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Compliance under control: Insights from an incentive-based conservation program in rural Bolivia

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ABSTRACT

Conditionality is often considered a key feature of Payments for Ecosystem Services (PES) and other incentive-based conservation programs. Critical components of conditionality – monitoring and sanctions for noncompliance – have received relatively little attention. We identified five groups of potential drivers of compliance based on the concepts of material costs and benefits; social pressure; environmental values and beliefs; trust, fairness and reciprocity; and household characteristics. We analysed data on 1823 monitoring visits from an incentive-based watershed conservation program in rural Bolivia. Drivers informed by material costs and benefits were significantly associated with compliance. Specifically, three program design features were associated with higher likelihood of compliance: less restrictive contracts, larger areas under contract, and having been previously monitored for compliance. Other drivers, including sensitivity to social pressure, environmental values/beliefs, trust, fairness and reciprocity, and household demographic and economic characteristics, were not consistently associated with compliance rates. These results suggest that conservation professionals and policy makers have a large amount of control over compliance in PES, and that clear communication with participants about program objectives and conditions and meaningful and repeated monitoring are key elements of successful and effective PES.

1. Introduction

Incentive-based environmental conservation programs such as Payments for Ecosystem Services (PES) schemes[1] have become increasingly popular over the last 30 years. Hundreds of such programs are operating throughout the world, with 36–42 billion USD spent annually on implementation (Salzman et al., 2018). The key characteristic of this environmental conservation approach is conditionality, by which participants in the programs agree to receive material rewards (cash payments or in-kind resources) in exchange for binding promises to adopt specific conservation behaviours or deliver specific conservation outcomes (Engel et al., 2008; Wunder, 2015, 2005; Wunder et al., 2020).

This conditionality feature includes a combination of incentives, monitoring and sanctions for noncompliance (Wunder, 2005). While the type, amount, and allocation mechanism of incentives to be provided have been the subject of a large body of research (e.g., Ajayi et al., 2012; Claassen et al., 2008; Ferraro, 2008), monitoring, (non)compliance, and sanctions have received little attention in the academic literature, especially with empirical studies. For example, the review of PES trends by Salzman et al. (2018) does not mention compliance rates. Although effective monitoring and sanctions are considered cornerstones of any meaningful conditionality regime (Wunder et al., 2018), enforcing compliance by frequent monitoring or meaningful sanctions is not always feasible or infrequently takes place (Bauchet et al., 2020; Wunder et al., 2018).

In this paper we take an interdisciplinary approach by incorporating factors from the economics, psychology, institutions, and environmental studies literatures to inform our understanding of compliance in

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[1] Although PES programs are very varied, and not all incentive-based conservation programs are PES programs, we use the term "PES" in this paper to include a broad range of incentive-based conservation programs, as long as they include a conditional payment element.

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Table 1
Groups of drivers of compliance.

Groups of compliance drivers	Description with examples	Variables used in the group
Costs and benefits	Individuals are motivated to comply when the cost of compliance is lower than the cost of noncompliance (Fisher, 2012; Keane et al., 2008), which is partially driven by contract design and by the perceived likelihood of punishment for non-compliance (Arias, 2015; Filteau, 2012; Fishbein and Ajzen, 2009; Keane et al., 2008; Pratt et al., 2018; Sutinen and Kuperan, 1999). • Poorer households have lower compliance rates (Nkonya et al., 2008). • Households lacking natural/social capital have lower compliance rates which could relate to economic considerations (Leimona and Carrasco, 2017). • As the fear of detection and severity of punishment increase, compliance rates increase in a lobster fishery (Keane et al., 2008).	Contract type, land enrolled in contract, land enrolled was previously monitored for compliance; total household monthly income; household bank account ownership; amount of loans taken in past 12 months; total land owned by household; non land, non-cattle wealth index
Social pressure	Individuals who are sensitive to local social pressures are more likely to conform if there are local sanctions or social costs for non-compliance (Arias, 2015). • Agent based modelling study found that perceived descriptive norms of neighbours influenced re-enrolment (Chen et al., 2012). • A review of PES programs in Indonesia, China, and the Philippines found that collective choice rules when developed by the community can increase compliance (Huang et al., 2009).	Respondent thinks it's important to teach children obedience; Household participates in community meetings; Household participates in community work
Environmental values and beliefs	Individuals are motivated to comply based on their intrinsic interests in a program, in an environmental context these can be caring for the environment based on values and morals or caring for the environment based on its provisioning functions to the individual (instrumental) (Keane et al., 2008; Wunder and Börner, 2012). • Intrinsic motivations were an important factor in increased compliance rates controlling for economic benefits in a Rwandan PES (Wunder and Börner, 2012). • Pro-nature environmental motivations led to higher compliance rates in a Bolivian conservation incentive program (Bottazzi et al., 2018). • Local community involvement can increase intrinsic motivations and lead to higher compliance rates (Clements et al., 2010).	Respondent thinks economy and environment are compatible; Respondent thinks need to hurt the environment to improve livelihoods; Respondent thinks it's important to teach children environmental protection
Fairness, trust, reciprocity	Individuals are motivated to comply when they perceive the program is fair and trust their monitoring body. Perceptions of trust and fairness can be developed through repeated reciprocal interactions (Isoni and Sugden, 2019; Rabin, 2011). • Lack of trust in monitoring agency can lead to lower rates of voluntary compliance around protected areas (Stern, 2008). • Study on regulatory compliance found that individuals are more likely to comply if they perceive the program benefits and rules as fair (Sutinen and Kuperan, 1999). • Study on Norwegian and Russian fisherman found higher compliance rates when fishermen felt respected by inspectors (Hønneland, 2000).	Respondent trusts NGOs always or most of the time; Respondent thinks higher income earners should share; Respondent thinks important to teach children altruism; Respondent thinks that if one works more, one should earn more

incentive-based environmental conservation programs. Specifically, this paper makes three main contributions. First, we empirically document rates of compliance in a large-scale PES-like program. With one exception (Bottazzi et al., 2018), previous research has documented compliance rates in datasets with fewer than 50 program participants (Ajayi et al., 2012; Asquith et al., 2008; Giudice et al., 2019; Honey-Rosés et al., 2009). Our data include 462 households who signed 757 contracts and were visited more than 1800 times to monitor for compliance. Our goal and contribution is to analyse compliance in depth in one program and particular local context, under one set of contract features, rather than through cross-program comparisons. Second, we categorize potential drivers of compliance in PES programs, based on broad conceptual understandings of human behaviour as well as specific evidence from existing PES programs. We identified (1) *material costs and benefits* drivers, such as the amount of incentive received, constraints on land use, and previous experience with conditionality and its enforcement; (2) drivers based on sensitivity to *social pressure*; (3) drivers related to *environmental values and beliefs*; (4) drivers based on *trust, fairness, and reciprocity*; and (5) *demographic characteristics* of participants. Last, we empirically estimated these drivers' correlation with compliance rates using our unique large dataset.

We combined administrative data from 1823 detailed monitoring visits of plots enrolled in the program, covering 8575 ha, with a detailed survey of the households who signed these conservation contracts conducted before the program was rolled out. We found that drivers informed by material costs and benefits, particularly representing program design features, were strongly associated with compliance. Households who entered into more restrictive contracts (that provide higher-value incentives) and households that enrolled more land in the program were less likely to comply than their respective counterparts. Having been previously monitored for compliance was also a strong driver. Other drivers related to social pressure, environmental values and beliefs, trust, fairness and reciprocity, and household demographic and economic characteristics, were not consistently statistically significantly associated with compliance rates. These results suggest that program design features may have a stronger influence on compliance than household and individual characteristics. This puts organizations that design and implement PES programs in a favourable position to

design programs for compliance, but also places a large part of the responsibility for ensuring compliance on getting program details right for each organization, participant, and setting.

2. Compliance and its drivers in PES

2.1. Limited existing empirical evidence on compliance rates and their drivers

The few existing studies of compliance in PES have noted that compliance rates are typically high, albeit often analysed for small samples of participants. For example, Honey-Rosés et al. (2009) reported that only 8% of 13 participants were noncompliant and sanctioned by withholding payment in a forest conservation program in Mexico in 2001–2003. Similarly, a case study of a water-focused, PES-like program in Bolivia reported that only 2% of 46 farmers did not comply with conditions for their conservation contracts (Asquith et al., 2008). In Peru, 11% of 45 communities were "evicted" for non-compliance from the National Forest Conservation Program, a PES program (Giudice et al., 2019). A study of an adapted version of the program we study in this paper indicated that 8–16% of 912 contracts (signed by about 500 households) were self-reported as non-compliant by participants themselves (Bottazzi et al., 2018). To our knowledge, the highest published non-compliance rates are those in a PES program in Indonesia: non-compliance at the mid-program monitoring point was near zero, but increased to 44% (of 34 participants) at the end of the program (Ajayi et al., 2012; Leimona and Carrasco, 2017).

Three empirical studies have provided insights into drivers of compliance in PES. Leimona and Carrasco (2017) reported four key findings about compliance in a soil erosion control PES program in Indonesia: (i) labour constraints (operationalized as household size) and longer land tenure were associated with higher compliance; (ii) compliance was not influenced by past conservation program investments; (iii) financial or cost-benefit considerations did not drive compliance; and (iv) participants themselves thought that sanctions should be higher in order to increase compliance. Bruner and Reid (2015) drew upon insights from behavioural economics to highlight the potential importance of non-economic factors of participation and compliance in PES, including intrinsic motivation, social norms, fairness, and reciprocity. Bottazzi et al. (2018), in an analysis of determinants of participation in Bolivia's Watershared program, found that households motivated to participate by the incentive were less likely to comply than those motivated by a desire for environmental conservation.

Finally, some studies have focused on compliance indirectly, as a function of the incentive allocation mechanisms, particularly auctions. Both theoretical models (Kawasaki et al., 2012) and empirical analyses (Jack, 2010) have aimed to determine the optimal design of PES, including addressing compliance concerns. Jack (2010) found 9.5% (0.3 standard deviations) higher compliance rates in a tree planting PES program in Malawi when incentive amounts were determined by participants bidding in auctions rather than through other mechanisms.

2.2. Four groups of possible drivers of compliance

Compliance in PES programs is both undertheorized and understudied empirically, making it an important area for exploratory research. Below, we draw on several conceptual understandings of human behaviour, in conjunction with existing empirical work on compliance in other settings to identify groups of program and participant characteristics that could plausibly affect compliance in PES programs specifically. Table 1 summarizes different groups of drivers, which we describe below.

2.2.1. Material costs and benefits

Economic theory emphasizes the role of material incentives, information, and constraints in shaping human behaviour. Applied to compliance in PES, this points us toward factors that influence the perceived costs and benefits of the program, as well as any potential constraints or barriers to complying with program requirements. In fact, initial development of PES programs was built around developing incentives that would offset costs of compliance (Wunder, 2005). Much of the enforcement literature has been devoted to instrumental influences on compliance that utilize economic cost-benefit models in understanding decisions to comply (Keane et al., 2008).

Research in community conservation programs suggests that participants balance the payoffs with the costs of noncompliance in choosing to participate in a program (Nkonya et al., 2008) or to break compliance (Keane et al., 2008). This balance is notably influenced by programs' design, including the size of sanctions, and modalities of and strictness in sanctioning non-compliance. PES program participants, if monitored, determined to be non-compliant, and then sanctioned, often only have to forgo the next round of payment, which tends to be a small expected loss and may not be sufficient to deter them from non-compliance (Ferraro, 2017). In Ecuador, for example, contracts for participating in the PROFAFOR carbon-sequestration, tree-planting program were bound by a lien on participants' lands, which constituted a strong leverage in compliance, while in the case of the Pimampiro watershed protection program, non-complying households were temporarily suspended from payments or permanently excluded for future enrolment in the program (Wunder and Alban, 2008). In addition, some PES programs have allowed a margin of non-compliance before sanctions are applied, such as the program that we study (see non-compliance definitions below) or Brazil's Bolsa Floresta Programme where non-compliance would only be sanctioned through payments suspension after two repeated warnings (Börner et al., 2013). Some researchers have suggested that some PES programs are reluctant to sanction non-compliance because they do not want to endanger the trust and social capital their programs have built with their local constituents (Ezzine-de-Blas et al., 2016; Ferraro, 2017; Wunder et al., 2020, 2018), while other researchers have argued that in fact, it is important to build in flexibility in PES programs to allow learning on the part of program participants (Chan et al., 2017; Pascual et al., 2014). Cross-program comparisons are beyond the scope of this study, which is based on data from a single program. However, the existing literature on the importance of program design features leads us to hypothesize that program design characteristics that influence the expected costs (required actions) and benefits (promised reward) of participation, such as the specific **contract terms**, affect compliance.

Drawing on the optimal enforcement literature, another factor that determines the expected costs and benefits of compliance to forest users, in addition to the level of fines, is the perceived probability of detection, which is partly a function of expenditures on forest monitoring and rarely involves perfect enforcement (Clarke et al., 1993; Robinson et al., 2010). The probability of detection directly affects the likelihood of being punished for noncompliance.[2] If an individual does not expect to be punished for noncompliance, then the benefits of compliance relative to noncompliance are diminished. As such, compliance can be influenced by clarity of rules, consistency in monitoring, and enforcement of noncompliance (Arias, 2015; Goldman-Benner et al., 2012; Honey-Rosés et al., 2009). Programmatic features such as the occurrence of **previous monitoring** can be expected to influence compliance behaviour. In addition, research has suggested that previous experiences with punishment can influence an individual's likelihood of complying with new programs (Arias, 2015; Fishbein and Ajzen, 2009). Thus, at the

[2] Optimal enforcement scholars would also encourage us to directly compare the benefits of increased expenditures on monitoring to the costs that the implementing agency must bear in conducting monitoring efforts, but that is beyond the scope of this paper, which strictly brings data to bear on the forest user decision function.

household level, **prior experience with NGO programs** may also influence compliance, through either actual or perceived knowledge of rules and likelihood of enforcement. Households that have received help from outside institutions may be more familiar with requirements for receiving help or participating in program and the penalty for failing to comply with such requirements (Ranjan et al., 2019). Finally, at the household level, material costs and benefits include **household economic characteristics** (for example, income and wealth) for the role they play in determining both opportunity costs and budget constraints.[3] Gender, for example, has been shown to be linked to effort in supplying ecosystem services following payment (Loft et al., 2020), and may also correlate with compliance. Similarly, households that are poorer have been shown to have lower rates of compliance in community conservation programs (Nkonya et al., 2008).

However, the field of behavioral economics has now well established that individuals do not always behave rationally (Kahneman, 2011; Thaler and Sunstein, 2008) and thus they do not always respond to incentives as expected by economic theory. This is demonstrated most clearly in the motivation crowding literature that shows the importance of program design in crowding in or out intrinsic motivations in PES (Ezzine-de-Blas et al., 2019). We consider this literature in the context of motivations, beliefs and values in section 2.2.3. below. Thus, in addition to the material costs and benefits of compliance, we also turn toward considering other influences on human behaviour.

2.2.2. Social pressure

While recognizing the role that material costs and benefits play in driving human behaviour, the sociological concept of embeddedness (Granovetter, 1985) points out that even market behaviour is embedded within a social system. Thus, **sensitivity to social pressure to conform** with certain norms can constrain rational behaviour. (Chen et al., 2012) developed an agent-based simulation model to demonstrate the impact of social norms on farmers' decision to re-enrol in a PES program and found that perceived descriptive norm (through observing neighbours' behaviours) influenced reenrolment decisions when leveraged with intermediate payments. Normative influence has also been found to affect compliance through social pressure that helps sanction noncompliance and creates social costs for noncompliance (Arias, 2015), and has been hypothesized to contribute to compliance in PES (Adhikari and Agrawal, 2013).

2.2.3. Intrinsic motivations, and environmental values and beliefs

The role of intrinsic motivations (loosely defined to include instrumental motivations based on internalized environmental values) has been widely explored in PES programs, as a correlate of both PES program enrolment and compliance. Studies have suggested that compliance can be expected to be higher when program participants possess strong intrinsic motivations for the environment (Bottazzi et al., 2018; Clements et al., 2010; Grillos et al., 2019; Keane et al., 2008). Specifically, Ezzine-de-Blas et al. (2019) developed a framework to understand when and how program features (including monitoring and enforcement), participant characteristics, and contextual elements determine whether PES crowds intrinsic motivation in or out. Aspects of this framework were then examined through a special issue on the effects of real or hypothetical PES interventions on motivation crowding. In a forest conservation-framed dictator game in Tanzania, Kaczan et al. (2019) found that, despite the game financially incentivizing noncompliance, the game's environmental conservation framing signalled to participants an expectation to comply, which they largely followed. Empirically, Chervier et al. (2019) analysed compliance in a Cambodian PES program, and found that households that perceived the values of forest conservation to be more money-related were less likely to comply once the PES payment stopped. In this paper, we hypothesize that program participants with stronger intrinsic motivations, measured by reporting higher **environmental values and beliefs**, are more likely to comply with PES contract conditions.

2.2.4. Trust, fairness, and reciprocity

Partly in reaction to the heated debate over intrinsic versus external motivations, the PES literature has recently emphasized relational values as "preferences, principles, and virtues associated with meaningful, reciprocal and just human-nature relationships" (Bremer et al., 2018, p. 116–117). Bridging the gap between purely internalized motivations, on the one hand, and external social or financial pressures, on the other, this line of work emphasizes relationships as a pathway for trust development and driver of behaviour. Inspired by this literature, we also consider household perceptions of the relational concepts of **trust, fairness, and reciprocity** as potential drivers of compliance behaviour in PES. Previous game theory and empirical research in protected areas has suggested that the development of reciprocal relationships between conservation organizations and their program participations through back-and-forth interactions can lead to the development of trust and trustworthiness, which can decrease opposition to conservation programs (Isoni and Sugden, 2019; Stern, 2008). Environmental policy studies on the influence of trust, fairness, and reciprocity have also suggested that high levels of trust, perceptions of fairness in how a program is implemented, and frequent interactions between program staff and participants can increase compliance (Hønneland, 2000; Jones, 2010; Stern, 2008; Sutinen and Kuperan, 1999). Outside of the context of environmental conservation, research on tax compliance have found that trust-building interactions can improve tax compliance better than deterrent measures (Lisi, 2014).

In conclusion, while we draw on various pre-existing conceptual understandings of human behaviour to identify potential program- and household-level drivers of compliance, we do not aim to test concepts against each other. The survey data we analysed in this paper were not collected with that goal in mind. Rather, informed by existing conceptual frameworks, we identified relevant variables and then conducted exploratory analyses with the goal of contributing to an applied theory of compliance in PES and spur further research on this understudied topic.

Based on this literature, we formulate five hypotheses (H1-H5) about the association of various factors with compliance rates. H1: Material costs and benefits of complying are associated with average compliance rates. H2: Beyond economic considerations, social norms and social pressure are correlated with compliance rates. H3: Compliance is associated with environmental values and beliefs of participants. H4: Trust, fairness, and reciprocity are related to compliance. H5: Households' characteristics. We detail the indicators we used to operationalize these hypotheses in section 4.2.2.

3. Study site and partner institution

This study utilizes data from Watershared, an incentive-based conservation program implemented in the Santa Cruz department of Bolivia by the non-governmental organization Fundación Natura Bolivia (hereafter Natura). Communities offered the program were located in five municipalities of the department – Vallegrande, Samaipata, Moro Moro, Pucará, and Postrervalle – in the foothills of the Andes mountains (Fig. 1 shows their location). Watershared promotes water and environmental conservation through reciprocal agreements ("Acuerdos Recíprocos por Agua" in Spanish) between owners/producers of resources and downstream users. Downstream users, typically water cooperatives, combined with municipalities, provide in-kind support to upstream landowners in exchange for their adoption of natural resource management practices that increase water quantity and quality. These

[3] The opportunity cost of the land under contract is likely to play a role in the material costs and benefits of compliance. Our data do not include any direct or proxy measure of opportunity cost of land, so we leave this consideration for future research with additional data.

practices include limiting cattle's access to streams and forests and reducing deforestation (Asquith et al., 2008; Pynegar et al., 2018; Wiik et al., 2019). Participants choose in-kind incentives from a list of options that are designed to help them adopt these behaviours and to benefit their livelihoods. Two of the most common incentives chosen are barbed wire and plastic piping, which are intended to be used to fence off streams and to supply water for cattle drinking troughs. Other incentives, such as beehives or fruit tree seedlings, provide additional income sources and reduce program participants' reliance on cattle for their livelihoods (Bottazzi et al., 2018).

While Watershared's focus on reciprocity and in-kind incentives differentiate it from traditional PES programs (Grillos et al., 2019), it shares with PES a strong focus on making the incentives conditional on landowners' compliance with behaviours clearly identified in a binding contract (Bauchet et al., 2020). Participants typically sign a three-year Watershared contract which includes information about annual compliance monitoring. Each contract covers one plot of land; members of a household can sign multiple contracts. Formal ownership of the land is required to sign a contract, and a contract must be signed by all owners of the plot of land to be put under contract (for example, both husband and wife). Land rights are well defined in the area and private land ownership is the most common form of land tenure (communal land ownership exists but is relatively rare).

The Watershared program was offered to all landowning households in target communities; we study contracts signed between 2011 and 2014. Households self-selected into participating or not participating in the overall program, and into a particular type of contract available. Since compliance is only defined for participants, we only study participants, and self-selection into the program does not bias our estimates. Because we exploit a cross-sectional survey, our analyses do not allow us to interpret any statistical result causally.

Three types of contracts were available. Level 1 contracts provide the highest incentive value but place the most stringent restriction on land use. In particular, it prohibits the presence of cattle close to streams or in the forest on the plot of land under contract. Level 2 and 3 contracts do not place restriction on cattle movement but commit the landowner(s) to prevent all forms of deforestation; these contracts provide lower amounts of incentives. All contracts are monitored on an annual basis.

Compliance with the conditions set forth in the Watershared contracts was monitored and measured by Natura. We describe here the monitoring regime designed by Natura; whether and how a contract was considered compliant by Natura is described in section 4.2.1 below. Compliance monitoring focused on six dimensions: presence of cattle in streams, cattle in forests, new paths/roads large enough for a vehicle, extraction of wood, forest fires, and slash-and-burn cultivation activities (which are illegal in the area where the study took place without a permit). Presence of cattle was determined based on the presence of hoof prints, excrement, and/or the animals themselves. For each visit, the technician scored the first five dimensions on a scale of *a* to *d*, with *a* indicating no evidence of monitored practices and *d* indicating the highest level of violations. For example, a score of *a* in the first dimension meant that the technician did not find any evidence of cattle in streams (no hoof prints or excrements observed), and a score of *d* would mean finding evidence of the presence of more than 50 head of cattle in streams. The sixth dimension was given a binary score indicating evidence of slash-and-burn practices or not. For all contracts, the technicians recorded data on all six dimensions for each visit, even though the first two dimensions (presence of cattle in streams or forests) were not used in determining compliance for contracts of levels 2 and 3 (since those contracts do not restrict cattle movements on the land).

4. Data and methods

4.1. Sources of data

We combined and analysed two sources of data. The first is a household survey conducted in 2010. All households living in the communities where the Watershared program was implemented were included in the survey. The dataset contains information on demographics, socio-economic status, environmental and social values, and perception of the environment from 462 households in 65 communities (Bottazzi et al., 2017). In our analyses, we used demographic data from the self-determined household head.

The second source is detailed monitoring data from up to three visits on each plot of land enrolled in the program. Data were collected by Natura compliance monitoring technicians and included information such as contract features and monitoring scores for 1823 visits conducted between 2010 and 2014. We describe the data collected and Natura's compliance score calculations in detail in the next section. As previously mentioned, a plot of land can be owned by several individuals from different households: for example, several adult brothers or a combination of parents and adult children. We excluded 81 monitoring visits from our analyses because the plots that were visited could not be linked to a single household.

4.2. Definitions of key variables

4.2.1. Measures of compliance

We use two measures of compliance. One focuses on perfect compliance with all dimensions of the monitoring, and one follow the definition of compliance used by Natura. Natura determines compliance at the contract level, over time, and considers a contract compliant even with less-than-perfect compliance (we provide specific details later in this section). Both definitions have advantages and disadvantages. Perfect compliance is an objective measure, albeit a very strict one and one that Natura's program was not designed to achieve. Compliance as defined by Natura may match the approach to sanctioning used by other implementing organizations, but is dependent upon a particular weighing scheme and threshold for compliance.

Our main measure, perfect compliance with all conditions, was computed at the visit level, the plot (or contract) level, and the household level. Specifically, perfect compliance at the visit level means that the technician reported perfect scores (*a* scores) on all six dimensions of compliance monitoring for a visit. Perfect compliance at the contract level means that all visits to the same plot of land for which a contract was signed were in perfect compliance. Finally, perfect compliance at the household level means that all visits to all plots of land owned by members of the same household were in perfect compliance; the binary variable was set to zero if the compliance score on any dimension in any visit was less than perfect.

The other measure is based on Natura's definition of compliance. Natura defined compliance at the contract level; we show results for Natura-defined compliance at the household and visit levels to match the levels of analysis of perfect compliance, although these are not well-defined. Each letter score for each dimension of the compliance monitoring done by Natura (a to d) was given a number of points, with weights according to the program's priorities (in decreasing order): keeping cattle out of streams, keeping cattle out of forests, preventing the opening of paths/roads, preventing extraction of forest products, and preventing forest fires. Any evidence of slash-and-burn forest clearing yielded automatic non-compliance. Utilizing this scoring structure, Natura monitored contracts over a period of three years. Built into the program is a small level of leeway that is provided in two ways. First, to "pass" a monitoring visit according to Natura's definition, the total score for that visit had to be 90% or higher of all possible points (i.e., excluding the two cattle-related dimensions for levels 2 and 3 contracts). Second, households were not penalized for obtaining fewer than 90% of available points on the first monitoring visit, completed within the first year of contract signing. Rather, Natura used the first visit to discuss issues with the landowner(s) and help bring the contract in compliance. However, if the second or third monitoring visits, conducted two and three years after signing the contract, yielded a score

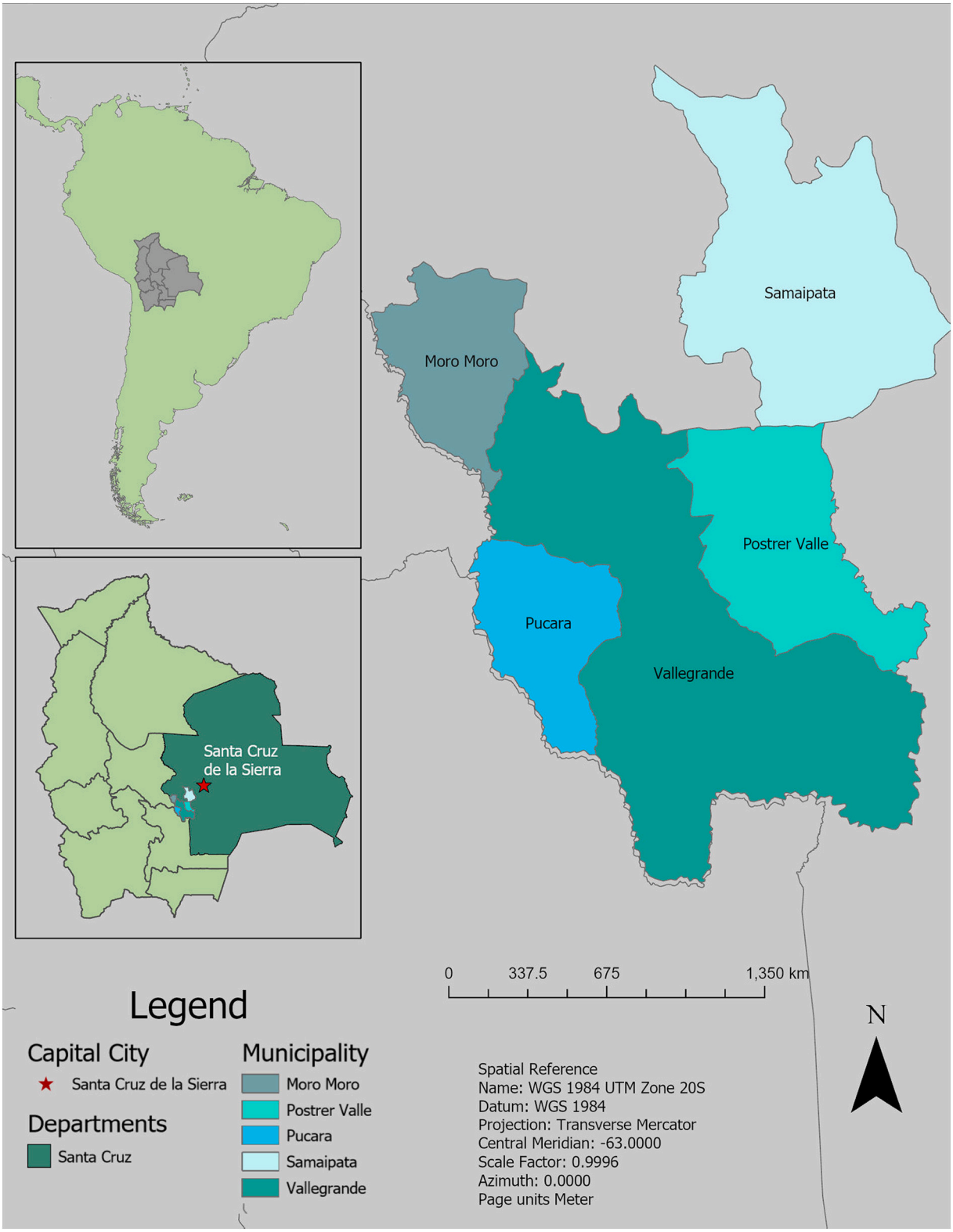

Fig. 1. Location of the program studied.

below 90%, the process of imposing penalty for non-compliance was triggered for that contract's signer(s) (Wiik et al., 2020).

Of the 415 contracts signed in 2011 and 2012 (i.e., at the start of the program), four cases of serious incompliance (< 1% of contracts) were recorded by 2013. Of these four cases, three were sanctioned as per the contractual agreement, and the landowner returned the value of the compensations back to their community. The fourth case followed the death of the landowner, and the community decided not to sanction his descendants, who claimed to have no knowledge of him signing the conservation contract. Natura followed the community's decision. Since 2013, no case of incompliance has been judged serious enough for Natura to engage a sanctioning procedure.

4.2.2. Measures of potential drivers of compliance

The *costs and benefits*-informed variables include contract terms, previous monitoring, previous experience with NGOs, and household economic characteristics. **Contract terms** include the level of incentives and conditions, and the area of the plot under contract, both of which directly determine the value of in-kind incentives received, and the amount of the penalty for non-compliance (i.e., returning the same value to the community). In visit-level regressions, the occurrence of **previous monitoring** is captured by a binary variable equal to one if the plot had previously been visited, and zero if the visit was the first visit. **Prior experience with NGO programs** is reflected by a binary variable equal to one if the household reported having received help from outside institutions (non-governmental organizations, government, other) and zero if it had not. **Household economic characteristics** are represented by measures of income, financial access, and wealth. They measure the household's ability to pay the penalty for non-compliance and influence the cost-benefit calculation in its decision to comply. Specifically, we used six variables: total household monthly income,[4] a binary variable equal to one if any household member owns a bank account and zero if not, the amount of loans taken in the past 12 months, the total land owned by household (in hectares), the number of head of cattle owned by the household, and an index of the household's non-land, non-cattle wealth. The wealth index includes home durable goods (e.g., refrigerator, radio), transportation assets (e.g., motorcycle, tractor), farm durable equipment (e.g., shovel, machete, wheelbarrow), and animals other than cattle (e.g., donkey, chicken, pig). All amounts are expressed in USD at the purchasing-power parity exchange rate at the time of the first roll-out of the program (2010).

We used three binary variables to represent the household's *sensitivity to social pressure*: (a) a variable equal to one if the respondent selected **obedience** from a list of values that they think are important to teach children, and zero otherwise; (b) a variable equal to one if the respondent **participated in community meetings**, and zero otherwise; and (c) a variable equal to one if the respondent **participated in community work** projects (e.g., road maintenance) or in reciprocal agricultural work with other community members, and zero otherwise.

Informed by the self-determination theory, we used three binary variables to measure the strength of a household's *environmental values and beliefs*: (1) a variable equal to one if the respondent agreed or completely agreed that **one can have higher income if the environment is protected**, and zero otherwise; (2) a variable equal to one if the respondent agreed or completely agreed that to **improve conditions of life one needs to damage the environment**, and zero otherwise; and (3) a variable equal to one if the respondent selected **protecting the environment** from a list of values that they think are important to teach children, and zero otherwise.

Finally, we constructed four binary variables related to *trust, fairness, and reciprocity*: (1) a variable equal to one if the respondent **trusted NGOs** always or most of the time, and zero otherwise; (2) a variable equal to one if the respondent thought that **higher-income earners in their community should share** with others, and zero otherwise; (3) a variable equal to one if the respondent selected **altruism** from a list of values that they think are important to teach children, and zero otherwise; and (4) a variable equal to one if the respondent agreed or completely agreed that one who **works more should earn more**, and zero otherwise.

4.3. Empirical strategy

The analysis proceeded in three steps. The goal of the first step was to select key variables to be included in our main analysis. To do so, we regressed the measure of compliance on all variables described above, but separately for each group of drivers of compliance. Because each of these regressions only include variables measuring one group of drivers of compliances, they do not provide a complete picture.[5] As such, we did not discuss these specific results in the results section; we show coefficients in Appendices A to D.

Second, the main regression model included those variables that were statistically significantly associated with compliance in each group-specific regression (i.e., in step 1) at the 10% level or higher.[6] We used the 10% cut-off because relatively few household-level variables were associated with compliance. We analysed compliance at the contract and visit levels; Natura defined compliance at the contract level, and examining compliance at the visit level allows us to focus on the role of repeated visits.[7] Our main regression specification is:

$$C_{hpv} = \alpha + \delta_1 CB_{hpv} + \delta_2 SP_h + \delta_3 EV_h + \delta_4 T_h + \delta_4 H_h + \varepsilon_{hpv} \quad (1)$$

where h indexes households, p indexes contracts (plots), and v indexes monitoring visits. C is one of two measures of compliance described above. CB is a vector of variables included in the material cost-benefits group, including the level of the contract signed, size of plot enrolled in program, a binary variable indicating whether a plot had already been visited,[8] a binary variable indicating whether anyone in the household owns a bank account, total household land ownership, and binary variable indicating households that reported having received help from outside institutions. SP is a vector of binary variables measuring sensitivity to social pressure: respondent thinks that teaching obedience to children is important, and respondent participated in community work in the previous 12 months. EV is a vector of three binary variables measuring environmental values and beliefs: respondent believes incomes can be improved if the environment is protected, that the environment needs to be hurt in order to improve livelihoods, and that teaching environmental protection to children is important. T is a vector of binary variables measuring trust, fairness and reciprocity: respondent thinks that higher income earners should share will lower earners, and that teaching altruism to children is important. H is a vector of control variables about the household and the municipality where the household resided, including age of the household head, self-reported gender of the household head, formal schooling completed by the household head, and a set of four binary variables for the five municipalities in which the program was implemented. H is included in all regressions. Since both outcome variables are binary (compliant or not), we used logistic regressions and presented marginal effect coefficients in all

[4] The measure of household income in the data we exploit does not capture all sources of income but focuses on agricultural (value of crops produced, sales of animals) and transfer (government and private) income. These are the main sources of income for the population we study. As a result 36 households have a calculated income of zero. We ran our main analysis excluding these households, results are unchanged (Appendix K).

[5] We calculated four indices for each group of drivers. Chronbach's alphas for all four groups were very low, with the highest of the four equal to 0.18. This is well below the target number of 0.6, suggesting that the individual variables within each group measure distinct dimensions. As a result, coefficients from regression analyses including these indices are not statistically significant (Appendix L).

[6] One exception is the inclusion of a variable measuring total land ownership. While not statistically significant in our test of material costs and benefits drivers (Appendix A), we include it in the main model alongside the measure of the hectares of land enrolled in the program. We show in Appendix J coefficients from regressions with all variables included: results are similar to our main results.

[7] We do not analyse compliance at the household level because it cannot take into consideration contract-specific features since many households sign more than one contract and different types of contract. It would also require clustering standard errors at the municipality level, which would lead to biased standard errors due to the low number of municipalities in our data.

[8] In the contract-level analysis, the variable measuring visit number is omitted; applicable subscripts to Eq. (1) become *hp* instead of *hpv*.

Table 2
Descriptive statistics on households.

	Obs.	Mean	SD	Min	Med.	Max
Total household monthly income (US$ PPP)	462	403	986	0	172	12882
Land owned by household (ha)	439	45	64	0.5	22	400
Household owns bank account (%)	461	12	33			
Heads of cattle owned	462	14	16	0	10	100
Household received help from outside institutions (%)	462	37	48			
Respondent thinks important to teach children obedience (%)	459	44	50			
Respondent participated in community work in last 12 months (%)	462	47	50			
Respondent thinks higher income is compatible with env. protection (%)	456	94	24			
Respondent thinks need to hurt environment to improve livelihoods (%)	455	8	27			
Respondent thinks important to teach children env. Protection (%)	459	43	50			
Respondent thinks higher income earners should share (%)	462	46	50			
Respondent thinks important to teach children altruism (%)	459	20	40			
Age of household head (years)	457	49	14	20	48	87
Respondent is female (%)	460	11	31			
Years of formal schooling	459	5.2	3.6	0	4	14
Household size (members)	462	3.8	1.7	1	4	8

The dataset includes 462 households; lower numbers of observations indicate missing values. Obs.: number of non-missing observations. SD: standard deviation. Med: median. Minimums, medians, and maximums of binary variables are omitted for clarity purposes.

tables. Standard errors were clustered at the household level in all contract- and visit-level analyses, and at the municipality level in all household-level analyses. The last step of our analysis consisted of two robustness tests of our results, described below in the Results section.

5. Results

5.1. Profile of households and their compliance

The final dataset we used for our analyses consisted of 462 households with 757 contracts and a total of 1823 monitoring visits. Key household characteristics are shown in Table 2. A full set of descriptive statistics for all variables used in the first step of the analysis is included in Appendix E.[9] The average household counted four members. Household heads were predominantly male and had completed an average of five years of formal education. Households owned 45 ha of land on average (median: 20, range: 0–400) and 14 head of cattle (median: 10, range: 0–100). The average annual household income was US$403 (median: $172, range: $0–$12,882). Twelve percent of households reported owning a bank account, and 37% had received help from outside institutions (such as NGOs or local and/or national government). About half of households reported having participated in some form of community work in the last 12 months. Overall, respondents reported valuing the environment and environmental protection highly: 94% believed that increasing incomes is compatible with environmental protection; only 8% thought that hurting the environment was necessary to improve livelihoods; and 43% listed protecting the environment as an important value to teach children (compared to 20% who listed altruism and 44% who listed obedience).

Table 3 details contracts and compliance rates. Of the 757 contracts included in our dataset, 571 (75%) were level 1 contracts and the rest were level 2 and 3 contracts. On average, each household signed 1.6 contracts, and we have data on 2.4 monitoring visits per contract (our monitoring data were extracted before the end of some contracts). Overall, 72% of visits were perfectly compliant, 54% of contracts were compliant on all their visits, and 38% of households were compliant on all their contracts and all their visits. In terms of compliance as defined by Natura, 83% of contracts and 85% of visits were in compliance; the percentage is undefined at the household level. This estimate is on the higher end, but still within the range, of compliance self-reported by participants in the program (Bottazzi et al., 2018).

Table 3
Descriptive statistics on compliance at the household, contract, and visit levels.

Panel A. Household-level data	
Number of households	462
Perfect compliance (%)	38
Panel B. Contract-level data	
Number of contracts – All levels	757
Number of contracts – Level 1	571
Number of contracts – Levels 2&3	186
Perfect compliance (%)	54
Natura compliance (%)	83
Panel C. Visit-level data	
Number of monitoring visits to plots	1823
Perfect compliance (%)	72
Natura compliance (%)	85

Households may sign more than one contract to protect more than one piece of land through Natura's program: 1 contract = 1 plot. Each plot of land is visited 1–3 times to measure compliance. Natura defines compliance at the contract level, based on visit-level measures; Natura-measured compliance is undefined at the household level.

5.2. Results of regression model combining all groups of drivers

In this section we report results from regression analysis, which included statistically significant variables from the models exploring the four groups of drivers of compliance, as well as additional socio-demographic characteristics. Fig. 2 shows plots of the coefficients, and Appendix F shows exact coefficients and standard errors. Four main findings emerged. First, contract level mattered for compliance, in all specifications and using both definitions of compliance. On average, level 1 contracts were 31–52 percentage points less likely to be in compliance than levels 2 and 3 contracts ($p \leq 0.001$).

Second, the area of plots under contract was consistently and statistically significantly associated with compliance, although the magnitude of the effect was small. Specifically, the likelihood that a contract or visit was in compliance increased by 0.2 percentage points for each additional hectare of land put under contract ($p \leq 0.018$). To put these coefficients in context, the average plot of land under contract was 11 ha (median = 2.5 ha).

Third, having been previously monitored for compliance by a Natura

[9] Descriptive statistics by contract type (level 1 vs. levels 2 and 3) are shown in Appendix M. The two groups of households are similar in most characteristics. We did not implement statistical tests to compare these averages since the two groups overlap significantly: 104 households out of 462 have signed both types of contracts.

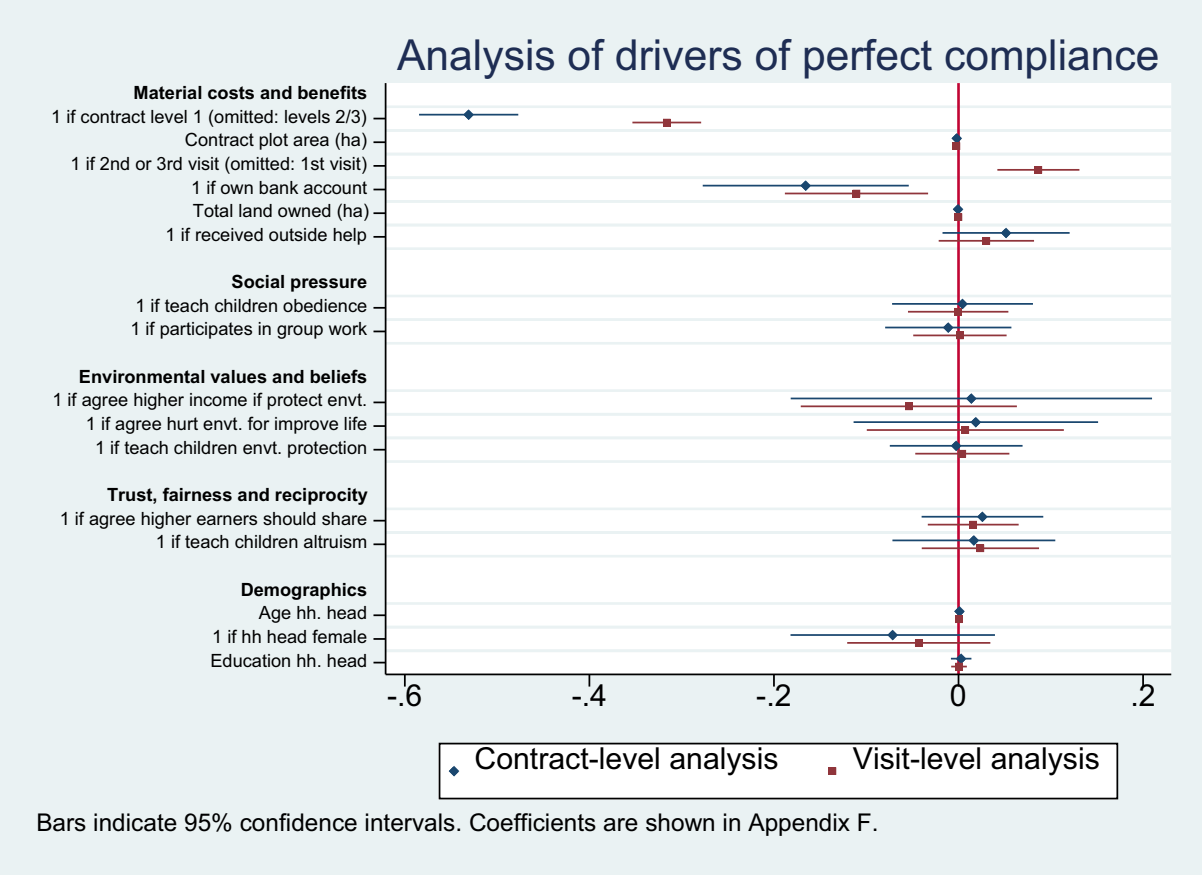

Fig. 2. Coefficient plot of analysis of perfect compliance.

technician was associated with a 9-percentage-point increase in the likelihood that a visit was in compliance ($p < 0.001$). Fig. 3 and Table 4 further shows that rates of perfect compliance increased from the first to the second visit but remained stable from the second to the third visit ($\chi^2 = 0.01$, $p = 0.905$). We further analysed learning over visits with a regression of compliance at the second and third visits, controlling for compliance at the first visit (Table 5). Coefficients on the variable indicating compliance at the first visit are positive and statistically significant in all three regressions in Table 5, and coefficients on the interaction between compliance at the first visit and at the third visit are not significant. These results suggest that initial compliance behaviour carries over visits, and some of the drivers of compliance are not visit-dependent. Yet compliance rates did increase from the first to the second visit (Fig. 3), so participants are learning about the reality of the monitoring regime.

Last, ownership of a bank account was strongly associated with a

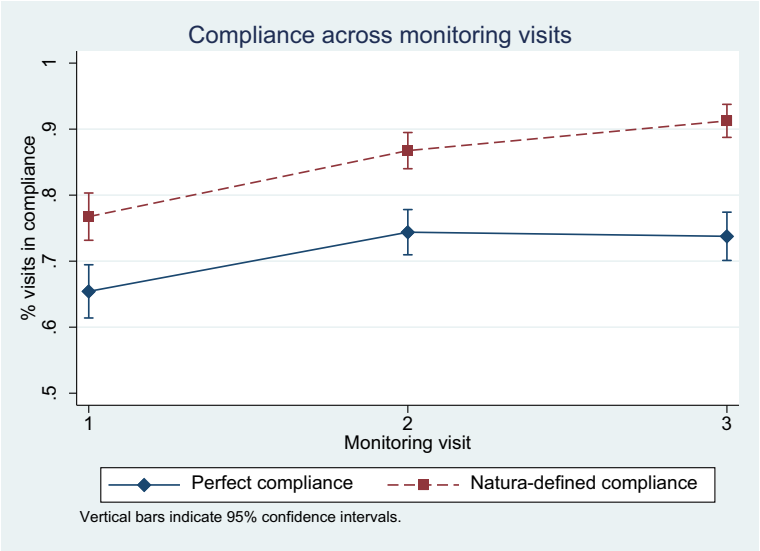

Fig. 3. Compliance rates by monitoring vist.

Table 4
Analysis of compliance for each monitoring visit separately.

	(1)	(2)
Dependent variable:	1 if visit was in compliance; 0 otherwise	
Definition of compliance:	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.316***	−0.151***
	(0.019)	(0.016)
Area of plot enrolled in program (ha)	−0.002***	−0.003***
	(0.001)	(0.000)
1 if visit is 2nd visit; 0 if 1st visit	0.090***	0.100***
	(0.025)	(0.020)
1 if visit is 3rd visit; 0 if 1st visit	0.083***	0.145***
	(0.026)	(0.021)
1 if household owns a bank account	−0.111***	−0.039
	(0.040)	(0.033)
Total household land ownership (ha)	−0.017	−0.020
	(0.203)	(0.155)
1 if household received help from outside institutions	0.030	0.049**
	(0.026)	(0.022)
1 if thinks important to teach children obedience	−0.000	0.021
	(0.028)	(0.024)
1 if household participates in community work	0.002	−0.028
	(0.026)	(0.021)
1 if thinks economy & environment are compatible	−0.054	−0.077
	(0.060)	(0.052)
1 if thinks need to hurt env. to improve livelihoods	0.007	0.007
	(0.054)	(0.040)
1 if thinks important to teach children environmental protection	0.004	0.040*
	(0.026)	(0.022)
1 if thinks higher income earners should share	0.016	0.018
	(0.025)	(0.021)
1 if thinks important to teach children altruism	0.024	0.020
	(0.032)	(0.027)
Age of the household head (years)	0.000	−0.000
	(0.001)	(0.001)
1 if household head is female	−0.043	−0.033
	(0.040)	(0.027)
Years of schooling of household head	0.001	−0.005
	(0.004)	(0.004)
Observations	1632	1606
χ^2 test that coefficient on 3rd visit = coefficient on 2nd visit	0.07	7.30***

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The level of analysis is the visit. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

lower likelihood that the household was in perfect compliance. Households in which one or more members owned a bank account were 11–16 percentage points less likely to perfectly comply ($p \leq 0.007$) than households without a bank account.

5.3. Analysis of compliance as defined by program implementer

A contract-level analysis of Natura-defined compliance provides generally similar results to our main analysis, in coefficients' magnitude and statistical significance (Fig. 4 and Appendix G). Recall from section 4.2.1 that Natura defines compliance at the contract level. Average compliance was lower for levels 2 and 3 contracts ($p < 0.001$), decreased with the area of land enrolled ($p < 0.001$), and was not statistically significantly associated with other variables in the model. The one difference between perfect and Natura-defined compliance is that ownership of a bank account was not statistically significantly associated with Natura-defined compliance; the regression coefficient was small (−0.025 versus −0.159 in the main analysis) and not statistically significant.

Table 5
Analysis of compliance over time.

	(1)	(2)	(3)
Dependent variable:	1 if contract/visit was in compliance; 0 otherwise		
Level of analysis:	Visit	Visit	Contract (=plot)
Definition of compliance:	Perfect	Natura	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−3.828***	−4.157***	−0.153***
	(0.952)	(1.065)	(0.024)
Area of plot enrolled in program (ha)	−0.018	−0.025*	−0.001
	(0.013)	(0.014)	(0.002)
1 if 1st visit was in compliance; 0 if not	1.192***	1.251***	0.190***
	(0.248)	(0.261)	(0.030)
1 if visit is 3rd visit; 0 if 2nd visit	0.132	0.119	
	(0.213)	(0.270)	
3rd visit * 1st visit was in compliance	−0.263	−0.167	
	(0.307)	(0.327)	
1 if household owns a bank account	−0.508	−0.529	−0.068
	(0.334)	(0.345)	(0.053)
Total household land ownership (ha)	1.676	1.201	0.122
	(1.726)	(1.727)	(0.305)
1 if household received help from outside institutions	−0.043	−0.096	−0.000
	(0.209)	(0.207)	(0.034)
1 if thinks important to teach children obedience	0.070	−0.046	0.007
	(0.223)	(0.220)	(0.036)
1 if household participates in community work	0.078	0.120	−0.019
	(0.203)	(0.203)	(0.033)
1 if thinks economy & environment are compatible	−0.774	−0.539	−0.061
	(0.482)	(0.521)	(0.104)
1 if thinks need to hurt env. to improve livelihoods	0.277	0.264	0.112
	(0.447)	(0.464)	(0.079)
1 if thinks important to teach children environmental protection	−0.114	−0.200	0.022
	(0.213)	(0.211)	(0.036)
1 if thinks higher income earners should share	−0.015	0.033	0.068**
	(0.197)	(0.195)	(0.032)
1 if thinks important to teach children altruism	0.402*	0.353	0.040
	(0.227)	(0.226)	(0.043)
Age of the household head (years)	0.008	0.010	0.002
	(0.008)	(0.008)	(0.001)
1 if household head is female	−0.397	−0.378	−0.079
	(0.311)	(0.320)	(0.056)
Years of schooling of household head	0.005	0.015	0.000
	(0.033)	(0.033)	(0.005)
Observations	861	859	468

Coefficients in columns 1 and 2 are from logistic regressions (constant omitted); coefficients in column 3 are marginal effects after a logistic regression. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. The sample in columns (1,2) is limited to the second and third visits. The measure of compliance at the 1st visit is the same as that indicated in the heading: perfect in column (1), Natura-defined in columns (2,3). Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

We implemented our analysis with a visit-level measure of Natura-defined compliance, which is equal to one if the visit monitoring score was ≥90% of all possible points and zero if the score was <90%. This analysis maintains the key results of the visit-level analysis of perfect compliance: contract level, area enrolled, and having been previously visited showed the same relation with compliance (Fig. 2 and Appendix F). However, four differences emerged. First, rates of Natura-defined compliance increased between the second and third visits by 5

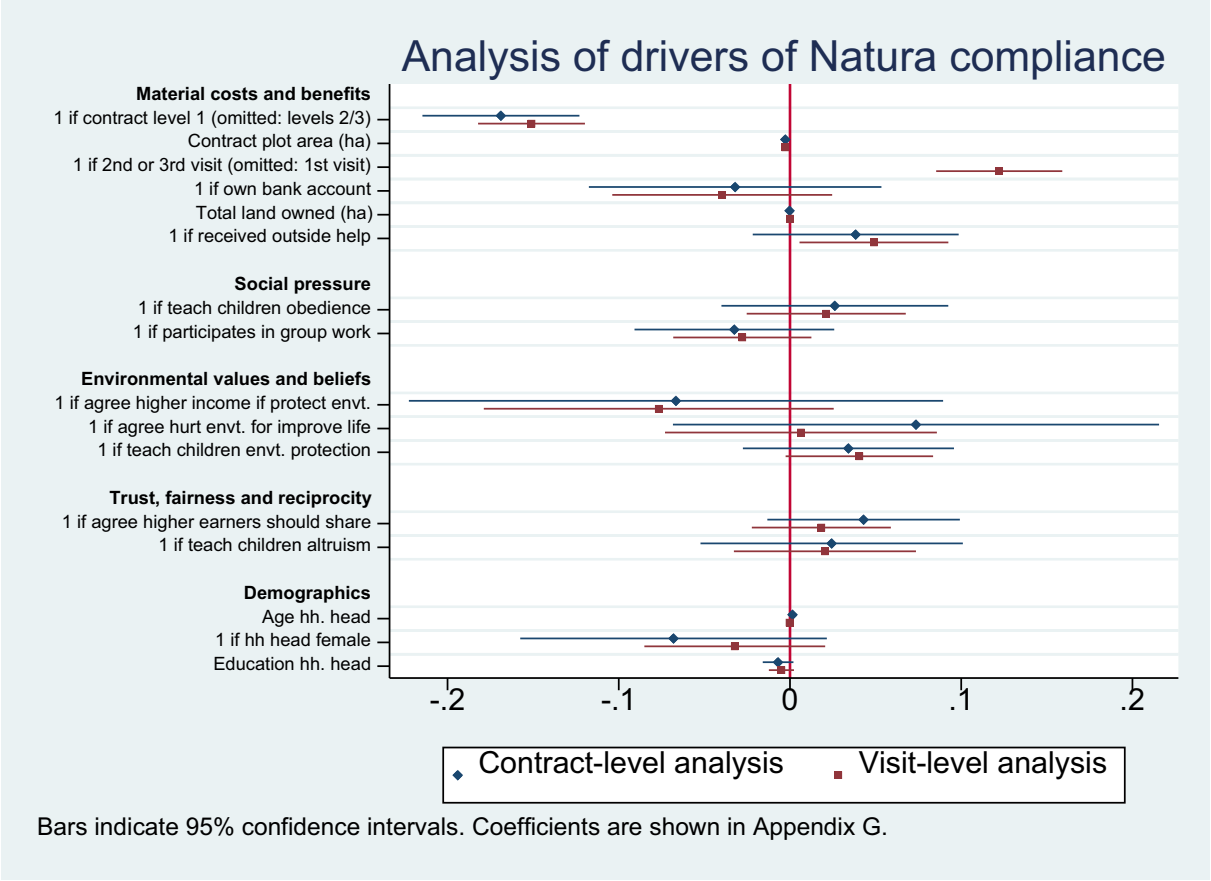

Fig. 4. Coefficient plot of analysis of Natura compliance.

percentage points ($\chi^2 = 8.18$, $p = 0.004$). Second, as mentioned above, there was no statistically significant association between ownership of a bank account and Natura-defined compliance. Third, having received help from outside institutions, including NGOs, municipalities, or the national government, was associated with a 5-percentage point higher likelihood that a visit was in compliance ($p = 0.021$). Last, a measure of environmental values and beliefs – the respondent stating that they considered teaching children about environmental protection as important – was associated with a 5-percentage-point higher likelihood that a visit was in compliance ($p = 0.041$).

5.4. Robustness tests

We conducted two tests of robustness of our main findings. First, we reduced the data to include only contracts that were visited three times for compliance monitoring (Appendix H). The objective was to estimate correlates of compliance in a sub-set of contracts and households that were subject to a complete monitoring regime. Results largely concurred with our previously reported main findings. Two differences stood out. One was that the size of the plot with a contract was not statistically significantly associated with the likelihood of compliance anymore. The magnitude of the association was very small in our main results, which may be related to this change. The other difference was that, when we limited the sample to contracts that were visited three times, the average compliance likelihood was 14 percentage points lower if the respondent considered economic growth and environmental conservation being compatible. Only one regression coefficient out of four shown for that variable in Appendix H was statistically significant, so this result itself was not robust.

In a second robustness test, we implemented multilevel mixed-effects regressions to model the three levels of the data: households, contracts, and visits. Households enrolled one or more plots into Natura's program, and each plot was visited up to three times. We specified random effects at the household and contract levels; as in the main model, we clustered standard errors at the household level. Results were very similar to our main findings (Appendix I).

6. Discussion

Taken together, our results indicate that drivers of compliance informed by material costs and benefits calculations (Hypothesis 1) were key to understanding compliance in the Watershared incentive-based conservation program. Other groups of possible drivers—social pressure (Hypothesis 2), intrinsic motivations and environmental values and beliefs (Hypothesis 3), trust, fairness and reciprocity (Hypothesis 4), and household demographics (Hypothesis 5)—were not consistently statistically significantly associated with compliance. In addition, not all material costs and benefits-informed drivers mattered for compliance: program design features, rather than household economic characteristics, exhibited the strongest association with compliance rates. We analysed three key program design features: contract type, size of plots enrolled, and frequency of monitoring visits. In this section, we discuss and contextualize the evidence on these features and the mixed results on household economic characteristics.

As detailed earlier, there are two types of Watershared contracts: the more restrictive contracts provided larger incentives (level 1) and the less restrictive contracts provided smaller incentives (levels 2 and 3). Level 1 contracts represented 75% of contracts in our data, likely due to the higher incentives. However, average compliance rates – measured as both perfect compliance and Natura compliance – were much lower for level 1 contracts than for levels 2 and 3 contracts. This suggests that participants with more restrictive contracts were either having trouble

abiding by the program conditions or were calculating that the benefits of the program outweighed the costs of any sanctions for non-compliance. Our data did not allow us to test these alternative hypotheses.

The size of plots enrolled (i.e., the second program feature we analysed) was also a significant driver of compliance in the Watershared program. Specifically, compliance was lower for contracts covering larger plots of land. The magnitude of the relationship was small, given the average size of the plots under contract being 11 ha, but the association was statistically robust across several regression models and using both definitions of compliance. This result may be explained by the fact that it can be difficult for participating households to enrol a large plot of land, particularly if it represents a large portion of their total land ownership, because it could limit the potential land uses that are important for their livelihoods (e.g., cattle grazing, timber harvesting).

These first two results shed light on several challenges facing PES programs. Generally, conservation professionals and policy makers would like to see more landowners putting more land into more stringent conservation programs because forest and other land conservation activities are more relevant to owners of larger land holdings; because large plots of land tend to provide more ecosystem services; and because more stringent land use restrictions are often considered to be more environmentally effective (e.g., Eggers et al., 2014; Farmer et al., 2017; Garrett et al., 2018; Hatcher et al., 2013; Lambin et al., 2014). Our data suggest that it is crucial to both incentivize landowners to put more land into conservation programs and to also facilitate their ability to comply with program conditions. This can perhaps be achieved by better clarifying what their trade-offs may be; we consider the specific trade-off in additionality between contract type and compliance in more detail in the conclusion. Another challenge relates to the potentially higher costs (i.e., time, effort, and/or money) associated with complying with program conditions on larger plots of land. In our study context, participants in the Watershared program often chose barbed wire as an incentive for program participation, which they used to fence off streams on their land from cattle access or for other purposes. However, in addition to barbed wire, households also needed posts to build fence. Conversations with Watershared program participants (as part of a separate, ongoing qualitative interview-based research project) suggest that fence posts can be costly (whether purchased or harvested from one's land, due to labour costs), especially when a household enrolled a larger plot of land. As discussed in Leimona and Carrasco (2017), labour constraints can significantly decrease compliance in PES programs. It is thus important for policy makers to consider the full range of costs associated with households' participation and their influence on compliance, and to identify potential strategies for providing supplemental resources to mitigate participants' hidden costs of conservation (Kabii and Horwitz, 2006; Sorice and Donlan, 2015).

The last key program feature we analysed was the frequency of monitoring visits. Our data show that having been previously monitored was strongly associated with higher levels of compliance. Compliance rates (perfect and as defined by Natura) increased sharply from the first to the second visit, then stayed roughly stable in the third visit, suggesting that some learning happens early on but additional learning was limited after the first visit (Fig. 3). One possible explanation is that over time program participants learned that Natura was serious about monitoring, leading to increased compliance. In a study of Ecuador's Pimampiro watershed protection program, researchers suggested that "participants have learned over time that they need to comply with the rules to be paid" (Wunder and Alban, 2008, p. 690). Another possible explanation of our result could be relational trust between Natura and program participants. Relational trust can be defined as the extent to which there is mutual understanding of expectations and obligations that often arises from repeated social interactions through which beliefs about good faith efforts of others, honesty, and good intention are developed (Lewicki et al., 2006; Stern and Baird, 2015; Zaheer et al., 1998). Previous studies have shown that relational trust can emerge from multiple sources including but not limited to the charisma of the trustee, shared experiences, assumptions of similar values and backgrounds, shared membership in a social group, and demonstration of active listening, and can be highly predictive of subsequent collaborative behaviours (Grillos, 2017; Stern and Coleman, 2019). The theory of change driving Natura's Watershared program is strongly based on reciprocity and relational trust between Natura and their program participants (Asquith, 2020). The second and third monitoring visits could have been viewed by program participants as a demonstration of Natura being reliable and committed to their communities which would contribute to the development of relational trust and in turn reinforce compliance with program conditions (Mould et al., 2020). Although our dataset did not allow testing of this explanation, conversations with Watershared program managers and participants support this explanation.

Beyond program design features, household economic characteristics – including income, land ownership, cattle ownership, ownership of non-land and non-cattle wealth – were largely not statistically significantly associated with compliance in our study. Even though income, wealth, land tenure, and other economic factors have been the subject of many studies, their role in shaping landowner participation in natural resource management and conservation programs is less than conclusive. A recent review shows that income is consistently and positively associated with the adoption of agricultural conservation practices (Prokopy et al., 2019), while other studies suggest that income may not be a significant determinant of participation in conservation programs for landowners who own land for reasons beyond production (e.g., Drescher et al., 2017; Ma et al., 2012). Our results provide further evidence that the role of income and other household economic characteristics in shaping compliance in incentive-based conservation programs is limited.

At the same time, our study suggests that one less frequently studied household economic characteristic may matter in predicting compliance. Specifically, ownership of a formal bank account was consistently associated with lower perfect compliance (although it was not associated with Natura compliance). This result is difficult to interpret, but two entirely different explanations seem plausible. First, having a bank account may be an indicator of the household's ability to access lump sums in case of need, for example, to repay a penalty for non-compliance. However, such lump sums could come from other sources such as loans, and the amount of loans received in the previous year was not statistically significant and did not change the bank account ownership result (Appendix J).

The second possible explanation is that owning a bank account may indicate that a rural household has only one foot in the community, with the other foot already formally connected with the world outside of the village where their land is located. Being less embedded in a rural community, and presumably less physically present in the rural community, may help explain why some participants in the Watershared program were less likely to fully comply with the program conditions that require landowners to be present and actively monitor cattle movements and other source conditions on their land (level 1 contracts). However, there was no significant association between ownership of a bank account and Natura-defined compliance, suggesting that this relationship may be spurious.

There are two other notable differences between strict compliance and compliance as defined by Natura. Having received help from outside institutions was associated with a 5-percentage-point higher likelihood that a visit was in compliance (as measured by Natura). There was a similar higher likelihood of compliance by respondents who considered it important to teach children about environmental protection, although the regression coefficient was only statistically significant at the 10% level. Both of these results may be predicted by Watershared's theory of change, which, unlike traditional PES programs, focuses on strengthening intrinsic motivations for conservation (Bottazzi et al., 2018) and

building relationships and community awareness about joint problems and shared solutions of incentive-based watershed management.

A limitation of our study was that our operationalization of different drivers of compliance was limited by the data available to us, which partially came from a household survey that was designed for a different purpose. We ran regressions with an expansive set of control variables to increase our confidence that our results did not depend upon the specific variables included in the main analysis; results were similar to the main results (Appendix J). Another limitation is that the studies from which we identified potential groups of compliance drivers were not all related to incentive-based conservation, or to our geographic region. Indeed, some of this prior research was aimed to understand compliance (or human behaviour more generally) outside of the field of natural resource management. Finally, our data and analyses are based on a single PES-like program implemented in a specific setting, and are therefore not well suited to assessing the role of a variety of program design features. Some design features of programs such as frequency of monitoring and size of sanctions, among others, could be related to compliance but we could not evaluate them using our dataset. Specifically, contract variations that account for varying opportunity costs (Ferraro, 2008), timing of awarding incentives (Snilsveit et al., 2019), and considerations for contract duration and strength of contract restrictions (Börner et al., 2013) may impact compliance drivers in different ways.

7. Conclusion

Although conditionality has been considered a key component of incentive-based conservation programs, like PES (Wunder, 2015, 2005; Wunder et al., 2018), few studies have examined drivers of compliance with the obligations that are required for the program participants to receive incentives. We drew upon the economics, psychology, sociology, and environmental studies disciplines to identify and empirically estimate such drivers. Our results indicate that program design features, rather than household characteristics, are key correlates of compliance. Specifically, our results emphasize the importance of the level of restrictions placed on land under contract, and the need for monitoring (although the marginal effect of repeated monitoring seemed to decrease beyond the second visit).

Although monitoring is often built into PES programs on paper, it is often lacking in practice (Bauchet et al., 2020). Our results show that least one round of intensive monitoring is critically important—to demonstrate to participants that the program really is quid pro quo. However, a third round of monitoring (or likely additional rounds) might end up costing more than it is worth and could perhaps be usefully replaced by less intensive regimes, or no monitoring.

Our results also provide additional insights into the potential of PES programs to produce ecosystem services on a large scale. Contracts that provide a higher value of incentives, in exchange for more restrictions, exhibited lower levels of compliance on average than less restrictive contracts. Contracts covering larger plots of land were also less likely to be in compliance than contracts covering smaller plots. Together, these results suggest important trade-offs in the ability of programs to generate large-scale ecological impacts: factors that increase the amount of ecosystem services to be produced also appear associated with increased non-compliance, hence, possibly reducing the associated ecological impacts of the programs. Within the PES literature, several scholars have explicitly discussed trade-offs associated with program design. For example, Ferraro (2008) identified a key trade-off between PES programs' additionality and budgets, due to information asymmetry between buyers and sellers of ecosystem services. Jack et al. (2008) and Jindal et al. (2013) also examined the trade-off between increasing programs' cost-effectiveness and poverty reduction impacts. As such, our results contribute to ongoing discussions about considerations of trade-offs when designing PES programs. It is particularly important for policy makers to carefully design their program features and clearly communicate with program participants about program conditions for receiving conservation incentives, subsequent monitoring, and potential sanctions for non-compliance (Bauchet et al., 2020).

Declaration of Competing Interest

Two co-authors previously held positions with Fundación Natura Bolivia, the partner organization that provided the data used in the study. We do not believe this affected the work reported in this manuscript. The analysis and interpretation of results was done jointly with all co-authors. All other co-authors have no competing interests to declare.

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Appendix A. Analysis of the material costs and benefits group of drivers of compliance

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.535***	−0.177***	−0.320***	−0.154***
	(0.026)	(0.023)	(0.019)	(0.015)
Plot area (ha)	−0.002**	−0.003***	−0.002***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.000)
1 if visit is 2nd or 3rd visit; 0 if 1st visit			0.089***	0.118***
			(0.022)	(0.019)
Log(total household monthly income (US$ PPP) + 1)	0.009	−0.003	0.008	0.002
	(0.010)	(0.009)	(0.008)	(0.007)
1 if household owns a bank account	−0.169***	−0.032	−0.112***	−0.041
	(0.055)	(0.041)	(0.038)	(0.033)
Amount of loans taken in past 12 months (US$, PPP)	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Total land owned by household (ha)	−0.319	−0.041	0.057	0.077
	(0.358)	(0.289)	(0.242)	(0.201)

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(*continued*)

	(1)	(2)	(3)	(4)
Heads of cattle owned by household	−0.001	−0.001	−0.000	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Index of household's non-land, non-cattle wealth	0.004	0.021	−0.018	−0.004
	(0.021)	(0.016)	(0.015)	(0.013)
1 if household received help from outside institutions	0.045	0.021	0.032	0.041*
	(0.035)	(0.030)	(0.026)	(0.023)
Age of the household head (years)	0.001	0.002	0.001	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.058	−0.058	−0.034	−0.028
	(0.056)	(0.043)	(0.038)	(0.026)
Years of schooling of household head	0.003	−0.009**	0.003	−0.005
	(0.006)	(0.004)	(0.004)	(0.004)
Observations	701	655	1668	1642

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented (not shown). Household-level regressions are not included because they could not include contract- and visit-specific variables. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix B. Analysis of the social pressure group of drivers of compliance

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if thinks important to teach children obedience	0.046	0.042	0.031	0.024
	(0.038)	(0.032)	(0.027)	(0.022)
1 if household participates in community meetings	−0.026	0.002	−0.033	0.004
	(0.059)	(0.049)	(0.040)	(0.033)
1 if household participates in community work	0.006	−0.029	0.014	−0.021
	(0.038)	(0.031)	(0.027)	(0.022)
Age of the household head (years)	0.000	0.001	0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.088	−0.063	−0.045	−0.040
	(0.063)	(0.046)	(0.043)	(0.028)
Years of schooling of household head	−0.002	−0.010**	−0.003	−0.007**
	(0.006)	(0.004)	(0.004)	(0.003)
Observations	738	691	1751	1725

Coefficients are marginal effects after logistic regressions. Clustered standard errors in parentheses: by municipality (cols 1–2), by household (cols 3–6). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented (not shown). Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix C. Analysis of the environmental values and beliefs group of drivers of compliance

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if thinks economy & environment are compatible	−0.085	−0.078	−0.080	−0.093*
	(0.093)	(0.074)	(0.062)	(0.049)
1 if thinks need to hurt environment to improve livelihoods	0.029	0.098	−0.006	0.007
	(0.076)	(0.076)	(0.056)	(0.044)
1 if thinks important to teach children environmental protection	0.020	0.028	0.014	0.037*
	(0.038)	(0.030)	(0.027)	(0.022)
Age of the household head (years)	0.000	0.001	0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.101	−0.067	−0.056	−0.042
	(0.065)	(0.047)	(0.043)	(0.028)
Years of schooling of household head	−0.004	−0.011**	−0.004	−0.007**
	(0.006)	(0.004)	(0.004)	(0.003)
Observations	722	677	1717	1691

Coefficients are marginal effects after logistic regressions. Clustered standard errors in parentheses: by municipality (cols 1–2), by household (cols 3–6). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented (not shown). Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix D. Analysis of the trust, fairness and reciprocity group of drivers of compliance

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if trusts NGOs always or most of the time	0.009	−0.025	−0.002	−0.007
	(0.039)	(0.032)	(0.028)	(0.023)
1 if thinks higher income earners should share	0.009	0.027	−0.002	0.006
	(0.038)	(0.030)	(0.027)	(0.022)
1 if thinks important to teach children altruism	0.018	−0.007	0.025	0.006
	(0.050)	(0.040)	(0.034)	(0.027)
1 if thinks one who works more should earn more	0.031	0.013	0.024	0.017
	(0.066)	(0.050)	(0.047)	(0.039)
Age of the household head (years)	0.000	0.001	0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.095	−0.063	−0.053	−0.040
	(0.063)	(0.045)	(0.044)	(0.028)
Years of schooling of household head	−0.003	−0.010**	−0.004	−0.007**
	(0.006)	(0.004)	(0.004)	(0.003)
Observations	734	689	1745	1719

Coefficients are marginal effects after logistic regressions. Clustered standard errors in parentheses: by municipality (cols 1–2), by household (cols 3–6). ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented (not shown). Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix E. Descriptive statistics, all variables in complete model

	Obs.	Mean	SD	Min	Med.	Max
Total household monthly income (US$ PPP)	462	403	986	0	172	12,882
Household owns bank account (%)	461	12	33			
Amount of loans taken in past 12 months (US$, PPP)	458	704	3462	0	0	40,500
Land owned by household (ha)	439	45	64	0.5	22	400
Heads of cattle owned	462	14	16	0	10	100
Index of household's non-land, non-cattle wealth	462	0	1	−1.94	−0.153	4.4
Household received help from outside institutions (%)	462	37	48			
Respondent thinks important to teach children obedience (%)	459	44	50			
Household participated in community meetings (%)	461	84	37			
Respondent participated in community work in last 12 months (%)	462	47	50			
Respondent thinks higher income is compatible with env. protection (%)	456	94	24			
Respondent thinks need to hurt environment to improve livelihoods (%)	455	8	27			
Respondent thinks important to teach children env. protection (%)	459	43	50			
Respondent trusts NGOs always or most of the time (%)	459	55	50			
Respondent thinks higher income earners should share (%)	462	46	50			
Respondent thinks important to teach children altruism (%)	459	20	40			
Respondent thinks one who works more should earn more (%)	462	91	29			
Age of household head (years)	457	48.8	14.1	20	48	87
Respondent is female (%)	460	11	31			
Years of formal schooling	459	5.2	3.6	0	4	14
Household size (members)	462	3.8	1.7	1	4	8

The dataset includes 462 households; lower numbers of observations indicate missing values. Obs.: number of observations. SD: standard deviation. Med: median. Minimums, medians, and maximums of binary variables are omitted for clarity purposes. The wealth index was built with a mean of 0 and a standard deviation of 1.

Appendix F. Combined analysis of compliance

	(1)	(2)
Dependent variable:	1 if contract/visit was in perfect compliance; 0 otherwise	
Level of analysis:	Contract (=plot)	Visit
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.531***	−0.316***
	(0.027)	(0.019)
Area of plot enrolled in program (ha)	−0.002**	−0.002***
	(0.001)	(0.001)
1 if visit is 2nd or 3rd visit; 0 if 1st visit		0.087***
		(0.023)
1 if household owns a bank account	−0.166***	−0.111***
	(0.057)	(0.040)
Total household land ownership (ha)	−0.416	−0.018
	(0.322)	(0.203)
1 if household received help from outside institutions	0.052	0.030
	(0.035)	(0.026)

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	(1)	(2)
1 if thinks important to teach children obedience	0.004	−0.000
	(0.039)	(0.028)
1 if household participates in community work	−0.011	0.002
	(0.035)	(0.026)
1 if thinks economy & environment are compatible	0.014	−0.054
	(0.100)	(0.060)
1 if thinks need to hurt env. to improve livelihoods	0.019	0.007
	(0.068)	(0.054)
1 if thinks important to teach children environmental protection	−0.003	0.004
	(0.037)	(0.026)
1 if thinks higher income earners should share	0.026	0.016
	(0.034)	(0.025)
1 if thinks important to teach children altruism	0.017	0.024
	(0.045)	(0.032)
Age of the household head (years)	0.001	0.001
	(0.001)	(0.001)
1 if household head is female	−0.071	−0.043
	(0.057)	(0.040)
Years of schooling of household head	0.003	0.001
	(0.006)	(0.004)
Observations	685	1632

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. This table presents regression coefficients used in Fig. 2. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more.

Appendix G. Analysis of compliance as defined by Natura

	(1)	(2)
Dependent variable:	1 if contract/visit was in compliance as defined by Natura; 0 otherwise	
Level of analysis:	Contract (=plot)	Visit
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.169***	−0.151***
	(0.023)	(0.016)
Area of plot enrolled in program (ha)	−0.003***	−0.003***
	(0.001)	(0.000)
1 if visit is 2nd or 3rd visit; 0 if 1st visit		0.122***
		(0.019)
1 if household owns a bank account	−0.032	−0.040
	(0.044)	(0.033)
Total household land ownership (ha)	−0.200	−0.019
	(0.226)	(0.156)
1 if household received help from outside institutions	0.038	0.049**
	(0.031)	(0.022)
1 if thinks important to teach children obedience	0.026	0.021
	(0.034)	(0.024)
1 if household participates in community work	−0.032	−0.028
	(0.030)	(0.021)
1 if thinks economy & environment are compatible	−0.067	−0.077
	(0.080)	(0.052)
1 if thinks need to hurt env. to improve livelihoods	0.074	0.006
	(0.072)	(0.041)
1 if thinks important to teach children environmental protection	0.034	0.040*
	(0.031)	(0.022)
1 if thinks higher income earners should share	0.043	0.018
	(0.029)	(0.021)
1 if thinks important to teach children altruism	0.024	0.020
	(0.039)	(0.027)
Age of the household head (years)	0.002	−0.000
	(0.001)	(0.001)
1 if household head is female	−0.068	−0.032
	(0.046)	(0.027)
Years of schooling of household head	−0.007	−0.005
	(0.005)	(0.004)
Observations	641	1606

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. This table presents regression coefficients used in Fig. 4. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix H. Main analysis, contracts with all 3 monitoring visits only

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Perfect	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.612***	−0.180***	−0.336***	−0.153***
	(0.028)	(0.024)	(0.020)	(0.015)
Area of plot enrolled in program (ha)	−0.003	−0.001	−0.004	0.001
	(0.003)	(0.003)	(0.003)	(0.004)
1 if visit is 2nd or 3rd visit; 0 if 1st visit			0.101***	0.133***
			(0.025)	(0.021)
1 if household owns a bank account	−0.320***	−0.110*	−0.160***	−0.073*
	(0.090)	(0.059)	(0.050)	(0.039)
Total household land ownership (ha)	0.294	0.051	0.226	0.137
	(0.434)	(0.306)	(0.245)	(0.191)
1 if household received help from outside institutions	0.075	0.023	0.032	0.043
	(0.047)	(0.040)	(0.033)	(0.027)
1 if thinks important to teach children obedience	−0.010	−0.006	−0.014	0.001
	(0.050)	(0.041)	(0.034)	(0.026)
1 if household participates in community work	−0.004	−0.020	0.008	−0.015
	(0.045)	(0.037)	(0.031)	(0.024)
1 if thinks economy & environment are compatible	−0.018	−0.116	−0.083	−0.137**
	(0.124)	(0.110)	(0.071)	(0.064)
1 if thinks need to hurt env. to improve livelihoods	0.005	0.105	−0.002	0.016
	(0.094)	(0.089)	(0.065)	(0.044)
1 if thinks important to teach childrenenvironmental protection	−0.009	0.042	−0.005	0.036
	(0.048)	(0.039)	(0.032)	(0.025)
1 if thinks higher income earners should share	0.020	0.083**	0.005	0.026
	(0.045)	(0.038)	(0.032)	(0.025)
1 if thinks important to teach children altruism	0.039	0.053	0.028	0.032
	(0.057)	(0.050)	(0.040)	(0.031)
Age of the household head (years)	0.000	0.001	0.000	−0.001
	(0.002)	(0.002)	(0.001)	(0.001)
1 if household head is female	−0.076	−0.111*	−0.042	−0.057*
	(0.085)	(0.059)	(0.049)	(0.030)
Years of schooling of household head	0.007	−0.000	0.003	−0.003
	(0.007)	(0.006)	(0.005)	(0.004)
Observations	407	406	1203	1202

Coefficients are marginal effects after logistic regressions. Standard errors cluster by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix I. Main analysis, multilevel mixed-effects regressions

	(1)	(2)
Dependent variable:	1 if visit was in compliance; 0 otherwise	
Definition of compliance:	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.308***	−0.137***
	(0.022)	(0.019)
Area of plot enrolled in program (ha)	−0.001**	−0.003***
	(0.001)	(0.001)
1 if visit is 2nd or 3rd visit; 0 if 1st visit	0.091***	0.126***
	(0.023)	(0.019)
1 if household owns a bank account	−0.116***	−0.040
	(0.043)	(0.038)
Total household land ownership (ha)	−0.037	−0.002
	(0.200)	(0.181)
1 if household received help from outside institutions	0.027	0.046**
	(0.025)	(0.021)
1 if thinks important to teach children obedience	−0.001	0.024
	(0.028)	(0.025)
1 if household participates in community work	0.002	−0.029
	(0.026)	(0.022)
1 if thinks economy & environment are compatible	−0.039	−0.053
	(0.051)	(0.038)
1 if thinks need to hurt env. to improve livelihoods	0.018	0.009
	(0.054)	(0.041)
1 if thinks important to teach children environmental protection	0.006	0.043*
	(0.026)	(0.024)
1 if thinks higher income earners should share	0.021	0.021

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	(1)	(2)
	(0.025)	(0.021)
1 if thinks important to teach children altruism	0.021	0.016
	(0.032)	(0.028)
Age of the household head (years)	0.000	−0.000
	(0.001)	(0.001)
1 if household head is female	−0.045	−0.025
	(0.042)	(0.031)
Years of schooling of household head	0.000	−0.006
	(0.005)	(0.004)
Constant	0.922***	0.956***
	(0.099)	(0.088)
Observations	1632	1606
Number of groups	425	420

Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. The analyses are at the visit level. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix J. Analysis of compliance, full regression model including all variables considered in all groups

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.537***	−0.171***	−0.320***	−0.152***
	(0.027)	(0.024)	(0.019)	(0.016)
Plot area (ha)	−0.002**	−0.003***	−0.002***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
1 if visit is 2nd or 3rd visit; 0 if 1st visit			0.086***	0.122***
			(0.023)	(0.019)
Log(total household monthly income (US$ PPP) + 1)	0.011	−0.002	0.008	0.001
	(0.010)	(0.008)	(0.008)	(0.007)
1 if household owns a bank account	−0.175***	−0.024	−0.109***	−0.034
	(0.058)	(0.044)	(0.040)	(0.034)
Amount of loans taken in past 12 months (US$, PPP)	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Total land owned by household (ha)	−0.335	−0.054	0.116	0.083
	(0.370)	(0.276)	(0.244)	(0.195)
Heads of cattle owned by household	−0.001	−0.002	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Index of household's non-land, non-cattle wealth	0.002	0.019	−0.024	−0.007
	(0.023)	(0.017)	(0.016)	(0.014)
1 if household received help from outside institutions	0.047	0.034	0.033	0.049**
	(0.036)	(0.032)	(0.027)	(0.023)
1 if thinks important to teach children obedience	−0.003	0.029	−0.004	0.023
	(0.039)	(0.035)	(0.028)	(0.024)
1 if household participates in community meetings	−0.007	−0.016	−0.025	−0.000
	(0.059)	(0.053)	(0.043)	(0.036)
1 if household participates in community work	−0.012	−0.033	0.001	−0.030
	(0.035)	(0.030)	(0.026)	(0.020)
1 if thinks economy & environment are compatible	0.029	−0.066	−0.040	−0.077
	(0.100)	(0.080)	(0.061)	(0.055)
1 if thinks need to hurt environment to improve livelihoods	0.023	0.070	0.001	0.002
	(0.070)	(0.073)	(0.055)	(0.042)
1 if thinks important to teach children environmental protection	−0.011	0.039	0.004	0.045**
	(0.037)	(0.032)	(0.026)	(0.022)
1 if trusts NGOs always or most of the time	0.011	−0.024	0.002	−0.006
	(0.036)	(0.032)	(0.027)	(0.024)
1 if thinks higher income earners should share	0.020	0.041	0.017	0.015
	(0.034)	(0.030)	(0.026)	(0.022)
1 if thinks important to teach children altruism	0.018	0.021	0.027	0.021
	(0.045)	(0.040)	(0.033)	(0.027)
1 if thinks one who works more should earn more	−0.010	0.028	0.018	0.036
	(0.057)	(0.049)	(0.044)	(0.037)
Age of the household head (years)	0.001	0.002	0.001	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.066	−0.071	−0.048	−0.035
	(0.057)	(0.047)	(0.040)	(0.028)
Years of schooling of household head	0.004	−0.009**	0.002	−0.005
	(0.006)	(0.005)	(0.004)	(0.004)
Observations	677	634	1613	1587
Standard errors clustered by	Household		Household	

Coefficients are marginal effects after logistic regressions. Clustered standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix K. Analyses of Appendix A, excluding 36 households with income equal to zero

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
1 if contract is level 1; 0 if contract is levels 2 or 3	−0.532***	−0.174***	−0.313***	−0.150***
	(0.027)	(0.024)	(0.019)	(0.016)
Plot area (ha)	−0.002**	−0.003***	−0.002***	−0.003***
	(0.001)	(0.001)	(0.001)	(0.000)
1 if visit is 2nd or 3rd visit; 0 if 1st visit			0.087***	0.113***
			(0.023)	(0.019)
Log(total household monthly income (US$ PPP) + 1)	0.007	−0.007	−0.006	−0.005
	(0.016)	(0.012)	(0.012)	(0.009)
1 if household owns a bank account	−0.171***	−0.028	−0.096**	−0.033
	(0.057)	(0.042)	(0.038)	(0.033)
Amount of loans taken in past 12 months (US$, PPP)	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Total land owned by household (ha)	−0.399	−0.099	−0.035	0.018
	(0.353)	(0.297)	(0.237)	(0.198)
Heads of cattle owned by household	−0.000	−0.001	0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Index of household's non-land, non-cattle wealth	0.005	0.026	−0.015	0.002
	(0.022)	(0.016)	(0.016)	(0.013)
1 if household received help from outside institutions	0.060*	0.025	0.042	0.049**
	(0.036)	(0.031)	(0.027)	(0.023)
Age of the household head (years)	0.000	0.001	0.000	−0.000
	(0.001)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.051	−0.046	−0.043	−0.028
	(0.057)	(0.043)	(0.039)	(0.026)
Years of schooling of household head	0.002	−0.011**	0.002	−0.007**
	(0.006)	(0.005)	(0.004)	(0.004)
Observations	646	610	1538	1516

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented (not shown). Household-level regressions are not included because they could not include contract- and visit-specific variables. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix L. Analysis of compliance, using indices of groups of drivers

	(1)	(2)	(3)	(4)
Dependent variable:	1 if contract was in compliance; 0 otherwise		1 if visit was in compliance; 0 otherwise	
Level of analysis:	Contract (=plot)		Visit	
Definition of compliance:	Perfect	Natura	Perfect	Natura
Index of variables measuring material costs and benefits	0.030	−0.013	0.011	0.001
	(0.022)	(0.018)	(0.015)	(0.012)
Index of variables measuring social pressure	−0.017	−0.020	−0.011	−0.015
	(0.023)	(0.017)	(0.015)	(0.013)
Index of variables measuring environmental values	−0.012	−0.014	−0.007	−0.001
	(0.021)	(0.017)	(0.014)	(0.011)
Index of variables measuring trust, fairness, and reciprocity	0.004	0.005	−0.004	0.001
	(0.021)	(0.015)	(0.014)	(0.012)
Age of the household head (years)	−0.001	0.001	−0.000	−0.001
	(0.002)	(0.001)	(0.001)	(0.001)
1 if household head is female	−0.088	−0.084*	−0.053	−0.044
	(0.064)	(0.048)	(0.044)	(0.029)
Years of schooling of household head	−0.005	−0.011**	−0.005	−0.008**
	(0.006)	(0.005)	(0.005)	(0.004)
Observations	677	634	1613	1587

Coefficients are marginal effects after logistic regressions. Standard errors clustered by household in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. Regressions include 4 binary variables controlling for the 5 municipalities in which the program is implemented. Indices are principal-component indices. Variables measuring material costs and benefits include a binary variable equal to 1 if contract is level 1 and 0 if contract is levels 2 or 3; plot area (ha); a binary variable equal to 1 if visit is 2nd or 3rd visit and 0 if 1st visit; log(total household monthly income (US$ PPP) + 1); a binary variable equal to 1 if household owns a bank account and 0 otherwise; amount of loans taken in past 12 months (US$, PPP); total land owned by household (ha); heads of cattle owned by household; the index of household's non-land, non-cattle wealth; a binary variable equal to 1 if household received help from outside institutions. The index measuring social pressure includes binary variables equal to 1 if thinks important to teach children obedience and 0 if not; 1 if household participates in community meetings and 0 if not; and 1 if household

participates in community work and 0 if not. The index measuring environmental values includes binary variables equal to 1 if thinks economy & environment are compatible and 0 if not; 1 if thinks need to hurt environment to improve livelihoods and 0 if not; and 1 if thinks important to teach children environmental protection and 0 if not. The index measuring trust, fairness, and reciprocity includes binary variables equal to 1 if 1 if trusts NGOs always or most of the time and 0 if not; 1 if thinks higher income earners should share and 0 if not; and 1 if thinks important to teach children altruism and 0 if not; and 1 if thinks one who works more should earn more and 0 if not. Perfect compliance is equal to 1 if the household fulfilled all conditions and 0 if it failed one or more. Natura compliance is equal to 1 if the household obtained at least 90% of points on Natura's weighted compliance scoring (described in detail in the paper), and 0 if not.

Appendix M. Descriptive statistics on households, by contract level

	Households with level 1 contract(s)			Households with levels 2&3 contract(s)		
	Obs.	Mean	SD	Obs.	Mean	SD
Total household monthly income (US$ PPP)	433	402	1012	133	481	1304
Land owned by household (ha)	411	45	62	124	56	74
Household owns bank account (%)	432	12	33	133	0	0
Heads of cattle owned	433	14	15	133	17	19
Household received help from outside institutions (%)	433	37	48	133	47	50
Respondent thinks important to teach children obedience (%)	430	44	50	131	46	50
Respondent participated in community work in last 12 months (%)	433	46	50	133	50	50
Respondent thinks higher income is compatible with env. protection (%)	427	94	23	132	92	28
Respondent thinks need to hurt environment to improve livelihoods (%)	426	8	27	131	7	25
Respondent thinks important to teach children env. protection (%)	430	44	50	131	44	50
Respondent thinks higher income earners should share (%)	433	46	50	133	44	50
Respondent thinks important to teach children altruism (%)	430	21	40	131	15	35
Age of household head (years)	429	49	14	132	47	14
Respondent is female (%)	431	11	31	133	9	29
Years of formal schooling	430	5.2	3.7	133	5.6	3.5
Household size (members)	433	3.8	1.7	133	3.7	1.7

The dataset includes 462 households in total; 433 signed one or more level 1 contracts, and 133 signed one or more levels 2 & 3 contracts (104 households signed contract(s) of both levels). Obs.: number of observations. SD: standard deviation.

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