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Factors affecting land reconversion plans following a payment for ecosystem service program

Xiaodong Chen [a,*], Frank Lupi [b], Guangming He [a], Zhiyun Ouyang [c], Jianguo Liu [a]

[a] Center for Systems Integration and Sustainability, 1405 S. Harrison Road, Suite 115, Manly Miles Building, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48823, USA

[b] Department of Agricultural Food and Resource Economics and Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824, USA

[c] Research Center for Eco-environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

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ABSTRACT

Humans have altered much of the natural land cover, resulting in ecosystem degradation and biodiversity loss worldwide. Many countries have implemented conservation payment programs for agricultural land conversion to counter this trend. However, the sustainability of ecosystem services from these programs is unknown due to uncertainty about land uses when payments cease. We studied post-program land use plans for China's Grain-to-Green Program (GTGP), one of the world's largest ecosystem service payment programs, in Wolong Nature Reserve for giant pandas. Although farmers in the reserve planned to reconvert only 22.6% of the land that was enrolled in the GTGP to agriculture after payments cease, these GTGP plots are distributed across the landscape and may be important for many ecosystem services. Along with regional differences, the amount of GTGP land households planned to reconvert was significantly reduced by the respondent's age and off-farm household income and was significantly increased by the number of household laborers and total amount of land the household had enrolled in the GTGP. Thus, regional, demographic and economic factors should be considered to more efficiently sustain conservation benefits from payment for ecosystem service programs.

1. Introduction

Much of the world's natural land cover has been transformed by human activities (Foley et al., 2005; Morton et al., 2006), resulting in ecosystem degradation and biodiversity loss worldwide (Green et al., 2005; Vitousek et al., 1997). Human alteration of land cover is not limited to human-dominated areas, as it is also very common in many of the world's protected areas, such as nature reserves (Dompka, 1996). Interventions have been used to counter this trend through development activities such as stimulating community economies (e.g., ecotourism), encouraging community-based natural resources management, providing social benefits (e.g., education), and redirecting labor and capital from activities that harm ecosystems. These indirect approaches have been referred to as "conservation by distraction" (Ferraro, 2001; Ferraro and Simpson, 2002). Although billions of dollars have been invested through these approaches, the deterioration of ecosystems continues (Fearnside, 2005; Ferraro and Kiss, 2002; James et al., 2001).

In recent years, some conservation payment programs (Jack et al., 2008) for agricultural land conversion have been implemented to prevent soil and wind erosion, restore wildlife habitat, improve water quality, and counter the trend of deforestation worldwide (Smith, 1995; Zbinden and Lee, 2005). These programs provide benefits by restoring degraded ecosystems and providing habitat to wildlife (Johnson and Schwartz, 1993; McMaster and Davis, 2001). However, compared to outright purchases, many of these programs are short-term with uncertainty about land use after the programs end. In some areas, when program payments end most of the land that was enrolled may be reconverted to crop production, and conservation benefits cannot be sustained without continued conservation payments (Cooper and Osborn, 1998; Johnson et al., 1997).

Like many other parts of the world, China also has been implementing conservation payment programs (Liu and Diamond, 2005). Among these programs is the Grain-to-Green Program (GTGP), which is also referred to as Sloping Land Conversion Program (SLCP) (Bennett, 2008; Wang et al., 2007a; Xu et al., 2006). The motivations for implementing the GTGP were complex, but one of the main reasons was reaction to the major floods in 1998, which caused tremendous loss of life and economic costs. Many scientists believe that soil erosion, due to excessive deforestation, was the main reason for the floods (Liu and Diamond, 2005;

* Corresponding author. Tel.: +1 517 4325025; fax: +1 517 4325066.
E-mail addresses: chenxia2@msu.edu (X. Chen), lupi@msu.edu (F. Lupi), heguangm@msu.edu (G. He), zyouyang@mail.rcees.ac.cn (Z. Ouyang), jliu@panda.msu.edu (J. Liu).

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World Bank, 2001). The GTGP has been implemented since 1999, and participating farmers receive payments for a maximum of 8 years for converting sloping cropland to forest and pasture. In addition to its main objective of conserving ecosystem services such as reducing soil erosion by increasing vegetative cover, the GTGP also aimed to subsidize rural household incomes and support rural economic development (World Wildlife Fund, 2003; Xu and Cao, 2002). Moreover, the GTGP may increase the capacity for timber harvesting from plantation forests. Conservation benefits of such a program can be sustained only if participants do not reconvert their enrolled land when the programs end (Uchida et al., 2005), which has also been referred to as "permanence" of ecosystem services provision (Wunder, 2007). However, little is known about how enrolled farmers will respond after the program ends.

The GTGP has already generated substantial ecosystem services. Its cumulative contributions to the ecosystems in China and the world are considered tremendous (Liu and Diamond, 2005; Liu et al., 2008). To sustain the conservation benefits, the GTGP has recently been extended for another cycle (2–8 years). However, another cycle of the program may not guarantee the sustainability of its conservation achievements into the future. For instance, some land enrolled in the GTGP may be reconverted to agriculture when the payments cease (Uchida et al., 2005). On the other hand, many GTGP participants may not reconvert their GTGP land even after the program ends, which suggests that it is inefficient to invest scarce conservation funds for land that requires no additional protection. Therefore, studies on post-program land-use plans of farmers who participated in the GTGP are very important for the "permanence" of ecosystem services provision (Wunder, 2007). For instance, GTGP would have a low "permanence" if the enrolled land is reconverted to agriculture immediately after the program ends. Moreover, understanding post-program land-use plans of farmers participating in the GTGP can help target key regions at risk of losing the conservation achievements, thus providing support for cost-effective policy decisions (Chan et al., 2006).

2. Conservation payment programs for agricultural land conversion

2.1. Land-conversion programs around the world

Conservation payment programs for converting cropland from grain production have been implemented in many countries, especially in developed countries. The most famous one is probably the Conservation Reserve Program (CRP) in the United States. The CRP is a subtitle of the Conservation Title of the Food Security Act of 1985. The main objective of the CRP was to reduce soil erosion caused by agricultural production, with secondary objectives of creating wildlife habitat, improving water quality, controlling crop supply, and transferring income to farmers (Johnson et al., 1997; Smith, 1995). Enrolled farmers receive conservation payments for converting highly erodible or environmentally sensitive cropland to grass, trees, or other conservation uses through a contract that typically lasts 10 years. From 1986 to 1992, about 36.4 million acres of cropland were enrolled in the CRP at an average annual payment of $50 per acre (Cooper and Osborn, 1998; Skaggs et al., 1994), which resulted in a cost of over $1 billion per year (Parks and Schorr, 1997). By the end of 2005, 35.9 million acres of land were enrolled in the CRP with an annual cost of approximately $1.8 billion (Claassen et al., 2008).

Some other developed countries have also implemented ambitious conservation payment programs for agricultural land conversion (Organization for Economic Cooperation and Development (OECD), 1997). The Permanent Cover Program (PCP) in Canada began in 1989. The PCP was intended to conserve and improve soil productivity by retiring cropland where annual cultivation was causing long-term soil damage and to generate benefits for water, wildlife habitat, and landscapes. About 1.3 million acres of marginal and erodible cropland were converted from grain production to pasture or forests. In return, enrolled farmers received one-time conservation payments of $15 and $22 per acre for 10-year contracts or $36 and $47 per acre for 21-year contracts for pasture and forests, respectively. The total cost of the PCP was around $51 million. The European Union (EU) also has implemented conservation payment programs for agricultural land conversion. As part of the reforms of the Common Agricultural Policy, two land-conversion programs were introduced in 1992. The first one is part of the agri-environmental regulation, a set of policies aimed to promote agricultural production compatible with protection of the environment. Enrolled farmers receive an annual conservation payment of up to $784 ha^{-1} for setting aside agricultural land for at least 20 years to prevent soil erosion and improve water quality. Specific implementations in member countries are different due to the diversity of environmental conditions and agricultural structures. Another program of the EU is an afforestation scheme, which pays for afforestation of agricultural land to reduce the wood shortage in the EU. Enrolled farmers receive a payment covering the cost of afforestation and new woodland maintenance along with an annual conservation payment of up to $947 ha^{-1} for up to 20 years. By 1997, the afforestation scheme had converted around 930,000 ha of land at a cost of about $2.6 billion.

In the developing world, Costa Rica's Pagos de Servicios Ambientales (PSA) program provides a well-known example of a payment for ecosystem service program. Since 1997, the PSA has been implemented with three subprograms: reforestation, sustainable forest management, and forest conservation (Pagiola, 2008; Sierra and Russman, 2006; Zbinden and Lee, 2005). The reforestation subprogram subsidizes conversion of cropland to forest for 15 years. Enrolled farmers have to maintain a tree survival rate of at least 85% to receive a total payment of approximately $550 ha^{-1}. In the sustainable forest management subprogram, only valuable trees beyond a threshold diameter are allowed to be cut during a contract of 10 years. As compensation, enrolled forest owners receive a payment of approximately $327 ha^{-1}. Moreover, access roads to forest plots are limited to reduce the disturbance due to timber harvesting. The forest conservation subprogram rents forest land from owners for 5 years with a payment of approximately $210 ha^{-1}, and enrolled owners were not allowed to harvest timber or develop the land for other uses (e.g., livestock breeding) during the contract. By 2001, the PSA had provided conservation payments to more than 4400 farmers and forest owners, and the total area of land enrolled in the PSA was more than 284,000 ha, which is about 5.5% of Costa Rica's national territory (Zbinden and Lee, 2005). In addition to agricultural land conversion, many other conservation payment programs for the protection of ecosystem services have also recently been launched at regional and national levels, such as the payment for forest protection programs in Los Negros of Bolivia and Pimampiro of Ecuador (Asquith et al., 2008; Wunder, 2008; Wunder and Alban, 2008) and Payment for Hydrological Environmental Services program (Pago de Servicios Ambientales Hidrológicos, PSAH) in Mexico (Munoz-Pina et al., 2008).

In addition to their main objectives of converting land cover and protecting forests, many of these programs have also achieved objectives in conserving/creating wildlife habitat and in restoring ecosystems (Asquith et al., 2008; Dunn et al., 1993; Johnson and Schwartz, 1993; McMaster and Davis, 2001; Sierra and Russman, 2006). However, the conservation benefits of these programs may not be sustained in the long run. For example, studies of the CRP in the United States have shown that most of the enrolled land (60% or higher) is likely to be reconverted to crop production when contracts end (Cooper and Osborn, 1998; Johnson et al., 1997). Since 1996, expired CRP contract holders could apply for re-enrollment. Even with continued payments with similar prices, only about 55% of previous CRP land was re-enrolled in new contracts by the end of 2001 (Claassen et al., 2008).

Past studies have suggested that post-program land use of farmers who participated in conservation payment programs can be determined by their sociodemographic conditions and characteristics of the land (Cooper and Osborn, 1998; Johnson et al., 1997). Agricultural income has been shown to have positive impacts on the reconversion of enrolled land (Cooper and Osborn, 1998). On the other hand, farmers tend to enroll marginal land into conservation programs (Zbinden and Lee, 2005). Livestock breeding may negatively affect land reconversion because farmers may maintain their previously enrolled land for grazing after the payments end (Cooper and Osborn, 1998; Johnson et al., 1997).

As to the characteristics of the land that is enrolled in a program, distance from a household to the land may negatively affect post-program reconversion, since land farther away creates increased travel cost. Land with flat slopes may be more likely to be reconverted because it may be easier to farm with relatively higher yields. In regard to the characteristics of respondents, older contract holders tend not to reconvert their enrolled land (Cooper and Osborn, 1998). Households with more labor are more likely to reconvert enrolled land because they have more labor available for farming.

2.2. China's Grain-to-Green Program

The pilot of the GTGP began in Sichuan, Shaanxi, and Gansu provinces in 1999, was expanded to 17 provinces in 2000, and was further expanded to 25 provinces in 2002 (Liu et al., 2008). Due to its main objective of reducing soil erosion, the criterion for program enrollment is slope steepness above 15° in northwest China and above 25° elsewhere in China. Although cropland with slopes above the threshold receives priority in enrollment, many cropland plots with slopes below the threshold can also be enrolled (Uchida et al., 2005). Farmers who enroll and convert cropland receive conservation payments for 2 years for pasture, 5 years for 'economic' forests that can be harvested for something other than wood (e.g., fruit trees), or 8 years for 'ecological' forests, which can be harvested for wood. Among different types of land conversions, most (>75%) of enrolled croplands have been converted to 'ecological' forests (State Forestry Administration of China, 2005–2007). The annual conservation payments were 2250 kg and 1500 kg of grain or cash payments of 3150 and 2100 Yuan ha^{-1} (1 USD = 8.3 Yuan at the time of our interviews with farmers) of enrolled cropland in the upper reaches of the Yangtze River Basin and in the middle-upper reaches of the Yellow River Basin, respectively. In addition, annual miscellaneous expenses of 300 Yuan ha^{-1} and subsidies for seeds or seedlings were provided.

By the end of 2006, the GTGP had converted about 9 million ha of cropland. To date, the GTGP has produced substantial gains in ecosystem services (Liu et al., 2008). These potential ecological benefits include increased forest cover, reduced water surface runoff and soil erosion, reduced river sediments and nutrient loss for maintaining soil fertility, and reduced desertification (Li et al., 2006; Liang et al., 2006; Liu et al., 2002; Long et al., 2006; Ma and Fan, 2005; Wang et al., 2007b; Xu et al., 2006). As this program continues and ecosystems recover, many other benefits are expected, such as restoration of habitat for endangered species (e.g., giant pandas) (Loucks et al., 2001), and the global contributions and implications of the GTGP can be substantial (Liu and Diamond, 2005). However, these benefits may not be achieved or sustained with short-term conservation payment programs due to uncertainty about land use after the program ends.

By the end of 2007, much of the GTGP-enrolled croplands had fulfilled their contracts, and the program was extended for another 2–8 years with different conservation payments. Under the extended contract, the annual conservation payments will be half of the payments in the initial program, while annual miscellaneous expenses of 300 Yuan ha^{-1} will remain the same.

3. Methods

3.1. Study area

Wolong Nature Reserve was established in 1963 with an area of 200 km^2 and was expanded to 2000 km^2 in 1975 (Fig. 1). Located in southwest China, within one of the 25 global biodiversity hotspots, Wolong Nature Reserve is one of the largest reserves for the protection of endangered giant pandas (*Ailuropoda melanoleuca*). The wild panda population in the reserve represents about 10% of wild pandas in China, the only country with wild pandas in the world. In addition to bamboo, which is the pandas' main diet, conifer and

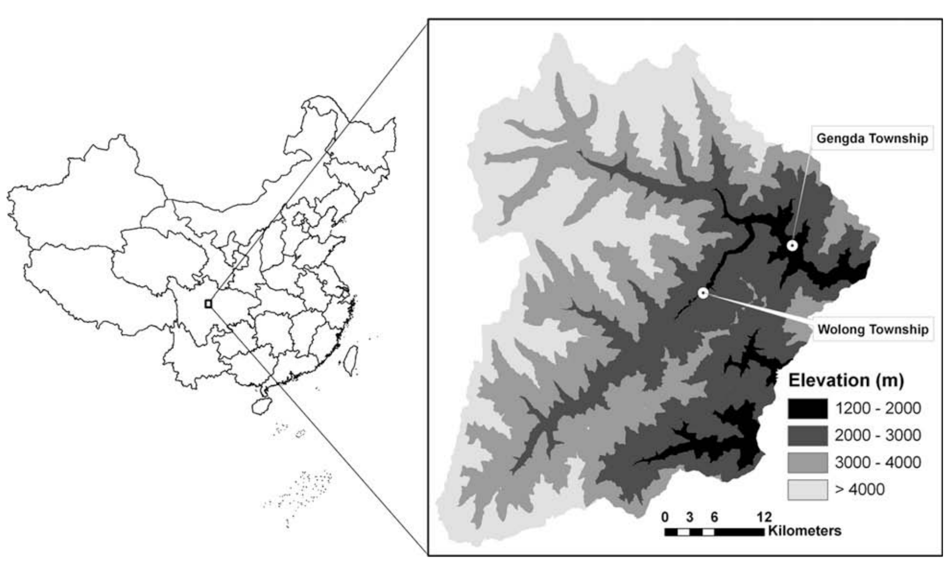

Fig. 1. Location and elevations of Wolong Nature Reserve.

broadleaf forests are important components of panda habitat by providing shelter and cover (Schaller et al., 1985). As a coupled human and natural system (Liu et al., 2007b), Wolong Nature Reserve also has approximately 4500 human residents in two townships (Wolong and Gengda), with various socioeconomic activities such as farming, fuelwood collection, and road construction. Although poaching is not threatening wild pandas due to severe legal sanction, giant pandas are threatened by rapid habitat degradation, mainly due to the removal of forest canopy cover (An et al., 2002; Liu et al., 2001).

The GTGP enrollment took place in Wolong Nature Reserve in 2000, 2001, and 2003. Farmers were encouraged to enroll their cropland plots with slopes over 25°, but many cropland plots with slopes below 25° were also allowed to enroll. All enrolled cropland was returned to 'ecological' forest in the reserve, and participating farmers received conservation payments for 8 years. From 2000 to 2004, the annual subsidies per hectare were 2250 kg of grain and 300 Yuan for miscellaneous expenses. Starting in 2005, the grain subsidy was replaced with a cash payment of 3150 Yuan ha^{-1}.

The GTGP may generate a number of positive impacts for the protection of panda habitat in Wolong Nature Reserve. The most immediate observable impact, for instance, is that part of the labor force has been released from agriculture and has boosted the trend of rural–urban labor migration, which has also been found in other regions of China where the GTGP has been implemented (Bao et al., 2005; Ge et al., 2006; Hu et al., 2006; Liu, 2005; Uchida et al., 2009); hence human population pressure on panda habitat has been reduced (Liu et al., 2007a). In the long run, degraded panda habitat may recover because the GTGP increased forest cover, which is an important component of panda habitat (Liu et al., 2001; Liu et al., 1999). In addition, GTGP land may generate substantial fuelwood, therefore alleviating further degradation of panda habitat due to fuelwood collection in natural forests. However, removal of trees for fuelwood from GTGP land may compromise the GTGP's potential for restorating panda habitat.

3.2. Household survey

We used an in-person interview approach to collect demographic and socioeconomic data, along with GTGP-enrolled land characteristics and the land-use plans of participants and their households when the GTGP ends. Our interviews were conducted from May to August 2006 in Wolong Nature Reserve. The GTGP contract did not mature at the time of our survey and we were not able to observe the actual behavior regarding post-program land use. In this study, we used GTGP participants' intentions regarding land use when the GTGP payment ceases. Other studies of land use plans following conservation programs have also successfully used intentions. For instance, studies of the CRP found that respondents' actual post-program land use behaviors after CRP contracts matured were generally consistent with their intentions (Claassen et al., 2008; Cooper and Osborn, 1998). Although intentions can deviate from actual behavior, intention is very often the strongest predictor of actual behavior (Madden et al., 1992; Schultz and Oskamp, 1996). Moreover, the correspondence between intentions and behavior can be increased by increasing the volitional control of respondents (Ajzen, 1985; Fishbein and Ajzen, 1975). We selected household heads or their spouses as our interviewees because they are usually the decision makers of households, and have the most volitional control over carrying out the stated intentions of land use.

Past studies in this reserve also suggested that respondents' intentions generally reflected their behaviors. For instance, in studying stated intentions of switching from fuelwood to electricity for energy use, An et al. (2002) found that higher voltage and better stability of electricity would increase respondents' intentions of switching from fuelwood to electricity. Since the reconstruction of electricity networks in 2001, the voltage and stability of electricity has been greatly improved. Meanwhile, a substantial amount of energy use has been switched from fuelwood to electricity (He, 2008), as suggested by the study of stated intentions of An et al. (2002). Similarly, studies of the intentions of young adults to move from their parental homes to establish their own households predicted that the number of households in the reserve would increase at a faster rate than the population due to the implied trend of household sizes in the reserve (An et al., 2005; An et al., 2003). From 1999 to 2005, the number of households has increased from 947 to 1156 (an increase of 22.1%) while the population size has increased from 4354 to 4550 (an increase of 4.5%) (Wolong Nature Reserve, 2005), which is consistent with the previously stated intentions of young adults in the reserve.

From the government's Wolong Household Registration list for the nature reserve for 2006, 321 households were randomly chosen for interviews. A response rate of 95% resulted in 305 valid interviews. Among them, one household did not participate in the GTGP and was removed from further analyses. Biophysical attributes of GTGP land were measured by combining GPS data and digital elevation model data, and were processed in ArcGIS 9.0 (software, Environmental Systems Research Institute, Redlands, California).

In Wolong Nature Reserve, 367.3 ha of cropland were enrolled in the GTGP (Wolong Nature Reserve, 2005). Among the 304 households in our survey, 110.4 ha of cropland were enrolled in the GTGP. Surprisingly, we found that farmers in the reserve planned to reconvert only 25.0 ha (22.6%) of the land that was enrolled in the GTGP to agriculture after payments cease. This stated planned reconversion rate is low compared to studies of post-program land use in other countries (Cooper and Osborn, 1998; Johnson et al., 1997). However, the low planned reconversion rate for GTGP lands in Wolong Nature Reserve is not unique, and even lower planned reconversion rates have been noted in some other places in China (Bao et al., 2005; Ge et al., 2006; Liu, 2005). Although the planned reconversion rate is relatively low in Wolong Nature Reserve, the land plots for possible reconversion are scattered across the landscape. If they are reconverted, they may increase human disturbances to the landscape and compromise ecological functioning for some ecosystem services such as providing habitat for giant pandas. Thus, they can be important for maintaining ecosystem services in the reserve.

3.3. Model specification

We seek to estimate the effects of sociodemographic characteristics and GTGP land features on the post-program land use of participants. In our model, the dependent variable is the amount of land that a farmer plans to reconvert to agriculture after the GTGP program ends. Since a substantial number of farmers did not plan to reconvert their GTGP land after the program ends, our dependent variable, the planned amount of GTGP land to be reconverted, is "censored" at zero. A censored dependent variable refers to a variable that takes values at the minimum or maximum limits of the observable range for a large fraction of observations (Greene, 2003). In this case, the planned amount of GTGP land to be reconverted takes on value zero with positive probability but is then a continuous random variable over strictly positive values, i.e., our dependent variable is censored at zero. When applied to censored data, traditional regression methods, such as Ordinary Least Squares (OLS), may predict negative outcomes that are inappropriate in this context, and estimated partial effects can be inconsistent. In the face of censoring, the Tobit regression model can produce consistent and efficient estimates of the model parameters and partial effects (Wooldridge, 2002). A Tobit model is described as

$$L^* = X\beta + \varepsilon \quad \varepsilon|X \sim Normal(0, \sigma^2) \tag{1}$$

$$L = \max(0, L^*), \tag{2}$$

where L is the amount of GTGP land planned to be reconverted, L^* is a latent variable that satisfies the classical linear model assumptions, X is a vector of household characteristics and GTGP land features, β is a parameter vector to be estimated, and ε is an error term that has a normal distribution with mean zero and variance σ^2. The expected value of the outcome is given by

$$E(L|X) = \Phi(X\beta/\sigma)X\beta + \sigma\phi(X\beta/\sigma), \tag{3}$$

where $\Phi(.)$ and $\phi(.)$ are the cumulative distribution and density of the standard normal distribution, respectively.

In the Tobit model, the marginal effect on the dependent variable of the jth continuous variable, x_j, is given by

$$\frac{\partial E(L|X)}{\partial x_j} = \beta_j \Phi(X\beta/\sigma), \tag{4}$$

and is usually calculated at the mean of the explanatory variables. The marginal effect for a dummy variable (d) is given by

$$E(L|\bar{X}(d), d = 1) - E(L|\bar{X}(d), d = 0), \tag{5}$$

where $\bar{X}(d)$ represents the means of all other variables in the model. Parameter estimation was conducted using STATA 8.0 (software, STATA Corp., College Station, Texas, USA).

4. Results

Our survey data are summarized in Table 1. Each surveyed household had an average of 2.55 laborers (ages 18–60 years). Household income was dominated by farming income (mean = 10.29 thousand Yuan yr^{-1}). However, incomes from off-farm employment, such as tourism business within Wolong Nature Reserve and jobs outside the reserve through rural-urban labor migration, were also substantial (mean = 6.03 thousand Yuan yr^{-1}), accounting for 36.9% of the household income. In addition, about half of the households bred livestock, and the average cropland per household was 0.28 ha. Most of our respondents were male, and the average age of respondents was 47. Our respondents had low levels of education (mean = 5 years), and almost all of them were married (98%). For the characteristics of GTGP-enrolled land, each household enrolled about 0.36 ha of land on average. The average walking time from households to their GTGP-enrolled land was 33.6 min, and the average slope of the GTGP-enrolled land was 27.0°. The average GTGP land that a household planned to reconvert was 0.08 ha. Approximately 56% of surveyed households were in Gengda Township.

Table 2
Tobit estimation of the effects of sociodemographic characteristics and GTGP land features on the GTGP land planned to be reconverted when the GTGP ends.

Independent variables	Parameters(standard errors)	Marginal effects
Laborers	0.048* (0.022)	0.015
Farming income	−0.004 (0.004)	−0.001
Off-farm income	−0.006* (0.003)	−0.002
Livestock breeding	−0.037 (0.053)	−0.011
Cropland	−0.096 (0.193)	−0.030
Township	−0.227** (0.051)	−0.074
Age	−0.006** (0.002)	−0.002
Gender	0.048 (0.051)	0.015
Education	−0.003 (0.008)	−0.001
Marital status	0.228 (0.175)	0.046
GTGP land	0.244* (0.124)	0.076
Average distance	−0.001 (0.001)	−0.000
Average slope	−0.003 (0.003)	−0.001
Constant	0.050 (0.221)	
Censored observations	206	
Uncensored observations	98	
Likelihood ratio statistic	52.98**	

Dependent variable: planned reconversion area.
* $p \leqslant 0.05$.
** $p \leqslant 0.01$.

Effects of household sociodemographic conditions and GTGP land features on the amount of GTGP land planned to be reconverted when the program ends are presented in Table 2. The GTGP land planned to be reconverted was positively related to the number of laborers in the household and the amount of land enrolled in the GTGP, but negatively related to the household's off-farm income, respondent's age, and the township indicator. In contrast to other studies (Cooper and Osborn, 1998; Johnson et al., 1997), the amount of land to be reconverted was not significantly related to farming income and livestock breeding.

The number of laborers had significant positive effects on the GTGP land planned to be reconverted, because households with more labor can handle more cropland to increase their farming income (Table 2). Consistent with other studies (Zbinden and Lee, 2005), having more off-farm income reduced the amount of GTGP land that was planned for reconversion, because such income raises the opportunity cost of using labor on the farm. Holding all other factors constant, households in Gengda Township planned to reconvert 0.074 ha (~20% of the average amount of GTGP land held by a household) less GTGP land than households in Wolong Township (Table 2). One of the main differences between the two regions is that Gengda Township is closer to the more developed urban areas outside the reserve.

The negative coefficient for age indicates that younger respondents planned to reconvert more of their GTGP land than older

Table 1
Summary statistics of variables used in modeling post-program land reconversion plans.

Variables	Description	Mean	Standard deviation
Planned reconversion area	GTGP land planned to be reconverted (ha)	0.08	0.15
Laborers	Number of laborers in the household	2.55	1.18
Farming income	In 1000 Yuan	10.29	6.89
Off-farm income	In 1000 Yuan	6.03	10.96
Livestock breeding	1 = own livestock; 0 = otherwise	0.56	0.50
Cropland	Cropland of the household (ha)	0.28	0.15
Township	1 = Gengda township; 0 = Wolong township	0.56	0.50
Age	In years	47	12
Gender	1 = male; 0 = female	0.60	0.49
Education	In years	5	4
Marital status	1 = married; 0 = unmarried	0.98	0.14
GTGP land	Land enrolled in the GTGP (ha)	0.36	0.20
Average distance	Average walking distance from the household to its GTGP land (minutes)	33.56	27.29
Average slope	Average slope of the GTGP land (degrees)	26.96	7.98

respondents (Table 2). Reconversion of GTGP land and farming are labor-intensive activities. Older farmers tend not to make such investments. The gender, education level, and marital status of respondents did not significantly affect the GTGP land planned to be reconverted. In addition, the more land the household had enrolled in the GTGP, the more GTGP land the household planned to reconvert when the program ends. Our two measures of households' GTGP land features, the average walking time from households to their GTGP land and the average slope of the GTGP-enrolled land, did not significantly affect the GTGP land planned to be reconverted (Table 2).

Examining the marginal effects of household sociodemographic conditions can help further understanding of the magnitude of their impacts on the GTGP land planned to be reconverted (Table 2). We estimated that one more laborer in the household increased GTGP land planned to be reconverted by 0.015 ha. One more thousand Yuan of off-farm income reduced 0.002 ha of GTGP land planned to be reconverted. One more year in respondent's age reduced 0.002 ha, and one more ha of land enrolled in the GTGP increased GTGP land planned to be reconverted by 0.076 ha.

5. Discussion

In our survey, only 22.6% of GTGP land area was planned to be reconverted when the GTGP ends. This relatively low share indicates that with no further program many of the conservation gains from the GTGP can be sustained even after the GTGP ends. Nevertheless, this small proportion of GTGP land may be important to sustaining ecosystem services in Wolong Nature Reserve. For instance, since households and their cropland are scattered across the landscape, their GTGP land plots are also scattered. The GTGP land at risk of reconversion may substantially affect landscape connectivity, which is very important to some ecosystem services, such as the recovery of the giant panda habitat (Liu et al., 2001). In addition, human activities in the reconverted GTGP land will affect other parts of the landscape, thus affecting ecosystem restoration and the use of habitat by wildlife species such as giant pandas (Bearer et al., 2008; Liu et al., 1999).

In modeling the participants' post-program land-use plans, we found that respondents who were younger and had less off-farm household income were planning to reconvert more of their GTGP land back to agriculture. As tourism has recently started being developed in Wolong Nature Reserve, tourism employment may be an important source of off-farm household income. The number of tourists has dramatically increased from 130,000 in 2000 to 206,100 in 2005; however, most local inhabitants have not been involved in tourism employment due to factors such as poor education and lack of relevant skills (He, 2008). In addition, more off-farm employment opportunities are available closer to urban regions outside of the reserve, and rural people in the reserve and many other regions where the GTGP has been implemented may increasingly take advantage of the transitional economy through rural–urban labor migration (Li and Zahniser, 2002; Yang, 2000). By 2005, more than 150 inhabitants of the reserve were working in urban regions outside of the reserve. The trends of labor migration in China and tourism development in Wolong Nature Reserve may have contributed to ecosystem restoration. Leveraging these trends can be an opportunity for governments and non-governmental conservation organizations to sustain conservation gains from ecosystem services payment programs, although labor migration and tourism development may also have negative environmental impacts and should also be carefully studied for policy development.

We also found households that had more laborers and/or had enrolled more GTGP land were more likely to reconvert part or all of their GTGP land, indicating the risk of losing the conservation benefits that had been gained through the GTGP. Even though Wolong Township is only 28 km from Gengda Township, on average a household in Gengda Township planned to reconvert 0.07 ha less GTGP land than a household in Wolong Township. This difference represents about 20% of the average amount of GTGP land managed by a household in the reserve.

Our results suggest policy instruments for improving the sustainability of conservation benefits of the GTGP in China should target younger farmers, those with little off-farm income, and farmers with many laborers and larger amounts of enrolled GTGP land. For instance, some young farmers can be given training in off-farm employment skills and provided with off-farm employment information, which are usually well developed in cities but not in rural areas. Moreover, conservation payments may be prolonged to those GTGP participants with high risks of land reconversion. Although conservation investment in only those participants with high risks of reconversion may be perceived as unfair to other participants, it can be much less expensive than paying all the participants for similar conservation achievements, hence targeting is typically a more efficient way of using conservation funds that are already scarce (James et al., 2001; James et al., 1999). In practice, it may be difficult to completely discriminate participants who will reconvert their enrolled land when the payment ceases from other participants because participants' opportunity costs of contractual compliance of PES programs are not observable (Ferraro, 2008). Therefore, experimentation in some pilot regions would be necessary before any widespread implementation of conservation investments that only target those participants with high risks of reconversion.

Within the 25 Chinese provinces where the GTGP was implemented and in other regions worldwide with conservation payment programs, the biophysical, sociodemographic, economic, and institutional heterogeneities are substantial. Investments required for conserving ecosystem services can be quite different due to these heterogeneities. As such, understanding the heterogeneities presents opportunities for targeting conservation to improve a program's cost-effectiveness or increase the amount of conservation that can be achieved by ecosystem services payment programs. Although our study area is relatively small compared to the overall amount of GTGP lands in China, our results were consistent with findings in many other GTGP implemented regions (Bao et al., 2005; Ge et al., 2006; Hu, et al. 2006; Liu, 2005). The relatively small area of Wolong Nature Reserve enabled us to have a higher proportion of households sampled than a large area could afford. It would be interesting to conduct studies on factors affecting the land reconversion plans in the broader regions where GTGP has been implemented as they may produce further understanding of the sustainability of conservation gains from this program.

Although regional level case studies have provided evidence that the GTGP has already generated various ecological benefits (Li et al., 2006; Liang et al., 2006; Liu et al., 2002; Ma and Fan, 2005; Wang et al., 2007b), studies of the ecological effects of the GTGP over all of the regions in which it has been implemented would provide better understanding of the ecological effects of this program. In the case of Wolong Nature Reserve, the GTGP has been expected to restore panda habitat (Wolong Nature Reserve, 2005). However, it usually takes several decades for panda habitat to fully recover (Bearer et al., 2008). More studies are needed to understand the potential restoration of panda habitat due to the GTGP, as well as the impact of the amount and spatial distribution of land reconversion on the restoration of panda habitat.

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