Sustainability Evaluation of the Grain for Green Project: From Local People's Responses to Ecological Effectiveness in Wolong Nature Reserve

Jian-Ying Xu · Li-Ding Chen · Yi-He Lu ·
Bo-Jie Fu

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Abstract This article examines the sustainability of the Grain for Green Project in the Wolong Nature Reserve. Pertinent data were collected through a questionnaire survey and a spatial analysis of reforested lands. The study results identified four critical issues that may influence the sustainability of the project in the study area. The first issue is concerned with the project's impacts on local sustenance. Because local grain consumption depends greatly on compensation awarded by the project, the potential for sustainability of the project is compromised. The second issue is that the project causes negative effects on local incomes in the Wolong Nature Reserve, which may undermine local economic prospects. The third issue is that the project failed to deliver suitable habitat for the giant panda, although two of the suitability requirements that deal with landform features were met. Lastly, the project neglects great differences among geographical areas in the country, providing the same compensation and length of compensation period to all participants. Appropriate com-

pensation mechanisms should be established and adapted to local economic, environmental, and social conditions. In managing nature reserves and moving toward sustainability, ensuring all aspects of local socioeconomic and ecological/environmental issues are properly addressed is a real challenge. Based on our study, some recommendations for improving sustainability of the project are given.

Keywords Grain for Green Project · Sustainability evaluation · Local people · Ecological restoration · Giant panda habitat

Introduction

Ecological restoration is gaining popularity in many areas of the world due to the need for sustainability. As a result, many new ideas and opportunities for biological conservation and natural resource management are being generated. However, despite countless attempts in the past, many restoration projects have been unsuccessful due to diverse reasons (Young 2004; Geist and Galatowitsch 1999). It has been pointed out that restoration success depends not only on technical feasibility and scientific validity but also on social acceptance (Cairns 2000; Geist and Galatowitsch 1999; Higgs 1997). Social acceptance and feasibility are necessary prerequisites for restoration success and need to be addressed first in the restoration planning and implementation process. Theoretically and practically, integrating local people into the restoration project will reduce roadblocks to restoration success (Cairns 2000; Geist and Galatowitsch 1999).

Nature reserves are a traditional approach to biodiversity conservation, but their effectiveness is limited by increasing human pressure. The objective to protect wildlife and

J.-Y. Xu
College of Resource, Environment and Tourism, Capital Normal University, 105 North Road of Western 3rd-Ring, Beijing 100037, People's Republic of China

J.-Y. Xu
State Key Laboratory of Urban & Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, P. O. Box 2871, Beijing 100085, People's Republic of China

L.-D. Chen (✉) · Y.-H. Lu · B.-J. Fu
State Key Laboratory of Urban & Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, P. O. Box 2871, Beijing 100085, People's Republic of China
e-mail: liding@rcees.ac.cn

other species is often in serious conflict with the needs and socioeconomic development of local residents (McNeely and Ness 1996). Therefore, linking local development with biodiversity conservation is required to advance the management and sustainable development of reserves (Bridgewater 2002; Price 2002). Involving local people in conservation and management, as well as providing them with economic incentives, is now a major feature of conservation policies and practices (Salafsky and Wollenberg 2000; Songorwa 1999; Gibson and Marks 1995; IUCN 1993). However, linkages between local livelihood opportunities and biodiversity conservation are complex and dynamic; conservation practices need to be based on a full understanding of social, economic, and biodiversity resources (Ferraro and Kiss 2002; du Toit 2002; Twyman 2001). Therefore, a systematic evaluation of the effectiveness of conservation practices has been highlighted as a key component of advancing scientific management for conservation (Sutherland 2000).

The Grain for Green Project is a significant ecological restoration project in China that was launched in 2000 and covers approximately 13 provinces (or municipalities). It is emphasized in the Western Development Campaign of the Chinese Central Government, and the objective is to improve ecological conditions by converting cultivated land with a slope greater than 25° to forest or grassland. Indubitably, at a national level the project has great potential to improve ecological conditions of middle and upper reaches of the Yangtze River and the Yellow River. On landscape and farmland levels, the project also has great potential to improve the local ecological environment. Shi and Wang (2003) studied the regional climatic effects of replacing farmland and re-greening desert lands with forest or grass in west China with the regional climate model. Dong and others (2004) found that the Grain for Green Project has improved the whole ecological environment of Zhifanggou Watershed by comparing changes in landscape pattern. On a farmland scale, researchers have found that soil quality, soil microbes, and root ecological niche have been improved by converting cultivated land into forest (Peng and others 2005; Liu and others 2005; Hu and others 2005). Despite its potential to improve the regional and local ecological environment, the project's sustainability is threatened by some socioeconomic problems, including grain production, economic compensation, local economic structure, and local employment (Hu 2005; Liu 2005; Shi and Wang 2005; Zhang and others 2005; Li 2004; Zhang and others 2004).

In remote and undeveloped regions of China, the Grain for Green Project is being implemented in biodiversity hotspots. The project impacts management of nature reserves and biodiversity conservation. Particularly, it provides a good opportunity to restore biodiversity regions

that have been destroyed or strongly influenced by human activity. Thus, this study investigated factors influencing the project's sustainability in a nature reserve and the project's contribution to biodiversity conservation. We selected Wolong Nature Reserve as our case study site because the project's effects on the management of the reserve have been previously documented (Xu and others 2006), and giant panda habitat within this reserve has decreased dramatically due to local human activities (Liu and others 2001).

Study Area

Wolong Nature Reserve is the largest among the 25 nature reserves in China designed for giant panda (*Ailuropoda melanoleuca*) conservation, a flagship species in China's biodiversity conservation. Approximately 100 giant pandas live in the study area, which represents 10% of the total giant panda population in China. The reserve was established in 1963 with an area of 200 km² and expanded to its current size of 2000 km² in 1975. It was upgraded to a biosphere reserve within the network of reserves established under the Man and Biosphere Program of UNESCO in 1980. The reserve is located in Wenchuan County, Sichuan Province, southwestern China ($102^\circ 2'$ to $103^\circ 24'E$, $30^\circ 45'$ to $31^\circ 25'N$) (Fig. 1). It is situated in the transition zone between the Chengdu plain and the Qinghai-Tibet plateau. The diverse habitats within the reserve are home to 57 endangered animal species besides the giant panda, such as the golden monkey (*Rhinopithecus roxellanae*), and 24 rare species of plants, including the dove tree (*Dacidia involucrate Baillon*).

The reserve is managed by the Administration Bureau of Wolong Nature Reserve, which includes two township

Fig. 1 Wolong Nature Reserve in southwest China

governments: Wolong Township and Gengda Township. In 2002, a total of 1097 households resided in the reserve, comprising a population of more than 4000 people. Approximately 70% of the local people belong to three minority groups in China: Tibetan, Qiang, and Hui. There is only one main road connecting inhabitants of the reserve to outside areas.

There are a total of six administrative villages in the study area, and committees are set up to manage each village. Among six villages, four villages (Gengda Yicun, Gengda Ercun, Wolong Yicun, and Wolong Ercun) are located near the main road; the other two (Gengda Sancun and Wolong Sancun) are located far from the main road. Local people depend mainly on traditional agriculture for subsistence in Wolong Nature Reserve. Maize, potato, and cabbage are the main crops in the reserve, of which cabbage provides the major source of income. Other employment opportunities in the reserve include housing construction, transportation, collection of Chinese herbal medicines, and forest guarding and patrolling. However, these types of employment are only seasonally available. Fu and others (2004) provided detailed information about the inhabitants of Wolong Nature Reserve.

Wolong Nature Reserve has implemented the Grain for Green Project. In the reserve, the project has great significance in restoring ecological conditions, improving local people's lives, and conserving biodiversity. Two types of cultivated land conversion are occurring in the study area. Land with a slope greater than 25° is being converted into forests. Land within 8 m on both sides of the road is being converted into bamboo fields. The former land conversion program is a policy of the Western Development Campaign of the Chinese Central Government and is currently being implemented in many western regions. The latter land conversion program is a unique policy of Wolong Nature Reserve. Food supplies and cash are awarded to farmers for their loss of income due to land conversion. However, farmers whose lands are near the road receive more compensation because these lands are generally flat and have high crop yield potential. Almost every household participated in turning cultivated land on slopes into forests, but only a few households participated in bamboo land conversion.

Data Collection and Analysis

Research about local attitudes toward and perceptions of the Grain for Green Project was conducted by means of a questionnaire administered through personal interviews during July and August 2004. One adult person (≥ 18 years old) from each household was interviewed in his or her residence. A total of 140 households were randomly se-

lected from the six villages, and 137 households were interviewed. Stratified sampling based on spatial distribution was employed to ensure proportional representation of households in the survey. To avoid potential bias, we made clear to the participants that the survey was for academic research and we were not affiliated with the management authority or any of the administration authorities. In addition, to avoid any influence of opinions from other members of the family, every attempt was made to hold a private face-to-face interview with the participant.

The questionnaire was designed with fixed-response and open-ended questions. The fixed-response questions and the possible alternative answers were read to interviewees, whereas the open ones were subsequently asked to gain an in-depth understanding of their answers. The fixed-response questions cover respondents' attitudes toward and comprehension of the Grain for Green Project and their perceptions of the influences of the project. In addition, demographic information of the respondents (gender, education level, age, and residence location) and household characteristics (household size, acreage of land owned, composition of household income, amount of household land that had been reforested under the project, and amount of compensation from the project) were also collected. Informal group discussions were held to probe deeper into the insights and perspectives of local people.

Data on the reforested land were collected from three sources: (1) The amount of reforested land held by respondents came from the survey; (2) the total amount of reforested land in each village was derived from statistical data published by the local government in 2004; and (3) due to lack of aerial photography and remote-sensing images with an appropriate scale for the study area, the spatial distribution of reforested land was recorded using GPS. GIS software, ArcView 3.2, was used to process the GPS location data to create reforested land coverage. A 1:50,000-scale digital elevation model was generated using Spatial Analyst to analyze landform distribution over the landscape.

Results

Demographic Variables

A total of 59 women (43%) and 78 men (57%) were interviewed. Respondents' ages were between 18 and 79 years, with an average age of 40 years. The 31- to 50-year-old group was the largest, followed by the 51- to 79-year-old and 18- to 30-year-old groups. With regard to education, approximately 19% of the respondents were illiterate, 32% educated to elementary school, 33% to junior high school, and 15% to senior high school or higher. Regarding the residence loca-

tion, the respondents were distributed approximately equally—50% of them dwelled in villages far from the main road, and the others were close to the road. Household size varied from 2 to 10 members, with a mean of 5.2 persons. More detailed information about the interviewees is available in the article by Xu and others (2006).

Local Attitudes toward the Project

In this study, we observed patterns in local attitudes about the implementation of the Grain for Green Project. In the reserve, the project received strong support from most people, with respondents in Wolong Town more supportive on average than those in Gengda Town (Table 1). In addition, local people recognized explicitly the project's purpose (Table 2), especially that the project could improve the ecological environment of the Yangtze River while advancing local development of the tourism industry.

Local attitudes toward the Grain for Green Project can be explained by the following reasons. First, when their cropland is converted to forest, local people receive grain and monetary compensation (2250 kg of grain/ha and 300 ¥/ha), providing them with basic subsistence needs without having to labor on sloped cropland. This is the main reason for their support of the project. Second, by implementing the project, local people expected to obtain other benefits, such as improvement of the ecological environment and the visual landscape, which made them even more supportive of the project, reserve management, and biodiversity conservation. However, some opposition to the project stemmed from dissatisfaction and unmet concerns. According to Chinese regulations, the duration of compensation under the project is only 8 years, which is a concern because there are no plans to replace the lost source of income from farming. Project participants were also dissatisfied with the government's delay in delivering promised compensation.

Table 1 Local attitudes toward the project

Response	Wolong	Gengda	Total
Support	58 (96.7%)	61 (79.2%)	119 (86.9%)
Oppose	2 (3.3%)	10 (13.0%)	12 (8.8%)
No opinion	0 (0%)	6 (7.8%)	6 (4.4%)

Table 2 Local knowledge about the purpose of the project

Response	Wolong	Gengda	Total
Know	50 (83.3%)	46 (59.7%)	96 (70.1%)
Do not know	7 (11.7%)	26 (33.8%)	33 (24.1%)
No opinion	3 (5%)	5 (6.5%)	8 (5.8%)

Fig. 2 The project's influence on local income

Project Influence on Local Economics

The Grain for Green Project can benefit local people by relieving their burden of farming. However, the project can also affect their family income. Sixty-one percent of respondents reported that participating in the project reduced their household incomes, whereas only 20% of respondents thought the project increased their incomes. Sixteen percent of respondents did not think the project had an influence on their household incomes, and the remaining 3% had no opinion about the project's influence (Fig. 2). Overall, more respondents in Wolong Town reported experiencing positive effects from participating in the project than those in Gengda (24 and 18%, respectively). More respondents in Gengda Town asserted that the project did not have any effect on their household income.

Local Cropland Holdings and Compensation

Beyond local attitudes and perceptions, we investigated information about local cropland holding and compensation to elucidate the Grain for Green Project's chances for sustainability and the real drivers behind the project.

According to the survey, compensation of an average of 89 kg of grain and an average of 17 Yuan RMB was granted to local people (Table 3). It was obvious that the Grain for Green Project did not bring enough economic benefit to local people even though they received enough grain to sustain their basic needs. Sixty-two percent of respondents were dissatisfied with the amount of land their

Table 3 Cropland, reforested land, and compensation

Indicator	Wolong	Gengda	Total
Average household size	5.49	4.98	5.18
Per capita cropland (ha)	0.035	0.045	0.04
Per capita reforested land (ha)	0.053	0.06	0.057
Per capita grain compensation (kg)	88.5	89.7	89.1
Per capita cash compensation (Yuan RMB)	15.9	18.0	17.1

Fig. 3 Spatial distribution of total reforested land

household owned. Also, on average, local people had converted more cropland into forest than they currently owned. Their reasons could be summarized as follows: (1) Cropland holding is not distributed evenly among households and some households, especially those of young families with small children, do not have enough cropland, and (2) some households have no choice but to convert cultivated land into forest because their croplands are either adjacent to or surrounded by reforested land that blocks out too much of the direct sunlight that their crops would require. Also, easy access to their cropland may no longer be possible because of surrounding reforested land.

Spatial Distribution of Reforested Land

The spatial distribution of reforested lands was evaluated in two aspects: (1) land distribution among different villages and distance between owners' residence and the main road and (2) land distribution over elevations and slopes. Considering total area (Fig. 3), the highest acreage occurred in Gengda Sancun, followed by Wolong Yicun and, lastly, Wolong Sancun. However, on a per capita basis (Fig. 4), the highest occurred in Wolong Sancun

Fig. 4 Spatial distribution of reforested land on per capita basis

Fig. 5 Distribution of reforested land over elevation

followed by Gengda Sancun (Wolong Sancun and Gengda Sancun are both located in remote regions). By analyzing the distance from the residence of each reforested land-owner to the main road, it was observed that respondents who live far from the road had converted more cropland into forest than those near the road (analysis of variance, $f = 4.918$, $P = 0.028$).

The survey results showed that in areas far away from the road, villagers are more willing to convert cultivated land into forest due to difficulties in planting, delivering their crops to market, and generating high crop yields. In addition, no government compensation is granted for destruction of crops by wild animals (except giant panda). In contrast, those near the main road have better opportunities to earn income by planting crops because their fields are flat, more productive, and closer to markets.

Distribution of reforested land in relation to elevation and slope was evaluated in terms of its suitability for giant panda habitat requirements. The results indicated that most reforested land is either at an altitude range of 1500–2500 m or on slopes greater than 25° (Fig. 5 and 6). The latter is consistent with requirements of the Chinese Central Government. Comparison of the reforested land with the slope

Fig. 6 Distribution of reforested land over slope

and altitude habitat requirements of giant panda (Ouyang and others 2001) revealed that most of the reforested land is suitable for giant panda habitat. In terms of altitude, all reforested lands are suitable for giant panda habitat. In terms of slope, 75% of reforested lands constitute suitable and marginally suitable habitat for giant panda. Thus, 75% of reforested land could be used as giant panda habitat if provided with suitable vegetation, another necessary aspect of habitat determining its overall suitability for giant panda.

Discussion

The Project and Local Sustenance

Grain production and security are paramount issues pertinent to the sustainability of the Grain for Green Project (Feng and others 2002). Prior to the project's implementation, most local people in the reserve relied solely on the sale of harvested crops such as cabbage, corn, and potatoes to buy grains that are not locally grown. After the implementation, agricultural income remains the main income source in the reserve, according to 2002 Wolong statistical data. However, our survey indicated that most local people experienced reductions in their income as a result of the project. So far, the project's compensation package (grain and cash) has not yet met local expectations for two reasons: The amount of grain for compensation is lower than the Chinese Central Government's requirement by approximately 16% (approximately 1875 kg/ha), and the compensation package (grain and cash) is not enough to meet the needs of families. In addition, families have to wait for compensation because of local government delays in delivering the promised compensation. As a result, grain supplies to local people are restricted by external factors beyond their control.

For most households, the amount of reforested land exceeded the amount of their remaining cropland. Limited cropland holdings not only reduced crop yields but also influenced local pork production, which is their main source of meat. Pork production in the reserve is closely related to agricultural production because some harvested crops, such as corn and potatoes, are used to feed pigs. Some processed pork products are also sold as a special local food (called *la rou*) to tourists and are thus an important additional source of family income. Since basic economic income and grain demands of local people depend highly on their cropland, the project's influence on local sustenance is wide and has cascading effects.

Therefore, it can be concluded that the Grain for Green Project does not have a positive effect on local sustenance in terms of grain and income. Also, high dependence on cropland and government compensation threatens the

sustainability of the project in this area. Indeed, this is a common threat factor in other regions where the project has been implemented (Dong and others 2005; Zhang and others 2004; Feng and others 2002). In general, the project influenced grain product and consumption in local communities, especially at the family level. However, effects at regional and national levels remain uncertain because of different environmental conditions and market regulation. Although local people support the project, some measures must be adopted to strengthen self-sufficiency in grain production or purchasing at the local level.

The strategy of substituting existing biodiversity- or natural resources-dependent livelihoods with alternative livelihood options to achieve conservation goals, especially in protected areas, is widespread. However, when this strategy is linked with programs that radically change land use relationships, it has the potential to significantly affect resource relationships within the rural population. This may have important impacts on dependency, welfare, and poverty, affecting, for example, the ability of people to respond to environmental stress and gain access to necessary resources, as well as affecting local livelihood sustainability and long-term viability (Twyman 2001; Toulmin 1991). Given the diversity and complexity of local livelihoods and needs, viable livelihood alternatives should be based on a thorough understanding of the local culture and a detailed analysis of the linkages between conservation and development. Otherwise, most initiatives are likely to lead to the failure through heightened antagonism and conflicts in people-protected areas (Jim and Steve 2002; Worah 2002; Blomley 2000; Wells and others 1999; Badola 1998; Kremen and others 1994).

The Project and Local Development

Local people not only need more money to sustain their grain consumption but also need other developmental opportunities to ensure the sustainability of the Grain for Green Project. Local acceptance of the project can be seen as an opportunity cost; that is, local people give up income from cropland for compensation from the project, which carries less risk and possibly higher reward potential than farming. The project has brought local people two obvious benefits that are the driving forces behind the successful implementation of the project in the reserve. One is that the project relieves local dependence on farming. The other is that local people have high expectations for the forest because they hope to receive income when trees are harvested for timber. However, the project could not be implemented in a long-term sustainable fashion for three reasons. First, local income decreased due to the project. Local people

have not received higher and timely income from the project. On the contrary, survey respondents thought that their previous income from selling cabbage that they grew on their croplands was more reliable and gave a higher reward. It is worth noting that many respondents claimed they preferred planting cropland rather than depending on government compensation. Second, many laborers were left without jobs due to limited employment opportunities. These unemployed laborers did not increase their family's income (Xu and others 2006). Third, the local people's high expectations for the reforested areas were difficult to fulfill. In the reserve, local people converted cultivated land to ecological forest, not economic forest. It is impossible for young seedlings to reach maturity for timber harvesting at the end of the 8-year term of compensation. In addition, the reserve's forested land plays an important role in maintaining ecological conditions of the upper reaches of the Yangzi River and restoring local destroyed wildlife habitat. Therefore, it is debatable whether the newly planted forest should be harvested.

It is obvious that local people's economic expectations for the Grain for Green Project have not been met in the Wolong Nature Reserve. In the long term, the project will bring more costs than benefits to local people. This is a potential threat to the sustainability of the project. As many conservation efforts have shown, local people's support is closely related to their perception of costs and benefits (Mehta and Heinen 2001; Fiallo and Jacobson 1995). It is important that benefits from the project be competitive with its costs because people are generally reluctant to accept higher opportunity costs (Norton-Griffiths and Southby 1995). Therefore, giving local people real and long-term benefits that exceed their costs is essential to the success of conservation practices (Barrow and Fabricius 2002; Pomeroy and others 2001).

The Project and Biodiversity Conservation

Unlike other reforested regions in China, this study area is a special region for biodiversity conservation. The Grain for Green Project provides an opportunity to restore giant panda habitat that has been occupied or fragmented by local people (Liu and others 2001). Giant pandas require not only suitable elevation and slope but also suitable vegetation. In the reserve, there are two types of vegetation in reforested land. The first type is larch and redwood, which occur on reforested land with a slope greater than 25°. The second type is bamboo, which occurs on reforested land near the main road. The first type provides the primary sites for restoring biodiversity and giant panda habitat. The recovery of giant panda habitat includes the recovery of both panda-edible bamboo and habitat structure. However, according to one study, larch and redwood

forest does not provide an efficient setting for giant panda habitat restoration because it is difficult to recover the bamboo resource and vegetation community under artificially planted forest (Ouyang and others 2002). Also, land reforested with bamboo under the project cannot be used as giant panda habitat because it is too close to human activity. Therefore, it is questionable whether the project could provide any contribution to giant panda habitat restoration, although restoration is urgently needed in the reserve.

The analysis of spatial distribution of reforested land indicated that residents living in remote areas of the reserve were more willing to turn their croplands into forest. They had difficulty in delivering their agricultural product to market on time because of transportation problems and, therefore, could not obtain the same level of income as those near the main road. Moreover, their agricultural fields were more likely to be destroyed by wild animals, and they could not derive compensation except for crops destroyed by giant panda. Thus, they were willing to convert their cultivated land into forest to pursue other employment opportunities. Our results support the relocation policy, which was discussed in another article (Xu and others 2006). Based on these two studies, we recommend that the relocation policy should first be implemented in remote regions of the reserve because it will not only help restore wild habitat but also improve the relationships between local people and the reserve.

Project Compensation

Edwards and Abivardi (1997) articulated that restoration activities "are inextricably embedded within an economic framework." It is well recognized that forest ecosystems provide diverse beneficial values to people, including direct-use values, indirect-use values, and existence values. From an economic perspective, it is important to determine whether a restoration project generates environmental benefits of equal or greater magnitude. In making decisions, it is essential to consider all values of ecosystem services and incorporate them into cost–benefit evaluations (Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems 2004). In addition, the costs and benefits of ecosystem conservation are unequally distributed, especially when all the ecosystem values are considered. Costs are borne mostly by local people, whereas benefits are shared by people at all levels, including local, regional, national, and even global levels (Fuentes-Quzada and others 2000; Wells 1992). The latter represent environmental externalities because most people enjoy the benefits but bear no costs. Considering the substantial local cost of conservation, management agencies need to design effective mechanisms so that a greater

proportion of the global benefit of forests can be captured to benefit both the endangered ecosystem and the welfare of local communities (Ferraro 2002; Muriithi and Kenyon 2002).

In the Wolong Nature Reserve, compensation for participating in the Grain for Green Project is based on agricultural production (just one part of direct-use values) and does not take ecological benefits or spatial and temporal factors into consideration. The project's ecological benefits increase with time, whereas compensation not only does not increase but also ceases after 8 years. At a local level, the best way to engage the whole society in efforts to conserve and restore ecological condition may be an appeal to self-interest. Therefore, it is essential to provide employment opportunities, reduce localized opportunity costs of the project, and take all values of the restored ecosystem into account when determining the compensation amount for participating in the project. This is also necessary for an equitable distribution of conservation costs.

Emphasis in ecological restoration has shifted from reestablishing a natural community of plants and animals in damaged ecosystems to restoring ecological functions, particularly those perceived as ecosystem services. Although such services are often difficult to quantify, they are increasingly being used to justify the commitment of resources to restoration projects. As any ecologist knows, it is difficult to predict the time needed for ecosystem recovery, given probabilistic events such as extreme weather conditions, pest outbreaks, and seed dispersal, coupled with limited scientific knowledge. Therefore, ecological restoration projects are characterized by considerable spatial and temporal variation. According to Chinese Central Government regulations, all of the regions where the Grain for Green Project is being implemented are treated equally and receive the same compensation amount over the same period regardless of the great differences that exist among these regions, especially in areas such as nature reserves. The issues dealing with compensation from the project in the reserve need to be recognized and adjusted.

It is essential that insights and approaches from ecology and economics be brought together if restoration efforts are to succeed at large scales (Mattison and Norris 2005; Münier and others 2004). A more holistic approach needs to be investigated to improve the Grain for Green Project. In the study area, the scientific approaches that serve to internalize what are commonly considered environmental externalities and provide a reasonable compensation amount over a reasonable time period should be studied to ensure the project's long-term sustainability. In addition, regional differences should be considered in establishing the regulations of the project.

Conclusions

Some of the factors affecting the sustainability of the Grain for Green Project were analyzed and discussed in this article, which disclosed how socioeconomic and ecological conditions are both linked to the project. To achieve long-term sustainability, resource managers and policy makers must commit themselves to taking an integrated view in evaluating and implementing policy to achieve long-term benefits. From a socioeconomic perspective, public participation is necessary to discern multiple stakeholders' benefits and incorporate these benefits into policy evaluation. Local people, important stakeholders in conservation policy, can avoid being marginalized by participating in the process where local needs and concerns are clearly identified and addressed. Also, in order to reduce opportunity costs of local people, a mechanism should be established to advance direct returns of conservation benefits from global, national, and regional levels to the local level. To realize this, managers need to integrate methods of markets, government policy, and tax collection into their management framework. From an ecological perspective, a carefully designed program needs to be implemented to monitor and evaluate ecological changes and functions. By combining socioeconomic and ecological insights in a holistic way, managers can balance and meet the multiple goals of the project. Also, due to considerable spatial variation, effective strategies must be tailored to specific local conditions if they are to succeed. It is beyond the scope of this study to address these management deficiencies in detail; however, these research findings can provide valuable information that could be integrated into management policy to achieve sustainability of the project in the study area.

With respect to livelihoods, the fragility of the Grain for Green Project could be avoided by developing local independence and self-sufficiency in grain and basic income. It is essential to develop employment opportunities and education/training programs to reduce opportunity costs of the project and increase local economic benefits, which in turn will decrease peoples' pressure on biodiversity conservation. Regarding biodiversity conservation, it is apparent that the existing reforested lands do not offer any significant contribution to giant panda habitat restoration. Relocating those residents living remotely may be an appropriate way to both restore wildlife habitat and improve the reserve's management.

A number of questions emerge regarding the Grain for Green Project's compensation amount and period. For making sound decisions on compensation, all values of the forestland should be incorporated into the cost–benefit evaluation to avoid an unequal spatial distribution of the costs and benefits. In addition, the government's compen-

sation policy should allow some flexibility to reflect regional and local differences. In the reserve especially, there is a need to extend the compensation period in order to ensure restoration of ecological function.

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