Land-Use Change, Environmental Service Payments, and Non-Financial Incentives: Results of a Survey of Landowner Interest in Costa Rica

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Abstract

I present results from a study of landowner interest in a proposed payment modality for Costa Rica's *Pagos por Servicios Ambientales* (PSA) program that is based on a sliding-scale payment scheme which transitions from higher monetary payment per hectare per year for the first units of land invested, to lower payments per hectares per year for additional units of land invested; however, as payments per hectares decrease, monetary payments become supplemented with non-financial rewards. This program structure is designed to: 1) offer higher per-hectare financial incentives to smaller-scale landowners, who would otherwise face steep trade-off costs by transitioning to conservation-based land-use, and 2) offer greater non-financial incentives to larger-scale landowners, who face less sharp trade-off costs, and who might be more interested in prestige- and status-based non-financial incentives than the currently meager PSA payments. I found support for the proposed program modality across all classes of landowners. Interest in PSA participation by small- and medium-scale landowners showed sensitivity to proposed payments, with landowners indicating a strong desire to participate in conservation land-use as soon as the the proposed financial incentives were sufficient to cover their opportunity costs. Large-scale landowners showed little sensitivity to payment size, and in general—with mode=10 and median=7 responses on a 10 point Likert-scale—indicated strong willingness to participate in the PSA program under the proposed structure, even if financial incentives per hectare were decreased significantly for large investments of land, but prestige- and status-based awards were introduced. These results are discussed in the context of an emerging literature on signaling theory, conspicuous conservation, and the interaction of financial incentives and social norms.

Keywords: Environmental service payments, ESP, *Pagos por Servicios Ambientales*, PSA, Incentive, Conservation economics, Costa Rica

1. Introduction

Despite its small (51,000 sq-km) size, Costa Rica is home to a surprisingly large amount of biodiversity; over 505,000 species of plants and wildlife have so far been documented [1]. While amounting to only about 0.03% of the earth's land area, Costa Rica contains over 9.5% of the world's bird species, 4.9% of the world's mammalian species, 3.31% and 3.88% of the world's reptile and amphibian species, and 3.7% of the world's plant species [2]. Such a plethora of diversity offers great hope for bioprospecting (the search for new chemicals, medicines, and foods from the rainforest or other biomes), and is one of the main draws for the burgeoning sector of ecotourism [1]. Decades of exploitative land-use, however, severely diminished the forest cover in Costa Rica. In an effort to protect what was left of Costa Rica's biodiversity, the Costa Rican government set aside many biological reserves, signed on to several international conservation programs, and implemented a private-sector conservation incentive program, *Pagos por Servicios Ambientales* (henceforth, PSA), to stimulate conservation land-use on private lands.

This paper explores the current manifestation of the PSA program and evaluates landowner interest in an alternative payment structure, based on a sliding-scale payment scheme that transitions from higher monetary payment per hectare for the first units of land invested, to lower payments per hectares for additional units of land invested; however, as payments per hectares decrease, monetary payments become supplemented with non-financial rewards. This program structure is designed to: 1) offer higher per-hectare financial incentives to smaller-scale landowners, who would otherwise face steep trade-off costs by transitioning to conservation-based land-use, and 2) offer greater non-financial incentives to larger-scale landowners, who face less sharp trade-off costs, and who might potentially benefit more substantially from non-financial incentives than from the currently meager PSA payments. For example, non-financial awards, like recommendation of landowners' businesses in popular tourism guides, might draw in enough business to compensate for reduced payments per hectare. Addi-

tionally, non-financial rewards that elevate landowners' prestige or social-capital could be valued more highly in the local context than the current payments.

The rest of the paper runs as follows: 1) I briefly discuss the history of land-use in Costa-Rica; 2) I comment on two strategies designed to reforest and/or protect the current natural resources of Costa Rica—the creation of protected reserves and national parks, and the stimulation of private sector conservation using environmental service payments; 3) I outline the impact and shortcomings of environmental service payments in Costa Rica; 4) I provide a theoretical justification for considering a sliding-scale payment system that includes a non-financial component; 5) I define specific predictions to be tested via interviews with a sample of Costa Rican landowners; 6) I then detail the methods used in this research project and provide the results of the study. Finally, 7) I conclude with a discussion of the results and comment on the implications of these results for future research on conservation economics and environmental service payments.

1.1. A Brief History of Land-Use and Economy in Costa Rica

Unsustainable land-use in Costa Rica is hypothesized to have begun during the Spanish colonial period, when Spanish farmers implemented land-use strategies that were effective on Spanish soils, but impossible to sustain in the highly fragile soils of the tropics [3, 4]. While ecological damage initially remained limited, the integration of Costa Rica as a producer of monoculture goods into an intense global market, beginning during the industrial revolution, accelerated the ecological destruction of Costa Rica's land [3]. In 1950, about 75% of Costa Rica's land mass was covered by forest; this decreased to about 23% by 1990 [3, 4, 5].

Early on, low population density and high wages provided opportunities for a decent quality of life. An open frontier encouraged large-scale landowners to pay workers enough to discourage them from claiming land on the frontier and instituting competing farms [3]. This organization of social economy continued into the mid-twentieth century, when population figures exploded, the price

of land soared, and the safety valve of the frontier expired [3]. During this transitional period, a large percentage of land was hoarded by a small percentage of wealthy landowners, and thousands of Costa Ricans were left landless and in need of government aid [3].

In the 1950s, many crops began to be replaced by extensive cattle production and pastureland [6, 7]. Cattle production was fueled by land titling laws, government subsidies, and credits for exporting cattle [5]. By the end of the 1960s, pastureland was the leading land-use in Costa Rica [6]. Due to the fragile nature of tropical soils, deforested pasturelands offered only short-term profit before becoming savannas. Valuable natural resources and long-term buffers against financial insecurity were lost as the forests of Costa Rica were converted into pasture-land for the short-term economic benefit offered to some private landowners [4, 5].

As this interplay of markets, producers, and land-allocation took place in Costa Rica, deforestation rates continued to accelerate as land was cleared for agricultural use [4, 5]. From 1950 to 1994, the rate of deforestation in Costa Rica (40,000-50,000 hectares per year) exceeded most other countries in the Americas [8]. Zbinden and Lee cite rapid road expansion, credits for cattle exportation, and land-titling policy that rewarded deforestation, as being the primary forces responsible for the massive amount of deforestation in the late 1900s [5]. The policies and practices leading to this run-away deforestation were soon found to be unsustainable and a threat to Costa Rica's future. During the 1990s, the Costa Rican government began to take measures to slow the destruction of their tropical forests, reducing the deforestation rate to 16,000 hectares per year [5], and restoring the amount of standing rainforest to 52% [9].

1.2. Restoring the Rainforests of Costa Rica: Two Approaches

The Costa Rican government approached the problem of deforestation on two fronts: one strategy was to create large reserves of protected area, such as the *Barra del Colorado-Torteguero* complex. The other strategy focused on stimulating conservation in privately-owned land, through programs such as the

highly innovative *Pagos por Servicios Ambientales* program, which offers cash incentives to private landowners for reforestation or forest preservation [5].

1.2.1. The National Park System

In the 1990s, the Costa Rican government came to realize that unsustainable land-use practices would spell an end to Costa Rica's development and growth as a leader in tourism, and lead to a decrease in the quality of life for its residents. This assessment was echoed by almost all of the landowners interviewed during this research project, even those engaged in unsustainable land-use practices.

Tourism is the leading industry in Costa Rica in terms of profit [9], and it is fueled in large part by Costa Rica's natural environment. Ecotourism often includes travel to national parks, sustainable farms, and organic coffee plantations [9]. To foster the tourism sector, the government of Costa Rica has created a strong national park system, and a network of protected refuges, amounting to over 26% of Costa Rica's land area [10].

Despite these impressive figures, interviews with several landowners and conservationists conducted during this study suggested that poaching and illegal lumber extraction occur frequently in protected reserves. However, even when controlling for such actions, and the spillover of resource extraction to areas outside of protected regions, the network of protected areas in Costa Rica has been quite successful in minimizing deforestation and ecological destruction [11].

1.2.2. Environmental Service Payments

Environmental service incentive programs, like the PSA, provide some (normally wealthy) landowners with financially sustainable alternatives to land-use strategies that rely heavily on methods of economic production with severe impacts on the health of the environment and people who live on the land (for example, monoculture plantation and the associated heavy use of pesticides, nematicides, and chemical fertilizers). Shifting the land-use management strategies of private landowners in the tropics to conservation-based usage is an important step in protecting the world's largest repositories of ecological diver-

sity and biomass [12]. While direct methods of conservation, such as the establishment of government reserves, are based on a comparatively straightforward link between policymakers and tangible results, indirect conservation strategies, like the PSA program, rely heavily on theoretical models of economic behavior [5, 13]. Because of this, much empirical study of the PSA is needed to maximize the conservation to payment ratio, avoid perverse incentives, and ensure fairness. To date, across a wide range of countries and conservation goals, environmental service payments have had an overall track record of empirical success, in spite of many program-specific inefficiencies [14, 15, 16, 17, 18, 19, 20, 21].

1.3. The Pagos por Servicios Ambientales Program

In 1996, Costa Rica enacted Forest Law No. 7575, which gave legal recognition to four environmental services provided by the forest ecosystems of private landowners: 1) carbon sequestration; 2) watershed protection/hydrological services; 3) biodiversity conservation; and 4) conservation of scenic beauty for tourism and aesthetics [22]. This law provided the basis on which the payments offered through the *Pagos por Servicios Ambientales* program would be founded in 1997 [22]. The PSA in its current form is the product of a long line of tax credits and incentive programs designed to sponsor forest conservation and timber plantations [22]. Currently, the PSA offers three modalities of participation: reforestation, sustainable forest management, and forest protection/conservation [5].

The PSA is supported by funding from a variety of sources. Zbinden and Lee argue that one of the innovations of the PSA is the application of 'polluter pays' and 'beneficiary pays' principles to ecological economics, where polluters pay compensation for the ecological cost they inflict on the commons, and where beneficiaries pay for the services provided by the commons [5]. Pagiola, however, claims that while it was envisaged that beneficiaries and polluters would pay into the PSA, this objective has only partially been met [22]. Instead, the bulk of PSA funding comes from an allocation of revenue generated by a domestic fossil fuel tax, World Bank loans, and a grant from the Global Environment

Facility [22, 23, 24]. The PSA has yet to achieve its vision as a market-based program transferring payments from polluters or recipients of environmental services to providers of such services; in some sense, it has instead functioned to transfer funds borrowed from the World Bank to wealthy (and often foreign) landowners, raising concerns that the program has abandoned an early-stated goal of integrating conservation and poverty alleviation [24, 25]. As such, at a broader scale, wealthier national and inter-national communities who receive the benefits of ecological services, but currently do not pay for their costs, have an obligation to fill the funding gap in tropical conservation [26, 27], and ensure that the promise of environmental service programs is not corrupted into a mechanism of underdevelopment and neocolonial exploitation [24, 28, 29, 30].

The areas where progress has been made in shifting the PSA from a government subsidized program to a market-supported program come mainly from water service contracts with bottlers, municipal water suppliers, irrigation users, hotels, and from carbon credits [22]. This growing transition of environmental service incentives into a market system is highly relevant theoretically, as it is a large step away from 'capitalism as usual,' in which profit is derived from the unpaid costs inflicted on the commons. However, the contexts in which market-based environmental service programs can be easily implemented are typically limited to situations like those listed above, where the effects of environmental services are direct, and the beneficiaries' willingness to pay meets the suppliers' willingness to accept payment [13]. In a wider range of circumstances, it could be argued that beneficiaries *should* provide payment for the environmental services provided by private or public landowners, but there does not exist a structural relationship that drives beneficiaries' willingness to pay. For example, there is ever growing social pressure for 'nature-conscious' corporations that profit from photography and videography of the natural beauty provided by the world commons to contribute to relevant environmental service payment schemes [31], but there does not, as of yet, appear to exist the kind of structural pressure necessary to force such businesses to pay for the services from which they benefit.

1.4. Shortcomings of the PSA

The PSA pays a flat rate per hectare of land to all landowners, regardless of land-size holdings or relative wealth [5, 17]. This payment structuring is significant, because Zbinden and Lee found that property area and human capital among Costa Rican landowners were the highest predictors of participation in the PSA program, and those landowners with less education and smaller land holdings were less likely to participate in the PSA program [5].

Additionally, despite significant promise in changing land-use, improving conservation efforts, and forging a more integrative and healthy market relationship between polluters, beneficiaries, and the community at large, the PSA program suffers numerous shortcomings, which include, but are not limited to, the following:

1. Requests for participation in the PSA program by landowners far outweigh the funding resources of the PSA program [22].

2. Much of the money currently paid through the PSA program is being claimed by wealthy/large-scale landowners previously engaged in conservation, thus these funds do little to change land-use, and could be better invested in other landowners [32].

3. PSA payments cannot effectively compete economically with extractive land-use strategies, and thus can only alter land-use in specific situations (marginal land, slow moving frontiers, etc.), or when PSA participation/conservation is pursued for reasons other than profit potential [32].

4. Funds are dispersed mostly to wealthy and large-scale landowners, and impoverished landowners are forced into non-participation due to unfavorable tradeoffs [5, 17].

5. The PSA is not structured to strategically invest money more heavily in the areas where it is needed most, like buffer-zones to national parks, international wildlife corridors, and watersheds [22].

As Pagiola states, "Costa Rica's PSA program offers a relatively low, undifferentiated, and mostly un-targeted payment. Thus it will only tend to attract participants whose opportunity cost of participation is low, or negative... Being undifferentiated and untargeted, the program will also attract many land users who would have adopted the desired practices anyway" [22, pp. 717]. Extractive land-use economically out-competes conservation-based land-use in the short-term (one growing season), and, in most cases, long-term. Due to this steep economic gradient, other additional factors of influence such as patriotism, moral commitment to environmentalism, concern for the collective, social signaling, or prestige seeking, may be responsible for landowners adopting conservation-based land-use strategies and participating in the PSA program [33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44].

1.5. Proposed Strategic Changes to the PSA Investigated in this Study

Field observations and meditation on the above-listed shortcomings of the PSA program have suggested possible value in an alternate program structure based on a sliding-scale payment system, to increase both the amount of land conserved (adjusted for its value to conservation goals), and the number of participating landowners. Furthermore, a sliding-scale payment system has the potential to create a more equitable balance of wealthy and poor landowners with the same program budget.

1.5.1. A Sliding-Scale System Integrating Non-Financial Rewards

In order to survive, poorer landowners typically have no alternative other than to pursue land-use strategies which maximize economic profit, even at the cost of destroying their forests, which are long-term buffers against future financial insecurity. Wealthier landowners, who are not in a financial struggle to survive, have the freedom to pursue land-use strategies which balance short-term profit and long-term security. Furthermore, among wealthy landowners there is also a trade-off between current profitability and access to prestige, social status, and community/international recognition of their properties or

business (if, for example, they forgo the profit of extractive land-use in order to create a private reserve). Among poorer landowners, the major trade-off is between intensive land-use and resource insecurity, as outlined in Figure 1.

[Figure 1 about here.]

In order to balance the needs of both wealthy and poor landowners, and make the PSA program attractive to both, the payment structure of the PSA could theoretically be changed to a sliding-scale system. This system would provide much higher financial payments per hectare for small amounts of land, the first 1-10 hectares invested per landowner, for example, and decrease for the next 11-50 hectares per landowner, and significantly decrease per hectare for investments of more than 50 hectares. However, as the price per hectare decreases, prestige-based awards, and regional or national recognition (in tourism guides, for example), could be granted, as more appropriate incentives for wealthier landowners, to whom the current PSA payment of approximately $58 per hectare, per year, is not financially significant. Such a sliding-scale system would provide smaller-scale landowners with enough money to cover the opportunity costs associated with conservation until a sustainable conservation-based land-use could be adopted, and would provide wealthier landowners with either prestige-based social capital or advertisement for their businesses.

Typically large-scale landowners are using their properties for some form of business, and the revenue generated by increased tourism (as a function of non-financial rewards) could possibly exceed the revenue generated through meager PSA payments. In this way, a sliding-scale system, which transitions from financial awards to non-financial awards, could be more attractive to both wealthy and impoverished landowners. Below I provide some theoretical justification for this hypothesis. I then list several specific predictions to be empirically tested.

1.5.2. Theoretical Motivation for Considering Non-Financial Incentives

Theoretical models in evolutionary biology [45] and economics [46, 47] have shown that altruistic cooperation can be stabilized by costly honest signaling

of high status [48, 35]. Although—and because—such signals are costly, they reliably signal the quality of an individual as a mate, coalition partner, or competitor and can result in advantageous alliances and outcomes for those signaling [36].

In the last few decades, a wide ranging literature has emerged focusing on the phenomena of social status and conspicuous consumption [49, 50], first introduced by Veblen [46]. In this literature, it is often show that wealthy individuals are willing to pay steep financial costs in order to honestly signal their elevated status (e.g. through purchase and display of expensive art, cars, or jewelry). However, many recent studies have come to understand that the social context surrounding consumption has change over the last century [51, 52, 34], and norms emphasizing the importance organic food, sustainability, conservation, and green living have come to be associated with elevated social status [33, 37, 38, 40], a transition sometimes dubbed 'the Prius effect' [42].

In the appropriate socio-ecological context—for example, where social norms link prestige and conservation [41]—conservation land-use can be driven by status seeking behavior and conformity to costly social norms that signal elevated status. In the Costa Rican context, the central importance of ecotourism to the economic well-being of the country has fostered cultural norms that link conservation land-use, moral commitment to environmentalism, and prosociality to patriotism and increased prestige/social-status. In such a sociological context, conservation of standing forest on one property serves as a costly signal of material wealth, prosocial concern for the good of the collective, and prestige/social-status.

If conservation land-use is being strongly driven by non-financial concerns among large-scale landowners (which must almost certainly be the case, given that the opportunity costs of destructive land-use exceed the expected gains under conservation land-use in almost all contexts), then meager financial incentives are unlikely to have a significant effect on shifting land-use. In fact, such financial incentives might even have the perverse effect of undermining the ability of conservation land-use to signal prosocial norms. Non-financial awards,

however, can function to provide wider recognition of conservation land-use, and thus elevate the social status and prestige of a conservationist landowner. Furthermore, non-financial awards are much less likely to undermine the value of conservation land-use as a signal of prosociality. Recent theoretical and empirical work in economics analyzing dynamically linked systems of social norms and financial incentives suggest that such perverse effects can undermine the overall effectiveness of incentive programs [53, 54, 55]. As such, environmental service programs that explicitly consider the direct effects of both financial and non-financial incentives on conservation land-use, and the indirect effects of these incentives on locally-contextualized social norms, may be more effective than environmental service programs that entirely neglect non-financial rewards and fail to consider the effect of financial rewards on existing social norms.

1.6. Predictions to Be Tested

P1) Contrasting the effects of resource-limitation versus knowledge/awareness on conservation land-use, I predict that a large percentage of poorer landowners, and landowners with small and medium property sizes, currently opt out of participation in the PSA program and instead pursue land-use strategies that offer higher short-term profit potential, but less long-term security and higher environmental costs. As such, wealth and the size of land holdings will be key predictors of: *a*) conservation land-use, and *b*) participation in the PSA program, in the sample of landowners. Education will not be a determining factor in: *c*) land-use choice, or *d*) PSA participation. Ethnographically, poorer and small-scale landowners may or may not be aware of the environmental impact or health risks of exploitative land-use strategies, but regardless of this knowledge, *e*) a high percentage of poorer and small-scale landowners will explain motivations for land-use strategy as a result of poverty or economic constraints.

P2) A large percentage of these same small-scale and medium-scale landowners will show a desire to participate in the PSA program under a sliding-scale

payment structure, when the payments offered can match the opportunity costs associated with more destructive land-use strategies.

P3) Previous studies have found that wealthier landowners with larger property sizes are more likely to: (a) pursue land-use strategies with less short-term profitability and increased long-term security, and (b) opt into the PSA program. I evaluate if the landowners interviewed in this study conform to this national pattern.

P4) A large percentage of (conservation conscious) wealthier landowners with large property sizes will continue to invest in conservation and participate in the PSA program, even if the payment amount per hectare is reduced, as long as non-financial rewards which garner prestige and can attract media attention and tourism dollars are offered.

P5) More generally, landowners participating in the PSA program currently would continue to participate under the proposed structure, and the proposed structure would attract landowners who are currently non-participants.

2. Methods

To test these predictions, fieldwork was conducted in Costa Rica during the Spring of 2010. The research protocol was reviewed and approved by the Institutional Review Board of California State University, Fullerton—protocol number 09-0290—prior to data collection. Informed consent was obtained from all research participants.

This study utilized a mixed-methods research design, which integrated quantitative and qualitative data collection strategies. A questionnaire was used to collect quantitative data describing land-use allocation and landowner demographics. Collected quantitative data included farm size, monthly income, number of dependents, education level, participation in the PSA program, land-use strategy, and a variety of other variables. In-depth interviews with these same landowners were used to assess motivation for the land-use strategy they

were using, as well as to assess the landowners' willingness to participate in the PSA program under alternative proposed structures. Both open-ended and Likert-scale questions were used to assess: 1) likelihood of participation in the PSA under current and alternative structures, 2) moral beliefs regarding conservation, 3) explanations for land-use decisions, 4) beliefs about government competency, and 5) views regarding the importance of prestige and national recognition. Surveys and in-depth interviews were conducted with N=62 landowners or property managers (27 small-scale, 16 medium-scale, and 19 large-scale; 11 current PSA participants and 51 non-participants), distributed across 12 cantons in 5 provinces of Costa Rica.

2.1. Sample Selection

A two-stage cluster sampling design was used. Six first-stage clusters—the cities of *Cariari*, *Turrialba*, *La Fortuna*, *Quepos*, *San Isidro de General*, and *Puerto Jimenez*—were chosen purposefully under advisement of a Costa Rican conservation ecologist, with the intent of capturing the major economic zones of Costa Rica. In all areas, interviews were conducted with the landowner, spouse of the landowner, or the property manager. Each landowner was asked if they had more than 1 hectare of land; if they said yes, they were invited to take part in the study.

Slightly different sampling methods were used in each of the six first-stage clusters to create the second-stage of the sample. In the cities of *Cariari*, *La Fortuna*, *Quepos*, *San Isidro de General*, and *Puerto Jimenez* most landowners were selected by conducting 'transect walks' along randomly chosen roads, and inviting any landowners who were visible from the road to participate. In *Turrialba*, landowners were invited to participate in the study at a local farmer's market.

Across all first-stage clusters, large-scale landowners were noticeably underrepresented after conducting sampling using transect walks. It was thus necessary to use respondent-driven and/or purposeful sampling of large-scale landowners, to complete the sample. This portion of the sample cannot be

looked at as random, since the majority of these landowners are both large-scale and conservation conscious (most truly large-scale landowners in Costa Rica are corporations not consulted in this research project). As such, the inferential domain of this study is limited to: 1) small- and medium-scale private landowners/residents, and 2) large-scale, normally conservation conscious landowners/residents, and not large-scale corporate landowners. As such, inference concerning whether or not large-scale landowners would be willing to accept a pay cut in the PSA program in exchange for alternate forms of (non-financial) incentives is limited to the indicated sub-set of large-scale landowners.

2.2. Data Analysis

To estimate the willingness of respondents to participate in the PSA under a sliding-scale system, I use a multi-level Bayesian Beta regression model [56].

Likert-scale questions are typically best analyzed using an ordered logistic model; however, the parameter-to-data ratio in this study renders the approach sub-optimal. Unlike the application of Gaussian models to Likert-scale questions, the increased flexibility of the Beta distribution allows for increased density on either or both endpoints of the scale, and can adequately capture the empirical data distributions produced in this project.

I conducted interviews with three classes of landowners: small-scale landowners with ≤ 10 hectares of land, medium-scale landowners with $10 - 50$ hectares of land, and large-scale landowners with > 50 hectares of land. For every landowner, I used a 10-point Likert-scale to inquire about willingness to invest up to 10 hectares in the PSA under three payment levels: 60,000 Colones hect/yr, 120,000 Colones hect/yr, and 240,000 Colones hect/yr (the actual PSA program paid approximately 60,000 Colones hect/yr, at the time of interviews, depending on the program modality).

For medium-scale and large-scale landowners, I also inquired about willingness to invest 10-50 hectares in the PSA under three payment levels: 45,000 Colones hect/yr, 60,000 Colones hect/yr, 75,000 Colones hect/yr.

Finally, large-scale landowners were asked about willingness to participate

in the PSA if payments per hectare over the first 50 were significantly reduced (to between 10,000 and 30,000 Colones hect/yr), but they were compensated with non-financial rewards, like recognition for protecting Costa Rica's land in periodicals or television, or if their businesses were given recommendations in tourism guides.

2.3. Statistical Models

2.3.1. Likert-Scale Responses

The response of each landowner, n, to each question, q, is denoted $\hat{R}_{[n,q]}$. The response from the 10-point Likert-scale is mapped to the open unit interval:

$$R_{[n,q]} = \frac{(\frac{\hat{R}_{[n,q]}-A}{B-A})(C-1)+0.5}{C} \tag{1}$$

where the constants $A = 1$ and $B = 10$ are the endpoints of the Likert-scale, and the constant $C = 50$ slightly scales the distribution off of the points 0 and 1, so that $R_{[n,q]} \in (0, 1)$.

$R_{[n,q]}$ can then be modeled from a Beta distribution parameterized with two positive real shape parameters, α and β. To obtain a useful regression structure using a Beta density [56], it is helpful to reparameterize the distribution in terms of a mean parameter, $\mu \in (0, 1)$, and a dispersion parameter, $\phi \in \mathbb{R}^+$. The mean and dispersion of the Beta distribution can be expressed as: $\mu = \frac{\alpha}{(\alpha+\beta)}$ and $\phi = \alpha + \beta$, respectively [likewise, $\alpha = \mu\phi$ and $\beta = (1-\mu)\phi$]. Thus, one can model $R_{[n,q]}$ using a reparameterized Beta distribution where:

$$R_{[n,q]} \sim \text{Beta}(\mu_{[n,q]}, \phi_{[n,q]}) \tag{2}$$

The parameter $\mu_{[n,q]}$ can then be modeled as a function of the interaction of landholding status—small-scale (10 hectares or less), medium-scale (greater than 10 hectares, but less than or equal to 50 hectares), or large-scale (greater than 50 hectares)—the quantity of land to be invested (10 hectares or less, greater than 10 hectares, but less than or equal to 50 hectares, or greater than 50 hectares), and the payment option being offered in question q. To accomplish

this, I use a 16-vector of random effects, $\omega_{[z]}$, where $z \in \{1 \dots Z\}$, and $Z = 16$ is the number of possible combinations of landholding status, proposed quantity of land invested, and payment option. A logit link ensures that all predictions of the mean are constrained to the unit interval, and a log link ensures that all predictions of the dispersion are strictly positive:

$$\text{logit}(\mu_{[n,q]}) = \kappa_1 + \omega_{[I(n,q)]} \tag{3}$$

$$\log(\phi_{[n,q]}) = \kappa_2 \tag{4}$$

The symbol $I(n, q)$ is a function that maps the correct random effect in the ω vector to the interaction of landowner ID and question ID. The dispersion parameter is shared across all landowners and questions.

The elements of each parameter vector are given vague priors:

$$\kappa \sim \text{Cauchy}(0, 5) \tag{5}$$

$$\omega \sim \text{Cauchy}(0, 5) \tag{6}$$

2.3.2. Land-Use Models

To model the percentage of a landowner's property in conservation land-use, I also use a Bayesian Beta regression model. I model the proportion of land in conservation land-use, $F_{[n]}$—adjusted in Equation 1, but with constants $A = 0$ and $B = 1$ indicating the endpoints of the proportion scale, and the constant $C = 50$ ensuring that all data points fall in the open unit interval—using a reparameterized Beta distribution where:

$$F_{[n]} \sim \text{Beta}(\eta_{[n]}, \theta_{[n]}) \tag{7}$$

I then model $\eta_{[n]}$ as a function of the property area (hectares), monthly income (Colones), and a binary completed education status indicator (of secondary education or higher):

$$\text{logit}(\eta_{[n]}) = \gamma_1 + \gamma_2 \log \text{PropertyArea}_{[n]} + \gamma_3 \log \text{MonthlyIncome}_{[n]} + \gamma_4 \text{Education}_{[n]} \tag{8}$$

The dispersion parameter is shared across all landowners:

$$\log(\theta_{[n]}) = \gamma_5 \tag{9}$$

and the elements of the γ parameter vector have vague priors:

$$\gamma \sim \text{Cauchy}(0, 5) \tag{10}$$

2.4. PSA Participation

PSA participation, $P_{[n]}$ is modeled as a function of property area (hectares), monthly income (Colones), and a binary completed education status indicator (of secondary education or higher) using a Bayesian Bernoulli regression model:

$$P_{[n]} \sim \text{Bernoulli}(\Delta_{[n]}) \tag{11}$$

where:

$$\text{logit}(\Delta_{[n]}) = \beta_1 + \beta_2 \log \text{PropertyArea}_{[n]} + \beta_3 \log \text{MonthlyIncome}_{[n]} + \beta_4 \text{Education}_{[n]} \tag{12}$$

and the elements of the β parameter vector have vague priors:

$$\beta \sim \text{Cauchy}(0, 5) \tag{13}$$

2.5. Model Comparison

Models are compared using the Watanabe-Akaike information criterion (WAIC) [57], a more fully Bayesian generalization of AIC. See Supplementary Model

Code for the specific scripts used to calculate WAIC for each model.

2.6. Software Environment

All data processing and visualization was handled in the R software environment [58]. All models were fit using Hamiltonian Marcov Chain Monte Carlo using the Stan version 2.6 C++ library and the Rstan interface [59, 60]. Raw data, model code, and model diagnostics are included in the Supplementary Materials.

3. Results

3.1. In-Sample Conservation Land-Use

Figure 2 illustrates that there is a positive trend in conservation land-use as a function of property size and, to some extent, income. There is a positive but non-reliable effect of education on conservation land-use controlling for property size or income. Table 1 shows the parameter estimates and model comparison; the models using property size to predict conservation land-use are preferred by WAIC.

[Table 1 about here.]

[Figure 2 about here.]

3.2. In-Sample PSA Participation

Figure 3 illustrates that there is a positive trend in the probability of PSA participation as a function of property size but not monthly income. In the model with property size, education has a positive but non-reliable relationship with PSA participation. Table 2 shows the parameter estimates and model comparison; the models using property size to predict PSA participation are preferred by WAIC.

[Table 2 about here.]

[Figure 3 about here.]

3.3. In-Sample Willingness To Participate in PSA

Figure 4 illustrates that for small-scale landowners, who own up to 10 hectares of land, willingness to invest up to 10 hectares of land in the PSA increases as payments increase from the current rate of 60,000 colones per hectare per year to rates of 120,000 or 240,000 colones per hectare per year. For medium-scale and large-scale landowners increasing payments does not lead to increasing willingness to invest up to 10 hectares of land in the PSA, because the current payment rate suffices to incentivize all landowners with an interest in participation.

For medium-scale landowners, there is a slight change in willingness to invest between 10 and 50 hectares of land as payments shift from 45,000 colones per hectare per year to rates of 60,000 or 75,000 colones per hectare per year, but there is a general decrease in willingness to invest more than 10 hectares at any of these payment rates. For large-scale landowners, however, willingness to invest between 10 and 50 hectares in the PSA remains high, and does not change as a function of change in payment rate.

Finally, for large-scale landowners, a severe cut in payments per hectare per year to between 10,000 and 30,000 Colones for investments beyond the first 50 hectares, coupled with increased non-financial/prestige-based awards, results in a moderate average willingness to invest more than 50 hectares in the program (relative to the elevated willingness to invest between 10 and 50 hectares); however, the modal response on the Likert-scale was still 10 out of 10, and the median response was 7 out of 10, indicating that such a program modality might be quite feasible, and even welcomed by many large-scale landowners, especially those with an interest in non-financial rewards.

[Figure 4 about here.]

Additionally, I asked all landowners about their willingness to invest in the PSA under a specific scheme where the first 10 hectares would be paid at a rate of 120,000 Colones per hectare, investment between 10 and 50 hectares would be paid at a rate of 60,000 Colones per hectare, and investment in excess

of 50 hectares would be paid at 10,000 Colones per hectare, but non-financial, prestige-based awards would be issued to landowners who invest more than 50 hectares of land. Of the 11 PSA participants interviewed in this study, the median and modal willingness to invest land in this restructuring of the PSA were both 10 out of 10 on the Likert-scale, with a mean willingness of 7.09. Only 3 of the 11 PSA participants indicated a response of 1 out of 10 on the Likert-scale, indicating in the qualitative interviews that they preferred the financial incentives (moral reasons were often emphasized, see Discussion). Of the 51 non-participants in the PSA interviewed in this study, the median and modal willingness to invest land in this restructuring of the PSA were 9 and 10 out of 10 on the Likert-scale, respectively, with a mean willingness of 7.45.

4. Discussion

4.1. Evaluation of Predictions

4.1.1. Prediction 1 - Property size, wealth, education, and conservation

As was predicted in P1, poorer in-sample landowners with smaller property sizes have a reduced proportion of land in conservation use and have lowered probability of participation in the PSA program. Contrary to the exact predictions, size of land holdings, but not monthly income, was a strong predictor of: conservation land-use, P1(a), and participation in the PSA program, P1(b). Education was not a strongly determining factor in: land-use choice, P1(c), or PSA participation, P1(d). Ethnographically, poorer and small-scale landowners were almost universally aware of the environmental impact and health risks of exploitative land-use strategies and the associated use of chemical pesticides, nematicides, and fertilizers; however, as predicted in P1(e), most poor and small-scale landowners emphasized economic constraints in preventing transition to alternative land-use strategies.

These results, like those of Pagiola [22], show that economic trade-offs structurally hinder the ability of poor and small-scale landowner to transition into conservation or extractive-yet-sustainable land-use. While having secondary

or higher education does not appear to be associated with transitioning towards conservation land-use, it is possible that education programs that teach landowners how to make conservation or extractive-yet-sustainable land-use strategies economically sustainable would be effective in shifting land-use strategies. Analog forestry methods [61] were mentioned by one Costa Rican landowner, who argued that wider education about the practice would allow landowners to sustainably and profitably conserve large tracks of primary forest, simply by replacing a subset of native plants with ecologically analogous, economically viable crops.

4.1.2. Prediction 2 - Sliding-scale payments in small/medium-scale landowners

Quantitative and qualitative data show that small- and medium-scale landowners are frequently interested in conservation, but are forced into alternate land-use strategies due to financial restrictions. As predicted in P2, small-scale and medium scale landowners show an increased desire to participate in the PSA program under a sliding-scale payment structure, when the payments offered can match the opportunity costs associated with alternative land-use strategies.

Transition to a sliding-scale system could help to unify the goals of environmental service and poverty reduction programs [62]. Poorer landowners often face harsher trade-offs than wealthier landowner when considering land-use strategies that benefit the public commons; increased financial investment in the first 10 hectares invested by any particular landowner would have an increased impact on impoverished landowners, and would help to balance the goals of social and ecological justice—especially as PSA payments evolve to better encompass the objectives of 'polluter pays,' 'beneficiary pays,' and 'provider receives' in the context of ecosystem services [24].

4.1.3. Prediction 3 - Large-scale landowners and conservation

As predicted in P3, there is a strong positive association of both conservation land-use and PSA participation with land-holding size in this sample; however, given the sampling methodology used in this study, it is unclear if this pattern is

truly indicative of the population-level bivariate relationships, or if this pattern emerges strictly from bias in the sampling of large-scale landowners. This being said, the results presented herein do mirror what other researchers have found using more robust sampling designs [see for example, 5, where Zbinden and Lee argue that large-scale landowners are more likely to be able to allocate a portion of land for reforestation, without jeopardizing household food security or income-generating potential]. However, in some environmental service schemes outside of Costa Rica, poorer and smaller-scale landowners have been able to achieve participation [63].

4.1.4. Prediction 4 - Large-scale landowners and sliding-scale payments

There is mixed support for prediction P4, that landowners with large property sizes will continue to invest in conservation and participate in the PSA program even if the payment amount per hectare per year is reduced, as long as non-financial rewards are offered. The modal response for large-scale landowners was 10 out of 10 on the Likert-scale, and most landowners expressed that they would happily participate in such a structure. These landowners normally justified their support of such a program either by emphasizing: 1) how the sliding-scale system with non-financial rewards would serve the social good by redirecting some of the program funding to more needy, small-scale or impoverished landowners, or 2) how such a program structure might improve the visibility of their businesses to prospective eco-tourists, and how they believed that increased promotion of their conservation projects in tourism guides and other media sources would amount to a larger increase in profit than the current PSA payment plan.

A small fraction of large-scale landowners, however, opposed my proposed program structure, noting that they prefer financial payments. These landowners primarily justified their choice by noting that their land is providing service to the world commons that they deserve to be compensated for financially. This critique was often contextualized by noting that the United States and other financially powerful nations continue to use resources and release pollutants at

a faster *per capita* rate than any Latin American nation, and that it is audacious to expect Latin American landowners to bear the opportunity costs associated with adopting the land-use practices needed to offset the climate-changing effects of carbon pollution by other nations, without explicit financial compensation.

4.1.5. Prediction 5 - Contrasting the current and proposed PSA structure

Generally, there is support for P5; the majority of both current PSA participants and current non-participants indicated strong interest in participating in the PSA under the proposed sliding-scale structure.

While this study was small-scale, landowners were very frank about their conditions and desires, and in no case did data collected on surveys and short-answer questions conflict with the attitudes and statements in the in-depth interviews. While the results presented here are certainly not sufficient to justify the policy recommendation of a new modality of PSA payment in-and-of-themselves, they suggest that a larger-scale, more finely-resolved study of landowner interest in non-financial incentives in the context of environmental service payments may be a useful line of future research, as might limited experimental studies.

4.2. Conclusions and Future Directions

4.2.1. Fairness and the Participation of the Poor in Conservation Programs

From a conservation perspective, it often makes more sense to protect 100 hectares of contiguous forest than it does to protect fifty 2-hectare plots of land, as many endangered species (especially large animals like primates, jaguars, and tapirs) require large home ranges. This very basic constraint serves to exclude small-scale landowners from consideration in many environmental service programs (unless, for example, land is being used for carbon sequestration rather than protection of biodiversity). In spite of this fact, poor and small-scale landowners could become effective participants by combining their land-holdings and entering into PSA program as a collective. However, little effort has been spent on creating an effective system for group contracting—which the PSA,

for example, abandoned in 2002—in the context of environmental services, and the balance of participation has typically come to favor wealthy individuals and corporations [24]. Human capital deficits are often a problem for poorer landowners, and there is thus a need for program infrastructure that can assist poorer participants in program enrollment and provide technical assistance.

It has been shown that environmental service payments and participation are biased toward wealthy, educated, large-scale landowners [22, 21] and this has led to some concern among conservationist and social scientists [23, 24, 64]. However, while it was initially thought that creation of protected areas and the bias in allocating PSA-type funds to wealthier landowners might exacerbate issues of poverty [see Discussion in 7, 65, 66], Andam et al. [65] found that creation of protected areas in Costa Rica did not cause elevated rates of poverty, but rather that a correlation between poverty rates and protected areas arose due to the fact that protected ares were disproportionately established in rural sectors with previously elevated poverty levels. Even if this is the case, the fact that protected areas and PSA-like programs do not directly increase local levels of poverty or inequality, does not invalidate the concern that the structure of PSA-like programs favors participation of wealthier landowners. Implementation of a sliding-scale payment scheme, with appropriate tailoring to local circumstances—including the extent of wealth differences among land owners—could provide a mechanism for better integrating poverty alleviation and environmental protection goals, and balancing participation of poor and wealthy landowners.

4.2.2. Non-Financial Rewards and Intrinsic versus Extrinsic Motivation

While the thought of beneficiaries and polluters paying ecosystems service providers for the benefits they provide seems like a morally-justified, compelling, and at times empirically successful conservation strategy, we must be aware of the sometimes intangible social and ideological consequences associated with monetizing nature [67]. Redford and Adams [68], for instance, claim that "...in a world of relentless pursuit of economic logic, there is a real risk that eco-

nomic arguments about services valued by humans will overwrite and outweigh noneconomic justifications for conservation..." [68, pp. 785], echoing a concern famously popularized by Gneezy and Rustichini [54] that monetization of otherwise intrinsic motivation, can have problematic and counter-intuitive consequences. In an experimental study, the introduction of a monetary fine to parents arriving late to pick children up from daycare had the perverse effect of actually increasing the number of parents arriving late [54]. By introducing an extrinsic monetized cost for violation of an otherwise unspoken intrinsic social norm (one must pick up their child at the agreed upon time), parents appeared to re-imagine a late arrival not as an unscrupulous violation of an accepted social contract, but rather as a service for which they could pay. In similar ways, many forms of explicit monetary incentivization can frame a decision setting as one in which "self-interested optimization rather than ethical behavior is appropriate" [53, pp. 1813], see also [69, 70, 71, 72]. Institutional frameworks that operate under the assumption that people are rational selfish maximizers, and present their justification in that way, can actually encourage people to become so through social learning and cultural transmission of ideology.

A key dilemma that emerges in conservation economics is that there are often heavy financial opportunity costs involved in the transition to sustainable land-use, especially among the poor, and there are well-justified arguments supporting the assertion that wealthier national communities, who receive benefits of ecological services on a global scale, have a moral obligation to offset these costs [26]. However, the tacit underlying neoliberal ideology—the ontological belief that nature can be commodified, privatized, and monitized, the right to pollute can be purchased (through payment of fines), and the right to determine tropical land-use can be transferred from local actors to foreign bidders [24]—which sometimes co-diffuses with ecological services programs, can change how local landowners think about the land on which they live; extrinsic, individualistic incentives can become major drivers of behavior, replacing the cultural norms and locally evolved institutions for collective decision making that would otherwise guide landowner actions [73, 74, 75].

In the course of fieldwork for this study, some large-scale landowners stressed economic arguments, either supporting the sliding-scale payment scheme on the assumption that non-financial incentives in the form of advertisement of their business might increase their earnings enough to compensate for the decreased PSA payments, or opposing the sliding-scale payment scheme on the grounds that their land-use offsets the climate-changing effects of carbon pollution by other nations, and that they deserve explicit financial compensation for the services they provide to the world community. However, the majority of large-scale landowners emphasized that they supported the proposed sliding-scale payment scheme, because it would increase the justness/fairness of the program, make the PSA program more accessible to poorer landowners, and could allow a larger amount land area to be conserved under the same program budget. For these landowners, the goal of maximizing conservation land-use in Costa Rica seemed to be based on an intrinsic moral concomitant to protect the natural environment and preserve the natural beauty of their county; a change in the program structure that would decrease their monetary gains, but increase the justness and accessibility of the PSA, and free additional funds to protect additional land, was positively regarded.

The responses of these landowners suggest that it is possible for environmental service programs to offset the opportunity costs involved with sustainable land-use without simultaneously transmitting the neoliberal *Weltanschauung* which has often accompanied their justification. It is, however, hard to generalize geographically from interest in non-financial environmental service incentives in the Costa Rican context; Costa Rica is a rich, democratically governed nation, with a booming ecotourism industry, peopled by a large number of conservation conscious foreign landowners [67]. Future comparative research on non-financial incentives in the context of environmental service payments will be needed to assess the extent of inter-cultural variation in landowner interest in such programs.

4.2.3. Three Ideas for Future Study

Quantitative analysis and qualitative interviews conducted during this research project suggests three possible scaling mechanisms for restructuring private-sector conservation incentives that would maximize conservation land-use and contribute to a more equitable distribution of PSA funds: 1) PSA funding could based on a sliding-scale system which integrates both financial and non-financial rewards, 2) PSA funding could be explicitly scaled to provide higher incentives in the areas where private sector conservation will be most effective or important (buffer zones, biological corridors, rare ecosystems, and habitats of spatially limited endangered species), and 3) the PSA scheme could be redesigned to foster the creation of long-term, self-sustaining systems (via practices like analog forestry), rather than simply paying for forests to sit undisturbed.

The first scaling mechanism is based on balancing conservation and fairness goals, and also incentizing large-scale landowners with forms of non-financial wealth that might have significant, yet indirect financial impact on their conservation-based businesses, and social standing in the community.

The second scaling mechanism is a reaction to the fact that because the PSA is officially undifferentiated and untargeted, the difference between supply of PSA contracts and demand for them could create *de falto* targeting outside of conservation objectives. As such, there is an increased risk of inefficiencies, like offering contracts on the basis of nepotism, bribes, or *quid pro quo* deals, rather than on the basis of the value of land areas to conservation and sustainability goals. Thus, there is a theoretical justification for creation of an explicit plan in targeting in environmental service payments, where objective, publicly-available criteria are used to determine how contracts are incentivized and distributed. Furthermore, non-differentiated payments have been found to weaken incentives in other programs, such as the CAMPFIRE program for wildlife services in Zimbabwe [16]; alternatively, use of deforestation risk as a targeting criterion for ecological service payments in Mexico was found to be more efficient and generate more payments to poor communities [76].

Finally, the third scaling mechanism of incentives focuses on how payments can be augmented over time, in order to foster development and implementation of self-sustainable conservation land-use strategies. In the future, environmental service payments may be most effective if they transition from being a life support machine for private sector conservation that will only work while the machine is plugged-in, to a system that supports the transition of destructive land-use to financially and ecologically sustainable land-use. While it has been argued that indirect approaches for redirecting labor and capital away from economic activities that degrade ecosystems (e.g., agricultural intensification) and into activities that integrate economic and ecological sustainability (e.g., ecotourism) [77] are unlikely to be as effective as direct payments for ecosystem protection, these approaches may be strongest when implemented together.

As described earlier, the PSA program already includes different modalities of participation (reforestation, forest protection, and sustainable forest management). These modalities, however, may be slightly outdated and could possibly be re-imagined in terms of now-emerging forms of sustainable land-use. Zbinden and Lee [5, pp. 257] describe the forest protection and sustainable management programs thusly:

> Forest protection includes a contract in which the forest owner transfers his/her forest use rights to the government for the contract period. The forest owner is not allowed to log timber or otherwise use the forest during this period. In some cases, the government requires a fence around the forested area to prevent cattle from entering. Sustainable management emphasizes the selective harvest of timber. First, an inventory of trees is taken and a detailed logging plan is established. Only valuable trees beyond a certain diameter are marked for cutting. Limited access roads are the laid through the forest plot, and timber extraction is done with as little disturbance as possible. After harvesting, the forest is left for 10–15 years for regeneration.

Neither of these modalities provides payment for the type of sustainable forest use enacted in analog forestry, permaculture, canopy tours, etc. It is no surprise that among wealthier landowners the most frequently cited reasons for non-participation were the fear of losing control over their own property rights and land-use freedom, excessive and complicated paperwork, and the inability to sustainability use their forests for other forms of production. Slight alterations to these program modalities could ease some of these concerns, and improve interest not only in the PSA, but also in development of novel sustainable systems of forest production.

4.2.4. Conclusions

In this pilot study, I used a mixed methods approach to assess landowner interest in a sliding-scale conservation incentive that integrates financial and non-financial awards. I show that such a system is strongly preferred by small-scale and medium-scale landowners, whose opportunity costs would be better covered by its implementation. Further, I show that a majority of large-scale landowners expressed a strong interest in this sliding-scale system, even though it might reduce the extent of direct financial payments relative to the current program structure. A minority of large-scale landowners, however, expressed disapproval of my proposed incentive structure, arguing that they deserved financial compensation for the ecological services they provide to the world commons.

This study was small-scale and was not conducted using a true probability sampling frame; a larger-scale, more methodologically rigorous study of landowner interest in non-financial incentives for conservation land-use in Costa Rica will be needed to assess the veracity of the initial findings presented here before any policy recommendations can be proposed. Experimental studies of the effectiveness of such incentives in the Costa Rican context might be more effective tools for investigation of true landowner interest than studies, like this one, based on self-reported willingness to participate in a proposed program structure.

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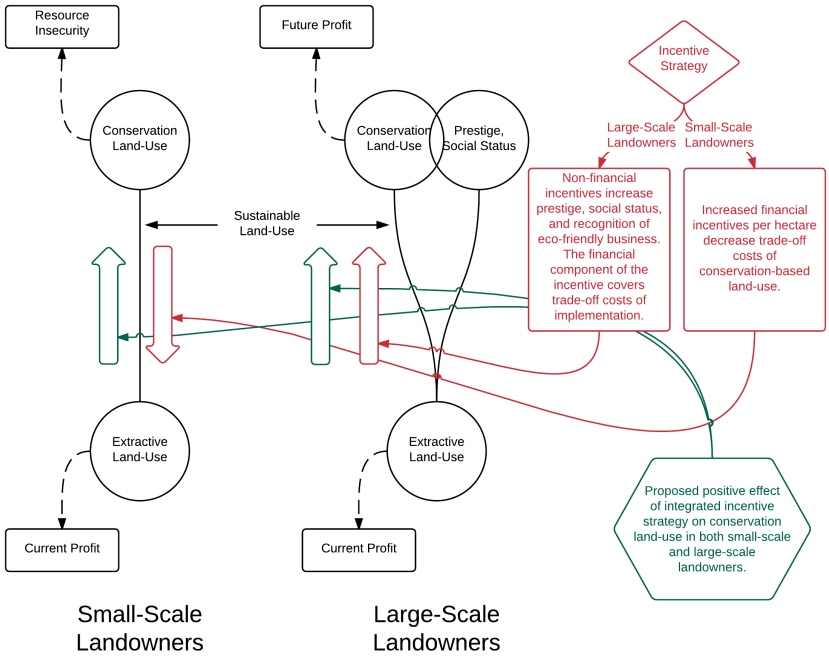
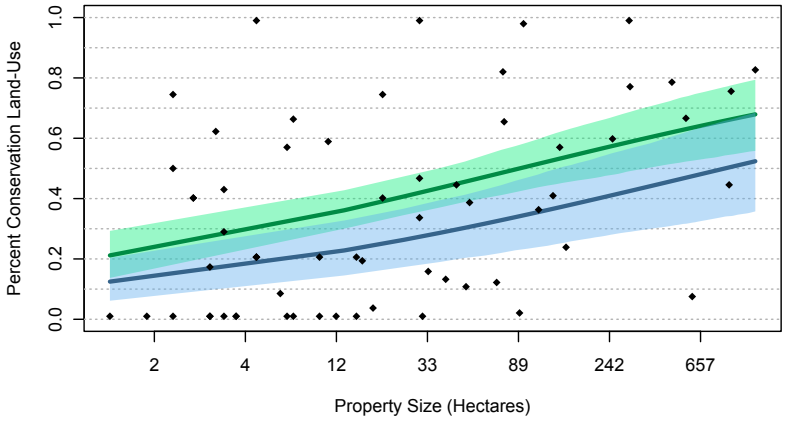
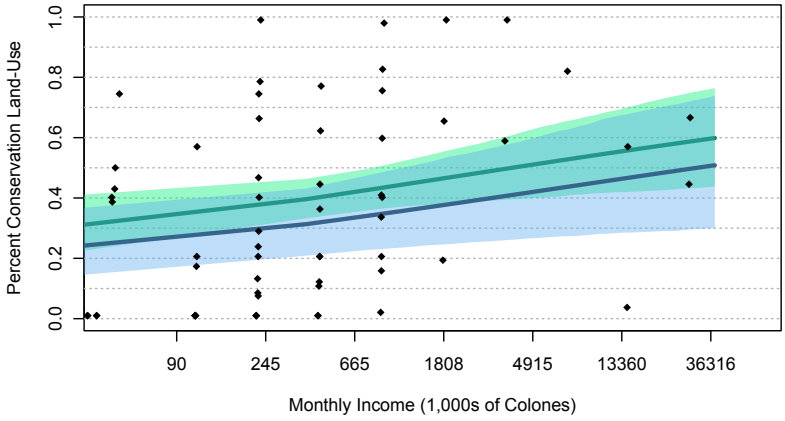


Figure 1: Visualization of trade-offs and the proposed effects of incentives. For small-scale landowners there is a major trade-off between current profitability (via extractive land-use) and resource insecurity (via conservation land-use). For large-scale landowners, the major trade-off is between current profitability from extractive land-use and future profitability from conservation land-use, as standing forest constitutes a store of value that can be drawn from at will. Additionally, there is a trade-off between extractive land-use and the prestige and social-status afforded to those landowners who conserve the natural environment. The proposed sliding-scale incentive strategy is designed to direct more funding per hectare to small-scale landowners, decreasing the costs associated with conservation land-use (as indicated by the red arrow); for large-scale landowners, non-financial rewards are used promote increased social status and wider recognition of the eco-friendly business of the landowner (as indicated by the red arrow). This incentive structure has the proposed effect of increasing conservation land-use by both small-scale and large-scale landowners (as indicated by the green arrows).

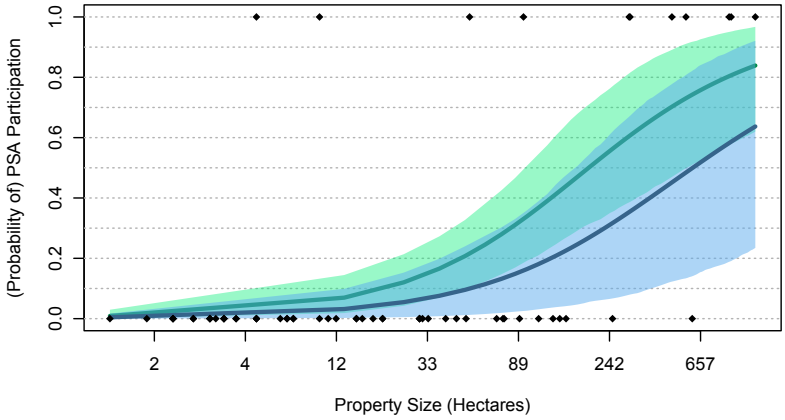


(a) Conservation Land-Use as a Function of Property Size

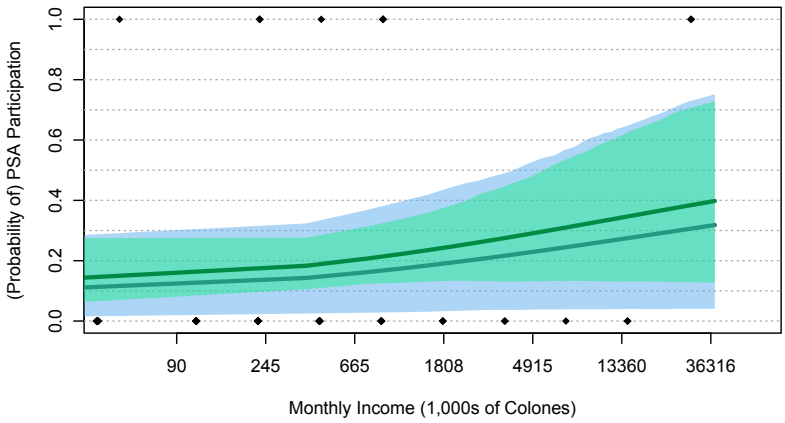


(b) Conservation Land-Use as a Function of Monthly Income

Figure 2: Figure 2a plots the percentage of land in conservation land-use (standing forest or tree plantation) as a function of property size. Figure 2b is the corresponding plot for monthly income. Green regression lines and confidence regions illustrate predictions for individuals with secondary or post-secondary education and blue indicates predictions for indivduals with primary education or lower.



(a) PSA Participation as a Function of Property Size



(b) PSA Participation as a Function of Monthly Income

Figure 3: Figure 3a plots PSA participation as a function of property size. Figure 3b is the corresponding plot for monthly income. Green regression lines and confidence regions illustrate predictions for individuals with secondary or post-secondary education and blue indicates predictions for indivduals with primary education or lower. There is a strong postive trend in PSA participation as a function of property size, but little evidence of an effect of monthly income or education.

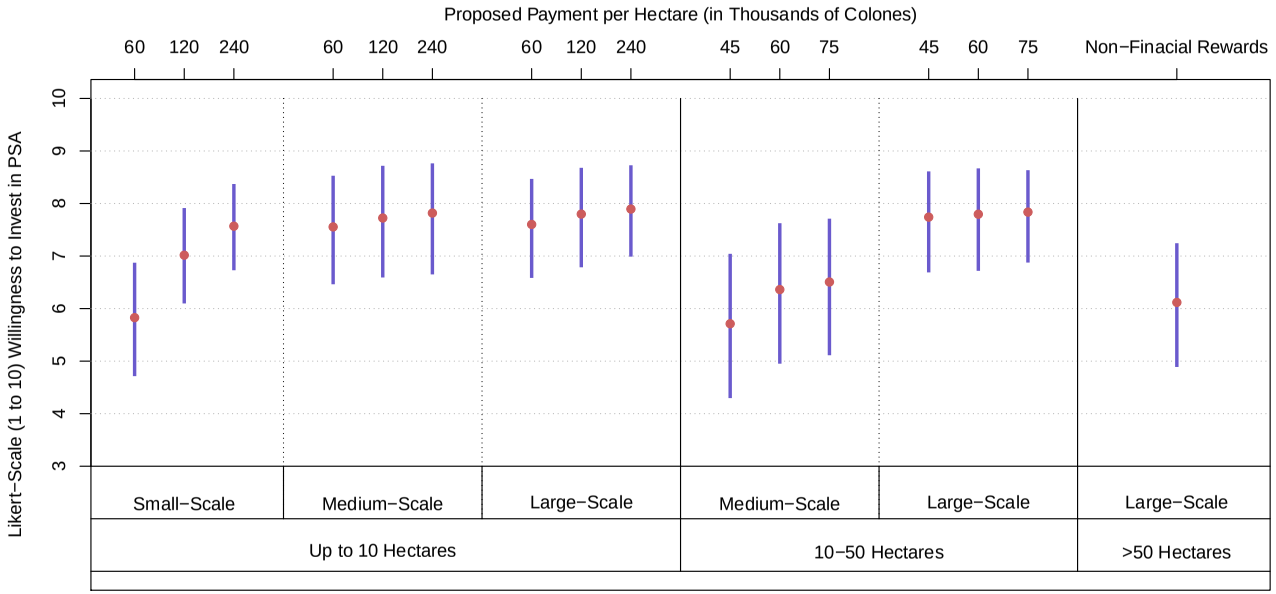


Figure 4: Figure 4 plots regression estimates of the self-reported willingness of landowners to invest varying quantities of land in the PSA under varying payment rates per hectare. Red points are posterior medians; blue bars are 95% posterior confidence intervals.

List of Tables

Table 1: Table 1 illustrates the result of model fitting and comparison. The upper block shows the parameter estimates from the Bayesian model as a posterior median with 95% posterior confidence intervals in parentheses. The lower block shows the results of model comparison with WAIC. Model M3 is the full model with all covariates, model M2 omits property size, and model M1 omits income. The parameters estimates across models suggest a significant relationship of property size, but not income or education, with conservation land-use. Model M1 performs the best on WAIC, suggesting that propery area is the best predictor of conservation land-use. The symbol lppd is the summed log pointwise predictive density, the symbol ep is an estimate of effective parameters, Δ-WAIC is difference in WAIC from the minimum in the set, and w-WAIC is the WAIC weight.

	M1	M2	M3
Intercept	-0.382 (-1.116, 0.321)	-1.894 (-3.162, -0.796)	-0.733 (-2.124, 0.448)
Property Size	0.293 (0.13, 0.452)	·	0.269 (0.08, 0.439)
Income	·	0.18 (0.015, 0.386)	0.059 (-0.105, 0.256)
Education	0.662 (-0.028, 1.405)	0.372 (-0.36, 1.114)	0.593 (-0.109, 1.34)
lppd	22.09	19.14	22.39
pD	3.21	3.73	4.24
WAIC	-37.75	-30.82	-36.30
Δ-WAIC	0	6.92	1.44
w-WAIC	0.66	0.02	0.32

Table 2: Table 2 illustrates the result of model fitting and comparison. The upper block shows the posterior parameter estimates from the Bayesian model, as a posterior median with 95% posterior confidence intervals in parentheses. The lower block shows the results of model comparison with WAIC. Model M3 is the full model with all covariates, model M2 omits property size, and model M1 omits income. Model M1 performs the best on WAIC, suggesting that propery area is the best predictor of PSA participation. The parameter estimates across models suggest a significant relationship of property size, but not income, with PSA paticipation. In the model using property size, education has a postive but non-reliable relationship with PSA participation. The symbol lppd is the summed log pointwise predictive density, the symbol ep is an estimate of effective parameters, Δ-WAIC is difference in WAIC from the minimum in the set, and w-WAIC is the WAIC weight.

	M1	M2	M3
Intercept	-0.898 (-3.108, 0.747)	-3.295 (-6.549, -0.803)	-0.27 (-3.395, 2.27)
Property Size	1.012 (0.525, 1.682)	·	1.112 (0.567, 1.828)
Income	·	0.218 (-0.122, 0.633)	-0.15 (-0.552, 0.283)
Education	1.073 (-0.662, 3.526)	0.422 (-1.213, 2.744)	1.443 (-0.475, 4.272)
lppd	-18.70	-27.38	-18.25
pD	2.87	3.03	3.97
WAIC	43.15	60.82	44.42
Δ-WAIC	0	17.67	1.28
w-WAIC	0.65	0.00	0.35