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Perception and decisions in modeling coupled human and natural systems: A case study from Fanjingshan National Nature Reserve, China

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ABSTRACT

Modeling human–environment systems presents many challenges, including incorporating structure and agency and addressing uncertainty in system components and relationships. Exploring perceptions not only gives us insight into decision-making (agency) but also reveals structural constraints influencing those decisions (including perceived constraints). This study focuses on the human–nature dynamics of Fanjingshan National Nature Reserve (FNNR) in China, a biodiversity hotspot and the only habitat for the Guizhou golden monkey (*Rhinopithecus brelichi*). The monkey is endangered and increasingly threatened by growing human activity and development but is also affected by changing habitat through reforestation programs. This research aims to understand how human demographics, a recent reforestation program (Grain-to-Green), land use, livelihood, and perception of conservation may affect local people's perception of human impact on the environment. This perception underlies many land use decisions yet is not uniformly shared among FNNR inhabitants. Using logistic regression, the data from a 263-household survey conducted in the spring of 2010 were analyzed. The results indicate the Grain-to-Green Program participation is insignificantly related to perception of human environmental impact. However, personal observation of the golden monkey is vital to locals reporting an enhanced appreciation for potential human environmental impacts. Other significant factors predicting sensitivity to human environmental impacts include having heard of climate change, interest in tourism entrepreneurship, current worries of food security, viewing FNNR regulations as restrictive, income source, and fuelwood consumption. Results suggest the importance of examining environmental perception for a more integrated understanding of coupled human and natural systems (CHANS).

1. Introduction

Modeling human–environment dynamics remains a pressing concern in tackling the major conservation challenges we are facing on the way to environmental sustainability. Emerging as a cutting edge in modeling and environmental study, coupled human and natural systems (CHANS) research integrates a broad range of techniques and approaches to better understand, quantify, and project these dynamics. One way to approach the complexities of CHANS (decision-making, structure and agency, non-linear responses, thresholds, and emergence; Liu et al., 2007a,b) is through looking at land use and land cover change (LULCC). Considering the myriad of far-reaching land use consequences (Foley et al., 2005), understanding LULCC remains vitally important to CHANS research towards environmental sustainability, but more progress is needed in the important research frontier of modeling LULCC (Lambin and Geist, 2006).

In addressing the uncertainty present in modeling LULCC, researchers often employ assumptions to link different system components or decisions. Without exploring the knowledge and perceptions behind individual land use decisions, our understanding of human–environment interactions may be incomplete or based upon untenable assumptions. Incorporating perceptions can lend insight to the structure and agency behind many LULCC observations and to previously unobserved relationships underlying such observations. Such insight could account for some 'surprises' in system outcomes (Liu et al., 2007a,b).

This article explores the complex relationships among policy, human socioeconomics, and environmental perception of human

Abbreviations: FNNR, Fanjingshan National Nature Reserve; CHANS, Coupled human and natural systems; LULCC, Land use land cover change; GLM, Generalized linear model; VIF, Variance inflation factor; GTGP, Grain-to-Green Program; NFCP, Natural Forest Conservation Program.

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impacts in Fanjingshan National Nature Reserve (FNNR). Similar to subtropical areas subject to rapidly changing land use and land cover (DeFries et al., 2006) as well as growing activity and development in the future (Li and Han, 2001), FNNR is important not only to golden monkey survival but also to understanding many CHANS-related processes, especially local land use decision-making and its interplay with sensitive habitat. Without understanding how local inhabitants perceive their surrounding environment, the formulation of protected area policy may have unintended consequences or limited efficacy. This investigation thus holds implications both for modeling CHANS and for conservation policy and management. We begin by providing background on the study area, then move on to the theoretical framework. Next we describe the methods and discuss the results. We conclude with implications for conservation and rural livelihoods in the FNNR and for future CHANS modeling.

1.1. Background: FNNR and forest change

Study area: Fanjingshan National Nature Reserve (FNNR), approximately 160 square miles in area (Bleisch et al., 1993), is located in Guizhou province, southwestern China (see Appendix A: Fig. A.1). FNNR is within one of the 25 global biodiversity hotspots identified by Myers et al. (2000), with over 3000 animal, plant, and insect species (Yang et al., 2002). FNNR has a local population of 21,000 residents living within or near the boundary of the reserve, many of which live in villages over a hundred years old. It was established in 1978 as a protected area for the Guizhou golden monkey, although conservation within FNNR borders extends to other animal and plant species within the management zone. FNNR remains the sole habitat for the endangered monkey (Bleisch et al., 1993). Rumors about the existence of the Guizhou golden monkeys remained unjustified until they were “rediscovered in the early 1960s by Chinese researchers” (Bleisch et al., 1993).

Called ‘golden’ for their coloring or alternatively ‘snub-nosed’ for their appearance, the snub-nosed monkeys ranged much farther 400 years ago (Li et al., 2002). The snub-nosed monkeys are currently limited to five species in three countries: the Guizhou, Sichuan, and Yunnan snub-nosed monkeys in China, the Tonkin snub-nosed monkey in Vietnam, and the Burmese snub-nosed monkey in Myanmar (Geissmann et al., 2011). Previous researchers have focused on the Sichuan snub-nosed monkey (*Rhinopithecus roxellana*), making groundbreaking progress in understanding the monkey and its environment (Kirkpatrick et al., 1999; Li et al., 2000; Ren et al., 2000; Tan et al., 2007). Still, the Guizhou golden monkey has yet to be subject to extensive research, which is especially an issue considering the major threat to the Guizhou golden monkey – direct and indirect effects from human activity (Xiang et al., 2009). Human activities (some regulated or forbidden) are widespread in FNNR, not limited to areas outside the reserve boundaries. With human activities (such as tourism) growing in China’s nature reserves (Li and Han, 2001; Liu et al., 2003) like FNNR, research on the monkey and impacts of activity is vital in order to better protect biodiversity in the reserve.

Forest change in FNNR: Along with a history of settlement and farming by Han and several ethnic minorities (e.g., Tujia, Miao, Dong, Gelao), FNNR involves rapidly changing land use, economic, and demographic patterns. Dynamics of deforestation and reforestation characterize transition in FNNR forest cover. Activities towards deforestation include fuelwood gathering, construction, timber harvesting, quarrying, development (i.e. for roads, parking, and tourism), forest fire, and small-scale forest disturbances with potential cumulative effects (e.g., illegal mining, mushroom and herb gathering, and poaching). Commonly begun by people either burning tributes to the dead at tombs or burning grass on fields for clearing and fertilizing soils, forest fires can cause serious damage in FNNR. Local regulations in place include fire and mining prohibition, designated location and area size for wood and plant harvesting, and development (Guizhou FNNR Administration Bureau, 2004). All of these activities have the potential to affect golden monkey habitat.

The framework for reforestation includes the regulations mentioned above, migration effects, and national reforestation policy. Temporary migration plays a part in reforestation and revegetation through reducing local labor availability (Liu et al., 1999; An et al., 2006). In many families, young adults are absent from FNNR for much of the year either attending school or working. This labor force reduction sometimes results in temporary abandonment of less productive fields or the placement of land into reforestation and development programs. However the implications of temporary migration for local land use change could be complex; with other factors such as education, temporary migration may also change consumption habits and thus bring forward new land use patterns (Davis and López-Carr, 2010).

Major land changes in FNNR include reforestation programs, such as the Natural Forest Conservation Program (NFCP) and the Grain-to-Green Program (GTGP). Restricting logging to allow for forest growth (Liu et al., 2008), the NFCP is geared towards preserving forests, water, and soil for higher plantation productivity and forest use diversity (Li, 2004). The GTGP arranges planting of trees in place of farmland on steep slopes, and the farmers are compensated through cash, rice, or corn (Feng et al., 2005). Since FNNR is already a high priority conservation area, implementation of the programs within the reserve takes precedence over outer areas, meriting more government support (Li, 2004). We chose the GTGP as a focus for the study due to the widespread participation of locals and the direct interaction locals have with the program while they enroll land and receive compensation.

Reminiscent of the U.S. Conservation Reserve Program, the GTGP was intended to address soil erosion by increasing vegetation cover but has broader effects than its original focus (Liu et al., 2008; Ribaudo et al., 2001). Also of note, the GTGP is not designed to return forests to heterogeneous, native states but rather to provide participants with construction timber or economic cash crops after a certain amount of growth (interviews in the spring of 2010). Hence it involves monocropping as well as pine and fir plantations. One unintended effect of conservation and reforestation within FNNR may be an increased wild pig population (Wang et al., 2006), which poses challenges for local farmers because of the crop damage in wild pigs’ acquisition of food.

Regarding conservation policies such as GTGP in the context of our investigation, it is reasonable to hypothesize that GTGP program participation would increase environmental awareness and knowledge of human impacts on the environment. This is based on the understanding that the GTGP, as a payment for environmental services (PES) program, places an economic value on reforestation, compensating participants for their land and for their caretaking of the new reforestation areas. As PES was created to offer a monetary meaning for conservation value, participation in a PES program may increase understanding of the value of conservation. Furthermore, positive attitudes towards the program could translate to behavior in other areas of environmental conservation (Horsley, 1977).

1.2. Theory: perception in modeling

In this investigation, our methodology approaches modeling through exploring the link between environmental perception and land use decisions within CHANS. Incorporating perception in addressing complexity in CHANS can contribute to a structure-agency approach (Chowdhury and Turner, 2006). Specifically, we will examine how local agents perceive their environment and livelihood options through the structures of policy and management. This not only provides added depth to understanding decision-making, essential in modeling, but also may lend insight into underlying processes and previously unobserved relationships that could manifest themselves within the system in non-linear responses or emergence. If agents are making decisions under motivations and perceptions other than those supposed, modeling and analysis could be based upon false assumptions. Incorporation of livelihood, through understanding local capacities, economic opportunities and perceptions, could therefore provide more complete understanding of the system of interest.

LULCC, decision-making, and perception: Decision-making is an intrinsic aspect of land use dynamics, however it is not often adequately acknowledged (DeFries et al., 2006). Examining perception (of the environment, of policy, or of livelihoods) offers a way to formulate effective conservation strategies (Salafsky and Wollenberg, 2000) and better understand many CHANS-related complexities, such as feedback and non-linearity (Liu et al., 2007a,b). Land use and land cover change researchers are increasingly using a diversity of modeling approaches such as multi-level modeling and agent-based modeling (ABM) in a growing number of applications in land use studies (Verburg et al., 2004; An et al., 2005, 2006; Rindfuss et al., 2008; An and Liu, 2010), but efforts to reach in-depth understanding of decisions in the context of systems are incomplete. Prior research on perception and land use has bordered on the topic of CHANS but has not addressed CHANS explicitly.

Work to incorporate perception in modeling and decision-making has been pursued in several fields, including behavioral economics (e.g., maximization of different benefits; Simon, 1959). In addition, efforts have been devoted to addressing limitations on decision-making, as explained in bounded rationality, which allows for imperfect information acquisition and processing during the decision-making process (Simon, 1972). Research within economics has focused on perception as a way to understand economic behaviors such as water consumption (Nieswiadomy and Molina, 1991) and technology adoption (Kuan and Chau, 2001). Agricultural research also examines adoption of technology and agricultural practices (an economic decision), with applications related to CHANS not only through exploration of human and natural interaction but also through incorporating feedbacks between perception and adoption (Negatu and Parikh, 1999).

Previous work has also endeavored to understand perception in decision-making through investigating conceptualization of risk (Johnson and Tversky, 1983; Slovic, 1987; Sjöberg, 2000; Wester-Herber, 2004), social psychology (e.g., reasoned action and planned behavior; Fishbein and Ajzen, 1975; Ajzen, 1991), and conservation policies and programs in the context of livelihoods (e.g., in Nepal; Müller-Böker and Kollmair, 2000). Risk perception, psychology, and conservation have all given attention to learning and the construction of knowledge, including but not limited to experiential learning (Epstein, 1985; Finger, 1994; d'Agincourt-Canning, 2005; Fazey et al., 2006), and depletion crisis and ecological understanding models (Berkes and Turner, 2006; Turner and Berkes, 2006). Drawing on this prior work in perception from economics, risk analysis and management, social psychology, and livelihood literature could be instrumental in understanding land use decisions while taking into account the mediation of political and social structures. Such incorporation would allow us to integrate agency and structure more comprehensively in modeling systems and to delve into deeper understanding towards decision-making processes in complex CHANS.

Structure and agency: The relationship between population and agriculture has been traditionally described as inclining more towards the work of either Malthus (reprint 1996) or Boserup (1965); population growth increases impact on land or it induces innovation and agricultural intensification. Recent work has added to this literature by incorporating multiphasic demographic change (Davis, 1963), and in reconciling Malthusian and Boserupian approaches (Bilsborrow, 1992; Carr et al., 2009) to address issues of land use and cover change (Ghimire and Hoelter, 2007; Carr et al., 2009; Massey et al., 2010; Davis and López-Carr, 2010). Application of multiphasic response theory adds to understanding human–environmental interaction through describing the avenues of population reactions and strategies in the face of growth (Davis, 1963).

Structuralist and humanistic debates on human action focus on structure versus agency. Proponents of structural explanations such as Durkheim and Harvey (Johnston et al., 2000) conceive of action through the bindings (i.e. policies, regulations) that control activity. On the other hand, agency proponents such as Febvre (Johnston et al., 2000) maintain the importance of humans acting as autonomous agents. Efforts to reconcile the two lines include structuration theory from Giddens (Livingstone, 1993), which is also subject to criticisms including its relative exclusion of culture and subjectivity. In proposing actor-network theory in 1995, Serres and Latour took this debate further by including the possibility of non-human agents (Aitken and Valentine, 2006). Another way of understanding this dichotomy is through the push and pull between the focus on agency in cultural ecology and that on structure in political ecology (Chowdhury and Turner, 2006). In understanding human decision making in the context of land change, it is important to probe equally the effects of structure and agency (Chowdhury and Turner, 2006).

Integrative approaches are increasingly utilized in the pursuit of understanding human–nature systems (Parker et al., 2003). Researchers and policymakers are gaining appreciation for the contribution that land change science can make in understanding patterns of drivers and consequences of environmental change. Manson (2001) discusses the applications of emergence in addressing agency and structure and the lack of research on the "effect of macro-structure on the micro-scale". Incorporating perception in decision-making can add useful insight to human–environmental interaction, especially related to LULCC drivers, but also deepens analysis by calling for the inclusion of actual and perceived structural constraints within systems. This investigation contributes to research on land use decisions embedded within conservation policy by addressing perception. This application aims to deepen our understanding of agency, structure and ecological knowledge, with implications for further apprehension of complex human–environment interactions.

1.3. Objectives

The overarching goal for this project is to contribute to improved understanding of human–nature interactions by incorporating perceptions into modeling approaches to human–environment relationships. Underlying this main goal, several related aims follow:

1. Analyze current FNNR conservation policy and offer potential areas of policy improvement, within the overall bounds of national policy, in order to enhance golden monkey conservation.
2. Improve our understanding of CHANS by including perception to approach aspects of structure and agency in our CHANS modeling efforts. The challenge of integrating the structural constraints (i.e. policy) on decision-making with the cumulative effects of decision-making processes (i.e. changing land or resource use) is a major but necessary aspect of modeling human–environment relationships in systems like CHANS (Liu et al., 2007a,b). This integration can lend insight to relationships that would otherwise remain uncaptured (Chowdhury and Turner, 2006).

3. Address trade-offs among land use choices (DeFries et al., 2006) in the context of how locals perceive structural factors and the ecology of FNNR.

Without understanding the trade-offs people consider in their decisions, CHANS modelers often capture their choices and the ensuing land use changes in a snapshot manner. Using such snapshot data alone may overlook decision-making in the context of the full process and de-emphasize the impacts of historical perceptions and cultural values. In viewing decisions in the context of perception, it is not just the action of agency that CHANS modelers should consider, but the motivation to that action as well. In the modeling arena, we strive to address not only local actors in the process we are modeling, but also broader contextual factors that interact with these actors. To fully capture these processes, we urge caution in choosing the variables to which we attribute observations or data collection. Further investigation of underlying relationships (such as those behind perceptions leading to actions) could potentially explain some of what is perceived as non-linearity and emergence, elucidating complex linkages between decision-making factors. Through this investigation, including our analysis and modeling through generalized linear models (GLMs), we explore what factors may affect local people's environmental perceptions that explain (or underpin) subsequent human activity. Shedding light upon the influencing factors and their interplays in FNNR, our research may facilitate improved modeling of CHANS and better policy formation and implementation.

1.4. Conceptual model and hypotheses

The conceptual model (Appendix A: Fig. A.2) presents the framework of our research approach and the elements of our hypotheses (1–4). Structural factors (hatched boxes of national policy as implemented through local management) affect local livelihood options directly (such as resource extraction), local perception of conservation (through community education and publicity), and monkey habitat (trail closure, logging bans, fire suppression, etc.). In making land use decisions (agency, shaded grey), local villagers draw from the livelihood options available as they perceive them. These land use decisions change golden monkey habitat (reduced human activity, abandoning farmland in core areas, etc.). Experience with or observation of habitat in turn feeds back into local understanding and perception of conservation. Since the Guizhou golden monkey habitat is a national conservation priority area, changes in habitat may also ultimately feed back into national policy. Our hypothesis is that participation in the GTGP increases environmental awareness (arrow #1 in Appendix A: Fig. A.2). More specifically, we hypothesize that the GTGP implementation strengthens locals' perception that human activity affects the environment either directly (1) or indirectly (2–4).

2. Materials and methods

2.1. Survey

In the spring of 2010, the first author developed and implemented a two-tiered or multi-stage probability sample in FNNR, and surveyed 268 households within 8 villages in 2 counties. At the top tier, we randomly selected villages from those within the reserve, as those were the only ones able to participate in the GTGP. We then selected households randomly from lists of reforestation participants within the chosen villages. We based sampling and survey design on earlier CHANS work in Guatemala (Carr et al., 2008), Nepal (Yabiku, 2006; Ghimire and Hoelter, 2007), and China (An et al., 2002, 2005, 2006). The interviewees included GTGP (see Section 1.1) participants and non-participants.

For villages partially within and outside FNNR, we adopted a 'trimmed village' approach, involving only those groups within FNNR, since those outside did not have the option to participate. We chose non-participants within the 'trimmed villages' based upon strategic sampling of every 4th house within the groups, as the sampling proportion averaged at 23% for the 'trimmed villages' sampled. Questions probed quantitative and qualitative data, focusing on demographics, livelihood status and concerns, reforestation participation, crop damage from pest species, land and resource use, and perception of conservation and regulation. Complementing the mixed methods survey, we also selected 16 village leaders and reserve personnel to participate in individual qualitative interviews, the results of which supplemented the household survey in providing the status of broader community livelihood factors.

2.2. Logit regression

Model fitting and comparison: The investigation employed the generalized linear model (GLM) technique in analyzing the survey data, using the logit link function in a binomial GLM. Falling under the term logit regression (Guisan and Zimmermann, 2000), we chose this technique for its flexibility and applications in predicting probabilities. First we coded survey data and reviewed it for data completeness and accuracy, resulting in a final sample of 257 households. Due to incomplete answers, we removed the results of eleven households. Households further excluded from single logistic regression associated with variables for which they had missing values were also omitted in the multiple logit regression models. We complete the analysis using the R statistical program. We performed binomial logit regressions separately with each of the independent variables as a single predictor, which may signal the relevance and importance of each independent variable in explaining local people's environmental perceptions.

The next step was to conduct stepwise multiple logit regression with and without control variables included as independent variables (age, gender, ethnicity, education). The multiple logit regression stage of modeling provided a more complete characterization of influential and related factors in local perceptions of human impact. Multicollinearity diagnostics, which included the variance inflation factor (VIF) within the regressions, suggest the variables are relatively exempt from the multicollinearity problem. VIF values did not exceed 2, and were thus below the common limits (4 or 10; O'Brien, 2007). Other diagnostics included Pearson's r, biserial and point biserial correlation testing, and Chi-squared testing for categorical data. We analyzed model fits based on indicators such as model deviance and Akaike Information Criterion (AIC). To estimate uncertainty within models, we completed simulation graphically within *R* using the arm package (Gelman and Hill, 2006; Gelman, 2007). We also calculated confidence intervals of selected relationships (Appendix A: Fig. A.3) in *R* using the MASS package (Venables and Ripley, 2002).

Dependent variable: We explored the following models using the answer to the question related to whether the interviewee thinks human activity would affect the environment as the dependent variable. Thinking human activity may affect the environment may seem self-evident, however prior work in the area indicated that the local relationship between humans and the environment is complex. In 40 interviews (preliminary fieldwork, Spring 2009) during which we asked respondents whether they think some human activities in FNNR are harmful to golden monkeys, everyone said "No". Questions formulated for the Spring 2010 household survey further explored the perceived human–environment relationship in FNNR, focusing on human activity's impact on the environment instead of only on golden monkeys. Since indirect effects from human activities are indeed a main threat to the species (Xiang et al., 2009), it is important to investigate local understanding of human–environmental interactions.

In the spring of 2010 household survey, 30% of the respondents answered questions of general human activity damage to the environment affirmatively, listing impacts such as garbage, pollution, cutting wood, development, pesticides, industry, and fire; 70% of respondents answered no/do not know/do not understand. For the purposes of our analysis we grouped the negative responses together, as we were interested in what distinguishes the people responding in the affirmative from the rest that were surveyed. This perception addresses the basic question of whether humans can noticeably impact the environment in their area at all. This is a premise inherent in ecological implications of land use decisions, and as such remains an important basic question when examining human–environment dynamics. If humans do not perceive their actions as affecting the environment, the trade-off in their decisions may be more unconscious and incompletely informed. In addition, if we do not understand the trade-offs that are taking place in people's decision-making, how can we completely understand resultant land uses? There is a drastic distinction between unknowingly harming the environment and consciously causing environmental degradation. If modelers approach decision-making under a pre-existing base that humans are considered to impact the environment, then we need to make sure that base exists and what it is.

Independent variables: We specified independent variables based on the aforementioned theoretical background and empirical observations from preliminary field work. We chose temporary work variables to address the growing trend of temporary work and potential ensuing changes in income, consumption (Grumbine, 2007), and knowledge that could arise from movement to and from cities and living (even part time) in urban areas. Several variables addressed the multi-faceted aspect of temporary work, including years worked, number of people in the household doing temporary work, and receiving remittances from family in the city (Appendix A: Table A.1). We included county and village information as dummy variables, with villages coded and regressed separately. The 2 counties have different levels of local autonomy, as defined in the 1984 Law on Regional Autonomy that was geared towards minority rights (Sautman, 1999). Although minority Tujia and Miao groups are present throughout the study area, only one of the two counties surveyed is designated as an autonomous county. We considered whether a household belonged to an autonomous county as a possible structural factor influencing people's experiences with environmental regulations, since autonomous counties can customize national policy locally (Sautman, 1999).

We included household factors in our survey and the subsequent models. Ethnicity could reflect differences in cultural values and history, while education level and number of children or adults in the household could indicate exposure of adults to newer ideas of environmentalism shared by children in school. We further incorporated interviewee variables (age, gender, education) since education achievement and access are different for younger generations and gender has been shown to be a factor in previous work on perception of conservation (Müller-Böker and Kollmair, 2000). Several of the household and interviewee variables thus became independent control variables in the stepwise logistic regression modeling.

Two major conservation foci in FNNR are the GTGP, in which a high percentage of local inhabitants take part (77% of our household survey population), and the protection of the golden monkey. We included reforestation variables in the models, and seeing the monkey was considered a potential factor impacting local environmental perception because of the high visibility of the monkey conservation program in FNNR. Since almost everyone interviewed in Spring 2009 and 2010 (98%) supported protecting the golden monkey, having seen the golden monkey was chosen as an independent variable for its connection to golden monkey conservation.

Other perception variables included livelihood concerns, lottery use, opinion of neighbor and personal activities damaging the environment, and attitude towards FNNR regulation impacts (Appendix A: Table A.1), since these variables potentially connect with the weighing of land use trade-offs in making decisions. Current and future concerns included responses such as food or fields, jobs and money, health, infrastructure, and education (Appendix A: Table A.1). Lottery use centered on the question of how people would apply money if they won 30,000 yuan in a lottery, with responses such as starting a business, using for medicine, investing for the future, and building roads. We included environmental damage (categorical of personal and neighbor activities impacting the environment) in the single predictor regressions to determine relationships among the perception of human impact on the environment on a general, community, and personal level. Participants perceived regulation impacts on their lives in several ways: as being minimal, as preventing people from harvesting wood, as protecting the environment, as protecting people from forest fire, and/or as preventing people from killing wild pigs (to stop the crop damage they cause).

We further added variables describing livelihood measures to the regressions, since they may play a part in approaching trade-offs in land use choices (DeFries et al., 2006). Measures of livelihood were frequency of meals, meat, egg, alcohol, crop, and fuelwood consumption, income, cropland, and crop damage (from animals such as wild pigs, rabbits, and rats). The crop consumption variable identifies the amount of surplus crops sold (a potential income source). Since underreporting of income is a possible challenge, we used several income measures. The income source variable (a dummy variable) captures the amount of income that comes from agriculture (e.g., rice, bamboo, potato, raising pigs, or tea cultivation) versus other sources (e.g., temporary work, restaurant, store, or hotel). The income source of 'none' merits explanation, as this may seem misleading. That response may include people who had recently given up their cropland and had no explicit occupation but were living off of compensation from the government for entering their land into the reforestation, road, or tourism development programs. People may also have described themselves as having no income if they engaged only in subsistence farming (i.e. growing crops strictly for their own consumption), having no outside income. The income variables thus complemented food consumption variables in describing relative livelihood levels in FNNR.

3. Results

3.1. Descriptive statistics of households

Several factors characterize the surveyed households (Appendix A: Table A.2), including education, age, size, ethnicity, employment, and land use. Interviewees were predominantly male, with approximately 24% of interviews conducted mainly with female household members. We interviewed females less often for several reasons: male heads of household are named on the lists of participants, shyness, variation in survey experience among field workers and households, and perceptions of women's roles (Aitken et al., 2011). Maximum household education levels varied, however half the households contained members who had reached a maximum of middle school education level at the time of the survey. For the overall sample of households, average age within households was 35.4, and the average household size was 4.55 (often parents, a grandparent, and a child). The majority of households sampled were of Han ethnicity (62%) followed by Miao (19%) and Tujia (17%). As for work and land use, an average of 42% of adults within households have engaged in or currently do temporary work in the city.

This can mean construction work in the closest city or also work in urban, coastal areas of China (far from the central mountains). The average amount of cropland per household was 0.27 ha, and reforestation level (as calculated by dividing the amount of land in the GTGP by overall land in crops and in reforestation) was about 47% in the surveyed households.

3.2. Single predictor results

Logistic regression results (Appendix A: Table A.3) of the independent variables as single predictors (of the logic of thinking human activity impacts the environment) indicate the importance of several expected variables but also display the lack of significance in several reforestation variables, contrary to hypothesized connections. We did not include all dummy variables and their significance measures (p values) in the table. Instead, we chose categories of the dummy variables for display based on significance.

Significant variables of interest: The independent variables exhibited varying levels of explanatory power that characterize the population in FNNR. Fuelwood consumption was negatively related to thinking humans impact the environment. The correlation between fuelwood consumption and education is not significant. We controlled for education, along with other variables such as age and gender, in the multiple logistic regression models (Section 3.3). Other significant variables include source of income, current and future livelihood concerns, being within certain villages (dummy), and regulation impact (categorical; Appendix A: Table A.1). Income source includes the dummy variables of no income, >50% income from agriculture, 50/50 agriculture/non-agriculture, and >50% income from non-agriculture. Both ‘no income’ (+) and ‘>50% agriculture’ (−) were significant, although in opposite directions. Two village dummy variables were significant as well, in opposing directions. Main current and future concerns included the worry about jobs and money (−), with another important current worry being that of food or fields (+). Having hypothetically won a lottery of 30,000 yuan, a significant positive relationship exists between their environmental perception (or acknowledging human impact) and their aspiration to begin a business (often for tourism). The impact of regulations is significant for none (−) and for seeing regulations as limiting options in dealing with crop damage from wild pigs (+).

Insignificant variables of interest: A noteworthy collection of variables is not significantly related to the general perception (human activity damage to the environment). Reforestation participation level and amount of land devoted to the GTGP was not significant, in opposition to our hypothesis that program participation would increase environmental awareness. Other variables of interest that are insignificant include those variables incorporated in the multiple regression models as control variables: ethnicity (which could have differed based on cultural values and history), age of interviewee, education levels, and gender. Further insignificant variables of interest are number of children or adults in the household (which could have indicated exposure of adults to newer ideas of environmentalism shared by children in school), average household age, household size, household income, the level of autonomy (i.e. semi-autonomous or not) for the county where the household lives, temporary work (including interviewee or overall household members engaged in temporary work and the years they have worked), and reception of remittances. Of particular interest is that crop damage is not significant although viewing regulations as restricting one’s ability to kill wild pigs to prevent crop damage is significant.

3.3. Multiple logistic regression models

Model 1 (*stepwise with control variables as final step*): We included several variables in the multivariate logistic model based upon better model fit without incorporating the control variables from the beginning (Appendix A: Table A.4). These variables exert significant influences on the perception of human activity impact through: physically having seen the golden monkey (+), having heard of climate change (+), being interested in starting a business if winning 30,000 yuan in a lottery (+), and currently being concerned about food security (+). All the variables are significant at the 0.05 (most ∼0.03) significance level. Adding control variables (interviewee age, gender, education, and ethnicity) changes the significance (but not the sign) of 3 variables – seeing the monkey, hearing of climate change, and lottery winning business investment.

Having seen the monkey is significant with control variables when the climate change variable is not present, so we explored the correlation of climate change and lottery winning business investment variables with the control variables through Chi-squared testing, point biserial correlation, and biserial correlation testing. Neither climate change knowledge nor lottery winnings application significantly correlates with ethnicity or gender. Both are significantly correlated with interviewee age (point biserial correlation coefficient with climate change: −0.1297, $p = 0.0189$; biserial correlation coefficient with business investment: −0.265, $p = 0.000009$). Hearing of climate change is further correlated with interviewee education level (Fisher’s exact test of Appendix A: Table A.5, $p = 4.945\text{e}{-07}$). From the test results, we determined that the proportion of respondents hearing of climate change is not the same for all education levels. Looking at Table A.5, we can see that the proportion of those who have not heard of climate change decreases with education levels.

Model 2 (*stepwise with control variables from beginning*): Controlling for age, education, gender, and ethnicity from the beginning, a somewhat different model emerges (Appendix A: Table A.4) in characterizing associated factors in environmental perception. Having seen the monkey is still significant, and indeed one of the basic components of both models. In addition, the impacts of regulation play a part (+), as well as income source (+) and fuelwood consumption (−). All variables in the model are significant ($p < 0.05$), with regulation and no income variables highly significant ($p < 0.01$). Seeing regulations as being restrictive overall (+) was significant, but this was explored and attributed to the importance of restrictions on wild pig killing rather than on wood gathering or on both combined. The income variables are dummy variables for no income source and for even 50/50 agricultural/non-agricultural income source (>50% agricultural being insignificant when combined with monkey sighting and restrictions). Having no income source and fuelwood consumption are positively correlated (biserial correlation coefficient: 0.174, 0.003 significance), however fuelwood consumption is only significant when the ‘no income source’ dummy is included in the model.

Confidence and uncertainty: Considering the inclusion of the ‘having seen the golden monkey’ variable in both models, we undertook confidence interval calculation and uncertainty simulation to investigate the coefficient estimate variation. Using having seen the golden monkey as a single predictor of the probability of thinking human activities affect the environment, the simulation of uncertainty is shown graphically (Appendix A: Fig. A.3) using techniques by Gelman and Hill (2006). The concentrations of points in the four corners of the figure illustrate the distribution of seeing the monkey (0 or 1) versus thinking human activity affects the environment (0 or 1). The black line is the logistic regression curve, with the grey curves illustrating variation within the 1000 simulations. There is a range of estimated coefficients and predicted probabilities. The 95% confidence interval calculated in R for the coefficient estimate of seeing the golden monkey is 0.296–1.397.

4. Discussion

4.1. Single predictors

The single predictor logistic regressions revealed several important relationships. The negative relationships between fuelwood consumption and thinking humans impact the environment was contrary to our expectation. This expectation followed our reasoning that higher consumption of fuelwood would get closer to fuelwood harvest limitations within FNNR borders. One may expect interaction with these limitations to increase awareness of FNNR conservation principles and human impacts on the environment. This negative relationship between fuelwood consumption and environmental perception may be mediated through lifestyle and education as follows. Higher consumption of fuelwood could possibly relate to more traditional subsistence-oriented livelihoods, in which more family members with lower education are more likely to stay in the area instead of going to the city for temporary work. Alternatively, households with lower fuelwood consumption may be purposefully more frugal in their fuelwood collection because they are aware of and follow harvesting limits in FNNR.

Income source significance may also relate to FNNR regulations, as those with no income could have given their land to reforestation or development and found their subsequent economic options limited by FNNR regulations. A possible explanation for those significant village dummy variables is that Village 4 (+) was located in a tourist area, while Village 5 (−) was not. We expected the positive relationship between tourism and perception of human impact on the environment because tourists or tourism campaigns/programs may bring in higher environmental awareness. However, factors beyond tourism may be important, thus explaining the lack of a significant relationship for other villages in tourist areas. For regulation impact, views of regulation impacts as being minimal or connected with wild pig rules are significant. This again indicates a trend of interaction with regulations as raising probability of acknowledging human impact.

Not significant of interest: The refutation of our hypothesis (program participation would increase environmental awareness) indicates that local farmers may be more concerned about the economic benefits of the program than its conservation purpose. Previous work on livelihoods and perception in conservation policy has indicated a similar disconnect between intended and perceived policy goals (Müller-Böker and Kollmair, 2000). Some locals have already converted reforestation land to other uses (e.g., from pine to tea), and if the program matures, locals may reconvert their reforested land to farmland given strong influences from social norms (Chen et al., in this issue). In connection with farmland, the insignificance of crop damage may seem contradictory in light of the finding that a significant variable relates to regulations restricting one's ability to kill wild pigs and prevent crop damage. Since these are single predictor logistic regression results, correlation between independent variables is not a concern, so perhaps the measure of crop damage does not mirror the relationship between damage and perception. Alternatively, this may indicate the influence of group opinions, a history of crop damage even if there was not damage in the past year, or possibly the effect of having neighbors with crop damage.

4.2. Model without control variables (Model 1)

Approximately 39% of interviewees have experienced seeing the monkey either in the wild or at the rescue center, where sick or injured monkeys are rehabilitated and researched. Pictures of the monkey are visible around villages and the reserve, and the reserve broadcasts adequately that the monkey is a Class 1 Nationally Protected animal, potentially making identification of the monkey easier. In addition, the reserve has an education program in effect (we have seen the brochure at one of the management offices within FNNR). However, over half of the people in FNNR have not seen the monkey. Without personal observation, people may think of it as a distant creature that they do not affect.

Having heard of climate change and entrepreneurial lottery investment are both likely linked to tourism. Many people have heard about climate change from the TV or from interaction with tourists. It is possible that the tourism link also influences the perception of environmental impacts of human activity through spreading the concepts of ecotourism. Locals interested in starting a business for tourism may consider environmental quality and conservation linked to economic gains. They may also view local ecotourism as an industry from which they may be able to profit. Since 55 of 69 local residents interviewed did not think they benefited directly from ecotourism in FNNR between 2004 and 2009 (An et al., 2010), perhaps the younger generation is interested in tapping into the economic gains from that sector. The final variable, that of a current main concern for food or fields, suggests food insecurity. This indicates that local people's concerns about food affect their environmental awareness. This could have a broad range of explanations, including a history of agricultural dependence and loss of cropland with accompanying loss of economic options within the FNNR protected area.

When incorporating control variables, collinearity causes dynamics within the model to change. Those who have not heard of climate change have lower levels of education, primarily at the elementary or middle school level. In addition, interviewees who have heard of climate change are generally younger and have higher education levels. This is logical in that public education in FNNR over the past decade has been mandated and made more affordable, and environmental concepts have been increasingly incorporated in educational materials. Like climate change knowledge, entrepreneurial lottery investment connects to younger generations, although the reasons may differ slightly, having more to do with risk taking. Younger generations are more inclined to engage in risk taking activities (Pålsson, 1996), such as starting a new business. This puts capital at risk that could be saved for use in case of eventualities. In addition, history of the area must be considered. During the 1959–1961 famine, it is estimated that 30 million people died prematurely (Ashton et al., 1984). Whereas the younger generation did not experience it directly, the older generation may remember that time and consider it in their planning for the future, making them less likely to take risks.

4.3. Model with control variables (Model 2)

Considering regulations as restrictive overall was significant, but we explored and attributed this to the importance of restrictions on wild pig killing (which people wanted the freedom to engage into protect their crops from damage) rather than on wood gathering or on both. This suggests that perceptions of regulation restriction relate to crop damage by wild pigs and not to fuelwood limitations. As mentioned earlier, current household crop damage severity was not a significant predictor, so the significance of perceiving regulations as restricting prevention of crop damage may indicate a more complex connection between crop damage and environmental perception. The understanding of FNNR regulations (wild pig protection in particular) as restrictive and negatively affecting livelihoods through uncompensated and largely unpreventable crop damage suggests that the perception that humans affect the environment is tied to negative experiences with FNNR regulations and wildlife besides the golden monkey; this holds serious implications for policy sustainability and efficacy.

We expected the correlation between fuelwood consumption and no income source since people with no current earnings may not have the ability to pay for electricity or coal and must use wood as their main energy source. It is possible that having no income source could lead to more awareness of the FNNR restrictions on human activity when searching for livelihood alternatives. However, high fuelwood consumers may be less informed or disregard regulations on wood gathering, possibly considering it benign to the environment. Thus the positive relationship between lacking an income source and the dependent variable could be lowered by interaction with the fuelwood consumption variable. Through the multiplicity of economic connections utilized by income-diverse households, household members may interact more with a variety of regulations and people. This interaction may lead to more exchange of ideas, including environmental concepts such as awareness of human activity impacts.

5. Conclusions

5.1. Policy implications

Perception modeling results reflect concerns for current policy and directions for future improvement. Results indicate that environmental awareness is strongly linked to physically seeing the golden monkey, which is made more difficult by the characteristics of the species (e.g., shy and endangered) and long travel time from most areas to the rescue center. This link supports research in experiential knowledge and environmental behavior that illustrates the importance of direct environmental experiences in decisions (Finger, 1994; Fazey et al., 2006) while emphasizing the need for balanced approaches (Fazey et al., 2006). In FNNR, efforts could be made to increase visibility of the species, while still protecting it, perhaps through increasing access to viewing at the rescue center. Furthermore, conservation and educational efforts could be focused to emphasize the link between human actions and the golden monkey itself, showing how indirect effects from human activity can impact the monkey population. Otherwise, people who have not seen the monkey may think of it as a distant animal, safe from human action. This lesson offers bitter irony for future policy prescriptions: if people becoming more aware of human impact on the environment is correlated with observing the golden monkey, how do we promote sustainable land use practices in FNNR and environments with similarly shy, endangered fauna?

Awareness of human impacts is further linked with viewing environmental regulations as restrictive in prohibiting locals from killing wild pigs that damage their crops. The issue of wild pig damage to crops is neither limited to FNNR (People's Daily Online, 2010), nor is the perception of policy colored by animal damage to crops only in China (Müller-Böker and Kollmair, 2000). However, in FNNR wild pig crop damage is locally associated with awareness of human environmental impacts, though not directly through personal crop damage. This indicates not only an indirect relationship but also highlights a potential problem for management. Support for conservation may be limited or unsustainable if environmental and conservation programs are linked to negative experiences of regulations. For instance, local people may be aware of human impact on the environment but feel regulations (e.g., for forest conservation) are limiting their ability to stop a livelihood threat. In this case, the regulations may be unsustainable for local people.

For policy to successfully address negative attitudes towards regulation and the lack of golden monkey visibility, emphasis may usefully be on providing environmental and economic benefits to the local population. The use of critical environmental assessment education, with a focus on improved local understanding of and involvement in environmental principles and regulation, has potential applications for conservation and sustainable development in complex human and natural systems (Diduck, 1999). However, applications in FNNR towards increasing local participation in resource use management would face challenges in balancing administration and involvement in the local government structure. Improved understanding may reduce local people's negative feelings related to simply imposing many limits and restrictions on them to protect a 'distant' and shy, albeit beautiful, endangered species. It is important to illustrate the role of regulations as a solution (Kotchen and Young, 2007) and to make efforts towards highlighting win-win situations in conservation and land use programs (DeFries et al., 2004).

Ecotourism, when carefully planned and managed in consideration of several sensitive issues (e.g., economic equity among different groups as well as potential harms to local environment), has potential to be a win-win option for FNNR. Ecotourism has been shown to have links to conservation attitudes through experiential learning (Tisdell and Wilson, 2005). In FNNR, it may increase monkey visibility. Furthermore, it may emphasize local conservation benefits and environmental impacts of human activity, leading towards a better understanding of trade-offs in land use decisions. The efficacy of these practices in FNNR remains to be seen but could improve the long-term sustainability of conservation programs and endangered species in other CHANS.

5.2. Implications for modeling and theory

The above insights and implications not only have much to offer policy formation in protected areas, but also hold potential for modeling human decision-making in CHANS. Rather than taking many perception-decision relationships for granted, more efforts could be invested in understanding decisions contextually, identifying conscious and unconscious trade-offs behind land use decisions, and incorporating such relationships in models. Incorporation of perception in modeling can assist in better understanding system relationships and developing robust process-based models (e.g., agent-based models; see An, in this issue) that better capture the proximate and distant drivers of relevant decisions.

Land change researchers are increasingly using a diversity of modeling approaches such as multi-level modeling and agent-based modeling (ABM) in a growing number of applications in land use studies (Verburg et al., 2004; An et al., 2005, 2006; Rindfuss et al., 2008; An and Liu, 2010). Both approaches have potential for application in understanding complex CHANS questions such as land use decisions and livelihood strategies. The inclusion of perception in modeling decision-making could contribute to more robustness in modeling CHANS dynamics because it provides added depth to addressing the issue of model uncertainty (Grimm et al., 2005). With these efforts, the effects of underlying or subtle relationships can be uncovered, leading to more robust results.

In the context of this investigation, an underlying relationship is that between environmental awareness and negative perceptions of regulation impact. Although a better understanding of the impacts of human activity is commonly considered to be a positive quality when advocating conservation, such understanding is linked to negative experiences with regulations in FNNR. If people perceive regulations as limiting their ability to protect their livelihoods against damage, they may act to secure more resources, most of which may be essential for protected species. This could lead to a feedback loop of increased environmentally damaging activity that requires further conservation regulations, potentially leading to further perceptions of livelihood-damaging restrictions and so on. Alternatively, pressure from perceived restrictions could build up until unexpected environmentally deleterious actions result as a threshold of tolerance is reached. Results from this investigation demonstrate that even basic environmental perceptions may not have solely positive linkages, despite commonly positive connotations. Without addressing perceptions in modeling human decision-making, complex linkages may be ignored that could be part of underlying feedbacks or lead to unexpected non-linear responses.

In this investigation, we have illustrated the significant strengths of our novel approach in modeling human–environment relationships. Incorporation of perception in modeling human decision-making in CHANS has yet to be made explicit, although its usefulness has been illustrated in other contexts. Considering the interdisciplinary nature of CHANS research, it is important to draw on knowledge advanced in the fields of behavioral economics, social psychology, livelihood studies, and risk analysis in formulating a theoretical base for modeling human perceptions in CHANS. We have shown that consideration of perception in modeling CHANS can contribute to this base through integrating structure and agency in understanding multiphasic land use decisions. This approach not only elucidates the complexities of agent actions and trade-offs in decision-making but also lends insight into perceived structural factors that affect system function. Agent perception of structures is critical to identifying underlying relationships in modeling processes in CHANS. Further strengths of the approach include highlighting previously unobserved or counter-intuitive relationships critical to reducing untenable assumptions in CHANS modeling.

The modeling approach not only allowed us to demonstrate the importance of close examination of driving forces (particularly perception) behind land use decisions but also to display its practical usefulness in assessing environmental programs (e.g., GTGP) and regulations. Future work will further investigate the relationships between income, livelihood variables, crop damage, and policies. The approach of incorporating perception can ultimately improve models of coupled human–nature systems by providing added insight into system complexity.

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Appendix A.

See Figs. A.1–A.3 and Tables A.1–A.5.

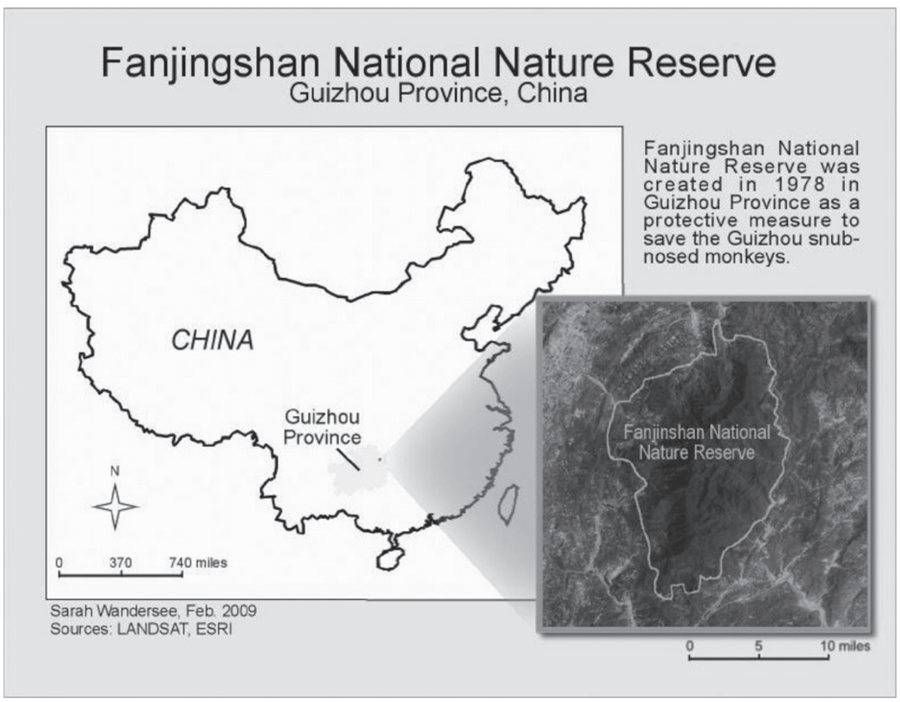

Fig. A.1. FNNR locational map.

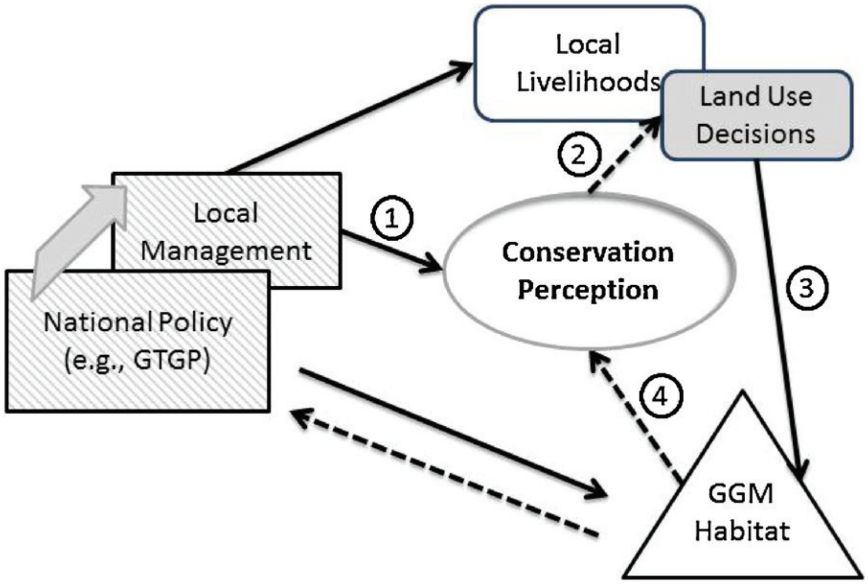

Fig. A.2. Conceptual model.

Table A.1
Variable definitions.

Category	Independent Variables	Definition
Reforestation	Participation	Binary participation/non-participation
	Level	Reforestation land/(cropland + reforestation land)
	Hectares	Hectares of reforestation
Temporary work	Interviewee years	# of years interviewee did temporary work
	Interviewee worker	Binary of temporary work for interviewee
	Household years	Total # of years of temporary work for household
	Household workers	# of individuals in household doing temporary work
	Remittances	Binary of receiving money from family in city
Livelihood	Meals per day	Average meals eaten per day
	Meat per week	Average times eating meat per week
	Eggs per week	Average times eating eggs per week
	Alcohol consumption	Frequency of drinking alcohol (ordered)
	Fuelwood consumption	Kilograms of fuelwood gathered per week (100 kg)
	Household income	Income in 2009 (yuan)
	Per capita income	Income in 2009/household size
	Crop damage	Animal damage to crops: no, yes, no crops[a]
	Income source	No income, >50% agricultural, 50/50 ag/non-ag, >50% non-agricultural[a]
	Cropland	Amount of cropland
	Crop consumption	Crops consumed or sold: crops all consumed, crops some sold, no crops[a]
County & Village	County	Binary autonomous county
	Village	Village: 1–8[a]
Household	Size	# of people in household
	Average age	Average household age
	Children	# of individuals in household under age 15
	Adults	# of individuals in household age 15 and up
	Max education level	Maximum household education level (ordered)
	Ethnicity	Ethnicity: Tujia, Han, Miao, other[a]
Interviewee	Age	Age of interviewee
	Gender	Gender of interviewee
	Education	Education level of interviewee (ordered)
	Preferred # children	Preferred number of children
Perception	Main current concern	Current livelihood concerns (food, education, health, money, jobs, infrastructure, etc.,. . .)[a]
	Main future concern	Future livelihood concerns[a]
	Lottery money use	Use of money if won the lottery[a]
	Neighbor damage	Perceived actions by neighbors that damage the environment[a]
	Personal damage	Perceived personal actions that damage the environment[a]
	Regulation impact	Perceived impact of regulations: none, protects ecology, prevents harvesting, prevents killing pig[a]
	Regulation restriction	Binary of FNNR regulations seen as restrictive (preventing activities) or not (no effect/protecting)
	Monkey protection	Reason for protecting the golden monkey[a]
	Heard of climate change	Binary heard/have not heard of climate change
	Seen the golden monkey	Binary seen/have not seen golden monkey
	Protect all species	Binary should/should not protect all species
	Forest change	Perception of forest change: shrinking, same, growing, do not know[a]

[a] Dummy variable.

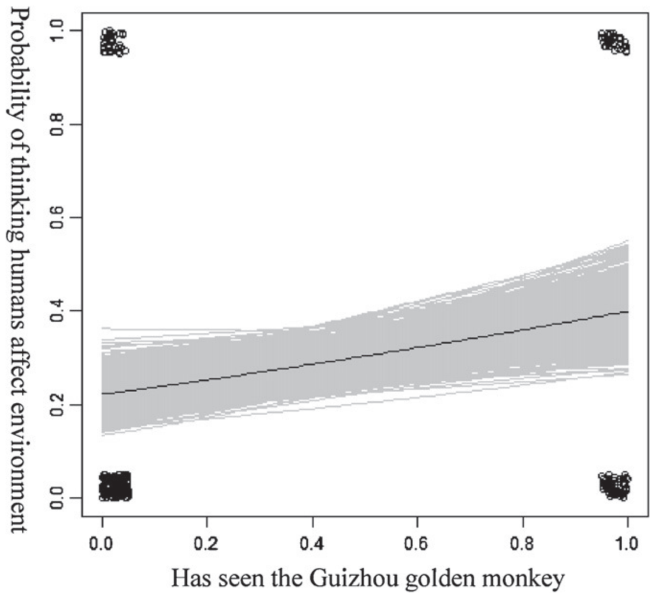

Fig. A.3. Simulated uncertainty in coefficient 1000 repetitions of Pr (thinking humans affect the environment) – having seen golden monkey.

Table A.2
Household survey population summary.

Mean average household age	35.4
Mean household reforestation level	46.57%
Mean household size	4.55
Household ethnicity	Tujia: 17%, Han: 62%, Miao: 19%, other: 2%
Mean cropland area	0.27 ha
Mean temporary work (% of household adults)	42.18%
Interviewee gender	Male: 76%, female: 24%
Maximum household education	None: 2%, elementary: 19%, middle: 51%, high: 17%, technical: 10%, university: 1%

Table A.3
Variables in GLMs & single predictor logistic regression results.

Category	Independent variables	Expected sign (+/–)	Coefficient	*p*-Value
Reforestation	Participation	+	–0.082	0.800
	Level	+	–0.0001	0.97
	Hectares	+	–0.975	0.17
Temporary work	Interviewee years	+	–0.011	0.81
	Interviewee worker	+	+0.267	0.33
	Household years	+	–0.011	0.52
	Household workers	+	+0.095	0.37
	Remittances	+	–0.263	0.46
Livelihood	Meals per day	–	+0.108	0.71
	Meat per week	+	+0.045	0.34
	Eggs per week	+	+0.065	0.21
	Alcohol consumption	+	+0.042	0.91
	Fuelwood consumption (100 kg)	+	–0.163	0.05**
	Household income	+	+0.000	0.50
	Per capita income	+	+0.000	0.89
	Crop damage (yes)	–	–0.255	0.37
	Income source (none)	–	+0.730	0.05**
	Income source (>50% agriculture)	+	–0.713	0.02**
	Cropland	–	–0.046	0.16
	Crop consumption (all)	–	+0.304	0.28
County and village	County (autonomous)	+	0.453	0.15
	Village 4	+	1.092	0.00***
	Village 5	–	–1.893	0.01**
Household	Size	–	0.018	0.83
	Average age	–	–0.010	0.38
	Children (<15)	+	–0.075	0.60
	Adults	–	0.020	0.83
	Max education level	+	1.015	0.35
	Ethnicity (Han)	–	0.546	0.06
Interviewee	Age	–	–0.017	0.10
	Gender (Female)	+	–0.084	0.80
	Education	+	9.919	0.99
	Preferred # children	–	–0.164	0.30
Perception	Main current concern (job/$/all)	–	–0.845	0.03**
	Main current concern (food/fields)	–	0.681	0.03**
	Main future concern (job/$/all)	–	–0.715	0.04**
	Lottery money use (business)	–	0.826	0.02**
	Neighbor damage (garbage)	+	0.896	0.05*
	Personal damage (development)	+	1.584	0.20
	Regulation impact (none)	+	–0.640	0.02**
	Regulation impact (unprotected damage)	–	1.347	0.04**
	Regulation restriction	–	0.722	0.02**
	Monkey protection (beauty)	+	–1.558	0.04**
	Heard of climate change	+	0.847	0.01**
	Seen the golden monkey	+	0.843	0.00***
	Protect all species	+	0.278	0.41
	Forest change (shrinking)	+	1.003	0.02**

* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table A.4
Multiple logistic regression models (1 & 2).

	Variables in model	Expected sign	Model 1 (without control variables) coefficients	Model 2 (control variables from start) coefficients
Significant	Having seen the golden monkey	+	0.62*	0.696*
	Having heard of climate change	+	0.75*	–
	Business interest	–	0.78*	–
	Food security concerns	–	0.67*	–
	FNNR regulations restrict pig	–	–	2.05*
	No income source	–	–	1.52**
	Balanced (Ag/non-Ag) income	+	–	1.73*
	Fuelwood consumption	+	–	−0.184*
Control	Interviewee age	–	–	0.00097
	Interviewee gender (female)	+	–	0.301
	Interviewee education: none	–	–	−0.183
	Interviewee education: grade school	+	–	−0.176
	Interviewee education: middle school	+	–	−0.167
	Interviewee education: high school	+	–	−0.171
	Interviewee education: junior/technical	+	–	−0.163
	Household ethnicity: Tujia	–	–	0.162
	Household ethnicity: Miao	–	–	0.160
	Household ethnicity: Han	+	–	0.162

– Not in the model.
* $p < 0.05$.
** $p < 0.01$.

Table A.5
Climate change versus education level*: number of respondents displayed with the percentage of respondents having heard/not heard of climate change by education category.

Education level	None	Elementary	Middle	Higher Education[a]
Has not heard	45 (96)	113 (89)	48 (65)	4 (44)
Has heard	2 (4)	14 (11)	26 (35)	5 (56)

[a] Includes high school, technical school, and university.
* Fisher's exact test p-value = 4.945e−07.

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