Linking social norms to efficient conservation investment in payments for ecosystem services

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Edited by Gretchen C. Daily, Stanford University, Stanford, CA, and approved May 6, 2009 (received for review October 6, 2008)

An increasing amount of investment has been devoted to protecting and restoring ecosystem services worldwide. The efficiency of conservation investments, including payments for ecosystem services (PES), has been found to be affected by biological, political, economic, demographic, and social factors, but little is known about the effects of social norms at the neighborhood level. As a first attempt to quantify the effects of social norms, we studied the effects of a series of possible factors on people's intentions of maintaining forest on their Grain-to-Green Program (GTGP) land plots if the program ends. GTGP is one of the world's largest PES programs and plays an important role in global conservation efforts. Our study was conducted in China's Wolong Nature Reserve, home to the world-famous endangered giant pandas and >4,500 farmers. We found that, in addition to conservation payment amounts and program duration, social norms at the neighborhood level had significant impacts on program re-enrollment, suggesting that social norms can be used to leverage participation to enhance the sustainability of conservation benefits from PES programs. Moreover, our results demonstrate that economic and demographic trends also have profound implications for sustainable conservation. Thus, social norms should be incorporated with economic and demographic trends for efficient conservation investments.

China | Grain-to-Green Program | program re-enrollment | stated choice | sustainability

Human activities are widely recognized as major forces of rapid landscape change, resulting in biodiversity loss and ecosystem degradation worldwide (1–5). Billions of dollars have been invested by governments, private sectors, and conservation non-government organizations to conserve biodiversity and ecosystem services. However, current investments are far below the requirements for conserving ecosystems globally (6, 7). Moreover, most of these investments are spent within wealthy countries, whereas places with rich biodiversity under threat are often poor (7, 8). To minimize biodiversity loss with limited conservation resources, priorities for conservation investments have been placed on areas where biodiversity and human impacts are highest, e.g., global biodiversity hotspots (8–10). However, priority settings based on biological values and threats to these values alone may not guarantee the efficiency of conservation investments.

Efficient conservation investments need to incorporate biological values with heterogeneous demographic, political, and socioeconomic conditions (11–13). The high human population and household density and growth rates in the biodiversity hotspots indicate that human population is and will remain an important factor in global biodiversity conservation (14, 15), and the uneven distribution of human population and households should be considered in conservation investments (3). Political conditions (e.g., political corruption and government stability) in targeted regions also have a pronounced effect on the efficiency of conservation investments (16). Like human population, per unit area costs of effective conservation also vary enormously across different places (17). The efficiency of conservation investments can be improved by considering economic conditions, such as land prices, at global, regional, and local scales (18–21). Although much has been learned about the effects of these socioeconomic factors on the efficiency of conservation investments (11, 12, 14–20), little is known about the effects of social norms at the neighborhood level (22).

Social norms are shared understandings of how individual members should behave in a community under a given circumstance, and members within the community reward or punish people for their behaviors in following or breaking the norms (23, 24). More generally, social norms may also be sustained by feelings attached to the reputation and self-esteem garnered by conforming to social norms or the shame and guilt garnered by detaching from the norms even in the absence of third-party punishment (23, 25, 26). In this paper, we study social norms, which may be sustained by self-enforced psychological feelings and/or third-party-enforced punishment, in a more general context. Specifically, we examine when an individual's behavior is directly influenced by the behavior of other members in the community, and substantial change in aggregate behavior of the community can change an individual's behavior (27, 28). Social norms also have been important in the collective actions of natural resources management (29–32) but have received little attention in studies of conservation investments.

One approach to conservation investments is through payments for ecosystem services (PES) (33–36), such as land set aside and forestry contracting in the United States and European Union (37). In contrast to outright purchase of land or permanent easements, short-term PES programs may result in only temporary conservation benefits, with uncertainty about land use after the programs end. Past studies have focused on the program participation of landowners (34, 38), but much less is known about the impacts of subsequent policies on land use when a PES program ends. Subsequent PES programs are very important for the sustainability of conservation benefits from initial PES programs.

People's decisions to participate in a PES program are made in a social context. Studies indicate that both economic incentives and social norms are important in an individual's behavior (39) in terms of common resources management (40, 41). Individuals whose land-use decisions differ from the majority in the community may be exposed to social pressures from the community. Studies of individuals' participation in PES programs have focused on the incentives provided by conservation payments (33, 42); little is known about the impacts of social

Author contributions: X.C., F.L., G.H., and J.L. designed research, performed research, analyzed data, and wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

Freely available online through the PNAS open access option.

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This article contains supporting information online at www.pnas.org/cgi/content/full/0809980106/DCSupplemental.

norms at the neighborhood level on the sustainability of conservation, although substantial conservation benefits (e.g., through land enrolled in conservation contracting programs) may be produced with a relatively small change in policy or other exogenous factors due to social norms (43, 44). To illustrate the impacts of social norms on the sustainability of conservation, we studied the impacts of subsequent policies on the land plots that have been enrolled in the Grain-to-Green Program (GTGP) in China's Wolong Nature Reserve.

The goal of the GTGP is to convert sloping cropland to forest or pasture (45, 46). Farmers who enroll and convert cropland plots receive an annual conservation payment for a maximum of 8 years. Because many scientists believe that soil erosion due to deforestation was the principal cause of the huge floods in 1998, the main objective of the GTGP is to plant trees or pasture on cropland with steep slopes to prevent soil erosion (47, 48). The criterion for enrolling in the GTGP is for the slope of cropland in southwestern China to be >25° and cropland in northwestern China to be >15°. By the end of 2006, the GTGP had converted ≈9 million ha of cropland nationwide (46).

The GTGP is expected to generate conservation benefits and improve degraded ecosystem services (45), especially in regions that are located within global biodiversity hotspots, such as Wolong Nature Reserve [supporting information (SI) Fig. S1] in southwestern China. Wolong is one of the largest reserves for the conservation of the world-famous endangered giant pandas (*Ailuropoda melanoleuca*). In addition to ≈10% of the total wild panda population and ≈6,000 plant and animal species, Wolong is also home to a rural human population of ≈4,550 (49). There are diverse economic activities in Wolong, such as farming, fuelwood collection, livestock breeding, transportation, and tourism development. Previous studies in Wolong have shown that panda habitat had experienced rapid degradation due to various human activities, such as deforestation for agricultural land, timber harvest, and fuelwood collection by local people (50–52). Much of the forest has been removed through these human activities. Although the reserve administration had implemented several policies, such as prohibiting the development of cropland and limiting the sites for and amount of fuelwood collection, these policies were not effective without providing conservation payment or strict enforcement (49).

The GTGP has been implemented in Wolong Nature Reserve since 2000. All households that participate in the GTGP receive an annual payment of 250 yuan/mu* for a fixed length of 8 years for converting cropland to forest and keeping the converted plots forested. Many land plots with slopes of <25° were also allowed to enroll. The GTGP has already generated positive impacts on panda habitat. For instance, by receiving conservation payments through the GTGP, part of the labor force has been released from farming and has been attracted to off-farm employment in more developed urban areas created by rapid economic growth in China (45), thereby reducing human population pressure on panda habitat in Wolong. The GTGP may also have other positive impacts on panda habitat in the long run. For instance, degraded habitat could be improved because the GTGP increases forest cover, which is an important component of panda habitat (50, 51). In addition, because fuelwood collection may be permitted in mature GTGP stands, the GTGP may provide substantial fuelwood, which is one of the main energy sources for residents, and alleviate further degradation of panda habitat in natural forests.

In this article, we focus on the re-enrollment intentions of local inhabitants regarding their GTGP land plots that are likely to be reconverted to agriculture when the program ends, given different PES policy scenarios following the GTGP. Our policy scenarios were combinations of 3 attributes: conservation payment, program duration, and neighbors' behavior (the percentage of neighbors reconverting their enrolled land plots to agriculture). We used stated-choice methods (53, 54) to relate these attributes to the re-enrollment of those GTGP land plots that are likely to be reconverted when the GTGP ends. In addition, controls were set for household economic and demographic conditions, features of the GTGP land plots, as well as characteristics of respondents.

Results

Effects of Social Norms and Conservation Payment on Re-Enrollment. Both social norms and conservation payments had significant impacts on the respondents' intentions of re-enrolling their GTGP land plots in PES programs (Table 1). It was estimated that an additional 10% of neighbors' reconverting at least part of their GTGP land plots to agriculture reduced the respondents' intentions of re-enrollment by 6.4% on average. In other words, people's re-enrollment intentions can be affected by the re-enrollment decisions of their neighbors and tend to conform to the majority. With a decreasing proportion of neighbors' reconverting at least part of their GTGP land plots to agriculture, an individual's probability of program participation will increase. For instance, with an annual payment of 200 Yuan/mu, 25% more land plots will be re-enrolled if the percentage of neighbors reconverting their GTGP land plots is changed from 75% to 25%.

The proposition of higher conservation payments increased the number of land plots intended for re-enrollment. Specifically, an additional yuan in the payment will increase the probability of re-enrolling in the PES program by 0.8%. Among the GTGP land plots that are likely to be reconverted to agriculture when the GTGP ends, more than half can be prevented from being reconverted under a PES program offering an annual payment of 200 yuan/mu. If the current GTGP can be renewed with the same payment (250 yuan/mu), >90% of GTGP land plots could be saved from reconversion. This finding is quite different from that in studies of the Conservation Reserve Program (CRP) in the United States, where maintaining enrolled land was much more expensive than the original cost (42). Compared to the land set aside in the CRP, the GTGP land plots have high costs of reconversion due to reforestation in the land plots. Moreover, the GTGP land plots may provide additional ecosystem services, such as fuelwood production, to participants.

Intentions of re-enrollment were also influenced by the combined effects of the conservation payment and neighbors' re-enrollment behavior (Fig. 1). For instance, offering an annual payment of 200 yuan/mu with 75% of neighbors' reconverting at least part of their GTGP land plots had effects on the total re-enrollment similar to those resulting from offering an annual payment of 158 yuan/mu with only 25% of neighbors' reconverting their GTGP land plots. Re-enrollment of 50% of land plots that will be reconverted when the GTGP ends would require an annual conservation payment of 184 yuan/mu or 142 yuan/mu if 75% or 25% of local residents were to reconvert at least part of their GTGP land, respectively. If the cost of program re-enrollment over multiple years and across all involved regions is considered, the differences in conservation cost under different social norms are substantial.

The impact of social norms on program re-enrollment was nonlinear across different levels of conservation payments. Social norms had the largest impact on the re-enrollment rate when the payment was intermediate, whereas the effects of social norms were smallest with the highest and lowest payments, where almost all or none of the respondents would participate (Fig. 1).

*At the time we collected field data, 1 U.S. dollar was equal to 8.3 yuan; also, 1 hectare is equivalent to 15 mu.

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Table 1. Estimation of policy attributes and other characteristics and their marginal effects on the program re-enrollment

Characteristics	Independent variables	Parameters	SE	Marginal effects
Social norms and conservation payment	Neighbors' behavior	−1.662*	0.581	−0.636*
	Conservation payment (yuan)	0.020*	0.003	0.008*
Program durations	3-year duration (dummy, reference = 6 years)	−0.598†	0.277	−0.230†
	10-year duration (dummy, reference = 6 years)	−0.270	0.281	−0.104
Household economic and demographic conditions	Farming income (1,000 yuan)	−0.075‡	0.042	−0.029‡
	Off-farm income (1,000 yuan)			
	Labor migration to outside of Wolong	0.253†	0.127	0.097†
	Tourism employment in Wolong	0.046	0.071	0.018
	Temporary employment in Wolong	0.063	0.062	0.024
	Permanent employment in Wolong	0.054	0.047	0.021
	Cropland after GTGP (mu)	0.361*	0.127	0.138*
	Livestock (dummy)	0.406	0.520	0.157
	Household size	−0.127	0.176	−0.049
	Total land enrolled in GTGP (mu)	0.025	0.085	0.010
Land plot features	Area of land plot (mu)	−0.110	0.246	−0.042
	Fuelwood production (kg)	0.003‡	0.002	0.001‡
	Average walking distance from each household to its land plots (minutes)	−0.038*	0.012	−0.015*
	Deviation of plot-household distance from the average distance (minutes)	0.015	0.013	0.006
	Elevation (1,000 m ASL)	0.050	2.099	0.019
	Slope (degrees)	−0.038	0.024	−0.015
	Aspect (180 = north-facing; 0 = south-facing)	−0.007	0.006	−0.003
	Labor cost of reconversion (persons·days)	0.002	0.003	0.001
	Geographic location (dummy)	0.498	0.816	0.185
Respondents' characteristics	Age (years)	0.077*	0.023	0.030*
	Gender (reference = female)	−0.841‡	0.474	−0.300†
	Education (years)	−0.049	0.072	−0.019
Constant		−3.812	4.902	

Significant parameters for $\sigma_\mu = 1.836$ ($P < 0.01$) and $\rho = 0.771$ ($P < 0.01$) suggest that the random-effects model is appropriate, and the test statistic $\chi^2 = 80.59$ ($P < 0.01$) indicates that the random-effects model is preferred to the model without random effects. The unit of measure for each parameter, SE, and marginal effects is given in parentheses next to the independent variable. Observations = 498; number of plots = 166; log likelihood = −219.209. SE, standard error; ASL, above sea level.

*$P \le 0.01$.

†$P \le 0.05$.

‡$P \le 0.1$.

Effects of Program Durations on Re-Enrollment. Program durations also had nonlinear effects on re-enrollment. As shown in Table 1, a 3-year program re-enrolled 23% fewer GTGP land plots than a 6-year program. However, re-enrollment for a 10-year program was not significantly different from a 6-year program (Table 1). Presumably, farmers made tradeoffs among stability, total payment, risks, and flexibility. Compared with short-term programs, longer-term programs provide more stable income and larger cumulative payment but also bring more risks and less flexibility by limiting farmers' ability to adapt to changing conditions in markets of crop products.

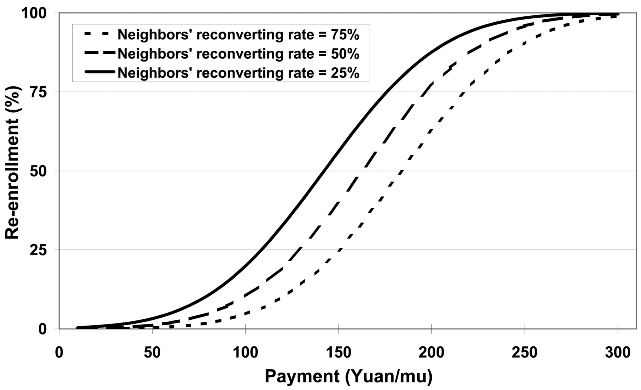

Fig. 1. Estimated program re-enrollment under different levels of payment and neighbors' reconversion behavior.

Effects of Household Economic and Demographic Conditions. We found that sources of household income had different effects on program re-enrollment (Table 1). Farming income had a significant, negative effect on people's re-enrollment intentions. It was estimated that 1,000 more yuan of farming income reduced the probability of re-enrollment by 2.9%. However, income from off-farm employment outside of Wolong significantly increased the number of GTGP land plots to be re-enrolled in the PES program: 1,000 more yuan of income from employment outside of Wolong increased the probability of re-enrollment by 9.7%, whereas the incomes from off-farm employment within Wolong (tourism employment, temporary off-farm employment, and permanent employment) did not have such an effect. Although there are conflicts of labor allocation between off-farm employment and farming, off-farm employment within Wolong is much more flexible in terms of labor and time allocation, compared with off-farm employment outside of Wolong, and therefore does not cause conflicts with the labor needs of farming. Thus, not all off-farm income may increase the participation in PES programs, and different types of off-farm employment should be treated differently.

Households with more cropland tended to re-enroll their GTGP land plots in the PES program (Table 1) because GTGP land plots are usually marginal for growing crops, and people would not reconvert them to agriculture as long as they already have adequate land for farming. One extra mu of cropland increased the probability of re-enrollment by 13.8% (Table 1). In contrast to other studies (42), livestock breeding did not affect people's re-enrollment intentions. Moreover, no effects of household size and total area of GTGP land plots on program re-enrollment were found (Table 1).

Effects of Land Plot Features and Respondents' Characteristics. The respondents' perception of fuelwood that can be sustainably produced[†] by land plots had a positive effect on the program re-enrollment. Fuelwood is one of the most important energy sources for local people in Wolong (52). Because fuelwood collection may be allowed in mature GTGP land, the prospect of more fuelwood production can increase the number of land plots to be re-enrolled. An expectation that the land plot will annually produce an additional 10 kg of fuelwood in the long run increased the probability of re-enrolling the land plot by 1% (Table 1). Among households, the average distance from each household to its land plots had a negative effect on the program re-enrollment, probably because the average distance was correlated to some unmeasured variables of households, such as social status. But within a household, the deviation of plot–household distance from the average distance (difference between each plot–household distance and the average distance of each household) was not significant in determining the GTGP land plots to be re-enrolled (Table 1). No effects of other plot features on the re-enrollment were found (Table 1).

For the characteristics of respondents, older people were more likely to re-enroll their GTGP land plots. One additional year of a respondent's age increased the probability of re-enrollment by 3.0% (Table 1). Because farming and reconverting GTGP land plots to agriculture are labor intensive, re-enrolling these land plots in the PES program would be a convenient way for older people to reduce labor demand (34, 55). Respondents' gender also affected the program re-enrollment. Male respondents were 30.0% less likely to re-enroll their GTGP land plots than female respondents (Table 1). Combining gender effects with a respondent's age, on average a 50-year-old man had the same likelihood of re-enrollment as a 40-year-old woman. A respondent's education level was not found to affect program re-enrollment (Table 1).

Discussion

Our findings suggested that the aggregate impacts of social norms at the neighborhood level on the cost of PES programs can be substantial. If most people in a community were to enroll their land in a conservation payment program, the extra cost for conserving an additional unit of land would be low due to social norms. Even in communities where most people would initially not participate in a PES program, social norms can be leveraged with increased conservation investments toward participation. Thus, the incremental cost of conserving an additional unit of land can be reduced when social norms are leveraged.

A sustainable gain from PES programs can be achieved only if participants are willing to maintain conservation benefits, even after the programs end (56). As an alternative source of income to farming, off-farm employment through rural-to-urban labor migration not only lowers farmers' dependence on the enrolled land but also reduces their ecological impacts (49). Numerous off-farm employment opportunities have been generated by the transitional economy in urban areas of China (57, 58) and many other developing countries (59). The trend of rural-to-urban migration is expected to continue over the next several decades (60). These labor and income trends provide a great opportunity for PES programs to lower costs and sustain conservation.

Economists have recognized that individuals' preferences over alternatives may depend on the actions of others (27), suggesting that not only economic incentives but also social norms may be analyzed by means of utility theory (39). Observed outcome data typically have limited power to distinguish the inference of social norms from other processes (27). With the main-effects design of our stated-choice model, however, the inference of social norms can be relatively easily distinguished from the effects of other factors.

In conclusion, the results of our study suggest that the efficiency of conservation investments can be improved by integrating social norms at the neighborhood level with demographic trends, economic conditions, and biological values.

Methods

Household Surveys. We conducted household surveys in Wolong from May to August of 2006. We chose household heads or their spouses as our interviewees because they are usually the decision-makers of household affairs. Our questionnaire was iteratively pretested and revised by using qualitative interviews with 54 randomly chosen local households (61). The finalized survey was implemented on a sample of 321 households, which represent ≈26.8% of households in the reserve, randomly chosen from the Wolong Household Registration list for 2006. The sample frame included all households regardless of whether they had enrolled in GTGP. After 5 revisits, 11 households did not have an eligible interviewee and 5 households refused, resulting in 305 respondents and a 95% response rate. Of these 305 households, only one did not participate in the GTGP and was removed from this study. Similarly high rates of participation in GTGP (>85%) have been found in other places in China (62–64). The elicited information includes household economic and demographic status, characteristics of enrolled GTGP land plots, and expected sustainable annual fuelwood production from that land. Interviewees were asked whether they plan to reconvert each of their GTGP land plots to crop production if the program ends in 2008, assuming that the prices of crop products will be the same as they were in 2005 and people will be allowed by the government to reconvert their enrolled plots if they want.

Stated Choice. Respondents who would reconvert all or some of their enrolled plots if the program ends were further questioned about their potential actions in the face of similar PES programs (e.g., extensions of the GTGP). Three contingent behavior questions were asked about their plans to re-enroll their land plots under different policy scenarios. Because actual behaviors in response to these scenarios cannot be observed, we asked respondents' intentions under these scenarios.

The proposed policy scenarios consisted of 3 attributes: conservation payment, program duration, and neighbors' behaviors. Each of these attributes had 3 levels. The amount of annual conservation payment ranged from 100 to 300 yuan/mu with an intermediate value of 200. After the first quarter of the survey, the high payment level was adjusted to 250 yuan/mu because almost all respondents would re-enroll all of their GTGP land plots under the annual payment of 300 yuan/mu, and changing the value to 250 yuan/mu allowed more variation in responses. The duration of proposed policy scenarios could be 3, 6, or 10 years. Neighbors were referred to as households who were located in the same group[‡]. There were 26 groups within 6 villages within 2 townships in the reserve containing ≈1,156 households, and each group contained from 14 to 89 households (65). We defined households in the same group as neighbors because our respondents clearly know who are in the group, and households in the same group tend to have more interactions among each other, e.g., in collaborative planting and harvesting, which are important for social norms to be formed and sustained (23, 26, 27). For the neighbors' behaviors, respondents were told that 25%, 50%, or 75% of households in the same group would reconvert part or all of their enrolled land plots. Therefore, there were 27 possible combinations of attribute levels.

In stated-choice models, it is generally impractical and statistically inefficient to include all possible combinations of attribute levels within an exper-

[†]The amount of fuelwood that can be generated in land plots in the long run was estimated by respondents based on their past experiences of fuelwood collection.

[‡]In rural China, a group is a well-defined administrative unit within a village, and a village is an administrative unit within a township.

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imental design (53). Instead, a subset of the attribute combinations that maintains independent variation among the attributes is usually used in the choice questions. To understand the main effect of each scenario attribute on the program re-enrollment choices, we used a main-effects design in which each of the 3 attribute arrays are orthogonal to one another (66). Each of the attribute combinations from the main effects plan then represents one of the ''scenarios'' presented in the stated-choice question. In this study for each household before the interview, the scenarios were randomly drawn without replacement from the 9 scenarios from the main-effects plan, and stated-choice methods (53) were used to query people's re-enrollment intentions for GTGP land plots under different policy scenarios.

In the statistical analysis of the stated-choice responses, both conservation payment and neighbors' behaviors entered as continuous variables (see *Econometric Model*). This specification is common in stated-choice models (53) and allows model-based inferences of respondents' land use plans at attribute levels other than the design levels. For instance, given different levels of neighbors' reconverting rate, conservation program re-enrollment was evaluated across different levels of payment (0~300 yuan) where all other explanatory variables were set as their mean values as in Fig. 1.

Econometric Model. We assume that farmers are willing to re-enroll their GTGP land plots in a renewed program if the utility of re-enrolling the plot is greater than the utility of the plot without re-enrollment. That is, $U_i^1 > U_i^0$, where U_i^1 and U_i^0 are the utilities of plot i being re-enrolled and not re-enrolled in the new program, respectively. The utility function $U(.)$ is unobservable; however, there is a probability of re-enrolling $\Pr(Y_i = 1) = \Pr(U_i^1 > U_i^0)$, where $Y_i = 1$ if the plan was to re-enroll and 0 otherwise, and a farmer's participation plan regarding the plot i, Y_i, can be observed.

Empirically, the program re-enrollment under different policy scenarios was modeled with a random-effects probit model (67):

$$\Pr(\text{enroll}_{ijk} = 1 | H_i, P_{ij}, S_{ik}, u_{ij}) = \Phi(H_i\alpha + P_{ij}\beta + S_{ik}\gamma + u_{ij}), \qquad [1]$$

where $\Pr(\text{enroll}_{ijk} = 1)$ is the probability of the ith household enrolling its jth GTGP land plot under the kth scenario; $\Phi(.)$ is the cumulative normal distribution; H_i represents household economic and demographic conditions as well as characteristics of the respondent associated with the ith household; P_{ij} represents the features of the jth land plot of the ith household; S_{ik} is the kth scenario that household i is exposed to; α, β, and γ are parameter vectors associated with household, plot, and policy scenario factors, respectively; and u_{ij} represents the unobserved random effects associated with the jth land plot of ith household.

Estimation of Marginal Effects. In the probit model, the marginal effects of continuous variables are obtained from the formula (68):

$$\frac{\partial \Pr(\text{enroll} = 1)}{\partial X} = \phi(X\beta)\beta, \qquad [2]$$

where X represents all model variables; $\phi(.)$ is the standard normal density function; and the derivative is calculated at the mean of the explanatory variables. The marginal effect for a dummy variable (d) is given by

$$\Pr(\text{enroll} = 1|\bar{x}(d),\, d = 1) - \Pr(\text{enroll} = 1|\bar{x}(d),\, d = 0), \qquad [3]$$

where $\bar{x}(d)$ represents the means of all other variables in the model.

ACKNOWLEDGMENTS. We thank Mingchong Liu, Weihong Tan, Shiqiang Zhou, Jinyan Huang, Jian Yang, Yingchun Tan, Xiaoping Zhou for help during fieldwork; Hemin Zhang (Wolong Nature Reserve Administration) and Zhiyun Ouyang (Chinese Academy of Sciences) for logistic support; the interviewees at Wolong Nature Reserve for their cooperation; and Simon A. Levin (Princeton University) and an anonymous reviewer for helpful comments on an earlier version of this article. This work was supported by the National Science Foundation, the National Aeronautics and Space Administration, the National Institutes of Health, the Michigan State University Environmental Research Initiative, and the Michigan Agricultural Experimental Station.

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