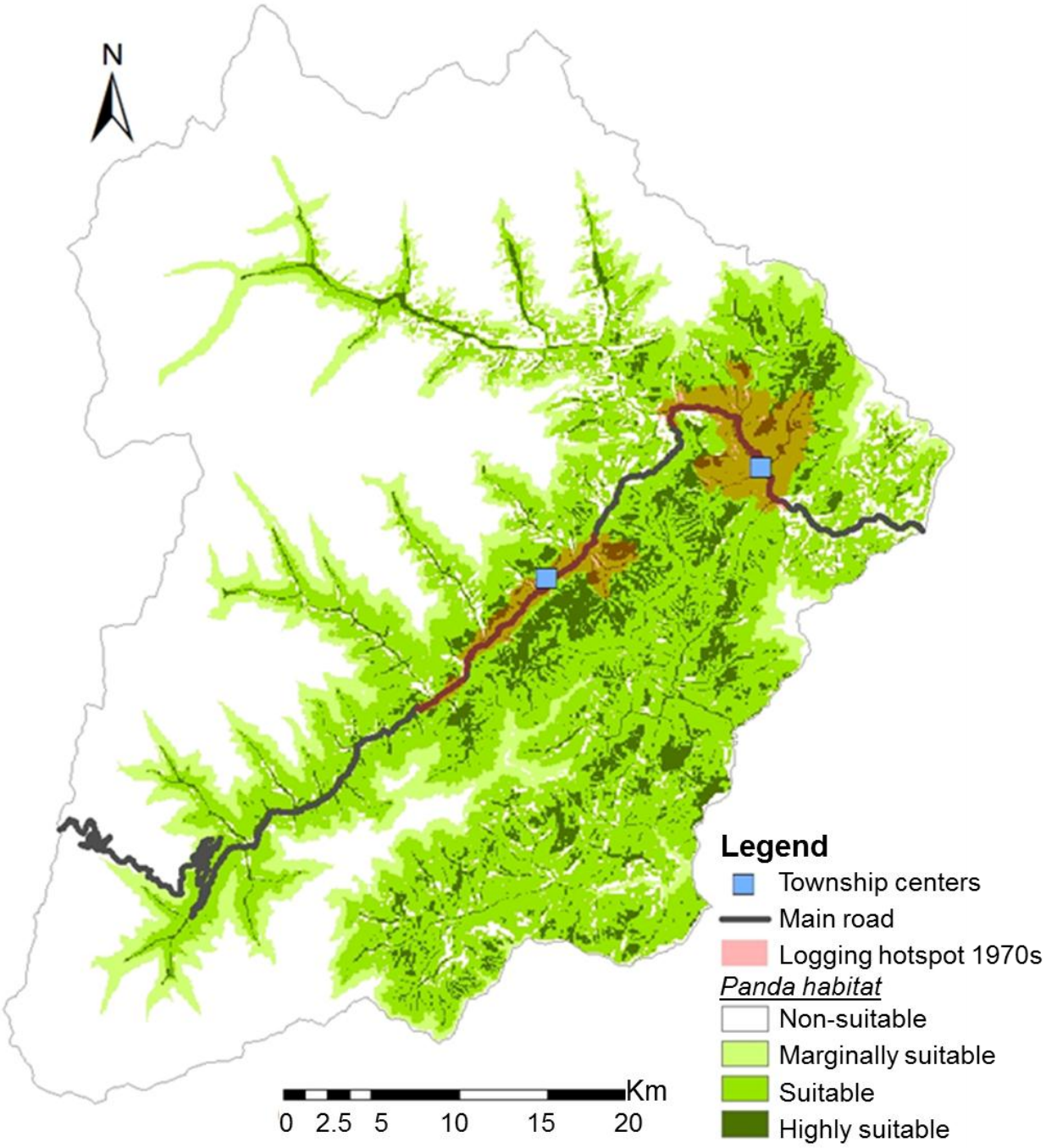


Figure 4.7 Logging focal area in 1990s and panda habitat suitability map in 2001. Only 25 (~5.6%) of all the panda signs found in the third national panda survey in 2001 were inside the area, most of which are close to the boundary.

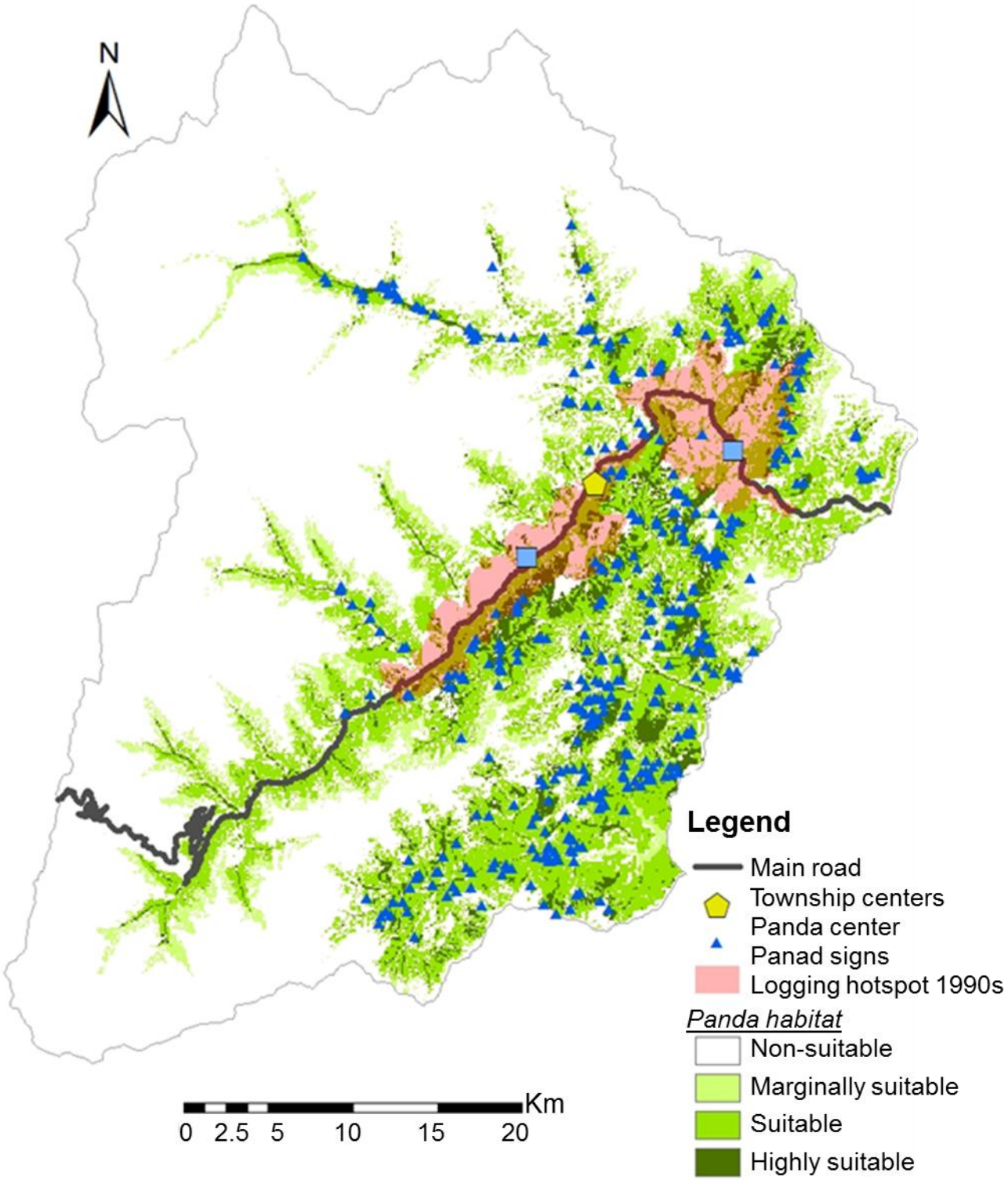


Figure 4.8 Frequency map of modeled adult female panda home ranges in the per-settlement period. Out of 100 HomeGrower model iterations, pixels in greener areas appear more frequently in adult female panda home ranges.

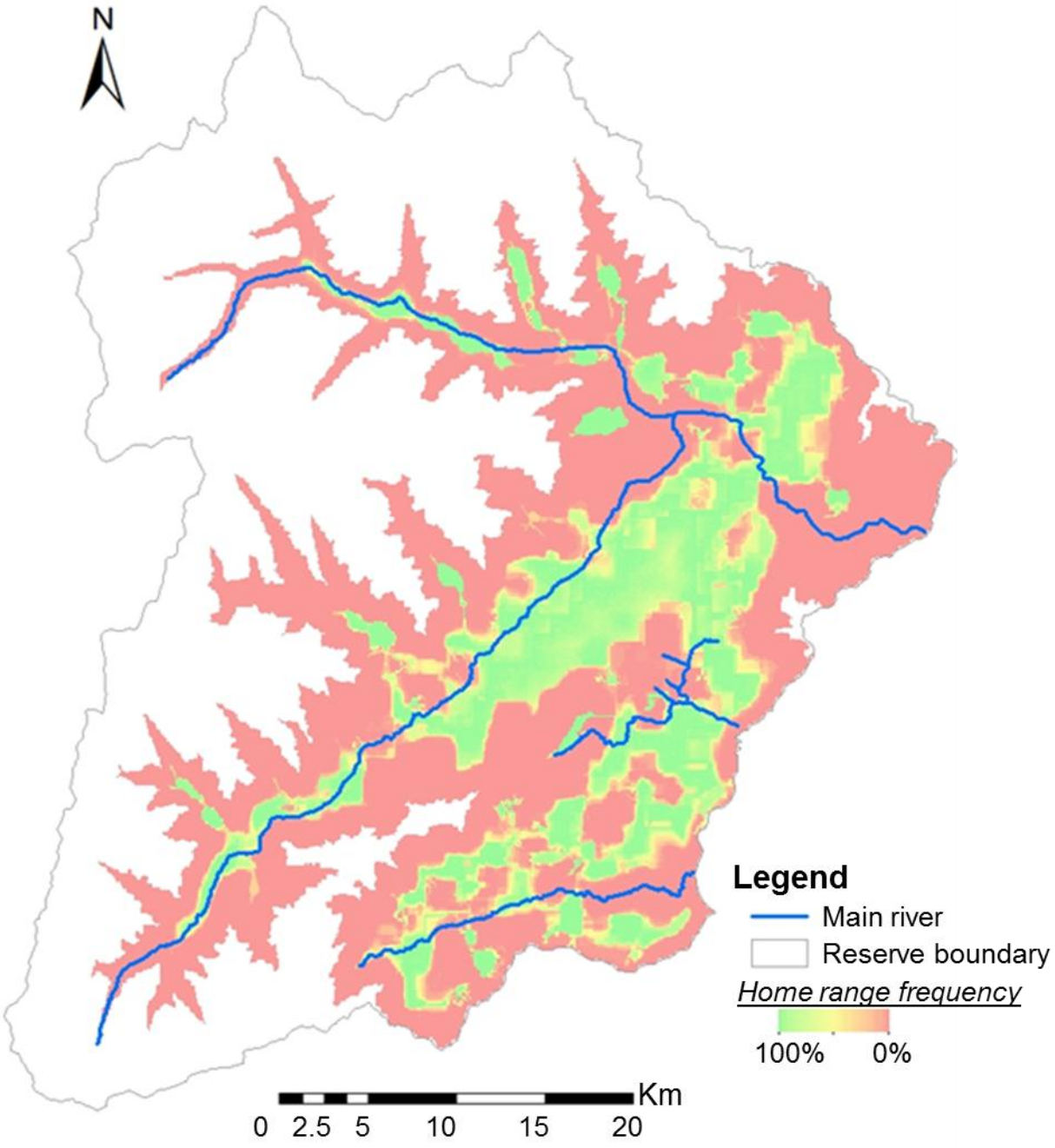


Figure 4.9 Frequency map of modeled adult female panda home ranges in 1974. The logging focal area (Fig. 4.4) in 1970s was excluded from the panda habitat maps input into HomeGrower.

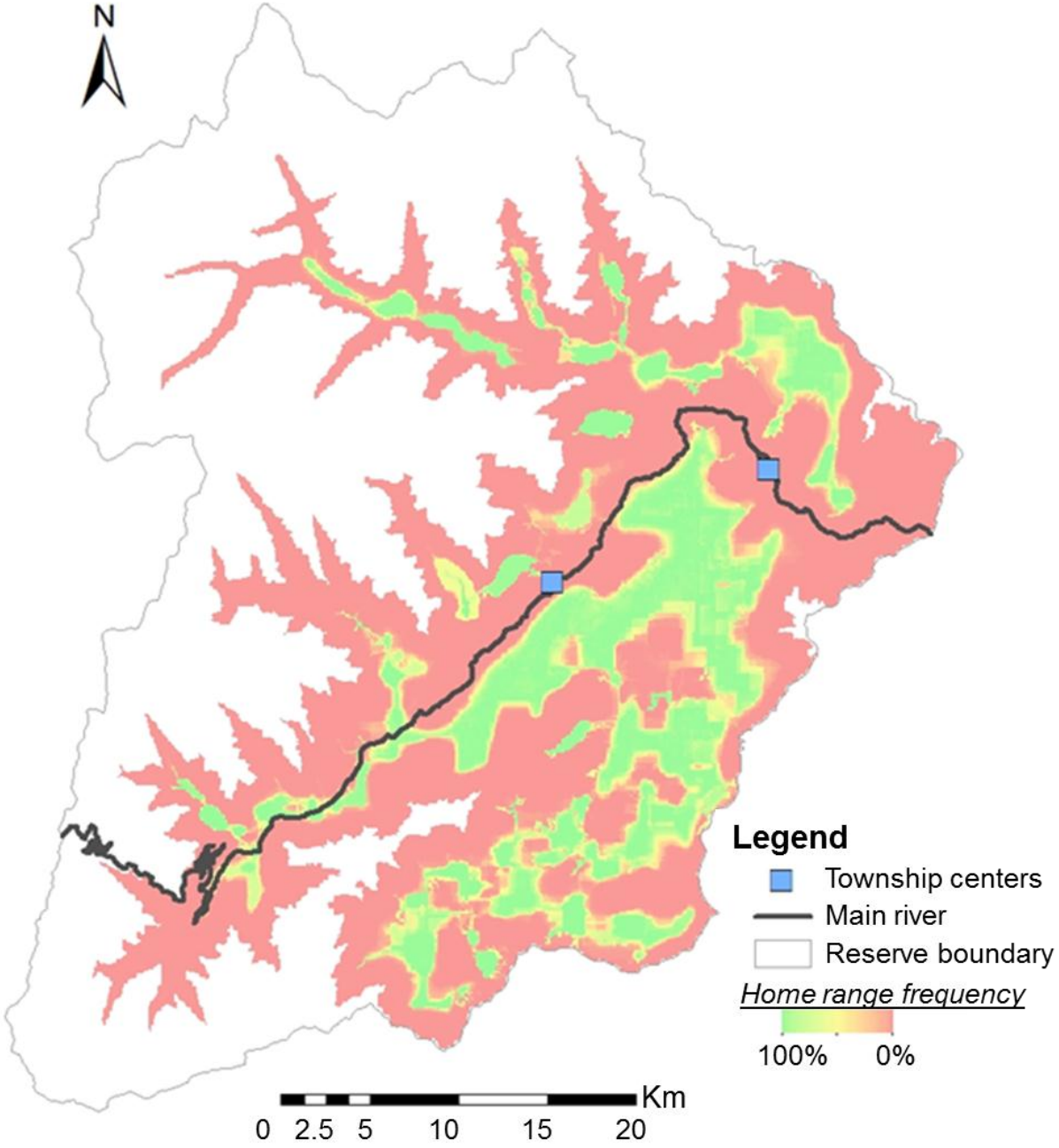


Figure 4.10 Frequency map of modeled adult female panda home ranges in 2001 and the locations of panda occurrence in the 2000 national survey. The logging focal area (Fig. 4.4) in 1990s was excluded from the panda habitat maps input into HomeGrower. More observed panda occurrences in the national panda survey in Wolong Nature Reserve in 2000 tend to locate in high frequency areas.

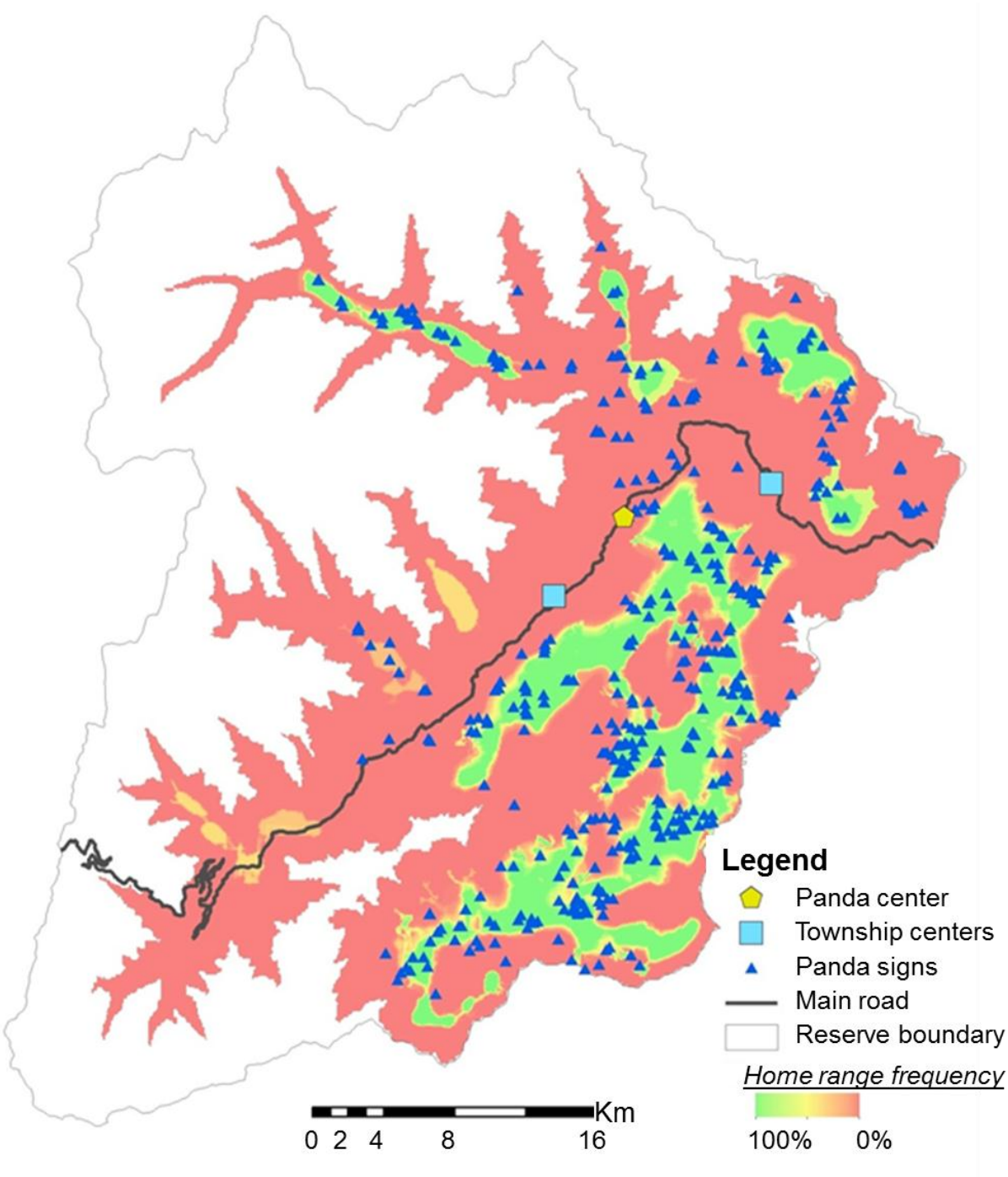
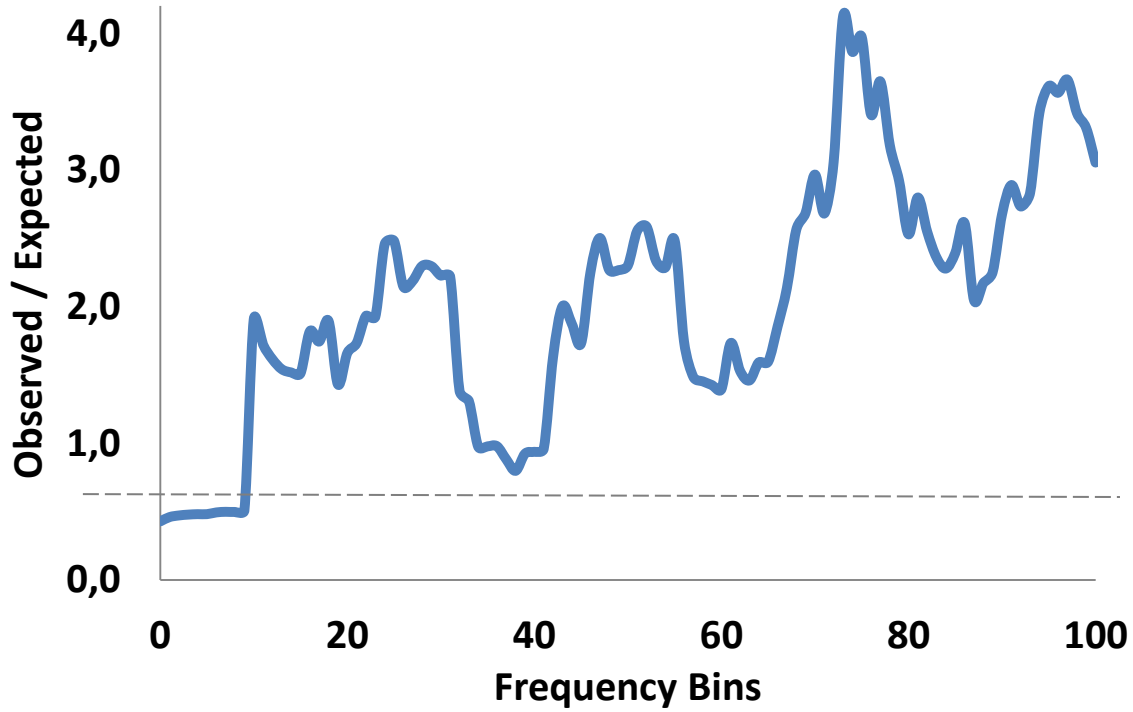


Figure 4.11 Validation results for the home range frequency map. The frequency of documented panda occurrences increased with increasing likelihood of a habitat cell occurring in a modeled home range (Spearman's $\rho=0.74$, $p<0.0001$).



CHAPTER 5

ECOLOGICAL IMPACTS OF TOURISM IN WOLONG NATURE RESERVE

5.1 Introduction

Globally the demand for nature-based tourism in landscapes and seascapes is growing (Conservation International 2003). Protected areas, because of their natural, ecological, and cultural values, are increasingly being managed to accommodate this demand. As public visitation to protected areas increases, tourism has emerged as a new major threat to biodiversity and endangered species (Conservation International 2003; Millennium Ecosystem Assessment 2005).

Visitation to protected areas may cause various types of unfavorable disturbances and negatively affect soil, vegetation, wildlife and water (Hammitt & Cole 1998; Leung & Marion 2000). For example, trampling from tourists may result in reduced cover of ground vegetation, loss of fragile plant species, and introduction of invasive exotic plant species and cause soil compaction and accelerate soil erosion. Tourists may also affect wildlife directly through behavioral modification and indirectly through habitat alteration and degradation. Existing studies on the ecological impacts of tourism on natural landscapes have been predominantly conducted in developed countries, while relatively few studies have been conducted in developing countries, such as China (Huang et al. 2007). Considering the importance of biodiversity in developing countries and the fact that nature-based tourism in protected areas are increasing faster in developing countries (Balmford et al. 2009), more research on this topic is urgently needed.

The recent expansion of tourism in China is one of the highest in the developing world. By the late 1990s, over 80% of the 2,000 nature reserves that occurred in China had tourism development (Han & Ren 2001). Recently more protected areas of new types, such as forest parks and wetland parks, have been established in China, with tourism being their main function

(Wang et al. 2012). A common pressing issue faced by protected areas in China is the increasing adverse impacts from tourism, including ecological degradation (Han & Ren 2001; Zhong et al. 2011) and threats to endangered species survival, such as the famous giant pandas (*Ailuropoda melanoleuca*).

Over 60 nature reserves have been established to protect pandas in China. A series of national conservation policies have also been implemented that stops logging in natural forests and encourages the return of croplands to tree plantations (Liu et al. 2008; Loucks et al. 2001). Since the early 2000s, tourism has emerged as one of the top sources of human disturbance in panda reserves (State Forestry Administration 2006), including Wolong Nature Reserve. Tourism development in Wolong Nature Reserve has a history of >25 years, but the pace of development increased after a road upgrade program was finished in the late 1990s to better connect the reserve to nearby metropolitan areas (Liu et al. 2012). The most famous attraction in Wolong was the China Center for Conservation and Research of the Giant Pandas (CCRCGP), where the largest in-captive panda population is housed. The Center has attracted tourists from around the world. The road also made Wolong part of a cluster of tourism destinations in the Aba Tibetan and Qiang Prefectures and many tourists traveling to Western Sichuan passed through the Reserve. As a result, annual visitation to the reserve quickly increased from about 20,000 in 1995 to over 220,000 in 2006 (Wolong Administration Bureau 2009a).

Since the early 2000s, a small but increasing proportion of tourists chose to hike off-road into the more remote areas of the Reserve. Some trekkers, usually guided by local people from inside the reserve or adjacent townships started to explore abandoned or semi-abandoned trails that were historically only used by local people before the first road was paved into the reserve in the 1960s. These trails connect one of the township centers in the reserve to the centers of three

townships located adjacent to the reserve in the west, northeast, and southeast (Fig. 5.1). These trails traverse critical panda habitat that was rarely visited by humans, including local residents, for decades. Hiking on remote trails, if not well regulated, may adversely disturb wildlife, including the endangered pandas.

Pandas are solitary animals except during a short mating season of 1-2 weeks in early spring (Schaller et al. 1985). Pandas have a strict diet on bamboo (99% of their diet) and their low ability to digest macromolecules result in a tight energy budget on a daily basis (Hu 2001; Pan et al. 2001; Schaller et al. 1985). Pandas tend to avoid areas of heavy human influence (Hu 2001), since encountering humans often result in unnecessary locomotion (for both avoiding humans and finding other feeding sites). Additionally, stress associated with encountering humans may further burden their energy budget. During the mating season (early April in Wolong Nature Reserve), any disturbance that disrupts mating may have significant long-term negative consequences on the population. In the seasons thereafter (i.e., fall and winter) females give birth to new offspring. During this period, to protect the juveniles, females are extremely sensitive to disturbances (Hu 2001; Pan 2005; Pan et al. 2001; Schaller et al. 1985). Overall disturbance to reproductive adult female pandas in the wild may put them under higher pressure and affect their fitness and reproduction success.

No systematically designed study to assess the impacts of tourism development on panda habitat and populations has been conducted. The goal of this study was to integrate field surveys with model simulation to study the ecological impacts of tourism in Wolong Nature Reserve. My specific objectives were to (1) identify factors influencing plant species assemblage on and around the trails in the Reserve, (2) assess the influence around trails on potential habitat of giant pandas, and (3) assess the potential long-term influence of trail use on giant panda population

capacity in the Reserve. From this research, I suggest management implications for protected areas where coexistence of wildlife and tourism is needed.

5.2 Methods

5.2.1 Data collection

5.2.1.1 Trail surveys

Between the summer of 2006 and the fall of 2008, I mapped all major trails used by tourists in the Reserve using a Global Positioning system (GPS) receiver (Fig. 5.1). Levels of visitations on the trails were estimated in 2007 based on information obtained through interviews with local conservation stations, the Department of Natural Resources Management of the Reserve, and local people who had experience guiding tourists on the trails. The interviewees were first asked to identify segments of trails beyond which tourist uses dropped significantly, based on which the trail segments were divided into two categories – heavily used and lightly used. All heavily used trail segments experienced at least a few thousands of tourists annually. The interviewees were also asked to estimate the total number of tourists to different key locations along four trails (see next paragraph) accurate to one hundred people.

Vegetation surveys (n=64) were conducted along four trails, Qicengloughou, Niutoushan, Wuyipeng, and Yeniugou (trails with the pink triangles, showing the survey sites, from east to west in Fig. 5.2) between June and August of 2007. Elevation ranged between 1600m and 3200m, crossing all major forest types of the reserve. Vegetation survey sites were located with a systematic random sampling strategy. A random location on the trail, within 100 meters from the start of the trail, was selected as the initial survey site. Sites were then selected at regular

intervals 200-300 m (depending on topography). The location (latitude/longitude) of each site was geo-referenced using the GPS receiver, which was also used to collect site elevation. Slope and aspect (i.e., slope azimuth) were determined using a clinometer and a compass. Signs of human uses in the surrounding areas, such as recreation, livestock grazing, and littering, were also recorded.

At each site two sets of quadrats were established (Fig. 5.3). As impact of tourists' uses on vegetation are usually most prominent immediate alongside the trail (Hall & Kuss 1989), the first set of quadrats was established just at the site location on the trail and include one 10 by 10m quadrat centered on the trail (with two edges parallel to the trail) and one 1m by 1m quadrat, with its boundary alongside the edge of the trail. Two control quadrats of the same sizes were located 10m away from the trailside quadrats. This control quadrats were considered to be located inside forest interior, but with similar topographic, vegetative, and edaphic characteristics.

In each of the 10m by 10m quadrats, all woody plant individuals with heights ≥1m were counted and species recorded. Stem diameters (diameter at breast height; DBH) for all live trees with DBH ≥5cm were measured with a diameter tape. All trees with DBH ≥5cm were collectively treated as the tree vegetation layer. All other smaller woody individuals were pooled as a shrub, sapling, and seedling vegetation layer. As bamboo is a dominant understory characteristic of all major forests types in the reserve and a critical component of panda habitat, we also recorded bamboo species composition and estimated relative coverage in each quadrat. In each 1m by 1m quadrat, all plant species with height lower than 1m were identified and coverage estimated. These plants constitute a sample of the herbaceous vegetation layer.

5.2.1.2 Panda sign surveys

We followed standard procedures used in the national panda surveys (State Forestry Administration 2006) to locate signs that confirmed wild panda presence (e.g., feces, sleeping bed, dens, feeding sites etc.) in their forest habitat. Transects (20m wide) were centered on trail segments of compass bearings and walked by 2-3 people who identified and geo-referenced panda signs. Panda signs found within 50m of a previously identified sign were grouped into a single record. This survey occurred once a season in 2006 and 2007. Additional panda presence information in 2005-2007 was also obtained from the Reserve's Department of Natural Resources Management, who also conducted seasonal panda surveys using the same protocol, but covered a larger area.

5.2.2 Data analysis

5.2.2.1 Measuring and modeling floristic similarity between trailside and forest interior

Floristic similarity among the trailside and forest interior vegetation quadrats was evaluated to assess the impacts of human trail use on vegetation along the trails. Similarity index matrices (Jost et al. 2010) were calculated for each pair of quadrats along trail side and in the forest interior in all the 64 sites using abundance (i.e., stem density, coverage) data. The Morisita-Horn index (Horn 1966) was calculated for each of the three vegetation layers. The index ranges from 0 to 1. If the species compositions of two quadrats are completely different, the index is 0, and if the species occur in the same proportions in both quadrats, the index is 1. For the shrub, sapling, and seedling layer, Morisita-Horn index was calculated with bamboo species excluded, since stem densities of tree and bamboo species are not comparable.

Ordinary least square (OLS) regression models were developed to identify significant biophysical, vegetative, and human disturbance characteristics that potentially affect the floristic similarity between trailside and forest interior quardrats. The biophysical variables include elevation, slope, and annual solar irradiation (light conditions) and wetness conditions of the site (Table 5.1). Annual solar irradiation represents potential incident radiation and heat load, portrayed as the heat load index (McCune 2007; McCune & Keon 2002), and was calculated from a Digital Elevation Model (DEM). Compound topographic index (Gessler et al. 1995) was computed to represent wetness based on DEM. The vegetative variables included basal area and a binary bamboo variable on whether the two quadrats combined had bamboo coverage above 25%. Human disturbance variables included Euclidian distance from each site to the main road, the estimated annual number of hikers using the segment of the trails associated with each sites, and a three-category grazing index. Sites on trail segments used by local people as passages to take their cattle or yaks to pasture lands were considered light grazing. Sites in areas along trails where cattle or yak stayed at least a season were considered intensive grazing. All other sites were denoted as not affected by grazing. Two binary variables (Table 5.1) were created to represent the grazing pressure in the OLS model.

5.2.2.2 Assessing the impacts of human trail-uses on the giant panda habitat use and populations

All panda presence locations compiled from the two sets of survey records were mapped in GIS. The Euclidian distances from each presence location to the nearest local household, road, and heavily used trails (Fig. 5.1) were computed in ArcGIS 10.0. It was assumed that human disturbances were concentrated in areas close to human activity centers and the 5th percentile nearest distance was treated as a threshold below which pandas tend to avoid human influence.

Bias-corrected and accelerated (BCA) bootstrapping (Efron 1987) was conducted to estimate the confidence intervals of the 5th percentile distances. BCA bootstrapping adjusts for both bias and skewness in the bootstrap distribution and provides an accurate estimate with reasonably narrow intervals (Efron 1987).

To investigate the potential long-term impact of human disturbance on pandas resulting from increasing recreational use of panda habitat, habitat-based home range mapping procedures were used (Roloff & Haufler 1997, 2002). Four sets of panda habitat suitability index (HSI) and core area maps were constructed to represent different development and conservation scenarios. These scenarios include: 1) vegetation potential, 2) local household impacts, 3) all human impacts, and 4) all human impacts with increased trail use.

For the vegetation potential scenario, a 2007 forest map from Viña et al. (Viña et al. 2007) was combined with elevation and slope maps to produce a four-category panda habitat suitability map, following the procedures in Liu et al. (Liu et al. 2001). No human disturbance was considered in this scenario. The habitat-based approach to modeling home range was used to estimate the potential distribution of adult female panda home ranges for the Reserve. These home ranges were used as an estimate of carrying capacity and potential spatial distribution of pandas. Signs of forest transition was observed in Wolong Nature Reserve, probably due to the implementation of two national forest conservation programs since early 2000s (Viña et al. 2007). The results of this scenario thus represent a maximal potential gain of panda population induced by the implementation of conservation programs.

In the local household impact scenario, two buffers were created around the local households locations. The upper and lower bound of the confidence intervals of the 5th percentile distance between panda presence locations and local households were used as the

buffer distances. These two areas were used to approximate the range of the extent of human disturbance when only residential impact was considered. These buffered areas were used as masks to re-code habitat pixels in the categorical habitat suitability maps to non-habitat pixels, to simulate a realized habitat suitability map. Then the same procedures of creating HSI and core area maps and running HomeGrower simulations as above were followed to generate adult female panda carrying capacity and distribution predictions in this residential impact scenario in 2007.

In the all human impacts scenario, potential disturbance effects of local households, roads and trails were simultaneously evaluated. Two buffered areas were created around local households, the roads and the heavily used trails with the estimated lower and upper bound 5th percentile distances, respectively. The three smaller buffered areas were merged to create a minimal disturbance zone of all impacts. Similarly a maximal disturbance zone of all impacts was created using the larger three buffered areas. The rest of the procedure was identical to that in the second scenario.

The fourth scenario is similar to the third one except that the all trails, either heavily or lightly used by 2007, were included as disturbance sources. This assumes that all lightly used trails in 2007 may become heavily used under future tourism development projects.

Estimated panda carrying capacity and distribution from all the four scenarios were then compared with those in 1974 and 2001, to understand the variability among these scenarios in a historic context.

5.3 Results

5.3.1 Human-induced disturbances on vegetation along trails

In the 10m by 10m (n=128) and 1m x 1m (n=128) plots, a total of 379 seed-producing plant species were identified, including 186 woody species and 193 herbaceous species. Japanese larch (*Larix kaempferi*) was the only exotic species identified. This species was widely used in the reserve for reforestation, thus was not introduced by tourists. Paired t-tests were conducted to compare the species richness between the trailside plots and the forest interior plots at the three vegetation layers (Table 5.2). The numbers of tree species at the woody tree layer in the trailside and forest interior quadrats were not significantly different ($p=0.34$). In terms of the shrub, sapling, and seedling layers, there are more species occurring at trailside quadrats than in the forest interior ($p=0.01$). Herbaceous species richness in the 1m by 1m plots at trailside was also higher ($p<0.0001$) than in forest interior.

Regression models (Table 5.3) suggested that hiking pressure, measured by the annual number of hikers, was not a significant predictor of floristic similarity between trailside and forest interior vegetation. Intensive grazing was positively related to floristic similarity at the shrub, sapling, and seedling layer ($p<0.05$). The impact of grazing on floristic similarity at the herbaceous layer seems to be nonlinear. When light and intensive grazing are combined, they negatively affect floristic similarity ($p<0.05$), but intensive grazing alone positively affects floristic similarity ($p<0.01$).

5.3.2 Long-term impacts of tourism on panda population potential and distribution

A total of 1,489 panda presence locations were compiled from the two sets of survey records and mapped in GIS. The mean distances between panda presence locations and the nearest local households, roads, and heavily-used trails in 2007 were 2,648m (SD=1,877m), 2,318m (SD=1,138m), and 1,789m (SD=1,180m), respectively. The observed 5th percentile distances were 1130m, 693m, and 542m, respectively. The confidence intervals of the 5% percentile distances estimated by BCA bootstrapping were 1,058-1,193 for local households, 619-778 for roads, and 439-567 for trails. The maximum and minimum of the confidence intervals were used for creating the range of the extent for each type of disturbance.

When no disturbance effects were considered, the predicted adult female panda carrying capacity reached almost 78 (SD=2.41) (Fig. 5.4), almost 40% larger than in 2001, when the all-time low panda population carrying capacity was predicted. Negative impacts of residential disturbance may reduce the carrying capacity by 7-8% to about 72 (Fig. 5.4), depending on whether the lower or higher bound of the distance threshold was used. When all residential, roads, and trails impacts were considered, the capacity dropped an additional 4% to about 69. This 4% may be considered as the marginal effect of roads and trails, and because they were mostly used for tourism, it may also be considered as an estimate of the net impacts of tourism on panda population in the Reserve. In the fourth scenario, the trail's impact were extended to all existing trails segments, and this results in an additional 7% drop (to about 64) in adult female panda population carrying capacity, thus, a total of ~18% drop from the vegetation potential scenario.

The mean size of the modeled panda home ranges increased from the vegetation potential scenario to the future tourism scenario, but the magnitude of the change was smaller, with a total

increase of 3-4% (Fig. 5.5). Frequency maps of predicted adult female panda home ranges in four scenarios are shown in Fig. 5.6. As more human disturbance effects are included in the home range modeling, the predicted panda population distribution becomes more fragmented.

5.4 Discussion

To assess the impacts of increasing tourism on biodiversity in Wolong Nature Reserve, we analyzed plant species composition along trails and modeled disturbance effects on endangered giant pandas.

I found that shrub, seedling, and sapling and herbacious species richness at trailsides was higher than species richness in forest interiors. First, it is possible that trampling along the trails has created some unfavorable environment for native species and this open ecological space was then filled in by trampling-resistant species, such as *Fragaria orientalis Lozinsk., Poa depressa Willd., Poa nemoralis L., Cyperus szechuanensis T. Koyama,, Duchesnea indica(Andrews) Focke,* that otherwise would be outcompeted by native species. Second, nutrient enrichment along the trails from the livestock's feces may enrich the nutrient load of soils, thus supporting additional species.

Hiking pressure was not a significant predictor of the floristic similarity between trailside and forest interior vegetation. This indicates that by 2007, tourists' uses of trails were probably still at an early stage, such that its trampling impact did not stand out from other existing anthropogenic disturbances along the surveyed trail segments, such as livestock, which could significantly impact vegetation through both trampling and grazing. This does not mean that hikers did not leave any impact along these trails. Visible littering was common on three of the surveyed trails, except on the Wuyipeng trail, which was centered in a field research station. In

two visits before and after the vegetation surveys along these four trails to pick up litter, a total of over 500 littering sites were recorded. Some local people also expressed their concern about their livestock eating litter, especially the plastic packaging of snacks for the salt flavor left on them.

Model simulation results showed that if all existing trails become heavily used (at the current level, which is only a few thousand visits annually), the panda population carrying capacity could drop. Also since parts of the forest recovery in the reserve may come from monoculture re-plantations of Japanese larch with no bamboo and other understory vegetation, which does not directly constitute suitable panda habitat (Viña et al. 2011), the predicted panda population potential in the vegetation potential scenario could be overestimated. Taking this into consideration, >60% of the total panda population gain potentially obtained from the implementation of conservation programs during the past decade could be canceled out if the seemingly non-consumptive human disturbances are not controlled, even without inducing changes in land cover.

Furthermore, additional negative impacts are warranted if the future tourism scenario does come true. As shown in Fig. 4.10, even in 2001, when predicted panda population potential was at the all-time low level, the panda individuals at the south side of the main river in the reserve were well connected into one large population with >40 adult females. This size will ensure a low extinction risk. The connectivity became a little worse by 2007 when some impacts of trails started to enter the areas containing the large population from several directions (Fig. 5.6C). If all the trails are crowded by hikers in the future, further functional fragmentation of the panda habitat in the reserve will become inevitable. As a result, the large population may run into

the risk of being segregated into few smaller populations, while the small northern population will be also further isolated (Fig. 5.6D).

The existing and potential impacts identified in this study require immediate attention from the decision makers in the reserve. Although tourism has not recovered from the May 12, 2008 Wenchuan Earthquake, and the captive panda breeding center will not be open until at least the fall of 2012, hikers have been reported to come back on the trails across the reserve. Many of them have entered from the southeastern township outside the reserve, as this area has been promoted as a 4A level scenic area to help promote tourism development and economic growth in the township. The potential disturbance to wild pandas through panda-hiker encounters needs to be addressed immediately.

Cole (Cole 2002) suggested three general approaches to minimize human disturbance to wildlife through management – the management of people, behavior modification of wildlife, and habitat modification. For such an endangered species, and in one of very few remaining large populations, precautious principles should be taken when management options are compared. Habituating the pandas to the increasing trail disturbance seems to be risky, impractical, and also ethically problematic (Whittaker & Knight 1998). Due to the spatial overlap between the existing trails and the best panda habitat, there does not seem to be much space left for habitat modification either.

Managing people is of foremost importance should the reserve managers still put protecting panda habitat and population as their conservation priority. On the one hand, spatial and temporal restrictions on tourist activities have to be planned and enforced across the reserve. Before the 2008 earthquake, the major tourism season in the Reserve encompassed from early spring to late fall. Trail use for non-scientific and conservation purposes right before and after

the mating season (early April) should be highly restricted or even banned. Visitation to areas close to adult female breeding sites during the breeding season (early fall to winter) should also be restricted. On the other hand, the reserve needs to establish new programs to educate trail users, including local residents, to avoid disturbance to, and conflict with, pandas and other wildlife.

More monitoring and research are also needed. The existing panda habitat monitoring program needs to be expanded with clear objectives on recording spatio-temporal changes of tourism-related disturbances. Such a monitoring program should also include surveys on tourists and local people who have direct contact with potential and actual trail users from outside the Reserve. In the long run, the accumulation of these types of information may help us better understand the behavioral responses of pandas, and also other wildlife in this area, to different levels and types of disturbances, so that better management plans may be made accordingly.

The effects of trampling on trails cannot be overlooked either. We hypothesize that trampling can open up space for new species. While we have not identified any exotic species potentially being introduced by hikers from outside the reserve, the potential of species invasion should be given special attention. Lonsdale (Lonsdale 1999) analyzed 184 studies from around the world and found that the risk of species invasion increases with elevating number of visitors. Invasive species are becoming an important threat to biodiversity in China (Xie et al. 2001). It was reported that species invasion induced or enhanced by tourism has been confirmed in Jiuzhaigou Nature Reserve (Zhu et al. 2006), a world heritage site and biosphere reserve that is only a couple of hundred kilometers north to Wolong Nature Reserve. Preventing invasive species being introduced by trail users, intentionally or unintentionally, should be part of a future trail user regulation program.

Tourism in protected areas of China is still at its infancy stage and management agencies in and around most protected areas still do not have enough experience and capacity to accommodate the increasing recreation demand (Zhong et al. 2011). The experience and lessons learned from this research and the conservation practice in Wolong Nature Reserve could be valuable for other biodiversity important areas in China.

Figure 5.1. Hiking trails in Wolong Nature Reserve. The red colored trails were frequently used before 2008. The blue ones were used less frequently, but are part of future tourism development plans.

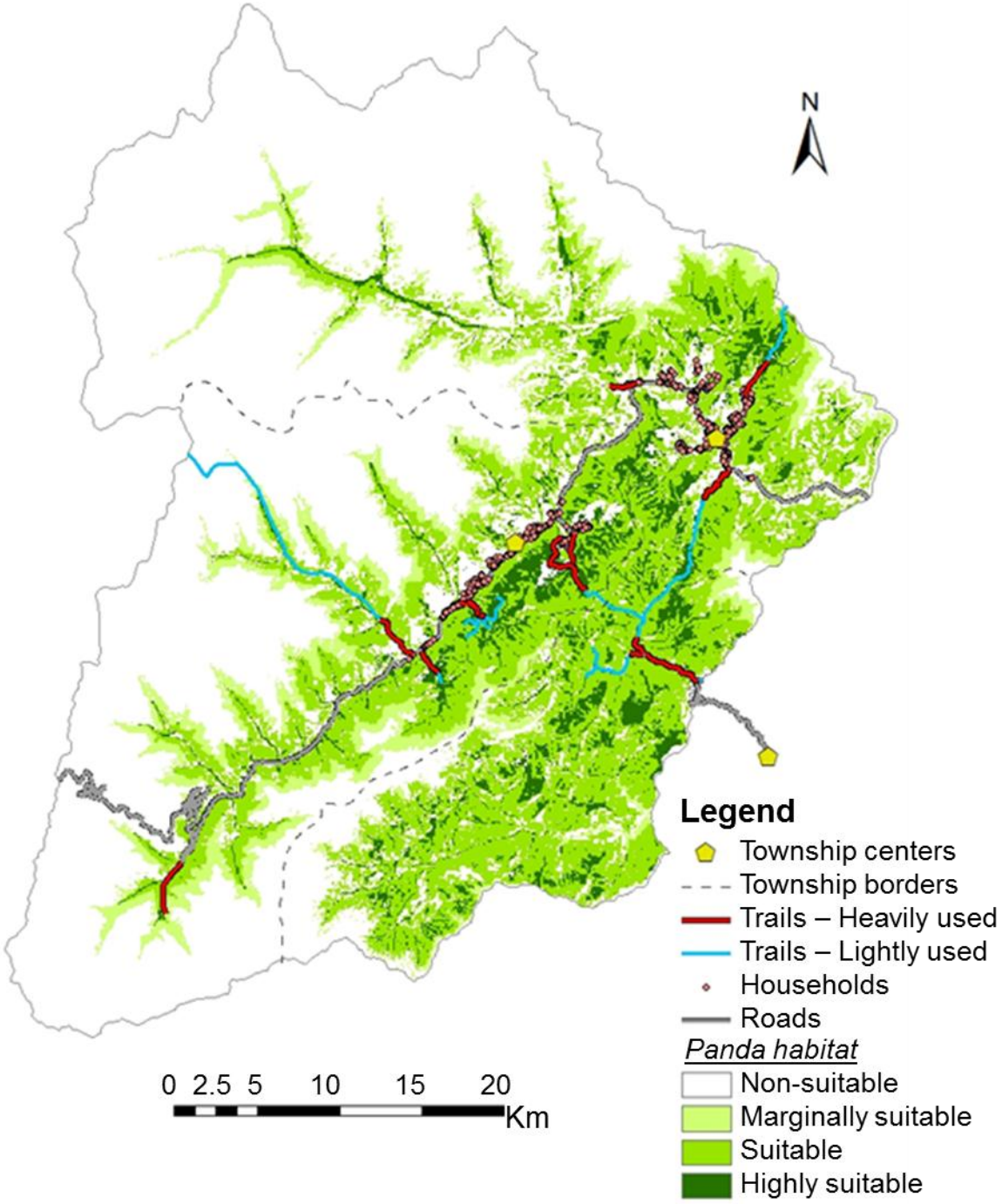


Figure 5.2. Distributions of the vegetation sampling quadrats across Wolong Nature Reserve. A total of 64 sites were surveyed along four trails.

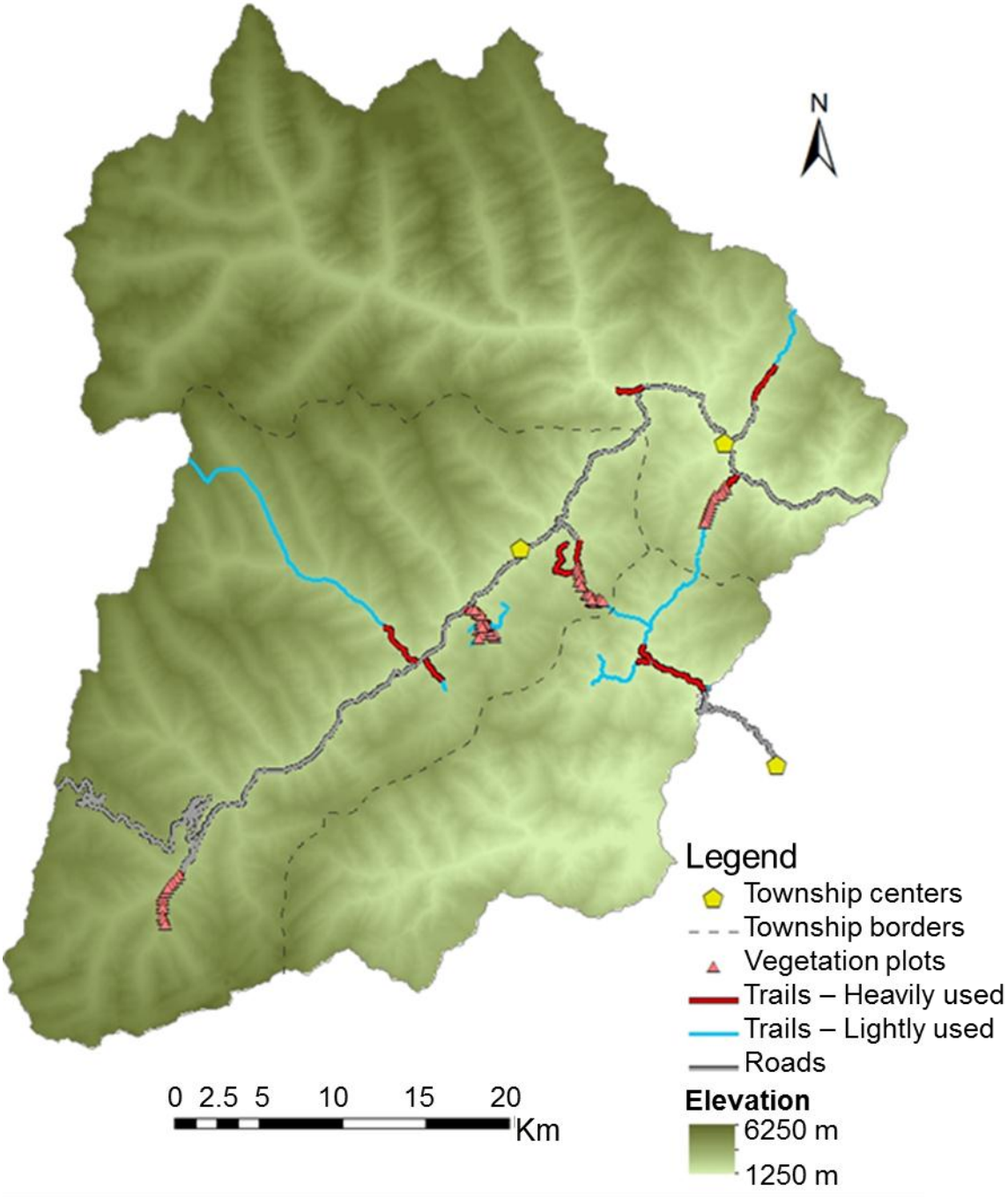


Figure 5.3 Sampling design of the trail vegetation survey. The two 10 x 10m plots are side by side. The trailside 1 x 1m plot is centered at 0.5m away from trail edge, and the forest interior 1 x 1m plot is centered at 10m away from trail center.

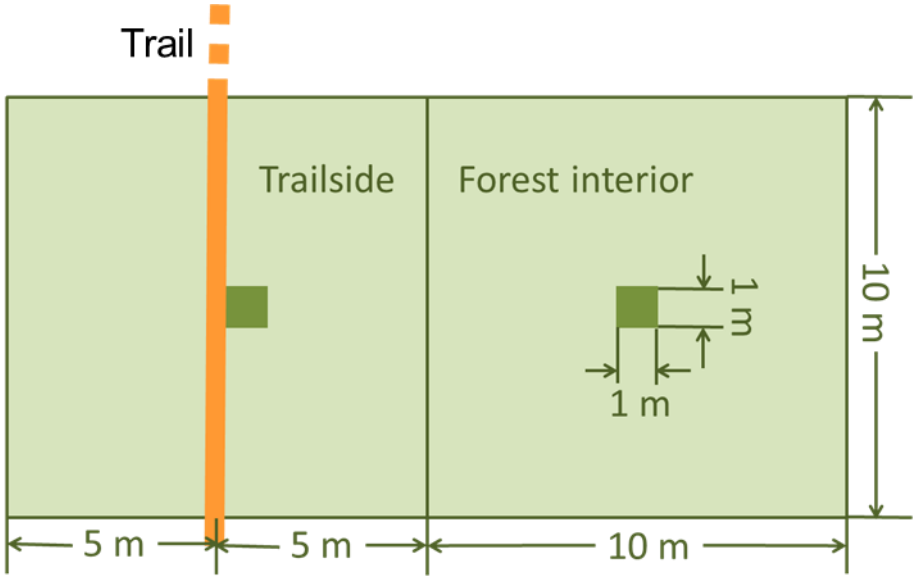


Figure 5.4 Predicted adult female panda carrying capacity in Wolong Nature Reserve in four different scenarios. The high-low lines represent two standard deviations from the mean. For the last three scenarios, the upper and lower boundary of each bar represents the high and low mean prediction in each scenario, when different buffer sizes were used to delineate the extent of human disturbances). Predicted carrying capacities in 1974 and 2001 are provided as a historic context for comparison.

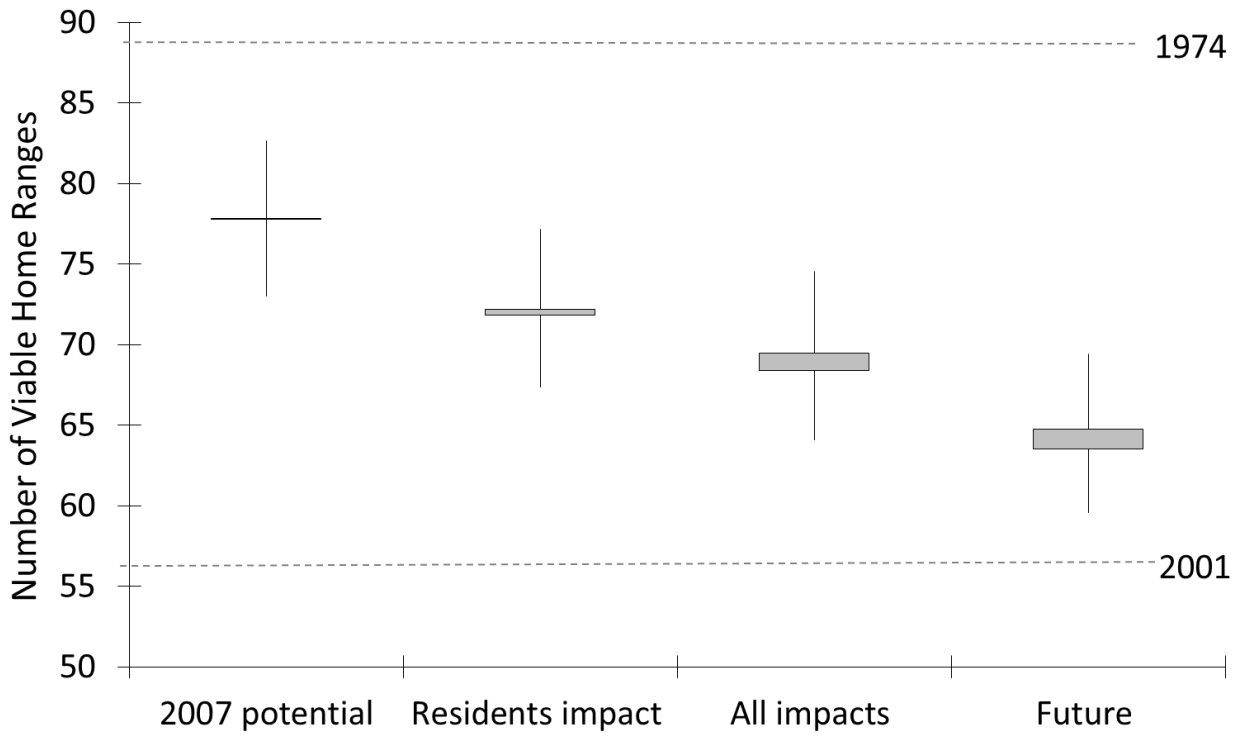


Figure 5.5 Predicted mean home range size of viable adult female panda home ranges across the reserve in four different scenarios. The high-low lines represent two standard deviations of the mean. For the last three scenarios, the upper and lower boundary of each bar represents the high and low mean prediction in each scenario, when different buffer sizes were used to delineate the extent of human disturbances). Predicted mean home range sizes in 1974 and 2001 are provided as a historic context for comparison.

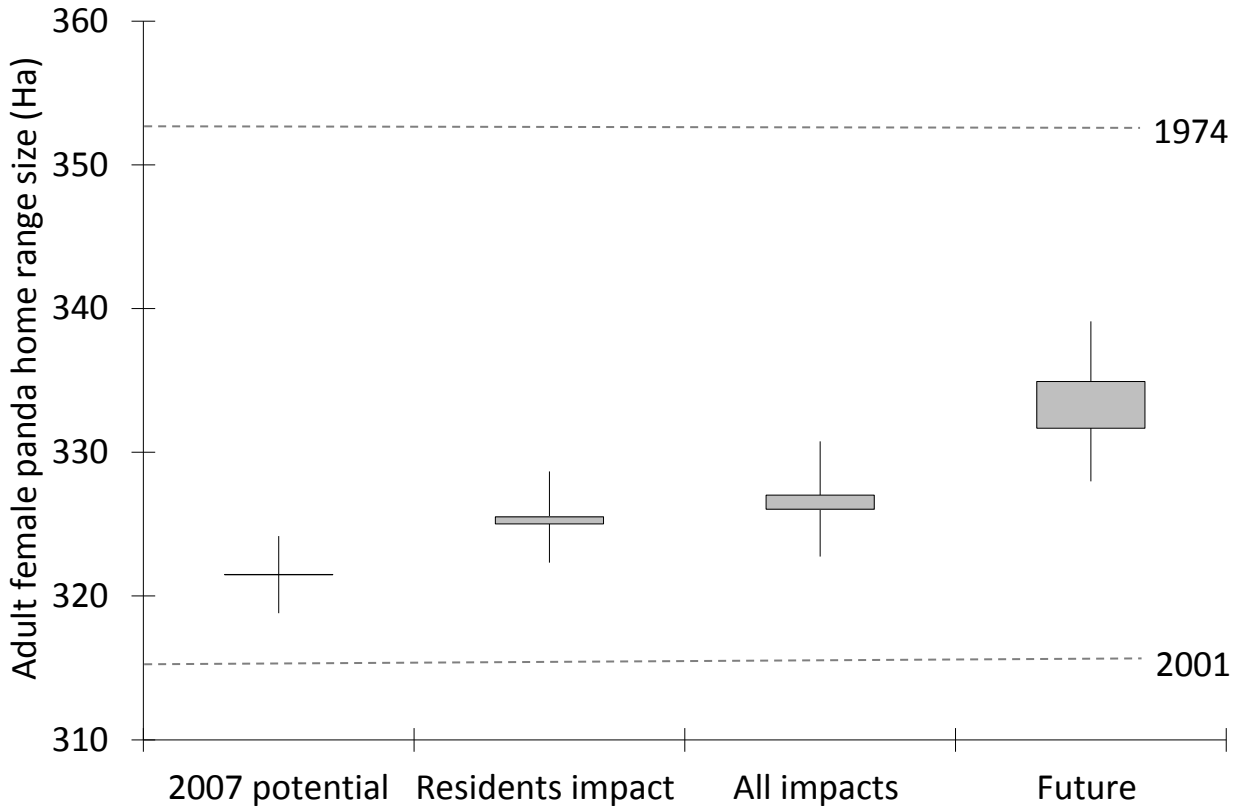


Figure 5.6 Frequency map of predicted viable adult female panda home ranges in four scenarios: A. Purely based on vegetation potential without considering any human disturbance; B. Residential impacts considered; C. Residential, roads, and trails impacts all considered; D. Future scenario assuming all trails being used heavily.

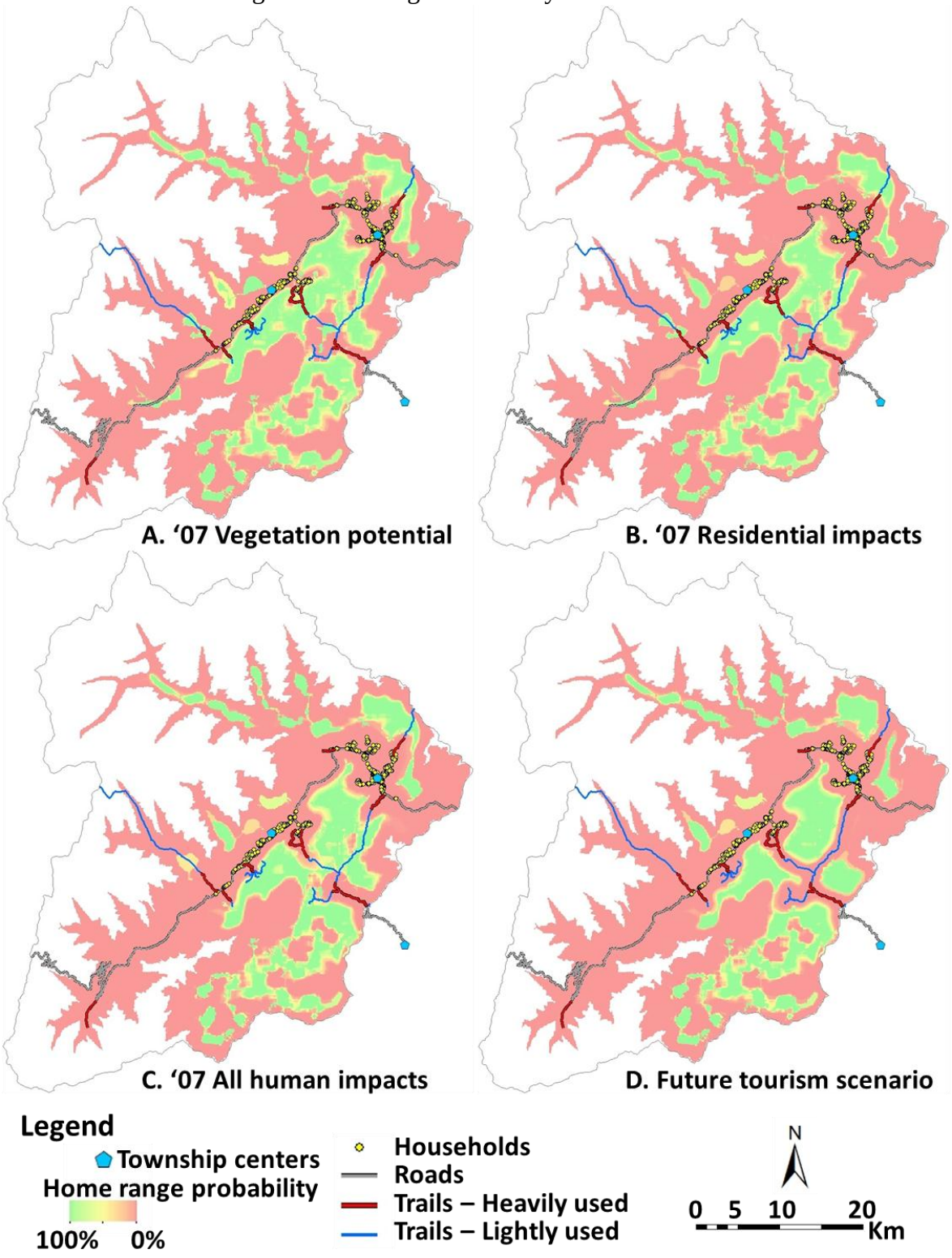


Table 5.1 Descriptive statistics of the biophysical and human disturbance variables used to predict floristic similarity between trailside and forest interior vegetation quadrats.

Variables	**Description**	**Mean (SD)**
Elevation	Elevation of the quardrats (in kilometer)	2.49 (0.44)
Slope	Slope derived from SRTM's DEM	24.33 (9.10)
Annual solar irradiation	Measured using Heat Load Index (HLI, (McCune 2007; McCune & Keon 2002))	0.81 (0.17)
Wetness	Measured using compound topographic index (CTI, (Gessler et al. 1995))	12.11 (3.29)
Basal area	Total basal area measured in the both quadrats (m^2/ha)	0.32 (0.33)
Bamboo	Overall bamboo coverage in the two quadrats, coded as 1 if >=25% and 0 if <25%	n_0=39, n_1=25
Distance to road	Distance to the main road (in kilometer)	2.41 (1.39)
Grazing 1	Presence of livestock grazing	n_0=28, n_1=36
Grazing 2	Presence of intensive livestock grazing	n_0=38, n_1=26
Hiker	Estimated annual number of hikers (in thousands)	1.75 (1.38)

Table 5.2 Plant species richness between the trailside and forest interior quadrats were compared within all three vegetation layers. Student's t-tests were used.

Vegetation layer	n	Mean species richness (SD)		Paired t test	p
		Trailside	Forest interior		
Tree	64	3.63 (2.30)	3.38 (2.04)	0.97	0.34
Shrub, sapling, and seedling	63	8.19 (3.91)	6.98 (4.05)	2.62	0.01
Herb	60	12.85 (5.38)	10.10 (4.97)	4.84	4.88E-06

Table 5.3 Results of the ordinary least square (OLS) models on the effects of biophysical, vegetative, and human disturbance factors on floristic similarity between the trailside and forest interior quadrats at all three vegetation layers.

Variable	Tree	Shrub, sapling, and seedling	Herb
Morisita-Horn Index	0.58 ± 0.30	0.45 ± 0.26	0.34 ± 0.33
N	54	60	61
		Parameter [a] (SD)	
Elevation	-0.0112 (0.1693)	-0.0549 (0.1209)	*0.3577 ** *(0.1391)*
Slope	0.0029 (0.0063)	-0.0007 (0.0051)	0.0063 (0.0058)
Heat load	*0.0398 ** *(0.0168)*	*-0.0261 ** *(0.0122)*	-0.0186 (0.0139)
Wetness	0.1531 (0.5926)	-0.2511 (0.4859)	*-1.1047 ** *(0.5580)*
Basal area	-0.1549 (0.1507)	0.1780 (0.1219)	*0.4125 *** *(0.1331)*
Bamboo	*-0.2131** *(0.0956)*	-0.0833 (0.0808)	-0.1130 (0.0911)
Distance to road	-0.0103 (0.0510)	0.0525 (0.0407)	0.0591 (0.0473)
Grazing 1	-0.0665 (0.1113)	-0.0852 (0.0951)	*-0.2145 ** *(0.1064)*
Grazing 2	-0.1525 (0.1613)	*0.2694 ** *(0.1290)*	*0.4676 *** *(0.1508)*
Hiker	-0.0390 (0.0334)	-0.0273 (0.0264)	0.0307 (0.0308)
Intercept	0.2721 (0.5517)	*0.9609 ** *(0.4648)*	0.0787 (0.5293)
VIF	2.49	2.35	2.38
R-square	0.2863	0.2903	0.4000
Adjusted R-square	0.1203	0.1455	0.2800

a. The signs * and ** represent significance level at 5% and 1% respectively.

CHAPTER 6

CONCLUSIONS

As one of the first and largest nature reserves in China, Wolong Nature Reserve is a flagship of all the protected areas in the country. The unique resources (e.g., the largest wild and in-captive panda populations) in the Reserve make it a popular tourism destination. The availability of rich information and previous research in the Reserve makes it a good candidate to study nature-based tourism from a coupled human and natural system perspective.

I studied tourism development in the Reserve over the last three decades. By compiling the tourism development history using secondary and interview data, I reconstructed the evolutionary trajectory and identified the main driving forces and changes of tourism in the Reserve (Chapter 2), and assessed how tourism development affected human well-being (Chapter 3) and panda population potential (Chapter 5). My findings provide important implications to the management of tourism and natural resources in Wolong Nature Reserve and other protected areas in China.

Applying the tourism area life cycle (TALC) model, I was able to portray tourism development in the Reserve, and the development conformed to the first three stages in the original TALC model. The earthquake arrived before tourism reached the stagnation stage. Changes in tourist arrivals, tourism revenue, and tourism infrastructure were monitored. Major events or milestones that shaped the trajectory of the evolution were identified. In this way, I had a holistic view of the tourism system spanning 30 years. Similar to what the TALC model would predict, as tourism in the Reserve grew from exploration and involvement stages to development stage, economic leakage became apparent and control of tourism by the local community was weakened. Currently, the reserve is in a post-earthquake reconstruction period, requiring system components to reorganize and recover so that another round of tourism development can continue.

For the first time, the TALC model's applicability was tested in a nature reserve in China. Both external and internal factors that modified the trajectory of tourism development were examined, as well as the changes associated with the evolution of tourism. Besides the environmental, social, and economic changes that relate to tourism, the change of governance or the control of tourism across developmental stages was specifically analyzed. While Wolong's specific tourism resource endowment might be different from other protected areas in China, the emergence of the new type of tourism governance in Wolong is becoming popular in China's nature reserves (Su et al. 2007).

Ideally, tourism in protected areas should be mutually benefit local community, the protected area, and tourism business, but these benefits are seldom realized simultaneously in practice. The collaboration with experienced outside investors has brought fast growth but has also contributed to economic leakage and local inequality and yielded mixed results on the commonly stated goals of improving residents' welfare and conserving biological diversity. The rural community's absolute income from tourism increased by three fold from Development I stage to Development II stage. However, their proportions of the tourism income have fallen, and their opportunity to participate in tourism dwindled. Thus while tourism flourishes, the rural community is marginalized from tourism.

Taking advantage of a longitudinal dataset, I was able to follow a representative sample of local households and monitor the changes of their tourism participation over an eight-year period, when tourism boomed in the Reserve. This offers an advantage over single-period studies. I was able to detect changes in tourism participation. Knowing the condition of each household at the beginning of the period helped to understand the mechanism behind the tourism

participation. I found that possession of different combination of livelihood assets affect local households' likelihood to diversify their income, in this case to participate in tourism.

Tourism is a new land use practice in the Reserve. To understand the potential impact of tourism on pandas in the reserve requires a general approach to investigate how different types of land cover and land use practices affect the panda population. Using the program HomeGrower a habitat-based approach was implemented to map the distribution of panda home ranges across landscape (Chapter 4). I was able to reconstruct the history of panda population capacity changes in the Reserve. Using field observed data as validation the model predicted the total panda carrying capacity and spatial distribution of panda home ranges with high accuracy.

Large and contiguous habitat is the basis of viable populations. HomeGrower model outputs showed that panda populations are naturally fragmented, largely due to the high-relief topography that they live in. Thus the population may be naturally sensitive to habitat fragmentation at critical locations (i.e., corridors). If any of these corridors are blocked or disappear, the potential population potential and viability will drop significantly.

The implementation of two forest conservation programs since 2000 has led to recovery of forests and increase of potential panda habitat in the Reserve, which was translated into a potential of 20-30% increase in panda population carrying capacity. However, if volumes of tourists start to use the trails across the reserve, combined with disturbance from local residents, the population potential gain from forest recovery could be largely compromised. Considering that both domestic and international tourists chose wild panda as the biggest attractor for them to visit the Reserve, chance is that this hypothetical scenario may happen in the future if no

regulation is imposed. Therefore, conserving pandas is fundamentally a job that manages people and their activities.

In this study, various tools and techniques from ecology, social science, and economics as well as other disciplines (e.g., geographic information sciences) are used for data collection, analyses, and integration; different perspectives (i.e., systems, agent-based, and narrative) are needed to examine the complexity of nature-based tourism system at different organizational levels and temporal scales.

The systems perspective is essentially about the organization and institutions of tourism system. Different institutions, such as villages, markets, or governments, operate interactively at various spatial and temporal scales. Some institutions, such as the Jiuzhaigou Scenic Area in the case of tourism in Wolong Nature Reserve, are direct drivers of change; others, such as markets, are inherent in decision-making. The systems perspective emphasizes the predictable trajectories observed in the system. The TALC model is essentially a systems view of tourism destination. The changes related to TALC, such as income structure of local households toward more off-farm components, economic leakage, and loss of local control, can all be understood from a systems perspective.

The agent-based perspective is about the general rule of decision making by individuals. It represents the motivations behind decisions and the external factors that influence decisions. In nature-based tourism, using Wolong as a case, there are at least three different groups of agents: the local households (or residents), the tourists, and the pandas. Each of them has different motives. For local residents, it may be social norm. For pandas, it may be energy optimization and disturbance avoidance. For tourists, it may be utility optimization. Local households and

pandas are both studied in this dissertation, while the understanding on tourists is relatively thin. The spatiotemporal distribution of tourist activities were developed mostly based on local experts' knowledge, rather than a direct measurement on tourists. Recently map-based survey (Connell & Page 2008) and semi-Markov-processes (Xia et al. 2011) have been used to study spatiotemporal movement of tourists. In the future, these techniques can both be used to study the space use of locals and tourists, so that the disturbance impacts of them can be better differentiated and managed. We may also put all agents simultaneously onto the same landscape. With understanding of biological/ecological processes, human activities and their interactions, this can have important implications for conservation and human-wildlife co-existence.

The narrative perspective focuses on in-depth understanding of a system in a real world context using historical information and interpretation. Both natural and human histories play an important role in shaping the current system and different processes take place at different temporal scales. Historical analysis of tourism on the unexpected events is an example. In Wolong, bamboo flowering (1983), SARS (2003), and earthquake (2008) are all stochastic and unexpected events that significantly shaped the trajectory of the evolution. It recognizes the path dependence and legacy effect. Scenario analysis, such as future trail use in Chapter 5, is a narrative story to describe the cause and effect relationship between tourist disturbance and panda population responses.

In summary, nature-based tourism system is an open and dynamic system and different components are highly interrelated. Complex interactions between local residents, tourists, wildlife, and the biophysical environment take place, shape the evolutionary trajectory of the system, and be shaped by the system. By focusing on tourism development in a flagship reserve of China, this in-depth study provides unique interdisciplinary insights into the complex

characteristics of a coupled human and natural system that cannot be observed in short-term studies. This dissertation has built a ground for continuing to study how tourism in the Reserve recovers from the disaster and starts another life cycle.

As many protected areas in China and around the world are also promoting and practicing tourism as a conservation development tool and face similar dilemmas as Wolong Nature Reserve, this dissertation also provides important lessons and experience to interested researchers and managers. To increase the generalization capacity of this research, more place-based studies on other protected areas are needed to establish long-term comparison and capture a full range of variations on how nature-based tourism systems behave under the context of socioeconomic transition and global change. Furthermore, it is also my hope that this dissertation can provide another piece to the large puzzle of enhancing human well-being and alleviating poverty, while committing to sustainable recreational use and conservation of wildlife.

APPENDIX

QUESTIONNAIRE ON LOCAL RESIDENTS' PERCEPTIONS AND ATTITUDE TOWARD TOURISM DEVELOPMENT IN WOLONG NATURE RESERVE

Interviewer: _____ Date: _____ Time: _____

Interviewee information

Household ID: _____ Township: _____ Village: _____ Group: _____

Interviewee's relationship with household head: _____
Birth year: ____ Gender: _____ Ethnicity: _____ Education: __
Other information: _____

Questions:

1. What is your general feeling about the tourism development plan in the reserve?
□ It is promising □ It is not promising
□ It is hard to tell □ I don't know the plan

2. In the past, in which year did you observe the highest volume of tourists in the reserve?
□ Before 2000 □ 2000 □ 2001 □ 2002
□ 2003 □ 2004 □ 2005 □ I have no idea

3. What are the peak tourism months in the reserve? _____

4. (For household participating in tourism activities) How do you think the tourism development plan will affect your business?
□ It will positively affect my business
□ It will negatively affect my business
□ I have no idea about how it will affect my business

5. (For household not participating in tourism activities) what have prevented your household from participating in tourism activities?

6. Based on your knowledge, what are the tourists coming to visit the reserve for?
□ Giant panda □ Mountainous landscape and scenery
□ Comfortable climate □ Local product
□ Other: _____

7. Based on what you have observed, which areas in the reserve do tourists go?
□ Dengsheng □ HetaoPing □ LaoyaShan
□ QicenglouGou □ ShaWan □ WuyiPeng
□ XingfuGou □ YingchangGou □ YingxiongGou
□ ZhengHe □ Others _____

8. Please, based on your best knowledge, rate the environmental impacts that have been caused by tourism development n the reserve.

Categories	High level	Medium level	Low level	No impact	Comments
Air and water quality	□	□	□	□	
Soundscape	□	□	□	□	
Road traffic	□	□	□	□	
Mountain trail	□	□	□	□	
Natural forest	□	□	□	□	
Medicinal herbs	□	□	□	□	
Wild pandas and other wildlife	□	□	□	□	

9*. I have had some communications with tourists.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

10*. I have received information about job opportunities from tourists.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

11*. There have been conflicts between local residents and tourists.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

12. Tourism development has helped improve public service and living environment.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

13. Tourism development has helped enhance my family's quality of life.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

14. Tourism development has helped enhance most families' quality of life in the reserve.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

15. Tourism development has helped to build a good image of the area among outside people.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement

Comments: _____

16. There are conflicts between tourism development and conservation in the reserve.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

17. Overall tourism development is good for the reserve.
□ Strongly disagree □ Disagree □ Neutral □ Agree □ Strongly agree
□ I don't understand the statement
Comments: _____

*. The answers in these questions were reclassified into binary classification in data analysis (Yes: "Strongly agree" and "Agree"; No: "Strongly disagree" and "Disagree"; No data: "Neutral")

BIBLIOGRAPHY

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Acott, T. G., H. L. L. Trobe, and S. H. Howard. 1998. An Evaluation of Deep Ecotourism and Shallow Ecotourism. Joural of Sustainable Tourism **6**:238-253.

Akis, S., N. Peristianis, and J. Warner. 1996. Residents' attitudes to tourism development: The case of Cyprus. Tourism Management **17**:481-494.

An, L., G. He, Z. Liang, and J. Liu. 2006. Impacts of demographic and socioeconomic factors on spatio-temporal dynamics of panda habitat. Biodiversity and Conservation **15**:2343-2363.

An, L., M. Linderman, A. Shortridge, J. Qi, and J. Liu. 2005. An Agent-based Spatial Model for Cross-discipline and Cross-scale Integration: A case study of households, forests, and panda habitats. Annals of the Association of American Geographers. **95**:54-79.

An, L., J. Liu, Z. Ouyang, M. Linderman, S. Zhou, and H. Zhang. 2001. Simulating demographic and socioeconomic processes on household level and implications for giant panda habitats. Ecological Modelling **140**:31-49.

An, L., F. Lupi, J. G. Liu, M. A. Linderman, and J. Y. Huang. 2002. Modeling the choice to switch from fuelwood to electricity: Implications for giant panda habitat conservation. Ecological Economics **42**:445-457.

Armesto, J. J., R. Rozzi, C. Smith-Ramirez, and M. T. K. Arroyo. 1998. Ecology - Conservation targets in South American temperate forests. Science **282**:1271-1272.

Arnold, M., M. Dilley, U. Deichmann, R. S. Chen, and A. L. Lerner-Lam 2005. Natural Disaster Hotspots: A Global Risk Analysis. Wrold Bank.

Baigas, P. E., R. A. Olson, R. M. Nielson, S. N. Miller, and F. G. Lindzey. 2010. Modeling seasonal distribution and spatial range capacity of moose in Southeastern Wyoming. Alces **46**:89-112.

Balmford, A., J. Beresford, J. Green, R. Naidoo, M. Walpole, and A. Manica. 2009. A global perspective on trends in nature-based tourism. PLoS Biology **7**:e1000144.

Bao, J. 1995. A study on tourist development of karst caves. Acta Geographica Sinica **50**:353-359.

Bearer, S., M. Linderman, J. Y. Huang, L. An, G. M. He, and J. Q. Liu. 2008. Effects of fuelwood collection and timber harvesting on giant panda habitat use. Biological Conservation **141**:385-393.

Berkes, F. 2004. Rethinking community-based conservation. Conservation Biology **18**:621-630.

Berkes, F., J. Colding, and C. Folke 2003. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press.

Blaikie, P., and S. Jeanrenaud. 1997. Biodiversity and human welfare. Page 342 in K. B. Ghimire, K. Ghimire, and M. P. Pimbert, editors. Social Change and Conservation: Environmental Politics and Impacts of National Parks and Protected Areas. Earthscan.

Bookbinder, M. P., E. Dinerstein, A. Rijal, H. Cauley, and A. Rajouria. 1998. Ecotourism's Support of Biodiversity Conservation. Conservation Biology **12**:1399-1404.

Boyd, S. W. 2006. The TALC model and its application to national parks: A Canadian example in R. W. Butler, editor. The Tourism Area Life Cycle: Vol. 1. Application and modifications. Channel View Publications, Clevedon, UK.

Brown, K. 2002. Innovations for conservation and development. Geographical Journal **168**:6-17.

Brown, K. 2004. Trade-off analysis for integrated conservation and development. in T. O. McShane, and M. P. Wells, editors. Getting biodiversity projects to work: Towards more effective conservation and development. Columbia University Press, New York.

Buckley, R. 2011. Tourism and environment. Annual Review of Environment and Resources **36**:397-416.

Buckley, R. C. 2010. Conservation tourism. CAB International, Oxfordshire, UK.

Butler, R. W. 1980. The concept of a tourist area cycle of evolution: Implications for management of resources. Canadian Geographer **24**:5-12.

Butler, R. W. 1999. Tourism - an evolutionary perspective in J. G. Nelson, R. W. Butler, and G. Wall, editors. Tourism and sustainable development: monitoring, planning, managing, decision making. University of Waterloo Department of Geography publication series, Waterloo, Canada.

Butler, R. W. 2006. The Tourism Area Life Cycle: Vol. 1. Application and Modifications. Channel View Publications, Clevedon, UK.

Carrier, J. G., and D. V. L. Macleod. 2005 Bursting the bubble: the socio-cultural context of ecotourism. Journal of the Royal Anthropological Institute, **11**:315-320.

Chiang, M.-H. 2010. China's booming tourism industry, EAI Background Brief No. 676.

China National Committee on Man and Biosphere 1998. Nature reserve and ecotourism. China Science and Technology Publishing House, Beijing.

China News. 2012. China has established 2640 nature reserves, covering 14.94% of the land.

Clark, W. C., and N. M. Dickson. 2003. Sustainability science: The emerging research program. Proceedings of the National Academy of Sciences of the United States of America **100**:8059-8061.

Cole, D. N. 2002. Ecological impacts of wilderness recreation and their management in J. C. Hendee, and C. P. Dawson, editors. Wilderness Management: Stewardship and Protection of Resources and Values (3rd Ed.). Fulcrum Publishing, Golden, CO.

Connell, J., and S. J. Page. 2008. Exploring the spatial patterns of car-based tourist travel in Loch Lomond and Trossachs National Park, Scotland. Tourism Management **29**:561-580.

Conservation International. 2003. Tourism and Biodiversity: Mapping Toruism's Global Footprint. Conservation International, Washington, DC.

Conservation International. 2005. Mountains of Southwest China. Biodiversity Hotspots. Conservation International.

Coria, J., and E. Calfucura. 2012. Ecotourism and the development of indigenous communities: The good, the bad, and the ugly. Ecological Economics **73**:47-55.

Daily, G. C., and K. Ellison 2002. The New Economy of Nature. Island Press, Washington D.C.

DFID. 1999. Sustainable livelihoods guidance sheets. DFID, London, U.K.

Dompka, V., editor. 1996. Human population, biodiversity and protected areas: Science and policy issues. American Association for the Advancement of Science, Washington, DC.

Dudley, N., editor. 2008. Guidelines for Applying Protected Area Management Categories. IUCN, Gland, Switzerland.

Efron, B. 1987. Better Bootstrap Confidence-Intervals. Journal of the American Statistical Association **82**:171-185.

Ellis, F. 1998. Household strategies and rural livelihood diversification. Journal of Development Studies **35**:1-38.

Ellis, F. 2000. Rural livelihoods and diversity in developing countries. Oxford University Press, Oxford.

ESRI. 2009. ArcGIS 9.3. Environmental Systems Research Institute, Redlands, USA.

ESRI. 2010. ArcGIS 10.0. Environmental Systems Research Institute, Redlands, USA.

Farrell, B. H., and L. Twining-Ward. 2004. Reconceptualizing tourism. Annals of Tourism Research **31**:274-295.

Farrell, T. A., and J. L. Marion. 2001. Identifying and assessing ecotourism visitor impacts at eight protected areas in Costa Rica and Belize. Environmental Conservation **28**:215-225.

Garshelis, D. L. 2002. Misconceptions, ironies, and uncertainties regarding trends in bear populations. Ursus **13**:321-334.

Gessler, P. E., I. D. Moore, N. J. Mckenzie, and P. J. Ryan. 1995. Soil-Landscape Modeling and Spatial Prediction of Soil Attributes. International Journal of Geographical Information Systems **9**:421-432.

Ghimire, K. B. 1994. Conservation and social development: a study based on an assessment of Wolong and other panda reserves in China. Page 54. United Nations Research Institute for Social Development.

Ghimire, K. B., K. Ghimire, and M. P. Pimbert 1997. Social change and conservation: environmental politics and impacts of national parks and protected areas. Earthscan Publications.

Gossling, S. 1999. Ecotourism: A means to safeguard biodiversity and ecosystem functions? Ecological Economics **29**:303?320.

Groom, M. J., G. K. Meffe, and C. R. Carroll 2006. Principles of Conservation Biology. Sinauer Associates.

Grossberg , R., A. Treves , and L. Naughton-Treves. 2003. The incidental ecotourist: measuring visitor impacts on endangered howler monkeys at a Belizean archaeological site. Environmental Conservation **30**:40-51.

Grumbine, E. R., and J. Xu. 2011. Creating a "Conservation with Chinese characteristics". Biological Conservation **144**:1347-1355.

Gunn, C. 2002. Tourism Planning: Basics, Concepts, Cases 4E CL. Taylor & Francis.

Haggblade, S., P. B. R. Hazell, T. Reardon, and T. A. Reardon 2007. Transforming the rural nonfarm economy: Opportunities and threats in the developing world. Johns Hopkins University Press, Baltimore.

Hall, C. N., and F. R. Kuss. 1989. Vegetation Alteration Along Trails in Shenandoah National-Park, Virginia. Biological Conservation **48**:211-227.

Hammitt, W. E., and D. N. Cole 1998. Wildland Recreation. John Wiley & Sons, Inc., New York.

Han, N., and Z. Ren. 2001. Ecotourism in China's Nature Reserves: Opportunities and Challenges. Journal of Sustainable Tourism **9**:228.

Hansen, A. J., R. Rasker, B. Maxwell, J. J. Rotella, J. D. Johnson, A. W. Parmenter, L. Langner, W. B. Cohen, R. L. Lawrence, and M. P. V. Kraska. 2002. Ecological causes and consequences of demographic change in the new west. Bioscience **52**:151-162.

Harris, R. B. 2004. Insights into population dynamics of giant pandas gained from studies in North America. Acta Zoologica Sinica **50**:662-668.

He, G. M., X. D. Chen, S. Beaer, M. Colunga, A. Mertig, L. An, S. Q. Zhou, M. Linderman, Z. Ouyang, S. Gage, S. X. Li, and J. G. Liu. 2009. Spatial and temporal patterns of fuelwood collection in Wolong Nature Reserve: Implications for panda conservation. Landscape and Urban Planning **92**:1-9.

He, G. M., X. D. Chen, W. Liu, S. Bearer, S. Q. Zhou, L. Y. Q. Cheng, H. M. Zhang, Z. Y. Ouyang, and J. G. Liu. 2008. Distribution of economic benefits from ecotourism: A case study of Wolong Nature Reserve for Giant Pandas in China. Environmental Management **42**:1017-1025.

He, J. M. 2005. On the development of rural tourism in China's urban suburbs: a case study on the evolution of Nongjiale in Chengdu. Tourism Tribune **20**:71-74.

Hirano, K., and G. W. Imbens. 2001. Estimation of causal effects using propensity score weighting: An application to data on right heart catheterization. Health Services and Outcomes Research Methodology **2**:259-278.

Hirzel, A. H., G. Le Lay, V. Helfer, C. Randin, and A. Guisan. 2006. Evaluating the ability of habitat suitability models to predict species presences. Ecological Modelling **199**:142-152.

Honey, M., and R. Gilpin. 2009. Tourism in the developing world: Promoting peace and reducing poverty. United States Institute of Peace.

Horn, H. S. 1966. Measurement of overlap in comparative ecological studies. American Naturalist **100**:419-&.

Hou, W.-R. 2000. Amendment on the life table and relevant datum indicators of Giant Panda (in Chinese with English abstract). Zoological Research **Oct.**:361-366.

Hovinen, G. R. 1981. A tourist cycle in Lancaster County, Pennsylvania. . The Canadian Geographer **25**: 283-286.

Hovinen, G. R. 1982. Visitor cycles: Outlook for tourism in Lancaster County. Annals of Tourism Research **9**:565-583.

Hu, J. 2001. Giant panda research. Shanghai Science and Technology Publishing House, Shanghai.

Huang, C.-M., J.-C. Hu, Y.-Q. Ge, Y. Song, and W.-G. Wu. 1990. The research on population dynamics and population stability of the giant panda in Wolong (in Chinese with English abstract). Pages 223-235 in J.-C. Hu, editor. Biological Research on Panda and Its Progresses. Sichuan Publishing House of Science & Technology, Chengdu.

Huang, X., G. Wall, and J. Bao. 2007. Comparative review of research on environmental impacts of tourism in English and Chinese literatures. Asia Pacific Journal of Tourism Research **12**:33-46.

Hughes, R., and F. Flintan. 2001. Integrating conservation and development experience: A review and bibliography of the ICDP literature. Page 24. International Institute for Environmental Development.

Hull, V., W. Xu, W. Liu, S. Zhou, A. Vina, J. Zhang, M.-N. Tuanmu, J. Huang, M. Linderman, X. Chen, Y. Huang, Z. Ouyang, H. Zhang, and J. Liu. 2011. Evaluating the efficacy of zoning designations for protected area management. Biological Conservation **144**:3028-3037.

IUCN 2006. Sichuan Giant Panda Sanctuary – Wolong, Mt. Siguniang and Jiajin Mountains. World Heritage Nomination - IUCN Technical Evaluation.

IUCN, and UNEP-WCMC. 2011. The world database on protected areas (WDPA). UNEP-WCMC, Cambridge, UK.

Johnson, J. D., and D. J. Snepenger. 1993. Application of the tourism life cycle concept in the Greater Yellowstone Region. Society and Natural Resources **6**:127-148.

Johnson, K. G., G. B. Schaller, and J. Hu. 1988. Responses of giant pandas to a bamboo die-off. National Geographic Research **4**:161-177.

Johnston, C. S. 2001. Shoring the foundations of the destination life cycle model, part 1: Ontological and epistemological considerations. Tourism Geographies **3**:2-28.

Jost, L., A. Chao, and R. L. Chazdon. 2010. Compositional Similarity and Beta Diversity in A. E. Magurran, and B. J. McGill, editors. Biological Diversity: Frontiers in Measurement and Assessment. Oxford University Press, Oxford.

Kates, R. W., W. C. Clark, R. Corell, J. M. Hall, C. C. Jaeger, I. Lowe, J. J. McCarthy, H. J. Schellnhuber, B. Bolin, N. M. Dickson, S. Faucheux, G. C. Gallopin, A. Grubler, B. Huntley, J. Jager, N. S. Jodha, R. E. Kasperson, A. Mabogunje, P. Matson, H. Mooney, B. Moore, T. O'Riordan, and U. Svedin. 2001. Environment and development - Sustainability science. Science **292**:641-642.

Kinzig, A. P., C. Perrings, F. S. Chapin, III, S. Polasky, V. K. Smith, D. Tilman, and B. L. Turner, II. 2011. Paying for ecosystem services: Promise and peril. Science **334**:603-604.

Kiss, A. 2004. Is community-based ecotourism a good use of biodiversity conservation funds? Trends in Ecology & Evolution **19**:232-237.

Klein, M. L., S. R. Humphrey, and H. F. Percival. 1995. Effects of ecotourism on distribution of waterbirds in a wildlife refuge. Conservation Biology **9**:1454-1465.

Kruger, O. 2005a. The role of ecotourism in conservation: Panacea or Pandora's box? Biodiversity and Conservation **14**:579-600.

Kruger, O. 2005b. The role of ecotourism in conservation: panacea or Pandora's box? Biodiversity and Conservation **14**:579-600.

Lagiewski, R. M. 2006. The application of the TALC model: A literature survey in R. W. Butler, editor. The Tourism Area Life Cycle: Vol. 1. Application and modifications. Channel View Publications, Clevedon, UK.

Lambin, E. F., H. J. Geist, and E. Lepers. 2003. Dynamics of land-use and land-cover change in tropical regions. Annual Review of Environment and Resources **28**:205-241.

Leung, Y.-F., and J. L. Marion. 2000. Recreation impacts and management in wilderness : A state-of-knowldege review.

Lew, A. A. 2003. Tourism in China. Haworth Hospitality Press, New York.

Li, C., S. Zhou, D. Xian, Z. Chen, and Z. Tian. 1992a. An investigation on tourism development in Wolong Nature Reserve (in Chinese) in Wolong Nature Reserve, and Sichuan Normal College, editors. The Animal and Plant Resources and Protection of Wolong Nature Reserve. Sichuan Publishing House of Science and Technology, Chengdu, China.

Li, C., S. Zhou, D. Xian, Z. Chen, and Z. Tian. 1992b. A study of the management of Wolong Nature Reserve (in Chinese). Pages 309-372 in Wolong Nature Reserve, and Sichuan Normal College, editors. The Animal and Plant Resources and Protection of Wolong Nature Reserve. Sichuan Publishing House of Science & Technology, Chengdu, China.

Li, W., and N. Han. 2001. Ecotourism Management in China's Nature Reserves. Ambio **30**:62-63.

Li, W., and X. Zhao 1989. China's Nature Reserves. Foreign Language Press, Beijing.

Li, Y. M., Z. W. Guo, Q. S. Yang, Y. S. Wang, and J. Niemela. 2003. The implications of poaching for giant panda conservation. Biological Conservation **111**:125-136.

Lindberg, K., J. Enriquez, and K. Sproule. 1996. Ecotourism questioned: Case studies from Belize. Annals of Tourism Research **23**:543-562.

Lindberg, K., C. Tisdell, and D. Xue. 2003. Ecotourism in China's nature reserves. Pages xix, 325 p. in A. A. Lew, editor. Tourism in China. Haworth Hospitality Press, New York.

Linden, D. W. 2006. Modeling current and historic habitat for Canada Lynx (Lynx Canadensis) in the Upper Penisular of Michigan. Page 153. Michigan State University, East Lansing, MI USA.

Linderman, M. A., L. An, S. Bearer, G. M. He, Z. Y. Ouyang, and J. G. Liu. 2005. Modeling the spatio-temporal dynamics and interactions of households, landscapes, and giant panda habitat. Ecological Modelling **183**:47-65.

Linderman, M. A., J. Liu, J. Qi, Z. Ouyang, L. An, J. Yang, and Y. Tan. 2004. Using artificial neural networks to map the spatial distribution of understorey bamboo from remote sensing data. International Journal of Remote Sensing **25**:1685-1700.

Liu, J. 1999. An integrated approach to evaluating the giant panda habitats. the Division of Environmental Biology, National Science Foundation, Washington DC.

Liu, J. 2001. (Guest Editor). Integration of Ecology with Human Demography, Behavior, and Socioeconomics. Special Issue of Ecological Modelling **140**:1-192.

Liu, J. 2003. SARS, wildlife, and human health. Science **302**:53-53.

Liu, J., and J. Diamond. 2008. Revolutionizing China's environmental protection. Science **319**:37-38.

Liu, J., T. Dietz, S. R. Carpenter, M. Alberti, C. Folke, E. Moran, A. N. Pell, P. Deadman, T. Kratz, J. Lubchenco, E. Ostrom, Z. Ouyang, W. Provencher, C. L. Redman, S. H. Schneider, and W. W. Taylor. 2007a. Complexity of coupled human and natural systems. Science **317**:1513-1516.

Liu, J., T. Dietz, S. R. Carpenter, C. Folke, M. Alberti, C. L. Redman, S. H. Schneider, E. Ostrom, A. N. Pell, J. Lubchenco, W. W. Taylor, Z. Y. Ouyang, P. Deadman, T. Kratz, and W. Provencher. 2007b. Coupled human and natural systems. Ambio **36**:639-649.

Liu, J., S. Li, Z. Ouyang, C. Tam, and X. Chen. 2008. Ecological and socioeconomic effects of China's policies for ecosystem services. Proceedings of the National Academy of Sciences of the United States of America **105**:9477-9482.

Liu, J., M. Linderman, Z. Ouyang, L. An, J. Yang, and H. Zhang. 2001. Ecological degradation in protected areas: The case of Wolong Nature Reserve for giant pandas. Science **292**:98.

Liu, J., Z. Ouyang, S. L. Pimm, P. H. Raven, X. Wang, H. Miao, and N. Han. 2003a. Protecting China's biodiversity. Science **300**:1240-1241.

Liu, J., Z. Ouyang, W. W. Taylor, R. Groop, Y. Tan, and H. Zhang. 1999. A framework for evaluating the effects of human factors on wildlife habitats: The case of giant pandas. Conservation Biology **13**:1360-1370.

Liu, J., and P. H. Raven. 2010. China's Environmental Challenges and Implications for the World. Critical Reviews in Environmental Science and Technology **40**:823-851.

Liu, J. G., G. C. Daily, P. R. Ehrlich, and G. W. Luck. 2003b. Effects of household dynamics on resource consumption and biodiversity. Nature **421**:530-533.

Liu, W., C. A. Vogt, J. Luo, G. He, K. A. Frank, and J. Liu. 2012. Drivers and Socioeconomic Impacts of Tourism Participation in Protected Areas. PloS One **7**:35420.

Liu, W., W. Yang, J. Luo, G. He, and J. Liu. 2011. Effects of payment for ecosystem service programs on rural energy transition. US Society for Ecological Economics Annual Meeting, East Lansing, MI.

Lonsdale, W. M. 1999. Global patterns of plant invasions and the concept of invasibility. Ecology **80**:1522-1536.

Loucks, C. J., Z. Lu, E. Dinerstein, H. Wang, D. M. Olson, C. Q. Zhu, and D. J. Wang. 2001. Giant pandas in a changing landscape. Science **294**:1465-1465.

Loucks, C. J., Z. Lv, E. Dinerstein, D. Wang, D. Fu, and H. Wang. 2003. The giant pandas of the Qinling Mountains, China: A case study in designing conservation landscapes for elevational migrants. Conservation Biology **17**:558-565.

Lovejoy, T. E. 2006. Protected areas: A prism for a changing world. Trends in Ecology & Evolution **21**:329-333.

Lundtorp, S., and S. Wanhill. 2006. Time path analysis and TALC stage demarcation in R. W. Butler, editor. The Tourism Area Life Cycle: Vol. 2. Conceptual And Theoretical Issues. Channel View Publications, Clevedon, UK.

Luo, J.-C., and L.-Y. Wang. 2010. Problems on ecotourism in nature reserves in China. Journal of Beijing Forestry University **32**.

McConnell, W. J., J. D. A. Millington, N. J. Reo, M. Alberti, H. Asbjornsen, L. A. Baker, N. Brozović, L. E. Drinkwater, S. A. Drzyzga, J. Fragoso, D. S. Holland, C. A. Jantz, T. A. Kohler, H. D. G. Maschner, M. Monticino, G. Podestá, J. Pontius, Robert Gilmore , C. L. Redman, D. Sailor, G. Urquhart, and J. Liu. 2011. Research on coupled human and natural systems (CHANS): Approach, challenges, and strategies. Bulletin of the Ecological Society of America **92**:218-228.

McCune, B. 2007. Improved estimates of incident radiation and heat load using non-parametric regression against topographic variables. Journal of Vegetation Science **18**:751-754.

McCune, B., and D. Keon. 2002. Equations for potential annual direct incident radiation and heat load. Journal of Vegetation Science **13**:603-606.

McNeely, J. A., and K. Miller 1983. National Parks and Protected Areas. UN Economic and Social Commission for Asia and the Pacific, Bangkok.

McShane, T. O., and S. A. Newby. 2004. Expecting the unattainable: the assumptions behind ICDPs in T. O. McShane, and M. P. Wells, editors. Getting biodiversity projects to work: towards more effective conservation and development. Columbia University Press, New York.

McShane, T. O., and M. P. Wells 2004a. Getting biodiversity projects to work: towards more effective conservation and development. Columbia University Press, New York.

McShane, T. O., and M. P. Wells. 2004b. Integrated conservation and development? in T. O. McShane, and M. P. Wells, editors. Getting biodiversity projects to work: towards more effective conservation and development. Columbia University Press, New York.

Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-Being: Current State and Trends Island Press, Washington, DC.

Ministry of Environmental Protection of the People's Republic of China. 2008. China's Fourth National Report on Implementation of the Convention on Biological Diversity

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403**:853-858.

Newsome, D., S. A. Moore, and R. K. Dowling 2002a. Natural area tourism : ecology, impacts, and management. Channel View Publications, Clevedon, England ; Buffalo, N.Y.

Newsome, D., S. A. Moore, and R. K. Dowling 2002b. Natural area tourism: ecology, impacts, and management. Channel View Publications, Buffalo, N.Y.

Nylen-Nemetchek, M. 1999. Lynx (Felis lynx) of Riding Mountain National Park: An assessment of habitat availability and population viability. University of Manitoba, Winnipeg, Manitoba, Canada.

Ouyang, Z., editor. 2000. Management system of China's nature reserves. Scientific and Technical Documents Publishing House, Beijing.

Ouyang, Z., X. Wang, H. Miao, and N. Han. 2002. Issues on nature reserve management system in China (in Chinese). Science and Technology Review.

Pan, W. 2005. The Panda Huzi. Guangxi People's Press, Nanning, China.

Pan, W., Z. Lv, X. Zhu, D. Wang, H. Wang, Y. Long, D. Fu, and X. Zhou 2001. A chance for lasting survival. Beijing University Press, Beijing, China.

Park, S. A., and A. H. Harcourt. 2002. Reserve size, local human density, and mammalian extinctions in US protected areas. Conervation Biology **16**:800-808.

Peng, L.-G., and Q. Zhang. 2011. How many nature reserves have been eroded. Southern Weekend, Guangzhou.

Peters, R. H. 1983. The Ecological Implications of Body Size Cambridge University Press New York.

Plume, D. A. 2001. Species home range in Monte Carlo: can home range be effectively managed by a roll of the dice? Resource Management. Central Washington University.

Plume, D. A. 2005. User manual for HomeGrower v3.

Pulliam, H. R. 2000. On the relationship between niche and distribution. Ecology Letters **3**:349-361.

Putnam, R. D. 2000. Bowling Alone: The Collapse and Revival of American Community. Simon and Schuster, New York.

Qi, D.-W., S.-N. Zhang, Z.-J. Zhang, Y.-B. Hu, X.-Y. Yang, H.-J. Wang, and F.-W. Wei. 2011. Different habitat preferences of male and female giant pandas. Journal of Zoology **285**:205-214.

Reardon, T., J. Berdegué, C. B. Barrett, and K. Stamoulis. 2007. Household income diversification into rural nonfarm activities in S. Haggblade, P. B. R. Hazell, T. Reardon, and T. A. Reardon, editors. Transforming the rural nonfarm economy: opportunities and threats in the developing world. Johns Hopkins University Press, Baltimore.

Refaeilzadeh, P., L. Tang, and H. Liu 2009. Cross Validation in M. T. Özsu, and L. Liu, editors. Encyclopedia of Database Systems. Springer, New York.

Reid, D. G., J. Hu, S. Dong, W. Wang, and Y. Huang. 1989. Giant panda *Ailuropoda melanoleuca* behaviour and carrying capacity following a bamboo die-off. Biological Conservation **49**:85-104.

Roloff, G. J., and J. B. Haufler. 1997. Establishing population viability planning objectives based on habitat potentials. Wildlife Society Bulletin **25**:895-904.

Roloff, G. J., and J. B. Haufler. 2002. Modeling habitat-based viability from organisms to population. Pages 673-685 in J. M. Scott, P. J. Heglund, M. L. Morrison, J. B. Haufler, M. G. Raphael, W. A. Wall, and F. B. Samson, editors. Predicting Species Occurrences: Issues of Scale and Accuracy. Island Press, Washington, DC.

Roloff, G. J., S. P. Mealey, and J. D. Bailey. 2012. Comparative hazard assessment for protected species in a fire-prone landscape. Forest Ecology and Management **277**:1-10.

Rosenbaum, P. R. 1987. Model-based direct adjustment. Journal of the American Statistical Association **82**:387-394.

Rosenbaum, P. R., and D. B. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. Biometrika **70**:41-55.

Rural Survey Department of National Bureau of Statistics 2000. Poverty monitoring report of rural China. China Statistics Press, Beijing.

Rural Survey Department of National Bureau of Statistics 2007. Poverty monitoring report of rural China. China Statistics Press, Beijing.

Salafsky, N., and E. Wollenberg. 2000. Linking livelihoods and conservation: A conceptual framework and scale for assessing the integration of human needs and biodiversity. World Development **28**:1421-1438.

Schaller, G. B. 1987. Bamboo shortage not only cause of panda decline. Nature **327**:562.

Schaller, G. B. 1994. The last panda. University of Chicago Press, Chicago.

Schaller, G. B., J. Hu, W. Pan, and J. Zhu 1985. The giant pandas of Wolong. University of Chicago Press, Chicago.

Scheyvens, R. 1999. Ecotourism and the empowerment of local communities. Tourism Management **20**:245-249.

Scoones, I. 1998. Sustainable rural livelihoods: A framework for analysis. Working Paper No. 72,. University of Sussex, Institute of Development Studies, Brighton.

Secretariat of the Convention on Biological Diversity. 2010. Global biodiversity outlook 3. Page 94, Montréal.

Sekercioglu, C. H. 2002. Impacts of birdwatching on human and avian communities. Environmental Conservation **29**:282-289.

Sichuan Province Committee on Annal Compilation, editor. 1996. Annals of Tourism in Sichuan Province. Sichuan People's Press, Chengdu.

Singh, I., L. Squire, and J. Strauss 1986. Agricultural Household Models. Johns Hopkins, Baltimore, MD.

Song, Z., Z. Ouyang, and W. Xu. In press. The role of fairness norms the household-based natural forest conservation: The case of Wolong, China. Ecological Economics.

Spiteri, A., and S. K. Nepal. 2006. Incentive-based conservation programs in developing countries: A review of some key issues and suggestions for improvements. Environmental Management **37**:1-14.

StataCorp. 2011. STATA 12.1.

State Council of China. 1994. Regulations of the People's Republic of China on Nature Reserves.

State Forestry Administration 2006. The third national panda survey report. Chinese Forestry Press, Beijing.

Stem, C. J., J. P. Lassoie, D. R. Lee, D. D. Deshler, and J. W. Schelhas. 2003. Community participation in ecotourism benefits: The link to conservation practices and perspectives. Society & Natural Resources **16**:387-413.

Stone, M., and G. Wall. 2004. Ecotourism and community development: Case studies from Hainan, China. Environmental Management **33**:12-24.

Su, B.-R. 2011. Rural tourism in China. Tourism Management **32**:1438-1441.

Su, D., G. Wall, and P. F. J. Eagles. 2007. Emerging governance approaches for tourism in the protected areas of China. Environmental Management **39**:749-759.

Taylor, E. J., G. A. Dyer, M. Stewart, A. Yunez-Naude, and S. Ardila. 2003. The economics of ecotourism: A Galapagos Islands Economy-wide perspective. Economic Development and Cultural Change **51**:977-997.

Timothy, D. J. 2002. Tourism and community development issues. Pages 149-164. in R. Sharpley, and D. Telfer, editors. Tourism and Development: Concepts and Issues. Channel View, Clevedon, Avon, UK.

Tuanmu, M.-N., A. Viña, S. Bearer, W. Xu, Z. Ouyang, H. Zhang, and J. Liu. 2010. Mapping understory vegetation using phenological characteristics derived from remotely sensed data. Remote Sensing of Environment **114**:1833-1844.

Tuanmu, M.-N., A. Viña, G. J. Roloff, W. Liu, Z. Ouyang, H. Zhang, and J. Liu. 2011. Temporal transferability of wildlife habitat models: implications for habitat monitoring. Journal of Biogeography **38**:1510-1523.

UN World Toruism Organization 2010. Tourism and the millennium development goals. United Nations World Toruism Organization, Madrid.

UN World Tourism Organization 2001. Tourism 2020 vision, Madrid.

UN World Tourism Organization 2002. Yearbook of Tourism Statistics. WTO, Madrid.

UN World Tourism Organization 2006. ST-EP Programme, Madrid.

UNED-UK. 1999. Gender and tourism: Women's employment and participation in tourism, United Nations Environment and Development UK Committee.

UNFPA. 2011. State of world population 2011 in United Nations Population Fund, editor, New York.

United Nations. 2010. The Millennium Development Goals Report, New York.

Viña, A., S. Bearer, X. Chen, G. He, M. Linderman, L. An, H. Zhang, Z. Ouyang, and J. Liu. 2007. Temporal changes in connectivity of Giant Panda habitat across the borders of Wolong Nature Reserve, China. Ecological Applications **17**:1019-1030.

Viña, A., S. Bearer, H. Zhang, Z. Ouyang, and J. Liu. 2008. Evaluating multi-temporal MODIS data for mapping Giant Panda habitat distribution in Wolong Nature Reserve, China.

Viña, A., X. D. Chen, W. J. McConnell, W. Liu, W. H. Xu, Z. Y. Ouyang, H. M. Zhang, and J. G. Liu. 2011. Effects of natural disasters on conservation policies: The case of the 2008 Wenchuan Earthquake, China. Ambio **40**:274-284.

Wallace, C. 2002. Household strategies: Their conceptual relevance and analytical scope in social research. Sociology-the Journal of the British Sociological Association **36**:275-292.

Walpole, M. J., and H. J. Goodwin. 2000. Local economic impacts of dragon tourism in Indonesia. Annals of Tourism Research **27**:559-576.

Wang, G., J. L. Innes, S. W. Wu, J. Krzyzanowski, Y. Yin, S. Dai, X. Zhang, and S. Liu. 2012. National park development in china: conservation or commercialization? Ambio **41**:247-261.

Wang, H., S. Li, and W. Pan. 2002. Population viability analysis on Giant Pandas in Qinling (in Chinese with English abstract). Acta Scientiarum Naturalium Universitatis Pekinensis **38**:756-761.

Weaver, D. B., and L. J. Lawton. 2007. Twenty years on: The state of contemporary ecotourism research. Tourism Management **28**:1168-1179.

Wei, F., and J. Hu. 1994. A study of breeding of wild giant pandas in Wolong Natural Reserve. Acta Theriologica Sinica **14**:243-248.

Wei, F., J. Hu, and G. Xu. 1989. A study of the life table of the wild giant pandas (in Chinese with English abstract). Acta Theriologica Sinica **9**:81-86.

Weizenegger, S. 2006. The TALC model and protected natural areas: African examples in R. W. Butler, editor. The Tourism Area Life Cycle: Vol. 2. Conceptual And Theoretical Issues. Channel View Publications, Clevedon, UK.

Wheelock, J., and E. Oughton. 1996. The household as a focus for research. Journal of Economic Issues **30**:143-159.

Whittaker, D., and R. L. Knight. 1998. Understanding wildlife responses to humans. Wildlife Society Bulletin **26**:312-317

Wolong Administration Bureau 2004. The History of Wolong Nature Reserve (in Chinese). Sichuan Science and Technology Press, Chengdu, China.

Wolong Administration Bureau. 2009a. Wolong National Nature Reserve ecotourism development plan.

Wolong Administration Bureau. 2009b. Wolong National Nature Reserve Post-earthquake Reconstruction Master Plan.

Wolong Administration Bureau Department of Social and Economic Development. 2006. Annual report on the rural economy of Wolong Nature Reserve. Wolong Administration Bureau.

Wolong Nature Reserve Administration Bureau, Department of Biology at Nanchong Normal University, and Conservation Bureau of Sichuan Department of Forestry 1987. Wolong Vegetation and Resource Plants. Sichuan Publishing House of Science and Technology, Sichuan, China.

World Bank. 2001. China: Air, Land and Water. Environmental Priorities for A New Millennium, Washington, DC.

World Travel and Tourism Council. 2012. WTTC world economic impact research report 2012.

Wu, B. 2001. A commentary on the Sichuan Province Tourism Development Master Plan (in Chinese). City Planning Review **25**:21-25.

Wu, R., S. Zhang, D. W. Yu, P. Zhao, X. Li, Q. Yu, J. Ma, A. Chen, and Y. Long. 2011. Effectiveness of China's nature reserves in representing ecological diversity. Frontiers in Ecology and the Environment **9**:383-389.

Wunder, S. 2000. Ecotourism and economic incentives - an empirical approach. Ecological Economics **32**:465-479.

Wunder, S. 2005. Payments for environmental services: Some nuts and bolts. CIFOR Occasional Paper No. 42.

Xia, J. H., P. Zeephongsekul, and D. Packer. 2011. Spatial and temporal modelling of tourist movements using Semi-Markov processes. Tourism Management **32**:844-851.

Xia, W.-P., and J.-C. Hu. 1990. Age structure and population dynamics of the giant panda in the Wuyipeng study areas, Wolong Reserve (in Chinese with English abstract) in J.-C. Hu, editor. Biological Research on Panda and Its Progresses. Sichuan Publishing House of Science & Technology, Chengdu.

Xie, Y., Z. Y. Li, W. P. Gregg, and L. Dianmo. 2001. Invasive species in China - an overview. Biodiversity and Conservation **10**:1317-1341.

Xinhua News Agency. 2012. Sanjiang township at Wenchuan, China: From a disaster area to a 4A level scenic spot. Xinhua News Agency, Beijing.

Xinhuanet. 2012a. Eighteen pandas returned to Wolong Nature Reserve and post-earthquake recontrution completed.

Xinhuanet. 2012b. The third round of recontruction of the Yingxiu-Wolong road started with four new tunnels and four new bridges.

Yan, X., and IUCN/SSC Conservation Breeding Specialist Group 1999. Giant Panda Conservation Assessment & Research Techniques Workshop: Final Report from the Workshop Held at the China Research and Conservation Center for the Giant Panda, Wolong Nature Reserve, 4-8 October 1999. IUCN/SSC Conservation Breeding Specialist Group.

Yeh, E. T. 2009. Tibet and the Problem of Radical Reductionism. Antipode **41**:983-1010.

Yeung, Y. M., and J. Shen 2004. Developing China's West: A Critical Path To Balanced National Development. Chinese University Press.

Yu, C. 2005. Inside story of the giant pandas (in Chinese). Mankind and Nature **5**:17-43.

Yu, D. W., T. Hendrickson, and A. Castillo. 1997. Ecotourism and conservation in Amazonian Per? short-term and long-term challenges. Environmental Conservation **24**:130-138.

Yu, L. 1992. Emerging Markets for China's Tourism Industry. Journal of Travel Research **31**:10-13.

Zhang, G. 2003. China's Tourism since 1978: Policies, Experiences and Lessons Learned. Pages 13-34 in A. A. Lew, L. Yp, J. Ap, and G. Zhang, editors. Tourism in China. The Haworth Hospitality Press, Binghamton, NY.

Zhong, L., J. Deng, and B. Xiang. 2008. Tourism development and the tourism area life-cycle model: A case study of Zhangjiajie National Forest Park, China. Tourism Management **29**:841-856.

Zhong, L. S., J. Y. Deng, Z. W. Song, and P. Y. Ding. 2011. Research on environmental impacts of tourism in China: Progress and prospect. Journal of Environmental Management **92**:2972-2983.

Zhou, Z. H., and W. S. Pan. 1997. Analysis of the viability of a giant panda population. Journal of Applied Ecology **34**:363-374.

Zhu, X., D. G. Lindburg, W. Pan, K. A. Forney, and D. Wang. 2001. The reproductive strategy of giant pandas (*Ailuropoda melanoleuca*): infant growth and development and mother infant relationships. Journal of Zoology **253**:141-155.

Zhu, Z., W. Bao, X. Pang, X. Yan, and Y. Li. 2006. Tourism effect on species composition and diversity of understory plants in Abies fargesii var. faxoniana forest in Jiuzhaigou, Sichuan (in Chinese with English abstract). Biodiversity Science **14**:284-291.

Zinda, J. A. 2012. Hazards of Collaboration: Local State Co-optation of a New Protected-Area Model in Southwest China. Society & Natural Resources **25**:384-399.