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Willingness of private landowners to participate in forest conservation in the Chaco region of Argentina

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ABSTRACT

To effectively conserve forests and the ecosystem services they provide, mechanisms are needed to promote conservation on private lands that reduce forest fragmentation, secure lands with high conservation value, and enhance landscape connectivity. Incentive-based programs like payments for ecosystem services (PES) are important policy tools for attaining conservation on private lands. In 2019, we conducted 81 in-person surveys with private forestland owners, whose properties are located on the border of protected areas and in corridors connecting protected areas in Argentina's Chaco forest. We examined landowners' preferences for alternative conservation incentives, how Argentina's current PES program could be altered to increase landowner enrollment, and the amount of compensation landowners require to enroll in PES. We found that knowledge of Argentina's PES program, motivations for forest ownership, attitudes toward forest conservation policy, and property characteristics influenced landowners' preferences for conservation program design. Although indigenous communities preferred conservation easements, other private landowners were more likely to choose a PES program. Research participants preferred PES programs with shorter contract lengths or that permitted them to engage in silvopasture. The payments research participants required to engage in land uses currently authorized under Argentina's PES program exceed current PES funding. Relying solely on PES to engage landowners in conservation may result in lost opportunities to conserve forest on private lands.

1. Introduction

Protected areas comprise only 14% of the planet's forests (Bertzky et al., 2012). Forest conservation on private lands is critical for reducing deforestation globally and ensuring spatial continuity of habitats (Jayathilake et al., 2021). Voluntary enrollment of landowners in conservation programs is essential to attain forest conservation on private lands. Tax reductions, payments in exchange for development rights (i.e., conservation easements) or ecosystem services provision (PES), and one-time land purchases that convert private lands to public protected areas are common incentives to engage landowners in forest conservation (Ma et al., 2012a; Sorice et al., 2013; Schuster et al., 2018). Regardless of incentive structure, for conservation programs to be effective, they must attract landowners and land in a manner that secures environmental benefits at a large scale (Sorice et al., 2013).

Existing research suggests that landowners' decisions whether to enroll in voluntary forest conservation programs depend on (1) their demographic (e.g., income, age, education) and socio-psychological characteristics (e.g., community identity, values, risk perceptions, stewardship motivations), (2) characteristics of their property (e.g., property size, land uses, whether they hold formal title to the land), and (3) the structure of available conservation programs (Zbinden and Lee, 2005; van Putten et al., 2011; Sorice et al., 2011; Ma et al., 2012b; Bremer et al., 2014; Selinske et al., 2015; Kreye et al., 2017a; Puri et al., 2021). For example, landowners with off-farm income may be more willing to assume the risks of entering into conservation contracts (Zbinden and Lee, 2005). Large landowners may be more likely to enroll a portion of their land in conservation programs because their

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agricultural production will not be jeopardized (Bremer et al., 2014). Individuals who are well-informed about conservation programs and have low risk aversion may also be more likely to participate in conservation programs (Greiner, 2015; van Putten et al., 2011; Ma et al., 2012a). Finally, conservation program design determines levels of program enrollment. Landowners are more likely to participate in voluntary conservation programs when payments are high, program compliance costs are low, and contracts are short (van Putten et al., 2011; Dickinson et al., 2012; Kreye et al., 2017a; Puri et al., 2021). Using Salta province, Argentina, as a case study, we investigated forest landowners' preferences for conservation program design, in order to assess how increased enrollment in voluntary forest conservation programs may be attained.

In 2007, the Argentine government implemented a PES program to secure environmental services by compensating landowners for forgoing conversion of native forests to agriculture (Núñez-Regueiro et al., 2019). The program was designed to counteract biodiversity and ecosystem service losses in the Argentine Chaco, a global deforestation hotspot. The Chaco forest (60% of which is located in Argentina) has experienced one of the highest rates of agricultural expansion globally (15.8 million ha, 21%, of woodlands transformed from 1980 to 2012; Vallejos et al., 2015, Barral et al., 2020). Agricultural expansion in the Argentine Chaco has resulted in globally relevant carbon emissions (Baumann et al., 2017) and widespread reductions in the ecosystem functions of erosion control, soil fertility, excess rainfall retention by vegetation, and carbon storage in biomass and soil (Barral et al., 2020). Associated ecosystem services of flood regulation, climate regulation and agricultural suitability have declined by 6% to over 20% across the Argentine Chaco since 1985 (Barral et al., 2020). Habitat loss combined with increased hunting for subsistence, commercial, cultural, and retaliatory reasons has further resulted in widespread biodiversity losses and defaunation in the Chaco (e.g., declining populations of near threatened species such as the jaguar *Panthera onca*, and vulnerable species such as the white-lipped peccary *Tayassu pecari* and the giant armadillo *Priodontes maximus*; Romero-Muñoz et al., 2020). Almost half of the largest frugivorous mammals and 80% of the largest herbivores in the Argentine Chaco are now threatened, which may result in important future changes in vegetation composition (Periago et al., 2015). Using a spatial optimization framework based on linear programming, Law et al. (2021) demonstrated that if forest cover falls below 50% the system will transition to a new state characterized by suboptimal biodiversity and carbon outcomes. The expansion of commercial agriculture also threatens indigenous communities and forest smallholders, who rely on forest resources, are usually poor, and often lack institutional support. Deforestation has reduced these communities' access to important natural resources, resulting in migration, social conflicts, loss of smallholder and indigenous knowledge and skills, and reduced resilience to shocks (Cotroneo et al., 2021; del Giorgio et al., 2021; Levers et al., 2021).

Argentina's PES program is intended to secure ecosystem services in the Chaco by reducing or preventing deforestation. The PES program operates within the framework of the National Forest Law (Act 26.331 *de Presupuestos Mínimos de Protección Ambiental de los Bosques Nativos*), which classifies forested lands into three zones (red, yellow, and green) according to their conservation importance (García Collazo et al., 2013). Landowners cannot use land in the red zone for extractive and commercial activities because these lands have the highest conservation value. The law allows sustainable extractive and commercial activities (e.g., timber production, silvopasture) in the yellow zone, which has medium conservation value. The law allows most land uses, including forest clearing, in the green zone because these lands have low conservation value. Landowners who enroll in the program must submit conservation or sustainable management plans for approval by the government to obtain payments. These plans detail the actions landowners will take to enhance six ecosystem benefits identified by the Argentine government, specifically: water regulation; biodiversity conservation; improved soil and water quality; greenhouse gas sequestration; landscape diversification and aesthetics; and defense of the cultural identity of criollos (smallholders) and indigenous communities. To date, less than 17% of forestland in the Chaco region has been enrolled in the PES program (Núñez-Regueiro et al., 2019).

In addition to PES, a few other incentive-based agreements exist in Argentina to protect forests. Non-profit organizations have promoted direct purchase of lands as a conservation strategy (Myron et al., 2009) and fostered conservation easements in Argentina since 2010. Currently three conservation easements exist in Patagonia (Patagonia Land Trust, 2020), but conservation easements have not been implemented in provinces outside Patagonia. Property tax reductions are another common conservation tool in other countries (Ma et al., 2014) but have typically not been used to secure conservation outcomes in Argentina.

Given the relatively low enrollment levels for the current PES program, we conducted a study to assess how the current PES program could be restructured to increase uptake by landowners, and whether alternative conservation programs would be preferred by landowners. Using a mix of landscape ecology, socio-psychological, and economic theories and methods, we investigated how private landowners in Salta province, Argentina, may be engaged in voluntary forest conservation programs. We conducted our research in the Argentine Chaco, the second largest forested ecoregion in the Americas (Grau et al., 2005). Most forested land in the Chaco is privately owned, and this region faces one of the highest rates of deforestation in the world (Hansen et al., 2013), owing to conversion of the forest to agriculture and pasture. In addition to the serious ecological consequences of deforestation (e.g., habitat and biodiversity losses), conversion of the Chaco to agricultural production is jeopardizing the survival of many rural and indigenous communities that rely on natural resources contained within the forest (Seghezzo et al., 2011). Smallholders and indigenous communities have received only a small share of PES payments (Cotroneo et al., 2021) and have been ecologically marginalized through loss of access to forest resources, thereby reinforcing poverty traps for these forest-dependent communities (Levers et al., 2021).

Our study was designed to expand the limited research on the effectiveness of Argentina's PES program. To date, this research literature has highlighted the importance of social norms (i.e., expectations by other landowners that individual landowners should conserve forest on their land; Mastrangelo et al., 2014) and the agricultural value of land (a 1% increase in the agricultural value of land doubles deforestation rates; Alcañiz and Gutierrez, 2020) in landowners' decisions to conserve forest. Adverse selection has undermined the effectiveness of Argentina's PES program, with lands with high conservation value being enrolled for short durations while lands with low conservation value are enrolled for longer periods of time (Núñez-Regueiro et al., 2019). Existing research suggests that absentee landowners are less likely to enroll in PES, only small parcels are enrolled in areas with high agricultural potential, and that landowners are more likely to enroll land for an extended period of time if they are permitted to engage in land use activities that generate income (Núñez-Regueiro et al., 2020).

We aimed to answer three questions: (1) which voluntary forest conservation programs would landowners and indigenous communities in the Chaco region prefer; (2) how could the current Argentine PES program be altered to increase enrollment; and (3) what payment per hectare would landowners and indigenous communities require to enroll in PES? We predicted that program structure (incentive type and level, program duration, permitted land use activities), the zone in which an individual owns land (green, yellow, red), and landowners' socio-psychological and demographic characteristics (e.g., source of income) would influence their decision to enroll in voluntary forest conservation programs. Our research targeted landowners and indigenous communities who have the potential to help conserve large, contiguous forested areas by protecting forestlands that surround and connect public protected areas in the Chaco forest in Salta province, Argentina.

2. Methods

2.1. Study area

The Chaco region has a low population density and landholdings are mostly private (Piquer-Rodríguez et al., 2018). Argentina's protected area system covers less than 2% of the Chaco forest (Izquierdo and Grau, 2009). Forest conversion outside protected areas has progressively isolated these protected areas, undermining their effectiveness in conserving the Chaco forest (de la Sancha et al., 2021), but the rate of deforestation has slowed with implementation of the National Forest Law (Matteucci and Camino, 2012).

Salta province contains nearly 8 million hectares of native forest distributed in the red (16%), yellow (65%), and green (19%) zones (Secretaría de Ambiente y Desarrollo Sustentable (SAyDS), 2017). PES participants in Salta province are comprised of individual private landowners (58%), companies (22%), government organizations (11%), indigenous communities (7%), and non-government organizations (2%) (Ministerio de Ambiente y Desarrollo Sustentable (MAyDS), 2017). Between 2010 and 2015, lands enrolled in the PES program accounted for almost 37% of native forested land in Salta province, a higher percentage of enrolled land than in other provinces in the Chaco region. We posited that, owing to higher PES enrollment, private and corporate landowners and indigenous communities in Salta would be more knowledgeable about the structure of the existing PES program (including limitations of this program), either through personal experience or communication with neighboring landowners. As such, landowners and indigenous communities in Salta would be better positioned to determine how the PES program could be restructured to improve its performance, and whether alternative conservation programs would be preferable to PES. To date, no conservation easements have been implemented in Salta province, and property tax reductions are usually granted to civil associations that improve social welfare rather than to secure conservation outcomes.

Our study area comprised buffer areas around key public protected areas in the Chaco and corridors between them. We defined key protected areas as those areas with potential to ensure spatial continuity of habitats (i.e., not completely surrounded by deforested properties), including the Provincial Reserve "Los Palmares", Provincial Reserve "Dragones", and some areas recently incorporated into the protected area system by the provincial Decree 616/2018. Using ArcGIS (version 10.6.2; ESRI, CA), we identified a 12-km radius (i.e., buffer zone) around these protected areas and 12-km wide ecological corridors between them. Buffers and corridors that are 12-km wide should be sufficient to facilitate movement of, and reduce human threats (e.g., hunting) to, vulnerable species such as peccaries and the largest predators in the

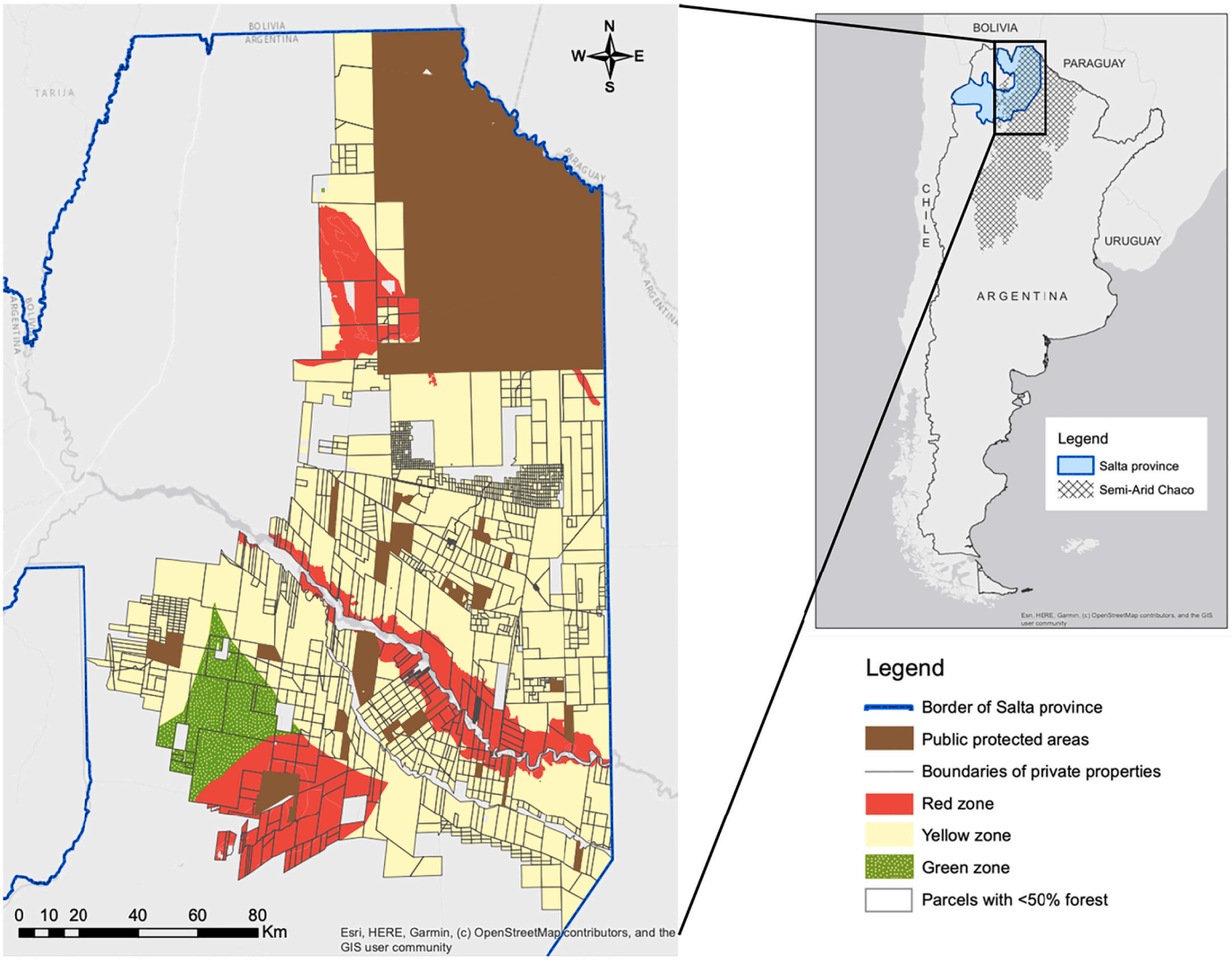

Fig. 1. Location of the study area in the semi-arid Chaco region of Salta province. The figure shows key public protected areas and the private forested properties that surround and connect them. The inset shows the location of Salta province (shaded) in northwestern Argentina.

Chaco (jaguars and pumas, *Puma concolor*; Canevari and Vaccaro, 2007). We based this buffer width on movement distances and home ranges for peccaries, pumas, and jaguars (Silver et al., 2004; Kelly et al., 2008; Figel et al., 2011; Noss et al., 2012; Piquer-Rodríguez et al., 2015) and distances into forests that humans exert hunting pressure on these species (Altrichter, 2005; Espinosa et al., 2014, 2018). We selected all privately owned parcels with more than 50% forest cover that fell inside the buffer zones and corridors as our study area (Fig. 1; see Appendix 1 for details of the spatial data processing).

We initially identified 1257 privately owned parcels within the buffers and corridors that contained more than 50% forest cover. We then excluded parcels that (1) were classified as urban, (2) were not found in the government tax database, (3) had missing landowner information (e.g., missing information on the address of landowners), or (4) were owned by absentee landowners (i.e., individuals living in other provinces). Budget constraints precluded interviews with absentee landowners because we conducted interviews in person and we had insufficient funds to travel outside Salta province. After excluding these parcels, our study population included 154 owners of 260 parcels. We were able to contact 99 of these forest owners using the government tax database and online telephone directories (64.3% contact rate; AAPOR, 2016).

2.2. Data collection

We conducted 81 in-person interviews from March to December 2019. A total of 70 of the 99 landowners we invited to participate in our survey completed the questionnaire (70.7% cooperation rate; AAPOR, 2016). Additionally, we recruited 11 landowners that were not yet listed in the government tax and land records, but who owned forestland in the study area. Surveyed landowners included individual landowners, indigenous communities, private companies, and non-profit organizations. We surveyed chiefs or elected presidents of indigenous communities and owners or managers of companies and non-profit organizations. Respondents owned 112 parcels in our study region (43% of the 260 parcels we identified for inclusion in this study). All respondents gave verbal consent to be surveyed and were assigned a code to ensure data confidentiality.

2.3. Survey development

We used an expert panel (4 experts in survey research, 3 local researchers) and cognitive testing (8 forest landowners) to assess how individuals mentally processed and responded to survey questions (Collins, 2003). Using a pilot study, we pre-tested (7 forest landowners) the final questionnaire (Appendix 2) prior to full implementation of our study. Respondents were first asked which of the following voluntary forest conservation agreements they would prefer to enroll in (selected = 1; not selected = 0), namely: a fee simple land sale (i.e., the transfer of full ownership of the property, including the underlying title, to the government or a conservation organization in return for a cash payment); a reduction in their property taxes; the sale or donation of development rights to their land (i.e., a conservation easement); the PES program; or none of these options. We explained to respondents that a "land sale" involved selling a portion of their forested land to create a national park or a reserve, whereas a "property tax reduction" is a tax reduction in exchange for conserving the forest (i.e., enrolled landowners would pay lower property taxes on the land they conserve). Property tax reductions are used in the United States to encourage private forestland owners to keep their lands forested, in order to secure forest ecosystem services (Kilgore et al., 2018). We explained that the "sale or donation of development rights" would limit how the landowner could use their forest in the future (timber harvesting, cattle ranching, and crop production would be prohibited), and that they would receive a lump-sum payment in return or no payment if they chose to donate their land use rights. These land use restrictions would apply in perpetuity, even if the lands were inherited or sold. We opted for the terms 'sale' or 'donation' of user rights because the term 'conservation easement' is not common in Argentina. Finally, we described the PES program as a program that provides annual monetary payments to incentivize conservation or sustainable use of the forest.

Respondents then indicated their preferences for different attributes of a PES program by answering stated preference discrete choice experiment (SPCE) questions. We did not present the SPCE questions to three respondents who stated they would not enroll in any conservation programs. To the best of our knowledge, this is the first application of SPCEs to identifying how landowners would prefer the Argentine PES program to be structured. The PES programs that we presented were not contingent on how respondents' property was zoned (green, yellow, or red), which allowed us to better understand respondents' preferred land uses regardless of current land use restrictions. Each choice scenario presented three alternatives (program A, program B, and an opt-out) that varied in authorized forest uses, contract length, and payment attributes (Table 1, Fig. 2). We included the opt-out option (i.e., not participating in any program and not receiving any conservation payments) to reflect the voluntary aspect of PES participation (Sorice et al., 2013; Puri et al., 2021). Forest uses included in the SPCEs encompassed those land uses that landowners are currently allowed to perform on their lands in return for a conservation payment, namely: forest conservation, ecotourism, sustainable timber production using native species, and silvopasture.

Prior research suggests that landowners have bimodal preferences for conservation program contract length, with landowners preferring either short-term (5 years; Balderas Torres et al., 2013, Sorice et al., 2013) or long-term contracts (10–17 years; Zabel and Engel, 2010, Bouma et al., 2014). In the Chaco forest, program enrollment currently ranges from 1 to 21 years (Núñez-Regueiro et al., 2019). Accordingly, we set the contract length at 5, 15 and 25 years, such that the shortest contract would reduce procedural transaction costs (e.g., approval) while also securing maturation of environmental benefits (Ando and Chen, 2011).

In Salta, landowners received an average of US$5 per hectare annually between 2010 and 2015 for enrolling in PES (Núñez-Regueiro et al., 2019). We set the minimum annual payment at US$2/ha per year because funding for the PES program has decreased greatly in recent years (Núñez-Regueiro et al., 2019). We set the maximum payment at US$32/ha per year (intermediate payments of US$12 and US$22), based on discussions with ranchers during preliminary fieldwork. Before implementing this study, we visited the study region and conducted semi-structured interviews with various stakeholders in the PES program, as part of our survey design. Ranchers informed us that they would expect to earn between US$20 and US$30/ha per year from livestock production.

We used SAS 9.4 to identify the D-optimal design for the SPCEs.

Table 1
Attributes and attribute-levels for the stated preference discrete choice experiments (SPCEs) pertaining to the design of the PES program.

Attribute	Description	Attribute-levels
Forest use	Activity allowed on the land	Conserve native forest Ecotourism Sustainable timber harvesting Silvopasture
Contract length	Minimum term of enrollment in the PES program	5 years 15 years 25 years
Annual payment	Annual payment per hectare for participating in the PES program	USD[a] 2 USD 12 USD 22 USD 32

[a] USD: United States dollars.

	PROGRAM A	PROGRAM B	NONE
Forest Use	Ecotourism	Silvopasture	
Contract length	5 years	15 years	
Annual Payment	US$ 32 / hectare	US$ 12 / hectare	
I would choose:	○	○	○

Fig. 2. Example of a choice-scenario presented to respondents.

There is evidence that D-optimal designs provide more efficient parameter estimates than orthogonal designs at smaller sample sizes (Rose and Bliemer, 2013). We used the %Choiceff macro to obtain an efficient fractional factorial design of 12 choice scenarios (D-Efficiency = 93.6%, Appendix 3). The %Mktblock macro generated 3 blocks of 4 choice scenarios (i.e., 3 survey versions to prevent respondent fatigue related to survey length).

Finally, we elicited information on respondents' demographics, characteristics of their properties, knowledge of and attitudes toward Salta's forest conservation policies, prior experience participating in PES, and motivations for maintaining forested areas on their land. We determined whether respondents were private, communal (i.e., indigenous community), non-profit, or corporate landowners, their age, years of education, and main sources of income. We used 5-point Likert-scale questions ("strongly disagree" to "strongly agree") to measure landowners' motivations for owning forested land and their opinions about Salta's forest conservation policy (adapted from Schaaf and Broussard, 2006, Ma et al., 2012b, and Farmer et al., 2017; see Appendix 4). Table 2 summarizes the independent variables used in our regression analysis, and how we coded variables.

2.4. Analysis

We first used logistic regression analysis to test for sampling bias, where the dependent variable captured whether a land parcel was owned by a respondent (1) or a non-respondent (0). Based on this regression analysis, we determined whether there was any significant difference in land size and zoning restrictions for parcels owned by individuals who chose not to participate in the survey. We did not test for sampling bias for indigenous communities and the only non-profit organization listed in our population frame because we surveyed them all.

We used factor analysis with varimax rotation and Kaiser normalization to determine whether individual survey items could be combined to measure socio-psychological constructs. Prior to conducting factor analysis, we used the Kaiser-Meyer-Olkin measure of sampling adequacy, the Bartlett's test of sphericity, and the determinant value to verify the appropriateness of data for factor analysis (Watkins, 2018; Appendix 5). We assumed that a scale measured a single construct if Cronbach's alpha$\geq$0.7 (George and Mallery, 2003) and the eigenvalue$\geq$1. We retained items on the scale if the factor loadings for these items were greater than 0.3 (Leech et al., 2005). Individual items that were excluded from scales during factor analysis were included as individual explanatory variables in our analysis of respondents' preferences for conservation programs.

For both respondents' choice of their preferred conservation program and the SPCE questions, respondent i's utility (U_{ij}) from selecting conservation alternative j was represented by a systematic component (V_{ij}) and a random error component (ε_{ij}; Louviere et al., 2000):

$$U_{ij} = V_{ij} + \varepsilon_{ij} = \mathbf{X_{ij}'\beta} + \varepsilon_{ij}$$

where $\mathbf{X_{ij}}$ is a matrix of characteristics (or attributes) of conservation program j and socio-psychological and demographic characteristics of respondent i, and $\boldsymbol{\beta}$ is the vector of estimated coefficients. The probability of individual i choosing alternative j from J alternatives can be modeled as the probability that the utility of alternative j is greater than the utility of any other offered alternative k:

$$\text{Prob}(U_{ij} > U_{ik}) = \text{Prob}(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \forall j \neq k; j, k \in J$$

Assuming that the error terms follow a type I extreme value distribution, the probability of individual i selecting program j is given by:

$$\text{Prob(individual } i \text{ chooses program } j) = \frac{exp\left(\mathbf{X_{ij}'\,\beta}\right)}{\sum_{j \neq k} exp\left(\mathbf{X_{ik}'\,\beta}\right)}$$

We used a random-effects logistic regression to determine respondents' preferences for different types of forest conservation agreements. We regressed respondents' stated willingness to enroll in a conservation program (yes = 1, no = 0) against the type of agreement offered (i.e., land purchase ('Sell'), tax reduction ('Tax'), purchase or donation of development rights ('Rights'), PES program; "none of the programs" omitted to avoid the dummy variable trap), their demographic and socio-psychological characteristics, and their property characteristics:

$$V_i = \beta_0 + \beta_1 \text{Sell} + \beta_2 \text{Tax} + \beta_3 \text{Rights} + \beta_4 \text{PES} + \mathbf{D_i'\beta}$$

where $\mathbf{D_i}$ is a matrix of respondents' demographics, motivations, attitudes, and property characteristics. We included interaction variables in the estimated models to determine which respondent characteristics altered the likelihood that they would select a specific conservation agreement.

To investigate landowners' preferences for different attributes of the PES program (forest use, contract length, payment), we estimated a random-parameters (mixed) logit model:

$$\text{Prob(individual } i \text{ chooses program } j) = \frac{exp\left(\mathbf{X_{ij}'\,\beta_i}\right)}{\sum_{j \neq k} exp\left(\mathbf{X_{ik}'\,\beta_i}\right)}$$

where the vector of random parameters $\boldsymbol{\beta_i}$ has a mean and variance, which captures preference heterogeneity across individuals. If the standard deviation coefficient for an attribute (or attribute level, e.g., silvopasture) is statistically significant, then this indicates that individuals are heterogeneous in their preferences for that attribute or attribute level (Train, 2009). We estimated 'payment' as a fixed parameter. The attributes 'annual payment' and 'contract length' were coded using their respective levels (US$2, 12, 22, 32 and 5, 15, 25 years). We binary coded the levels of the 'forest use' attribute and we set the attribute level 'forest conservation' as the reference level. Accordingly, the utility function took the form:

$$V_i = \beta_{0i} + \beta_{1i}\text{Ecotourism}_{ij} + \beta_{2i}\text{Silvopasture}_{ij} + \beta_{3i}\text{Timber}_{ij} + \beta_{4i}\text{Length}_{ij} + \beta_5 \text{Payment}_{ij}$$

where β_{0i} is the alternative-specific constant (or coefficient attached to the opt-out option). We interacted respondent and property characteristics with the alternative specific constant (opt-out dummy) and

Table 2
Independent variables used in the regression models. See the appendix 2 for the complete survey questionnaire.

Variables	Details
Land characteristics	
Land size	Size of land parcel in hectares
Land zoning	Zone(s) in which parcels fall (binary coded variables) 'Red' indicates that part or all of the land parcel was located in the red zone 'Yellow' indicates that part or all of the land parcel was located in the yellow zone 'Green' indicates that part or all of the land parcel was located in the green zone
Respondent characteristics	
Type of owner	Type of landowner (binary coded variables) Company: corporate landowner (yes = 1, no = 0) Indigenous community: land owned by an indigenous community (yes = 1, no = 0) Individual: non-corporate, individual landowner (yes = 1, no = 0) Non-profit organization: organization owned the land (yes = 1, no = 0)
Main income generating activity	Main source of income for landowner (binary coded variables) Commercial agriculture: respondent engaged in commercial agriculture or livestock production (yes = 1, no = 0) Non-commercial agriculture: respondent engaged in fishing, hunting, or subsistence cattle production (yes = 1, no = 0) Other activity: respondents earned income from another source, such as construction, transportation, dentistry (yes = 1, no = 0)
Knowledge of and experience with, Argentina's PES program	
Know law	Respondent was familiar with the National Forest Law (yes = 1, no = 0)
Know zone	Respondent was aware of the categorization of their lands (i.e., zones) under the National Forest Law (yes = 1, no = 0)
Know PES	Respondent had heard about the availability of funding under the National Forest Law (yes = 1, no = 0)
PES plan	Respondent had submitted a plan or project requesting funding from the National Forest Law in the past (yes = 1, no = 0)
Respondent's motivations for keeping forest on their land, coded as very unimportant = −2, unimportant = −1, neutral = 0, important = 1, very important = 2	
Obey	To obey the National Forest Law
Heirs	To pass forested areas onto their heirs
Scenery	To enjoy scenery
Nature	To protect nature
Livestock	To provide shade to livestock
Wildlife	To conserve wildlife
Production	For timber production
Unsuitable	Because their land is unsuitable for agriculture
Accessibility	Because it is difficult to access the forest on their land
Investment	Because the forest is a financial investment
Respondent's attitudes toward conservation program design (strongly disagree = −2, disagree = −1, neutral = 0, agree = 1, strongly agree = 2)	
Regulate	The government should be able to regulate the use of forests located on private land.
Extraction	There should be regulations regarding the extraction of native trees on private forestland.
Fine	The government should fine private forest owners who fail to practice forest protection.
Subsidies	There should be financial incentives, such as subsidies, to encourage private forest owners to practice forest conservation.
Workshops	The government should conduct workshops on forest conservation techniques for private forest owners.
Technical	The government should provide technical support on forest conservation for private forest owners.
Promotion	The government should promote the importance of forest conservation.
Collaboration	The government and private forest owners should work together toward forest conservation.
Images	The government should use positive images, such as *Tatu Carreta* or *Oso Hormiguero*, to promote forest protection.
Consequences	The government should use negative images, like floods and mudslides, to show the consequences of not protecting forests.

permitted land uses and included them as non-random covariates in an extended RPL model (i.e., RPL with interactions) to identify sources of preference heterogeneity (Puri et al., 2021).

Finally, we determined what annual payment per hectare respondents required to conserve forest under PES (reservation payments at which respondents would enroll in the PES program; see for example Puri et al., 2021), based on a random-effects logistic regression of respondents' decision whether to enroll in the offered PES programs. Consistent with the RPL, we used binary coding for the forest use attribute levels and continuous variables for contract length and payment, and we included interaction variables in the model to identify which respondent characteristics influenced their decision whether they would enroll in the offered PES program. Following Puri et al. (2021), we derived reservation payments as:

$$\text{Reservation payment} = \frac{-\sum_j X'_{ij}\beta_j}{\beta_{\text{payment}}}$$

We tested variables for correlation before estimating models. We selected best-fit models based on the stepwise procedure (combination of forward entry and backward removal) and the minimum Akaike Information Criteria (AIC). Coefficients were considered significant at the $p \leq 0.05$ level. We used STATA (v.16.1), IBM SPSS Statistics (v.26), and R (v.1.1.383) software programs to conduct statistical analyses.

3. Results

3.1. Respondent demographic characteristics, land ownership and knowledge of Argentina's PES program

We found no statistical difference in landholding size across respondents and non-respondents ($p = 0.82$; Appendix 6). However, respondents tended to have properties with more restrictive land-use zoning (i.e., more land in red and yellow zones) than non-respondents ($p < 0.05$). Respondents were mainly individual, non-corporate landowners (63%; Table 3). The median age of non-corporate landowners and respondents from indigenous communities was 51 years old (mean = 52.9 years, SD = 11.8 years, range of 27 to 81 years). On average, respondents had completed technical school or part of an undergraduate degree (mean years of education = 12.8, SD = 5.3 years; range of no education to a graduate degree). Nearly 25% of all respondents earned

Table 3
Respondents' socio-economic characteristics and knowledge of Argentina's PES program ($N = 81$).

	No.	%		No.	%
Number of properties that the respondent owns in the Chaco region			Main income-generating activity		
1 property	49	60.5	Commercial agriculture	20	24.7
2 properties	17	21.0	Non-commercial agriculture and resource use (e.g., fishing)	22	27.2
Over 2 properties	15	18.5			
Land use zone(s) for respondent's properties[a]			Other	39	48.1
Red	27	33.3	Know about the National Forest Law	71	87.7
Yellow	67	82.7			
Green	2	2.5	Know about the land-use zone regulations	70	86.4
Type of landowner					
Individual, non-corporate	63	77.8	Know about the PES program	60	74.1
Company	12	14.8			
Indigenous community	5	6.2	Have submitted a PES plan in the past	22	27.2
Non-profit organization	1	1.2			

[a] Note that respondents could have properties that were located in more than one zone (e.g., properties that were located in both the yellow and red zones).

most of their income from commercial agricultural activities (e.g., crop and livestock production, agricultural supplies), while 27% engaged in non-commercial agricultural activities (e.g., fishing, hunting, subsistence livestock ownership), and 48% engaged in other income-generating activities (e.g., transportation, retail trade, construction). The median landholding size was 1500 ha (mean = 8723 ha, range of 20 ha to 318,000 ha). Nearly 30% of respondents owned more than one property in the Chaco region. Most respondents knew about the National Forest Law (88%), land-use zone regulations (86%), and the PES program (74%), but only 27% of respondents had participated in the PES program.

3.2. Respondents' socio-psychological characteristics

Respondents indicated that passing forested areas onto their heirs, enjoying scenery, protecting nature, and providing shade for livestock and wildlife (median = important) were their most important motivations for maintaining forest on their land (Table 4). Timber production, the unsuitability of their land for agriculture, and difficulty accessing land were not reasons why respondents kept forest on their land (median = unimportant). Factor analysis indicated that these items could be used to generate a single scale (Cronbach's alpha = 0.87; eigenvalue = 3.3), which we termed 'the importance of forest conservation' (Conserve). This scale captured the importance that respondents placed on conserving forest on their land to protect nature, enjoy the aesthetics (or scenery) of the land, provide shade to wildlife and livestock, and pass forested land to their heirs.

Respondents strongly agreed (median = strongly agree) that the government should fine landowners who fail to conserve forest, provide financial incentives to encourage forest conservation, and conduct educational workshops on forest conservation (Table 5). Respondents also agreed, although less strongly, that the government should provide technical support and work with landowners to attain forest conservation, promote the importance of forest conservation using appropriate images, and regulate forest uses and timber extraction on private lands. Factor analysis indicated that these items generated two scales that dealt with how forest conservation should be attained, namely: the importance of the government's role in forest conservation (Government's role; Cronbach's alpha = 0.842, eigenvalue = 4.6); and the need for incentives and rules to attain forest conservation (Regulatory tools; Cronbach's alpha = 0.771, eigenvalue = 1.2). Higher scores reflected greater agreement that the government should play a central role in forest conservation and that a mix of incentives and regulations should be used to ensure forest conservation.

3.3. Preferences for conservation agreements

In general, respondents preferred to enroll in a PES program over other types of conservation agreements (positive and significant coefficient for the PES program; Table 6). However, respondents whose main income source was commercial agriculture and whose property was difficult to access preferred to sell their land (positive and significant interaction variables). Respondents who knew about the PES program were less likely to select a property tax reduction. Indigenous communities preferred to sell or donate their development rights. We found some evidence that respondents' choice of conservation program was influenced by how strongly they agreed that incentives and rules should be used to attain forest conservation, whether their land was located in the red zone, and whether they were corporate landowners. However, these results were only significant at the $p = 0.1$ level.

3.4. Preferences for PES program design

Respondents selected a PES alternative in 86% of the choice situations presented in the SPCEs. The basic RPL model suggested that although, on average, respondents were indifferent about enrolling in PES (mean coefficient for the opt-out dummy was not statistically significant; Table 7), respondents were heterogeneous in their preferences (statistically significant standard deviation coefficient). As such, some respondents preferred to enroll in PES over the status quo. When interaction variables were included in the RPL (Table 7), the positive

Table 4
Distribution of responses to the question "How important are the following as reasons for why you have forest on your land?" and factor loadings for 'the importance of forest conservation' to survey respondents (Conserve).

Statements	Median	Mean	Mode	Std. Dev.	Min.	Max.	Skewness	Kurtosis	Factor Loading[b]
To protect nature	1[a]	0.91	2	1.30	-2	2	−1.14	0.22	0.886
To enjoy scenery	1	0.47	2	1.51	−2	2	−0.44	−1.34	0.819
To provide shade to native wildlife	1	0.52	2	1.42	−2	2	−0.61	−0.96	0.729
To provide shade to livestock	1	0.52	2	1.55	−2	2	−0.61	−1.17	0.686
To pass forested areas onto my heirs	1	0.30	2	1.47	−2	2	−0.24	−1.41	0.681
To obey the National Forest Law	0	0.11	2	1.65	−2	2	−0.10	−1.65	
For timber production	−1	−0.56	−2	1.43	−2	2	0.48	−1.26	
Because my land is unsuitable for agriculture	−1	−0.84	−2	1.34	−2	2	0.96	−0.29	
Because it is difficult to access to the forest	−1	−0.98	−2	1.34	−2	2	1.20	0.14	
Because the forest is a financial investment	0	0.00	2	1.67	−2	2	0.03	−1.70	
Variance explained (%)									66.33
Cronbach's alpha									0.87

[a] Response options: very unimportant = −2, unimportant = −1, neutral = 0, important = 1, very important = 2.
[b] Only factor loadings above 0.30 are shown.

Table 5
Distribution of respondents' attitudes toward conservation program design and factor loadings for 'the importance of the government's role in forest conservation' (Government's role) and 'the need for incentives and rules to attain forest conservation' (Regulatory tools).

Statements	Do you agree or disagree with the following statements?[a]								Factor Loadings[b]	
	Median	Mean	Mode	Std. dev.	Min	Max.	Skewness	Kurtosis	Govt. role	Regulatory tools
The government should provide technical support on forest conservation for private forest owners	1	1.22	2	0.98	−2	2	−1.46	2.01	0.974	
The government should conduct workshops on forest protection techniques for private forest owners.	2	1.19	2	1.11	−2	2	−1.51	1.67	0.840	
The government and private forest owners should work together toward forest protection.	1	1.32	2	0.91	−2	2	−2.03	5.12	0.679	0.346
The government should promote the importance of forest conservation.	1	1.36	2	0.71	−1	2	−0.86	0.30	0.575	
There should be financial incentives, such as subsidies, to encourage private forest owners to practice forest protection.	2	1.47	2	0.94	−2	2	−2.39	5.97	0.378	0.344
The government should use negative images, like floods and mudslides, to show the consequences of not protecting forests	1	0.22	2	1.50	−2	2	−2.31	−1.44	0.359	0.302
There should be regulations regarding the extraction of native trees on private forestland.	1	0.88	1	1.14	−2	2	−1.03	0.28		0.663
The government should be able to regulate the use of forests located on private land.	1	0.40	1	1.41	−2	2	−0.50	−1.12		0.607
The government should fine private forest owners who fail to practice forest protection.	2	1.10	2	1.19	−2	2	−1.29	0.64	0.327	0.598
The government should use positive images, such as *Tatu Carreta* or *Oso Hormiguero*, to promote forest.	1	0.86	2	1.12	−2	2	0.24	−1.44	0.433	0.463
Variance explained (%)									45.66	12.41
Cronbach's alpha									0.842	0.771

[a] Response options: strongly disagree = − 2, Disagree = − 1, Neutral = 1, Agree = 1, Very Agree = 2.
[b] Only factor loadings above 0.30 are shown.

Table 6
Random effects logistic regression model showing the estimates of respondents' willingness to enroll in conservation agreements.

Variables	Coefficient	Std. Err.	*p*-Value	95% Conf. Interval
Intercept	−2.721	0.462	0.00	[−3.63, −1.82]
Conservation Agreements				
None	Reference	Reference	Reference	Reference
PES program	2.794	0.515	0.000	[1.78, 3.80]
Tax reduction	1.356	0.713	0.057	[−0.04, 2.75]
Sell the land	−0.575	1.230	0.640	[−2.98, 1.83]
Sell or donate development rights	0.068	0.654	0.917	[−1.21, 1.35]
Interaction terms				
Sell × Agricultural activities	2.296	0.838	0.006	[0.653, 3.939]
Sell × Inaccessible	0.461	0.227	0.042	[0.016, 0.905]
Sell × Company	−2.089	1.094	0.056	[−4.232, 0.054]
Sell × Knows PES	2.215	1.178	0.060	[−0.093, 4.524]
Sell × Regulatory	−0.781	0.426	0.067	[−1.616, 0.549]
Tax × Know PES	−1.745	0.791	0.027	[0.016, 0.905]
Tax × Red zone	1.637	0.879	0.063	[−0.859, 3.360]
Sell or donate development rights × Indigenous community	2.248	1.023	0.028	[0.242, 4.254]
PES × Regulatory	0.557	0.285	0.051	[−0.002, 1.115]
Log-likelihood	−149.77			
Wald chi2	77.93			
AIC	329.53			
Observations	405			

mean coefficient for the opt-out dummy suggested that, on average, respondents would prefer not to enroll in PES, although respondents varied in the strength of this preference (statistically significant standard deviation coefficient). Respondents who knew about the current PES program preferred not to enroll in PES but their preferences for opting out were weaker than respondents who did not know about the PES program. Respondents who placed greater weight on the government's role in forest conservation had stronger preferences for opting out of PES.

Results from both RPL models showed that respondents preferred not to enroll in PES programs that required them to engage in sustainable timber production (no preference heterogeneity). Respondents were heterogeneous in their preferences for PES programs that required them to engage in silvopasture or ecotourism, with both models indicating that some respondents preferred to engage in these activities while others did not. Respondents who stated that ecotourism or silvopasture were their preferred land uses demonstrated stronger preferences for PES programs that allowed them to engage in these activities (positive, statistically significant interaction variables). For both models, respondents preferred shorter contract lengths for PES (no preference heterogeneity). Consistent with economic theory, respondents preferred higher contract payments.

3.5. Willingness to enroll in PES and reservation cash payments

The random effects logistic regression confirmed that respondents were less likely to enroll in PES as contract length increased, but higher payments would increase enrollment (Table 8). This model also provided further evidence that respondents preferred to enroll in PES programs that would permit them to engage in silvopasture and preferred not to enroll in programs that restricted them to sustainable timber harvesting (although this effect was less strong for individuals who preferred this land use). The random effects logit suggested that respondents were less likely to enroll in PES if they were required to engage in ecotourism (again this effect was less strong for individuals who preferred this land use). Respondents with properties in the red zone were more likely to enroll in PES programs that required them to engage in forest conservation and were less strongly inclined to select

Table 7
Random Parameters Logit (RPL) models for the PES program's attributes.

Attributes and interactions	RPL model						RPL model with interactions					
	Mean			Standard deviation			Mean			Standard deviation		
	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.	Coeff.		S.E.
Opt-out	0.939		0.599	2.388	***	0.456	2.637	***	0.797	1.959	***	0.430
Forest use												
Conservation	–			–			–			–		
Ecotourism	−0.904		0.556	2.169	***	0.762	−1.736	**	0.692	2.218	***	0.632
Timber	−0.998	**	0.426	0.806		0.655	−1.378	**	0.558	1.022		0.851
Silvopasture	1.641	***	0.488	1.910	***	0.641	−1.619		1.404	1.974	***	0.701
Contract length	−0.046	**	0.019	0.028		0.030	−0.055	***	0.022	0.023		0.023
Annual payment	0.083	***	0.016				0.086	***	0.018			
Opt-out × red zone							−0.977		0.623			
Opt-out × know PES							−1.889	***	0.675			
Opt-out × govt. role							0.686	**	0.319			
Opt-out × regulatory role							−0.622	*	0.342			
Ecotourism × preferred land use							3.109	***	1.134			
Timber × preferred land use							1.195		0.741			
Silvopasture × preferred land use							4.006	**	1.599			
Log-likelihood	−278.852						−255.548					
LR chi2	65.79						41.08					
AIC	579.704						547.096					

Significance levels: *10%, ** 5%, *** 1%.

Table 8
Random effects logistic regression model used for estimation of reservation cash payments.

Variable	Coefficient	Std. Err.	*p* value
Opt out	−0.538	0.117	<0.001
Conservation	–	–	–
× red zone	1.103	0.419	0.009
× yellow zone	−1.545	0.405	<0.001
× no commercial activity	−1.565	0.552	0.005
× forest is a financial investment	0.250	0.146	0.087
Ecotourism	−2.658	0.399	<0.001
× preferred land use	1.569	0.441	<0.001
× red zone	0.805	0.441	0.068
× received PES funding	0.715	0.440	0.104
× conserve	−0.623	0.229	0.007
Timber	−1.631	0.791	0.039
× preferred land use	1.099	0.560	0.050
× yellow zone	−1.528	0.714	0.032
× plan to harvest timber	0.352	0.186	0.059
× no commercial activity	−1.843	0.757	0.015
× land is unsuitable for agriculture	−0.555	0.251	0.027
Silvopasture	2.712	1.305	0.038
× preferred land use	1.400	0.719	0.052
× red zone	−2.009	0.702	0.004
× yellow zone	−4.329	1.116	<0.001
× land size	0.041	0.017	0.015
Contract length	−0.126	0.033	<0.001
× yellow zone	0.095	0.035	0.006
× green zone	0.148	0.055	0.007
× conserve	−0.623	0.229	0.007
× forest is a financial investment	−0.015	0.004	0.001
× land size	−0.001	0.001	0.049
Payment	0.069	0.011	0.000
Log-likelihood	−503.872		
Wald chi2	163.00		
AIC	1065.744		

PES programs that would allow them to engage in silvopasture (an activity that is not permitted in the red zone). Respondents with land in the yellow zone were less likely to enroll in PES programs that required them to engage in forest conservation, sustainable timber harvesting or silvopasture, but were less opposed to PES programs with longer contract lengths. Respondents who earned most of their income from non-commercial activities were less likely to enroll in PES programs that required forest conservation or sustainable timber harvesting. Respondents who considered their land to be unsuitable for commercial agriculture were less likely to enroll in PES programs that required sustainable timber harvesting. Respondents who placed importance on forest conservation were less likely to enroll in a PES program that required them to engage in ecotourism or PES programs with long contract lengths. Respondents who considered their forest to be a financial investment were also less likely to enroll in PES as contract length increased. Respondents with land in the green zone preferred longer contract lengths, while respondents with larger landholdings disliked longer contract lengths and preferred PES programs that would allow them to engage in silvopasture.

On average, respondents required ~US$19/ha/year (S.D. = 19.4) to enroll in a PES program that allowed them to engage in silvopasture, ~US$31/ha/year (S.D. = 32) to enroll in a PES program that required them to engage in forest conservation, ~US$34/ha/year (S.D. = 16.3) to enroll in a PES program that required them to conduct ecotourism, and ~US$50/ha/year (S.D. = 20.8) to enroll in a PES program that required them to engage in timber production (Table 9). Although the reservation payment was lower for forest conservation than ecotourism or sustainable timber harvesting, this should not be interpreted as respondents preferring conservation over alternative land uses. Respondents with red-zoned lands must conserve their land, which would prevent them from selecting alternative land use options in reality, and thereby likely

Table 9
Estimated reservation cash payments for forest uses permitted in the PES program and landholdings zone of respondent.

	Median	Mean	Std. Dev.
Conservation	$ 29.96	$ 31.08	$ 18.86
Green zone	$ 9.77	$ 11.43	$ 8.65
Yellow zone	$ 31.08	$ 33.28	$ 18.19
Red zone	$ 14.83	$ 22.35	$ 26.60
Ecotourism	$ 38.38	$ 34.48	$ 16.31
Green zone	$ 42.17	$ 36.02	$ 10.65
Yellow zone	$ 38.42	$ 34.96	$ 14.38
Red zone[a]	$ 23.97	$ 26.38	$ 20.69
Silvopasture	$ 14.58	$ 19.39	$17. 42
Green zone	$ 0.00	$ 0.00	$ 0.00
Yellow zone	$ 14.69	$ 20.22	$ 17.45
Red zone[a]	$ 29.74	$ 30.87	$ 21.22
Timber	$ 48.18	$50.19	$20.84
Green zone	$ 32.28	$ 31.86	$ 14.30
Yellow zone	$ 48.25	$ 50.50	$ 21.12
Red zone[a]	$ 46.82	$ 48.30	$ 20.90

[a] Land use not permitted.

deflated the reservation payment for conservation. Respondents with yellow- and green-zoned lands only selected conservation in 1.7% ($N = 15$) of cases. Accordingly, we also provide estimated reservation payments broken down by zone in Table 9. Respondents with land in the yellow zone required the lowest payment to enroll in a PES program that allowed them to engage in silvopasture (~$20/ha/year). Respondents with land in the green zone required no payment to enroll in a PES program, provided that they were allowed to engage in silvopasture (although respondents with green-zoned land rarely selected this PES program, preferring instead not to enroll in PES).

4. Discussion

Incentive-based programs are important policy tools to attain conservation on private lands. However, designing conservation programs that are likely to attain additionality (i.e., conservation actions by landowners that would not have occurred in the absence of these programs; Engel et al., 2008, Bennett, 2010) is challenging without a clear understanding of landowners' financial and socio-psychological motivations for engaging in conservation (Kaczan and Swallow, 2013; Kreye et al., 2017b; Puri et al., 2021). We found that our study participants were more likely to choose a PES program over tax reductions, selling their land, or selling or donating their development rights. Their choice of a PES program is consistent with a common pattern of individuals choosing the familiar over the unfamiliar (Kabii and Horwitz, 2006; Singh et al., 2018). In total, 74% of respondents were familiar with the Argentine PES program, whereas no one knew about conservation easements.

Only indigenous groups preferred to sell or donate their property's development rights in perpetuity, possibly because they want to permanently conserve the forest on their lands. As documented by other researchers, the expansion of commercial agriculture in the Chaco has resulted in the ecological marginalization of indigenous communities and forest smallholders, who rely on these forest resources for subsistence use (Cotroneo et al., 2021; del Giorgio et al., 2021; Levers et al., 2021). Given that smallholders and indigenous communities have received only a small share of PES payments (Cotroneo et al., 2021), it is unsurprising that they would eschew financial payments in favor of conservation programs that would reduce the threat of land conversion and secure their access to forest resources (Levers et al., 2021).

We found some evidence that landowners who rely on commercial agricultural income or have inaccessible land may prefer to sell their land for conservation purposes. Road infrastructure is poor in the Chaco forest, which prevents landowners from utilizing their land for commercial or recreational purposes. Selling land may be a good option for individuals who own land in the red and yellow zones, where land use regulations have limited commercial agricultural uses and reduced the market value of land.

Despite most respondents' preference for PES over other conservation alternatives, our models indicated that respondents would prefer not to enroll in PES (i.e., they would prefer to opt out of the PES program). Respondents' socio-psychological characteristics influenced their willingness to participate in PES (see also Mastrangelo et al., 2014). Respondents were familiar with the current PES program, which has been characterized by delayed payments and high levels of regulatory burden. As such, respondents may have lost trust in the government and the PES program (Kreye et al., 2017b). Lack of trust in the PES program or the government might explain why respondents who placed importance on conserving their forest preferred not to enroll in PES programs with long contract lengths. Respondents who believed that the government should be responsible for forest conservation were also strongly opposed to enrolling in PES programs.

PES program design strongly influenced respondents' decisions to enroll in the program (Sorice et al., 2011; Kreye et al., 2017b; Puri et al., 2021). Respondents' recognition of how zone restricted their available land use options was also reflected in their choice of PES programs or whether to enroll in PES. Consistent with prior findings, respondents preferred higher payments, shorter contract lengths, and PES programs that permitted silvopasture (Christensen et al., 2011; Balderas Torres et al., 2013; Drechsler et al., 2017; Kreye et al., 2017b; Núñez-Regueiro et al., 2020). Respondents were least likely to enroll in a PES program that required them to engage in sustainable timber harvesting. Although jaguar tourism may generate substantial revenues (Tortato et al., 2017), respondents' lack of interest in ecotourism might be attributable to concerns about the financial viability of ecotourism, which requires significant capital investment, marketing, and infrastructure, and is highly susceptible to economic downturns (Clements and Cumming, 2018).

Consistent with the theory of rational behavior (Becker, 1993), respondents demanded higher compensation for less desirable forest uses (e.g., sustainable timber production) and lower compensation for the most desirable forest use (i.e., silvopasture). Landowners may prefer not to engage in PES out of concerns that they might not be able to carry out the contractual obligations or reluctance to assume contractual risks if the payment offered does not cover their opportunity and transaction costs (Puri et al., 2021). Unfortunately, regardless of permitted land use, respondents required higher payments than the available funding for PES in Argentina allows. This suggests that enrollment in the PES program is unlikely to increase and conservation benefits will remain limited. In areas where there has already been substantial loss of forest on private lands, landowners' preference not to enroll remaining forested lands in PES may result in scattered conservation lands, fragmented landscapes, and isolated patches of habitat that do not support essential processes for ecosystem health. Habitat fragmentation in the Chaco can lead to biodiversity loss with forest interior species, like giant anteaters, being most impacted (Núñez-Regueiro et al., 2015). Habitat fragmentation can also lead to alteration of water and nutrient cycles, lower carbon storage, and reduced production of non-timber forest products, all of which have negative implications for human welfare (Laurance et al., 2011).

Even with much higher payments that might increase enrollment, there is a trade-off between maximizing participation in the PES program and maximizing conservation benefits. In 2016, the government of Salta approved silvopasture as part of the PES program to balance native forest conservation and economic development (Córdoba and Camardelli, 2017). Landowners may raise cattle and plant nonnative pasture grasses beneath mature trees after removal of shrubs, vines, and cacti, and may deforest parts of their property (Peri et al., 2017). Respondents' strong preference for this land use over other land uses that are more consistent with biodiversity conservation is an urgent call for research on the ecological impacts of cattle production in the Chaco. Information is needed on how tree removal, the replacement of native understory vegetation with fast-growing nonnative grasses and the application of agrochemicals may affect native tree recruitment, habitat fragmentation and habitat degradation on landholdings (Aprile et al., 2016; Peri et al., 2017). Cattle can reduce recruitment of some plant species, while augmenting seed dispersal and germination of other species, thus creating major shifts in species composition. Such shifts can have cascading effects (i.e., changes in species composition change the resource base for other species, change habitat structure, etc.) and may increase the need for active reforestation and restoration efforts (Tálamo et al., 2021) – which is inconsistent with the stated aims of the National Forest Law and PES program to conserve the Chaco forest. Finally, increased allocation of forested land to silvopasture may increase conflicts with predators that prey on livestock such as the jaguar and puma, which the PES program was intended to benefit (Quiroga et al., 2016). Accordingly, Law et al. (2021) have argued that larger forest patches should be protected from conversion to silvopasture and focus should be placed on establishing carbon- and biodiversity-rich silvopastures.

5. Conclusion

Understanding landowners' willingness to enroll in conservation programs is challenging. Our results suggest that landowners' knowledge about conservation programs, attitudes toward forest conservation policy, and land characteristics influence their willingness to participate in forest conservation and their preferences for conservation program design. Although indigenous communities preferred conservation easements, other private landowners preferred PES over alternative conservation programs. As such, using PES as the only approach to engage landowners in conservation may result in a lost opportunity to enroll more land in conservation by exploiting alternative funding approaches. As currently structured, the payments landowners prefer to engage in permitted forest uses (ranging from approximately $15/ha for silvopasture to $48/ha for sustainable timber production) exceed the average payment offered under the PES program. If PES remains the main conservation approach, then higher cash payments and allowing landowners to engage in silvopasture may increase enrollment. However, increased adoption of silvopasture may provide limited environmental benefits, rather resulting in changes to species composition and increased human-predator conflicts. Caution should be exercised if the PES program is restructured to ensure that landowners' need to generate income from their land and indigenous communities' subsistence needs are balanced with activities that are ecologically beneficial.

CRediT authorship contribution statement

Cristina C. Nunez Godoy: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization, Funding acquisition. **Elizabeth F. Pienaar:** Conceptualization, Methodology, Formal analysis, Resources, Writing – review & editing, Visualization, Supervision, Funding acquisition. **Lyn C. Branch:** Conceptualization, Methodology, Resources, Writing – review & editing, Visualization, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

References

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