Designing forest conservation payments in settings with a variety of land tenure systems

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Abstract

We use a simple stated preference approach to assess appropriate payment levels and frequency required for forest conservation across varying tenure systems in Uganda. In individually-managed forests, average willingness to accept (WTA) is 60$/acre, and we find no difference in willingness to participate between those offered quarterly versus annual payments. Among households who share forest access, WTA annual estimates are similar to those of private forest-holders, but WTA in the quarterly treatment arm is higher, possibly as a result of transactions costs required to distribute payments to large numbers of users. Regional variation in WTA is high, and policy simulations indicate that the area of forest at risk enrolled would be maximized by a system of payments that varies by region, since higher payments are required to induce participation in the region with the greatest deforestation risk. In terms of payment distribution, respondents with shared forest state that they would prefer an equal distribution of the payment across all forest users. 30% of tenants with overlapping property rights say that they would require permission from the owner of the land to participate, and 22% indicate that they would need to share their forest conservation payment with the owner. However, despite this sharing conditionality, participants with overlapping forest tenure do not require higher payments to participate.

Keywords: Conditional cash transfers; payments for ecosystem services; stated preference
JEL codes: Q56; O13; Q21

1 Introduction

Despite a growing global commitment to natural climate solutions (Griscom et al. 2017), policymakers continue to struggle with designing an effective policy to combat deforestation, which is a threat to both environmental services and rural livelihoods (MacDicken et al. 2016, Fadairo et al. 2021). Payments for ecosystem services (PES) programs, which compensate land managers for conservation activities on their own land, present a potential win-win market solution to the challenge of ecosystem conservation. There are a number of successful PES programs in countries across the wealth spectrum, including the United States, Europe, Costa Rica, and Mexico. However, questions remain about PES program design in settings where land tenure is complex and thin land markets make it difficult to establish appropriate payment levels. This paper assesses Ugandan households' willingness to accept forest conservation payments, and illuminates key design features including potential variation across land tenure systems and payment frequency.

Uganda is an important location in which to examine these questions. In 2009, the executive director of the Ugandan National Environment Management Authority (NEMA) reported that if deforestation continued at the current rate, Uganda would have no forests left within 41 years (Kelly 2009). Since then, Uganda's deforestation rate has increased from 3.3% per year between 2000 and 2010 to 5.5% between 2010 and 2015 (MacDicken et al. 2016), mostly driven by subsistence agriculture and charcoal production (Fisher 2010). Further, Uganda has a land tenure structure which is unique (Musinguzi et al. 2020, Ali & Duponchel 2018), but also representative of the types of property rights complexities that arise as a result of colonial histories (Initiative & Resources 2015).

It has been demonstrated that trading money for forest conservation can lead to conserved forest (see Miteva et al. (2015) and Alix-García & Wolff (2014) for reviews of the literature). PES programs have existed in large scale for many years in Costa Rica, China, Argentina, Ecuador, and Mexico, among other countries. Evaluations of PES programs in developing countries have found modest impacts in terms of avoided deforestation and generally positive but small impacts on livelihoods (Arriagada et al. 2012, Alix-García et al. 2012, Robalino & Pfaff 2013, Robalino et al.

2014, Alix-García et al. 2015, Jayachandran et al. 2017). However, the results of both Jayachandran et al. (2017) in Uganda and Alix-García et al. (2015) in Mexico reveal that these programs are only 50% effective, so that some deforestation continues in enrolled properties.

Until now, the vast majority of PES schemes for forest conservation in developing countries have used fixed annual payment rates per hectare, and generally pay land with formally established titles. It is unclear if changes in payment level and frequency might attract land at higher deforestation risk, thereby increasing impact. It is also unknown if offering payments on a different schedule might attract more participants by offering the opportunity for consumption-smoothing (Jayachandran 2013). Furthermore, in spite of the fact that only 30% of the global population is considered to have secure title, and less than 10% in Africa (World Bank 2023), there is little research on payment designs that accommodate customary land tenure systems.

We use a simple contingent valuation referendum question to assess appropriate payment levels and structures for forest conservation in Uganda. We include experimental variation in pricing and in the timing of payments to illuminate whether quarterly rather than annual payments might be more appealing, and if one frequency or another might require a different overall payment level. Further, we examine whether responses differ according to the type of land tenure associated with the forest, and if those sharing forests would also have to share payments. Finally, we examine if offering one level of payment across the country or differential payment levels across regions would lead to greater avoided deforestation or differential enrollment of poor households.

There are three official types of land tenure in Uganda: private, customary, and mailo. Private land includes "leasehold" and "freehold" situations, wherein user and owner rights are well defined; customary land includes a variety of traditional tenure arrangements that can include both individual and shared management of land; and mailo is a form of tenure where landowner and land user rights overlap, and is associated with land insecurity (Deininger & Ali 2008). In some cases, forests are shared among multiple users; this arrangement can be found within both customary and mailo systems of tenure.

For forested land that does not have shared access, we find a median WTA of around 60 USD

per acre, with no difference in willingness to participate or in payment levels for those offered quarterly versus annual payments. Households with forest under customary (but *not* shared) tenure have a slightly higher propensity to accept bids, which leads to a lower estimated WTA for this group. There is no statistically meaningful difference in WTA for households with overlapping (mailo) tenure compared to those with private land rights. Further, the estimated distribution of the WTA is consistent with a previous randomized experiment to enroll households in forest conservation (Jayachandran et al. 2017). In this earlier work, 30% of the sample took up a payment of 17$ US/acre in today's currency. Our own estimations yield a value of WTA at the 25th percentile of between 11 and 18$ US.

Among households who share forest access, WTA estimates for annual payments are similar to those of private forest-holders, but WTA in the quarterly treatment arm is significantly higher. We subject this estimate to a number of tests for outliers and consistently find much larger payments required for this quarterly group. We speculate that this is due to the high transaction costs required to distribute payments to large numbers of users, and possibly also to the challenges associated with compliance in shared forests.

Regional variation in WTA is high, with estimates for the Central region (near the capital, Kampala) on average being twice as high as WTA near the Kenyan border. Our policy simulations indicate that the area of forest at risk enrolled would be maximized by a system of payments that varies by region. The most cost effective program would enroll fewer participants from the Central region, and would yield higher participant surplus.

In terms of payment distribution, respondents with shared forest who indicated that they would like to participate state that they would prefer an equal distribution of the payment across all forest users. 30% of tenants in the mailo system of overlapping property rights say that they would require permission from the owner of the land to participate, and 22% indicate that they would need to share their forest conservation payment with the owner. However, despite this sharing conditionality, participants with mailo forest tenure do not require higher payments to participate.

This paper adds to the evidence on forest PES design in low-income countries. Most forest

conservation PES programs that exist at scale currently establish payment levels using rules of thumb related to the opportunity cost of foregone agricultural profits. However, several studies have found discrepancies between payment levels and willingness to participate (see, Jones et al. (2020) for a review), suggesting scope for experimentation in how payment levels are set. In Africa, framed field experiments by Handberg & Angelsen (2019) in Tanzania and Yehouenou et al. (2023) in Benin suggest that higher payments reduce harvest rates. Yehouenou et al. (2023) also find that splitting high (as opposed to low) payments among all forest users reduces the extraction of leaves, but not trees. A survey experiment in Kenya by Veronesi et al. (2012) suggests that payments indexed to opportunity costs would be effective in reducing time spent on charcoal production. Using methodologies more closely related to our study, experimental auctions for tree-planting (not avoided deforestation) have been conducted in Tanzania (Jindal et al. 2013) and Malawi (Jack 2013), and for soil conservation investments in Indonesia (Jack et al. 2008). These cases have revealed substantial variation in prices that producers are willing to accept, information which, if combined with estimates of deforestation risk, could aid significantly in targeting payments to the land at highest risk of deforestation for the lowest cost.

Furthermore, while many PES programs exist in countries or are given to groups of people where land tenure is clearly defined, the delineation of land tenure is often ambiguous in lesser-developed countries. Despite this, few studies have directly examined the role of land tenure in the participation in and success of PES programs.[1] One exception to this is Naime et al. (2022), which presents framed field experiments on collective PES in Indonesia, Brazil, and Peru. They examine the role of different types of monitoring and sanctions on hypothetical program effectiveness, efficiency, and equity. Externally-imposed individual sanctions worked the best across all three sites, but an important finding was that the best performing combination of monitoring and sanctions varied according to site history. We designed an experiment to elucidate the appropriate payment levels for avoided deforestation in a context with high deforestation risk and variation in tenure systems. Our results demonstrate considerable variation in willingness to accept that is correlated

[1] In a systematic review of 78 studies in the Global South, Jones et al. (2020) identify five papers which found that the stated reasons for participation in a PES program were to strengthen land tenure security.

with regional factors that are likely related to the opportunity cost of the land. The results on shared access land suggest that this type of tenure may present some challenges for payment design, but we also observe that forest users who access customary land do not necessarily suffer from these same challenges.

Our findings also shed light on an existing question about the appropriate timing of payments. All existing PES programs for forest conservation operating at scale administer payments once per year. However, liquidity constraints in developing countries are pervasive (see Hoff & Stiglitz (1990) and Bardhan & Udry (1999), among many others) and so the timing and frequency of payments may change both the propensity to participate (Jayachandran 2013) and the effectiveness of the transfers (Alix-García et al. 2012). Studies of other types of cash transfer programs have suggested that higher frequency payments support consumption smoothing and reduce the incidence of hunger (Shapiro 2005, Aguila et al. 2017). Recent work in Burkina Faso shows that timing PES payments to arrive during the lean season can better support household food security (Adjognon et al. 2021). Vorlaufer et al. (2017) find in Zambia that farmers prefer in-kind payments of agricultural inputs delivered before the growing season over cash payments, regardless of whether they are administered annually or monthly. We find that in the Ugandan context, changing the payment frequency would not affect participation rates for households that use forests individually. This implies that payments that might help smooth consumption either do not offer particularly high benefits or that respondents are not considering this seasonality when responding to our question. Furthermore, respondents who share forest access, a much smaller number in our sample, would have to receive significantly *higher* payments in order to induce participation in a quarterly payment program. In this case any perceived benefit of smoothing seems to be outweighed by coordination costs.

Finally, we add to a growing literature that uses stated preference experiments to generate recommendations for PES design in specific settings. In a systematic review, Schulze et al. (2024) identify 127 discrete choice experiments that study agri-environmental contracts for land use prescriptions, including fertilizer application, use of pesticides, water use constraints, soil health im-

provements, cropping practices, livestock management, and silvopasture integration. They also look at contract design features, including duration, the amount of land to enroll, reward schemes, technical assistance, and monitoring, among other administrative features. Jones et al. (2020) review 78 studies in the Global South, focusing on the factors and motivations for participation. Of the reviewed studies, 41% examined programs for forest conservation. In addition, the authors find that 47% of studies focused on financial motivations (e.g., payment level or amount), about half of which used discrete choice experiments to measure the amount of payment required to induce participation or the opportunity costs of conservation.

Discrete choice experiments focusing specifically on avoided deforestation are more limited. There are two such existing studies in Africa of which we are aware. Kaczan et al. (2013) conducted a discrete choice experiment in Tanzania for a PES program that included variation in the stringency of enforcement, group versus individual payments, and whether there was an upfront fertilizer payment included. Our study varies payment frequency and focuses on differences in the decision for forests that are shared versus individually owned. Vorlaufer et al. (2017) elicit preferences for cash versus in-kind forest conservation incentives in Zambia, finding that people prefer in-kind transfers of agricultural inputs over cash payments, regardless of their frequency. In Uganda, Geussens et al. (2019) conduct a choice experiment in Mt. Elgon, which is within our study region, that examines several variations in the structure of a potential PES program for riparian buffer conservation, soil conservation practices, and contour trenches (not avoided deforestation), making it difficult to compare their results to ours. However, in one program permutation, they examine individual versus communal payments and find that farmers prefer individual compensation. Our framing of payments for shared forests differs from theirs in that we assume that payments for shared forests are provided to all relevant users. When asked how they would prefer to have payments distributed, we find that shared forest users prefer to have payments distributed equally among all users.

2 Land tenure institutions in Uganda

In many settings the complexity of land tenure systems challenges the design of land-based incentive programs (Wunder et al. 2020). Uganda has a unique set of tenure institutions that have emerged from a history of traditional practices, colonial legacies, and recent land reforms. One of the questions that we seek to understand is if contracts for forest conservation might need to differ across these categories. This section provides essential background for this issue.

Prior to British colonization in 1894, all land was held in customary tenure, an umbrella term that encompasses a diverse array of local practices based on kinship or clan ties. In 1900, an agreement between the British colonial government and Buganda Kingdom established four types of land tenure: freehold, leasehold, customary, and mailo, which remain intact today. Freehold and leasehold tenure consist of registered titles, full transferability, and exclusion rights. We refer to these two categories together as "private" land.

Customary land in Uganda is *not* synonymous with common property. In many cases it is considered at least as secure as traditional private property and is managed by individual households. This is important for our analysis, because we present respondents with a different question framing in the event that they share forest access with others than if they state that they do not share this access. In our sample, 26 percent of respondents stated that their forest was found on customary land. However, 63 percent of these said that they did not share forest access with anyone else.

Mailo land is a distinct form of tenure in which owners and occupants share overlapping rights to land use. The mailo system was created out of the 1900 Buganda agreement, which designated square mile blocks of land allocated to specific offices of the colonial government, typically reserved for nobles and royalty of the Buganda Kingdom. A series of reforms in 1908 and 1928 introduced registered titles for mailo owners and clarified the legal relationship between owners and tenants by creating a system of rents. Formally, mailo owners are a person or institution that bought, inherited or was gifted an original mailo title, and may transfer their land freely (e.g., sell, gift, or subdivide). Most mailo tenants have no proof of legal occupancy, while many owners are absentee landlords. Recent evidence suggests that only half of mailo tenants know their landlord,

while only 26% have ever paid rent (Ali & Duponchel 2018). However, in our sample, 74% of mailo tenants pay an access fee to their landlord.

For the purposes of this study, we are interested in understanding whether there are differences in willingness to accept (WTA) associated with the official land tenure categories (private, customary, mailo). In addition, since 10% of respondents in our sample report that they access trees on protected forest reserves, we explore preferences in this dimension, as well. Finally, we will evaluate whether the desired payment structure varies according to whether forest management is de facto shared.

3 Data

Our main data source is a survey implemented in spring 2023. The survey was designed to measure willingness to accept payments for ecosystem services and also to examine the relationship between land tenure insecurity and deforestation behavior, a topic we identified in pilot studies and examined in a separate paper (Walker et al. 2024). We wished to sample regions that had experienced significant deforestation in recent years. To establish this sample, we used the dataset described in Hansen et al. (2022). This dataset combines previous work by the same authors quantifying land use type, forest gain, and forest loss, with forest cover metrics for 2019 and changes between 2000 and 2019. We selected regions of Uganda with the greatest percentage of land covered by the forest category labeled "dense forest". The selected regions based on this criteria are Central region, the area around Mt. Elgon in the east, and districts in the southwestern part of the country. Within these selected regions, we dropped districts with tiny amounts of detectable forest (less than 10%), and also island districts. We then selected districts with the highest historical deforestation and area of dense forest. The two districts per region that qualified under these criteria were for Central-Luwero and Mpigi districts; Mt. Elgon-Bududa and Namisindwa, and Southwest-Kazo and Kiruhira districts. We then replaced Mpigi with Mubende because most of the forest in Mpigi is located in protected areas.

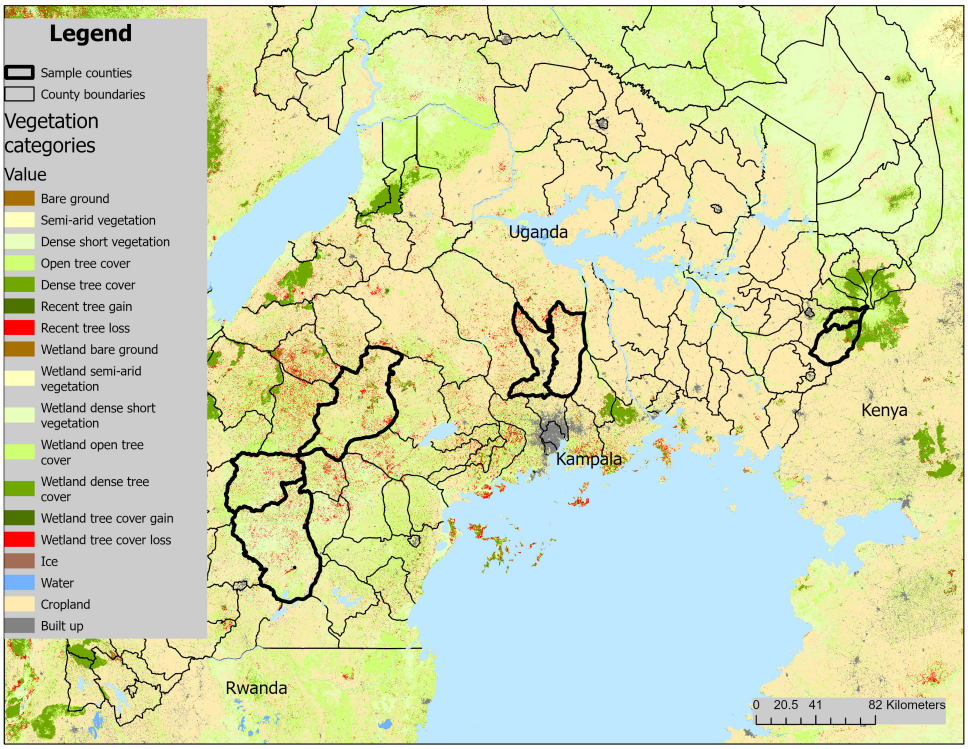
Our final sample districts are: Luwero, Mubende, Bududa, Namisindwa, Kazo, and Kiruhira districts (see Figure 1). Within each of the three regions, we targeted a sample of 560 households, for a total of 1,680 households. To identify villages with potential access to forest, we used the Ugandan Bureau of Statistics village locations layer from 2019, which is a series of lat-long points. We drew a 3 km buffer around each village point, and dropped from the sample villages that had no identifiable forest cover within the buffer. From the remaining points, we selected a sample of 28 villages per region, with the intention of surveying 20 randomly selected households per village.

Respondents were identified via a listing exercise with the local leader in their village. A Ugandan survey firm visited these villages to hold a meeting with the local leaders and introduce the project. During this meeting, they showed the local leaders images of the forested area in their village on a map and asked them to identify all households with access to the forested land. This list of households served as the sample frame. This method of identification has been successfully implemented in Uganda with previous studies on PES (Jayachandran et al. 2017). We randomly selected 20 households from each village. The final sample included 1,632 households, although for our analysis we use mostly the 1,566 that stated that they have access to trees for construction, charcoal, or fuelwood.

Enumerators from the local survey company interviewed household heads in private. In addition to the willingness to accept referendum questions, respondents answered survey questions regarding their forest access, land use behavior, and current land tenure arrangement on their forested land. We also elicited risk, time, and trust preferences using standard measures from the literature.[2]

[2]The incentivized risk metrics used the method developed by Eckel & Grossman (2008), which is a simple way of measuring risk preferences in populations with lower math abilities (Charness et al. 2013). Trust metrics were elicited using questions from the World Values Survey and also play in the trust game following the design of (Berg et al. 1995). We measured unincentivized time preferences using the method developed by Falk et al. (2018), which has been experimentally validated at a global scale.

Figure 1: Sample counties



Sample counties are outlined in bolded black lines. Land use data comes from Hansen et al. (2022).

4 Measuring willingness to accept

Our goal is to measure households' underlying willingness to accept payments for forest conservation, and to test whether this willingness to accept varies by foundational characteristics (i.e., land tenure type) and by experimental ones (i.e., timing of payments). These households have not participated in such a program before. We conduct a simple experiment whereby survey participants are offered the hypothetical opportunity to participate in a program at a randomly chosen price and are asked to say whether they would like to participate or not at that price (Mitchell & Carson 1989). As respondents were describing the land tenure situation of the forest that they access, they were also asked if they share decision-making over the forest with people outside of their immediate household. Based upon their response to this question, we presented the question in the following two formats:

Individual (not shared) access to forests

> "We are going to discuss a type of support that is called payments for environmental services. A payments for environmental services program pays people to conserve their trees. These types of programs tend to be run by non-governmental, non-profit organizations that are interested in environmental issues. They pay forest owners to NOT cut down forest for a period of 5 years. Every year they check to see if all of the trees that were on the land to start with are still on the land, and then they give a payment of money for having conserved the trees.
>
> You would not get paid if trees are missing, whether you are the one who cut them down or not. That is to say, rather than earning money from cutting down the trees for poles or charcoal or any other use, you are paid to take care of them and keep them from being cut down. I am now going to ask you questions about your willingness to participate in a program like this. This program does not yet exist, but the information that we collect will help to better-design programs like this.

> Suppose a non-profit organization was offering the possibility to participate in the program Payment for Environmental Services. If you would receive an amount of [X] UGX for one acre of trees ONE TIME A YEAR in July over 5 years, would you choose to participate?"

Half of the participants were randomized into a framing of quarterly payments, which read:

> "Suppose a non-profit organization was offering the possibility to participate in a program for Payments for Environmental Services. If you would receive an amount of [X/4] UGX for one acre of trees 4 times a year (i.e., every 3 months—January, April, July, and October) for 5 years (so UGX [X] per year), would you choose to participate?"

Here [X] refers to an amount between 13 and 1500 $USD, where the set of possible payment levels included: 50,000 UGX, 100,000 UGX, 150,000 UGX, 225,000 UGX, 450,000 UGX, 900,000 UGX, 2,225,000, and 5,625,000, where 1 $USD was equivalent to roughly 3,670 UGX at the time of our study. A single payment amount [X] was drawn randomly from a uniform distribution and displayed to the respondent, who was unaware of the underlying distribution of possible payment levels. These payment levels were parameterized through focus group discussions that were conducted in August of 2022. These focus groups were also used to establish the appropriate phrasing of the WTA referendum questions.

After answering the first question, a follow-up question offered the same arrangement at a higher (lower) value in the event that the respondent said no (yes) to the first value. As specified in our pre-analysis plan, we do not use these follow-up responses directly in estimation, but rather to check to see if some proportion of households change their responses, which would indicate that they are both paying attention and that the values are not set at levels outside of the range that might actually change behavior.

Shared access to forests

If a respondent stated that they shared their forest with other households, they received a modified framing of the last paragraph in the question:

> "Suppose your community [the majority of the people with access to the forest] was voting to decide if it wanted to participate in the program Payment for Environmental Services. If the community would receive an amount of [X] UGX for one acre of trees ONE TIME A YEAR in July over 5 years, and if you could vote, would you vote for or against participating?"

The framing of this question is more similar to a standard referendum question. Similarly to those in the first group, participants were randomized into annual or quarterly arms.

4.1 Minimizing strategic response

A long tradition of research has shown that this take it or leave it style of question (rather than an open-ended or checklist approach) can produce truthful preference revelation[3]. There is general agreement that binary choice for WTP public good studies have attractive incentive properties and also present a familiar context for respondents, who respond to a posted price as they would in many markets (Johnson & Lipscomb 2017, p.345). Studies by Vossler et al. (2012) and Carson et al. (2014) show that a single issue, binary choice referendum over a public good that individuals care about – i.e. is 'consequential' (Carson & Groves 2007) – is incentive compatible if the payment mechanism is enforceable, and the probability of implementation is increasing in the proportion of yes votes. Carson et al. (2014) further show that an advisory referendum preserves incentive compatibility. These studies develop rigorous theory and verify their predictions using field experiments that compare real and hypothetical payment scenarios.

Our context differs from this in that while the forest provides the public goods of carbon sequestration, biodiversity and erosion control, the benefits of converting the forest to non-forest uses

[3]The conditions for truthful revelation are delineated in the literature on voting (e.g., Farquharson 1969, Gibbard 1973, Satterthwaite 1975). Carson & Groves (2007) discuss the importance of information structure, and Vossler & Holladay (2018) examine the incentive properties of alternative elicitation formats.

are private. Further, we are asking about willingness to accept rather than willingness to purchase. Stated preference scholarship on WTA formats is thin relative to that of WTP. There are important challenges to estimating WTA, including the fact that the context may be unfamiliar, since respondents are being offered payment rather than making a purchase, and that there are concerns with incentive compatibility. A recent review by Whittington et al. (2017), however, highlights that in the scenario of a payment for ecosystem services to landowners, the WTA format is preferable, as it accurately represents status quo property rights.

Carson & Groves (2007) and Lloyd-Smith & Adamowicz (2018) describe two types of strategic responses in this type of private good stated preference context: for existing goods, there is incentive to respond no to an offer to indicate more price sensitivity, and for new or future goods there is incentive to respond yes to secure a future chance to participate. Since this is not an existing program, the latter seems more likely in our case. This would cause households to be more likely to say yes, which could cause us to underestimate the costs of program participation.

Finally, our main interest is in the variation in WTA across tenure categories and also across experimental offers. There is not a strong theoretical reason to expect that any hypothetical bias would vary across these sub-samples. First, if participants are inflating their willingness to accept, this is by design orthogonal to our randomization of payment frequency. Although land tenure arrangements have existed in their current form for over 100 years, and while these arrangements may affect a household's underlying WTA, it does not seem plausible that any underlying differences in WTA would be systematically related to the randomly assigned payment frequency.

4.2 Estimation

We follow the strategy to estimate median willingness to accept delineated in Phaneuf & Requate (2017). We use the log-transformed price, so the probability of a yes response is:

$$Pr(y_i) = Pr(B_i \geq WTA)$$

$$= Pr(ln(B_i)) \geq X_i\beta + \varepsilon_i = Pr(\varepsilon_i \leq ln(B_i) - X_i\beta),$$

where y_i is equal to 1 if the response is yes, B_i is the random payment offer, and WTA_i represents the individual's unobservable willingness to accept a PES payment. X_i are covariates and ε_i are unobservables, possibly clustered at the village level. To estimate the parameters, we normalize by the standard deviation of ε_i, which leads to:

$$Pr(yes) = Pr(\frac{\varepsilon}{\sigma} \leq \frac{1}{\sigma} lnB - X\frac{\beta}{\sigma})$$

$$= Pr(\varepsilon^* \leq \gamma lnB + X\theta),$$

where $\varepsilon^* \sim N(0,1)$, $\gamma = 1/\sigma$, and $\theta = -\beta\gamma$. Estimation by maximum likelihood recovers values of γ and θ, which are used to recover elements of the distribution of willingness to accept. We calculate the WTA for every individual using their observed characteristics ($WTA = exp(-\frac{X\theta}{\gamma})$), and report on key percentiles in the distribution.

4.3 Summary statistics

Respondents tend to be from relatively large households (7 members), with 2.5 children under 14 years at home (Table A1). We have few female respondents (17%). Most have completed some primary school and almost everyone earns income from land, including agriculture (94%) and livestock (76%). Roughly a quarter sell charcoal or charcoal trees, although only 12% list this among their top three income sources. By design, the sample is split evenly across surveyed regions.

Table A2 shows characteristics of respondents who received the individual and shared questions, divided according to their randomization into the annual or quarterly payments question.

The randomization generated very similar groups across different payment frequencies, with the exception of a slightly larger proportion of respondents with customary tenure receiving the annual question rather than quarterly in the group with shared forest. Shared forest land is more common in the Mt. Elgon region, and respondents in the shared forest category have much more access to both grazing and forest land, with the quarterly payments group having the greatest access to forest area. The Mt. Elgon respondents tended to be located near, but not inside of Mt. Elgon National Park, which straddles the Uganda/Kenya border.

The average WTA offer in USD is $325 per acre (Table 1). On average just over 50% of respondents say that they would accept the price they are offered. Only 20% of respondents (330 households) say that they share forest land with others. Although many of these are on customary land (155 households), a large number (140) are also using forest reserves to access forest products. Of respondents who are on shared forest land, 88% say that they would split the payment equally between all forest users. The majority of households under customary tenure (270) indicate that they would *not* have to share payments. Of the small number of respondents on mailo land, 30% say that they would have to ask permission from the owner, and 22% would have to share the payment with the owner.

We also show mean values for key variables by tenure category (Table A3). Here we observe that all of the mailo properties are located in the Central region, and that forest reserves are mostly located in the Mt. Elgon region and tend to be poorer than other households in the sample according to our asset index. Households under customary tenure also have low asset indices, smaller land endowments, and exhibit more trust.

In terms of follow-up questions, we do observe that respondents change their response when they are presented a price that is higher or lower than their first offer. If they respond no to the first offer, we present a second, higher price, at which point 20 percent of respondents change their response to yes. Of those who say yes to the first offer and are then presented a lower price, 75 percent accept the lower offer, meaning that 25 percent change their response. We take this as evidence that people are paying attention during the survey and consider their responses

consequential. Finally, 71 percent are interested in enrolling more than one acre in such a program, preferably around 8 acres on average. This result is skewed upwards by a few participants who have access to large areas of forest.

Table 1: WTA offers and structure

	Mean	SD	Min	Max	Count
Experimental variation and responses					
Forest land is shared	0.20	0.40	0.00	1.00	1566
Quarterly	0.51	0.50	0.00	1.00	1566
WTA offer in USD	325.44	484.34	13.66	1537.31	1566
Accepted price offer	0.54	0.50	0.00	1.00	1566
PES would require permission from mailo owner	0.28	0.45	0.00	1.00	210
PES would be shared with owner, mailo	0.21	0.41	0.00	1.00	210
Prefer equal distribution of PES, shared	0.88	0.32	0.00	1.00	113
Follow-up responses					
Prop. yes follow-up — no first offer	0.20	0.40	0.00	1.00	725
Prop. yes follow-up — yes first offer	0.74	0.44	0.00	1.00	841
Willing to enroll more than one acre	0.71	0.45	0.00	1.00	841
Additional acres would like to enroll	8.03	70.82	0.25	1000.00	601

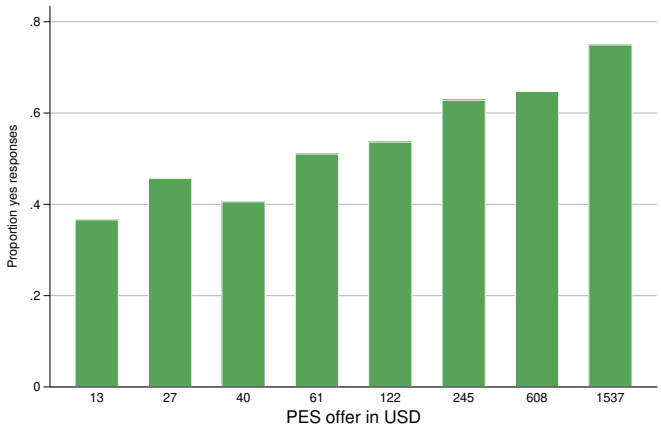
Table shows mean, sd, min, max and number of observations of variables from the household survey.

Figure 2 shows the proportion of yes responses by payment category across the entire sample (a), split according to frequency of payment (b), and separated according to whether or not households shared forest access (c). In general, households are more likely to say yes as the offer gets higher. However, the price response seems to be less sensitive for the quarterly payments, with slightly higher proportions stating yes at low offers, and a lower proportion stating yes at the highest level of offer.

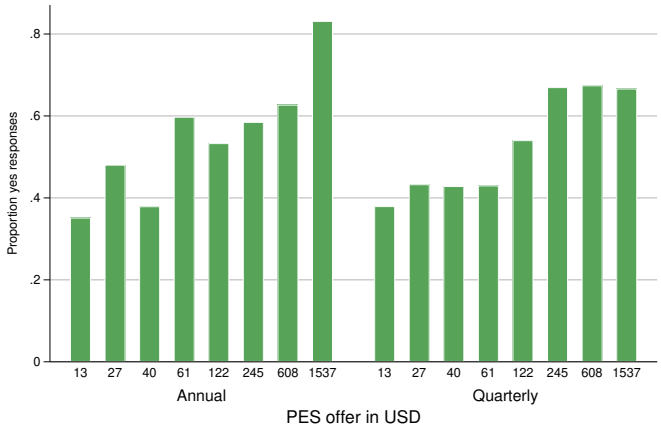
When we split the data by tenure category (3) instead of by whether or not payments might be shared, we observe that those on forest reserves are less likely to say yes at any bid level. We included forest reserves as a separate category in this figure, even though forest reserves are not an official tenure category – these are bodies of forests that are managed by the government, but to which households may have access. Households using forest reserves make up a substantial share

Figure 2: Proportion yes responses across offers for full sample, by payment frequency arm and by forest management status

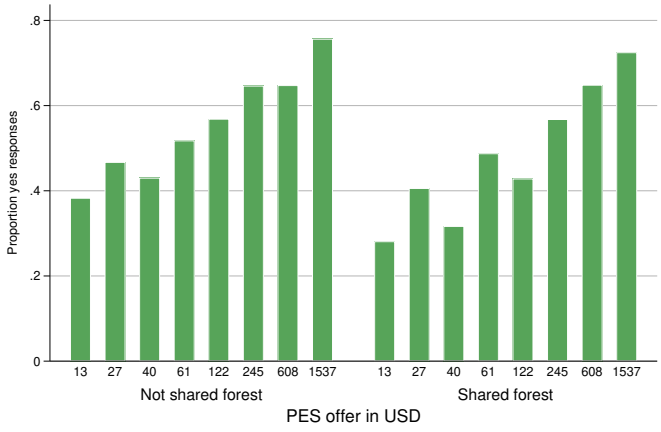
(a) Full sample



(b) By payment frequency

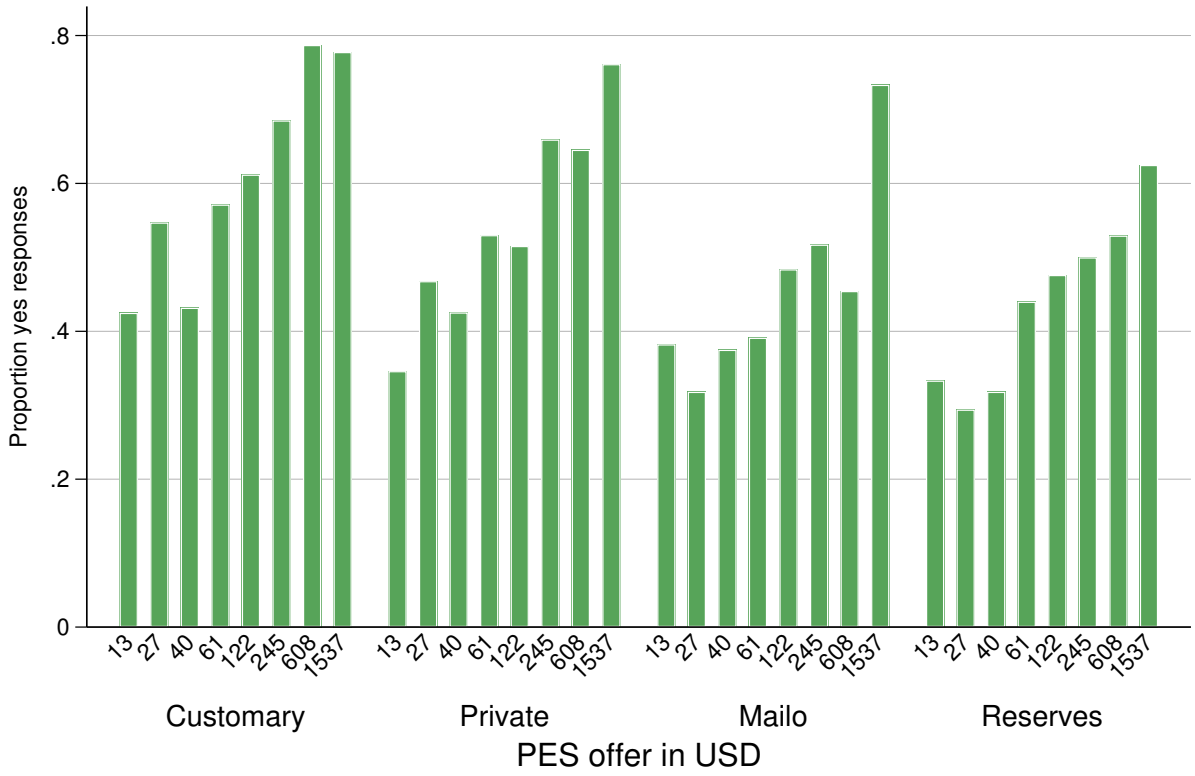


(c) By forest sharing



of those in the "shared forest" category, and so these differences will drive important variation in the estimates of WTA across shared and not-shared forests.

Figure 3: Proportion yes responses across offers according to tenure category



5 Results

We estimate the probability of acceptance using a probit with three different approaches: (1) no covariates; (2) regional effects plus a limited set of indicators for key income sources, whether the payment offered was quarterly, land tenure category, and if the forest is in a reserve; and (3) a full set of covariates including household characteristics and risk, trust, and time preferences. The estimations are separated for individual versus shared payments.

The probit results are displayed in Tables B4- B6. The regional effects are powerful predictors, with the likelihood of acceptance being much lower in the Central region than around Mt. Elgon,

and slightly lower in the Southwest region relative to Mt. Elgon. This results in a much higher payment level for the Central region than for the others (see Appendix Figure B1). In terms of individual payments, customary landholders and those with higher measured levels of patience are much more likely to say yes at any payment level. This implies that customary landholders would accept lower payments – this may be correlated with the fact that they tend to have lower incomes. Being offered a quarterly payment has no statistically significant effect on the probability of acceptance, and the coefficient is tiny.

For those whose forest is shared with others, there is a large negative effect of being offered a quarterly payment. Those whose main income source is livestock are more likely to accept payments, and accessing a forest reserve is associated with a lower likelihood of acceptance, though this variable is not statistically significant. In general, household characteristics other than patience do not seem to be deterministic of acceptance, nor does producing charcoal.

Figure 4 shows the median estimated values of WTA across payment frequency, type of payment, and for different constellations of control variables. For individual payments, there are no meaningful differences between the WTA across annual and quarterly payment frequencies, and for annual payments, the individual estimates are broadly similar or slightly larger than those required for households that would need to share payments. The median values range from 57 with full covariates to 66 with parsimonious covariates in the quarterly treatment. They are quite similar across different payment timing.

For shared-payment households, there are very large and surprising differences across annual and quarterly payments, and depending upon the included covariates. The median value is 56 for the parsimonious estimates in the annual treatment, but 215 for the quarterly treatment with no covariates. It is possible that this is simply the result of noise in the data. To investigate this possibility, we bootstrap the WTA estimation process 1000 times, drawing a 75% sample stratified by whether an observation is in the shared forest group or not. We plot the estimated median WTA from this process for observations between the 5th and 95th percentile in figure B2. We observe almost perfect overlap between annual and quarterly estimates for the individually-

managed forests. The large difference between annual and quarterly for shared forests remains.

We also note that the shared forest sample is small (128 respondents in the annual category and 148 in the quarterly)[4]. In order to assess whether the effect is driven by outliers that might substantially affect a small sample, we recalculate the WTA estimates systematically dropping subgroups to examine heterogeneity in responses (see Appendix Figure B3), including those whose forest is in reserves, the Mt. Elgon subsample, those who returned less money in the trust game (and hence have lower trust), those with access to very large amounts of forest (> 100 acres), and those using the forest for less than 2 years. In addition, we also randomly select a subsample such that the distribution of bid offers has the same number of observations in each bin. In all of these cases, the quarterly/annual difference remains for shared forest, and there is no such difference for privately managed forest.

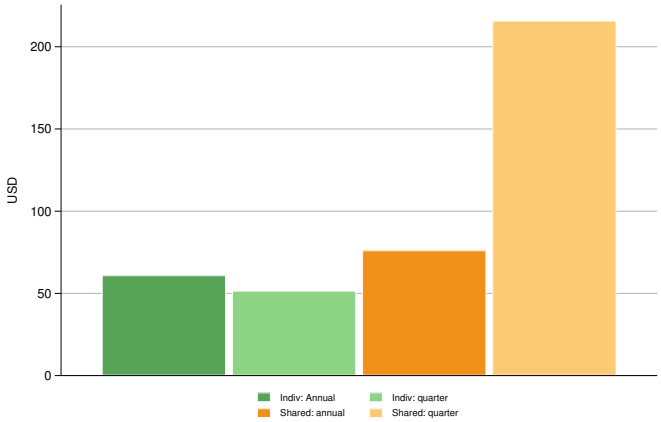
A final possibility is that this divergence may result from the fact that individuals with this type of shared tenure may have more uncertainty about their future rights to receive payments associated with this type of access arrangement. They may also have significantly higher transaction costs to manage in the event that a payment is quarterly versus annual – participants accessing shared forests report an average of 24 people (median 7) with whom they share access. 24% of individual forest users report that they have given others access to their forest, and of these the average number of additional users is 7 (median 4). Transactions costs in the management of payments presents the most plausible explanation of the discrepancy between quarterly and annual WTA for the shared forest subsample for which we can provide any evidence.

We also consider other percentiles in the distribution of WTA in Table 2. The top panel shows estimates for the annual treatment and the bottom for the quarterly. The table highlights again

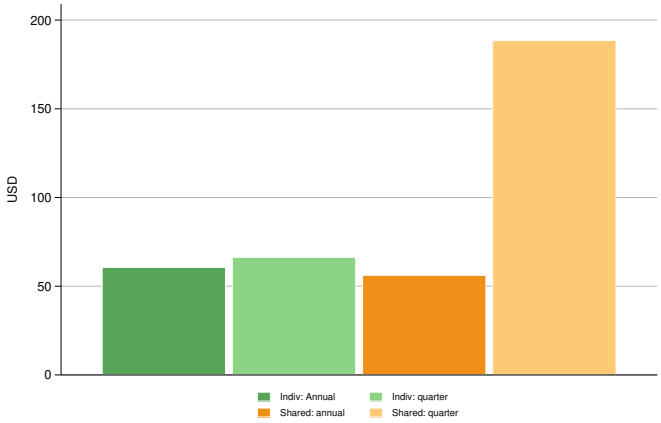
[4]The end of our survey also contained a question about enumerator perception of whether respondents understood the questions in the survey. Overall, understanding was quite high – 91.5 percent of respondents appeared to understand the questions very well (as opposed to "so-so" or "not very well"). Among the group that did not have a very good understanding, 17% were in the shared access group (relative to the mean proportion of shared access responses of 20%). This implies that the shared access group in general had a similarly adequate understanding of the questions as the individuals who were not sharing forest. However, there is some evidence that understanding of those in the quarterly payment arm among the shared forest sample had a weaker general grasp of the questions – 58% of those with poor understanding in the shared access group were randomized into the quarterly arm, as opposed to 40% in the individual access group.

Figure 4: Estimated median WTA with varying levels of controls, by payment frequency and forest sharing status

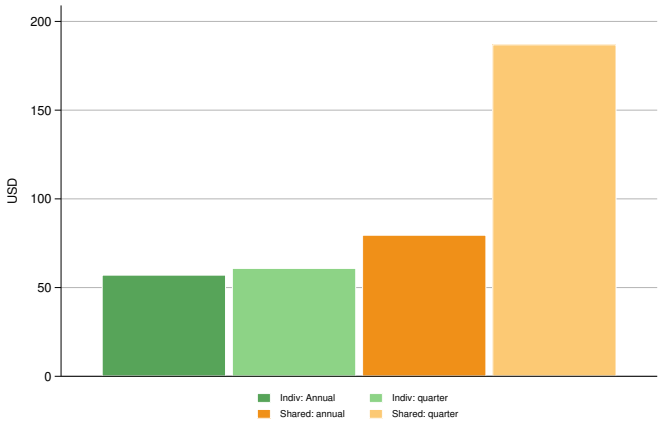
(a) No covariates



(b) Parsimonious covariates



(c) Full covariates



Estimates show WTA for simple (no covariates), parsimonious (limited covariates) and full (see text for description) set of controls. Individually managed forests are green and shared forests orange. Darker shades indicate estimates for the annual payment offer and lighter shades for the quarterly offer.

the similarities across treatment arms for the private payments and the large differences between annual and quarterly shared payments.

In terms of the estimated magnitudes, it is useful to compare these to the randomized controlled trial payments described in Jayachandran et al. (2017), which took place in Western Uganda. In 2012, this experiment offered payments of 28$/ha. Adjusting for inflation and for the fact that our payments are in acres, those payments today would be 17$/acre. In the 2012 experiment, the take-up rate was about 30%. Our own calculations for the WTA of private payments at the 25th percentile range between 11$ and 18$. This similarity between our stated preference results and the behavior in the RCT increases our confidence that participants are responding to the hypothetical question in a way that is consistent with how they would behave in an actual PES program. Further, among those who are involved in charcoal production either by selling trees or by producing charcoal, the median annual reported revenue in these activities for the 404 households that engage in them is 65 USD.

Table 2: WTA: estimates by experimental arm and tenure

	p25	p50	p75	Count
Annual treatment				
Individual, no covars	60.97	60.97	60.97	624
Individual, parsimonious	26.89	60.80	198.31	624
Individual, full	23.21	57.19	175.72	621
Shared, no covars	76.13	76.13	76.13	149
Shared, parsimonious	5.83	56.33	812.25	149
Shared, full	6.73	79.67	851.84	149
Quarterly treatment				
Individual, no covars	51.58	51.58	51.58	626
Individual, parsimonious	12.51	66.48	200.37	626
Individual, full	12.30	60.99	235.26	626
Shared, no covars	215.84	215.84	215.84	167
Shared, parsimonious	70.12	188.63	556.01	167
Shared, full	63.63	187.01	853.07	167

Top panel shows estimates of WTA annual payments by forest management type with varying levels of controls. The bottom panel shows the same calculations for the quarterly treatment arm.

6 Policy simulations

This section presents a brief simulation of possible policy structures based upon the responses to our survey. Specifically, we examine outcomes from targeting in the following manner:

1. Offering the median WTA to all properties in the sample, and enrolling those who accept (half the sample). This simulation sets up the budget constraint for the remainder of the scenarios.

2. Targeting payments such that those properties with the highest ratio of predicted deforestation risk to WTA are prioritized, paying all participants the maximum value of WTA within the high-ranked group, such that the budget is equal to the budget from (1).

3. Allocating budgets equally by region, where payment levels are such that within a region all participants with WTA below the regional payment level enroll, and the budget constraint binds.

The first scenario reflects a politically simple design where all participants are treated equally in terms of payments, but there is no attempt to target areas of higher deforestation risk. Our sample, however, implicitly prioritizes places with baseline forest and with recent deforestation risk. This is a "best case" scenario for identifying appropriate forest to generate additionality. If such a strategy were to be rolled out nationwide, it is possible that it would produce a relatively lower amount of avoided deforestation.

The second approach is theoretically appealing since it maximizes potential environmental gains relative to payments given. Under the assumption that WTA is related to opportunity cost, this approach maximizes environmental benefits relative to private costs. Though this would be an efficient approach, it would require implementing a targeting strategy that incorporates the prediction of deforestation risk.

The third scenario reflects a situation that is plausible in the event that politicians wish to treat regions equally in a budgetary sense. Here there is no specific targeting but payment levels are

established such that all recipients within the same region receive the same payment and that the number of properties enrolled times the payment is less than or equal to the budget constraint. As in the first case, our sample generates a best case scenario for the generation of avoided deforestation.

To implement these simulations, we create out of sample predictions for all respondents using the coefficients from the annual payment regressions, allowing for differentiation between shared and individual forests.

To create a measure of expected environmental benefits, we also predict future avoided deforestation based upon the measured percentage of deforestation within the village buffer between 2000 and 2019. We estimate this using a lasso regression to select the best set of predictive covariates from among the following: baseline forest area, regional dummies, mean and standard deviation or slope, mean and standard deviation of elevation, distance to Kampala city, soil type, percentage of the village under mailo tenure and percentage of respondents selling charcoal. The final prediction regression is shown in section C, which also gives more details regarding the prediction process.

Table 3: Outcomes by program type

	Baseline	Risk/WTA	Regional
Payment per participant	55.08	57.85	54.69
Number participants	781.00	741.00	783.00
Predicted village deforestation	4008.88	3825.79	4066.07
Participant surplus	26204.61	28004.63	22920.58
Mt Elgon districts	0.64	0.64	0.53
Central districts	0.07	0.06	0.16
Southwest districts	0.28	0.28	0.29
% forest, 2019	50.05	49.90	48.00
Forest land: mailo	0.03	0.03	0.07
Forest land: private	0.50	0.48	0.45
Forest land: customary	0.37	0.38	0.39
Forest land is shared	0.21	0.21	0.19
Asset index	2.90	2.89	3.03
Food score index	37.65	37.66	37.87

Each column represents outcomes for the payment distribution strategies described in section 6.

Table 3 reports the results of this exercise. The average payment levels are similar across all scenarios. The first two offer the same payment for all participants. The third presents a different offer for each region based upon the criteria to enroll all those whose WTA is below the regional payment until the budget for the region is exhausted. The final price per acre for Mt. Elgon is 40 USD/acre, for the Central region 110, and for the Southwest region 57. This reflects the fact that WTA is much higher in the Central region. However, with the regional approach the number of participants from this region is doubled relative to the other strategies at the expense of enrollment from Mt. Elgon households. Participant surplus, which is the sum of the difference between the payment offer and respondents' WTA across all participants, is highest in the risk/WTA targeting approach, and lowest in the regional payments scheme, which prioritizes enrolling more participants from the higher WTA Central region.

Interestingly, the amount of predicted total deforestation – based on the village level estimates scaled up by the area within which we measured forest (a circle of 3 km from the village center) – is quite similar across approaches. This reflects the fact that deforestation risk is generally high in Uganda, and also that our villages were selected based upon having both high levels of forest and previous deforestation activity. The program that targets participants based upon village risk divided by individual WTA results in participation from slightly lower deforestation risk villages whose ratios of risk to payment levels is high. The smaller magnitude results from the shifting of payments towards individuals with lower WTA. As is mentioned above, the results on deforestation risk may differ in a nationally-scaled program. This is because our sample was specifically selected to include households in areas with existing forest and previous deforestation. By definition, these are areas with a higher risk of deforestation. A program targeting "any forest" may not necessarily capture the highest risk areas unless it is intentionally designed to do so.

Figure 5 shows the full distribution of village level predicted forest loss across the different programs. The distributions are quite similar in the baseline and risk/WTA approach, while the scheme to give equal budgets by region results in a rightward shift of the deforestation risk distribution, driven by the greater enrollment in the high risk (but expensive) Central region.

The enrollment of different tenure types is slightly different than the average in the data – mailo land is less represented in the enrolled properties (4-8% relative to 14% in the sample), and private and customary increase commensurately. The proportion of properties with shared forest land is similar to the average in the sample.

In terms of household characteristics, the asset and food indices are nearly identical in the baseline and risk/WTA simulations, and marginally higher in the regional approach. The regional distribution (Figure 5, panel (a)) of the asset index suggests a small rightward shift in the regional targeting, toward households with greater index values.

Figure 5: Wealth and avoided deforestation by program type

(a) Asset index



(b) Predicted avoided deforestation

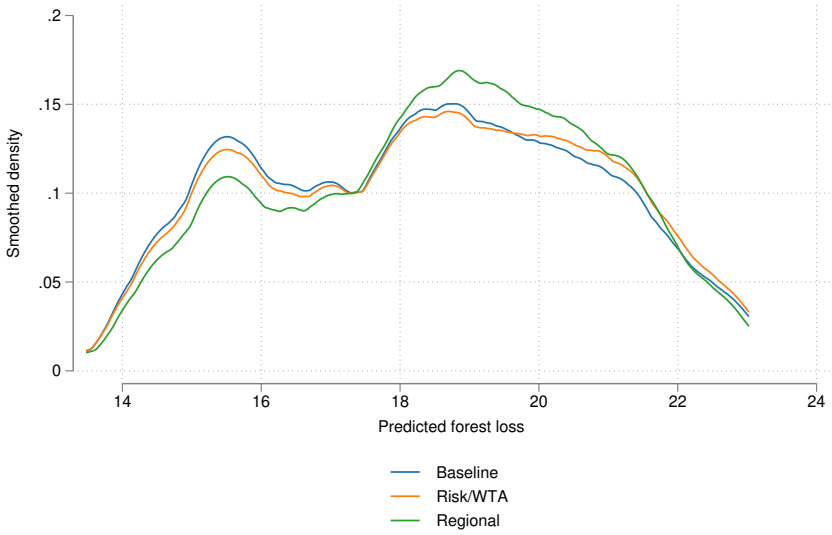


Figure (a) shows the smoothed distribution of the assets index from the household survey according to simulated PES program type. Figure (b) shows the smoothed distribution of predicted avoided deforestation according to simulated program type. See Appendix for description of prediction methodology.

7 Conclusion

This paper investigates the parameters for a potential program of conditional cash transfers for forest conservation in Uganda. We were particularly curious about whether different tenure systems might require higher or lower payments to induce participation, and whether participants might prefer a payment scheme that would better allow them to smooth consumption (via quarterly rather than annual payments). We document some enthusiasm for such a program – at a payment level of around USD $60 per acre, half of the survey respondents who use forests with individual tenure say they would participate. This magnitude is consistent with inflation-adjusted estimates of an earlier RCT of payments for ecosystem services in Uganda (Jayachandran et al. 2017), although our sample covers a wider geographic area.

Stated preference exercises are always subject to the possibility of strategic behavior on the part of respondents. However, a number of our findings are based upon the relative behavior within the experiment, and we cannot identify a compelling reason why they would be driven by differentially strategic across experimental arms or different tenure categories. In particular, our results show that individuals managing private forests are equally willing to participate under an annual or a quarterly payment scheme. The results also do not reveal any differential willingness to engage across the key tenure categories in Uganda – customary, mailo, and private land. Finally, respondents who share forests with others require slightly higher annual payments to participate, and significantly higher quarterly payments. We attribute this to the fact that distributing payments and enforcing the conditionality of no deforestation in this setting may be significantly more costly.

We also simulate the participation rates, environmental effectiveness, and distributional consequences of three different PES schemes: a single, nationwide payment scheme, a scheme that targets land based on the ratio of predicted deforestation risk to WTA, paying all participants maximum WTA within the targeted group, and one which allocates budgets equally by region, but allows each region to set its payment rate. Different payment schemes do not enroll systematically wealthier or poorer households. A single flat payment would limit the number of participants in the Central region, where deforestation risk is high and participants require larger payments. A

scheme of regional budgets captures forest with a higher risk of future deforestation, enrolls just as many participants as a simple flat scheme, and distributes payments more equally across regions.

Although this experiment was designed for the Ugandan context, we believe that many of the findings are generalizable. Stated preference surveys with simple referendum questions, for example, could be used to calibrate starting levels for a PES program in almost any situation. We also show that differentiated payments by level of tenure security (mailo versus private land) are not necessary, and that participants do not value the possibility of payments that are disbursed to facilitate consumption smoothing. Further, we demonstrate that the issue for participation is not customary tenure as a category, but rather the nature of the forest management. Our finding that higher payments would be required to enroll shared forests with quarterly disbursements suggests not only that annual payments might be preferable, but also that there may be important coordination costs associated with targeting this type of land.

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Online Appendix

Designing forest conservation payments for Uganda

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A Additional tables

Table A1: Characteristics of respondent households

	Mean	SD	Min	Max	Count
Household characteristics					
Household size	7.12	3.50	1.00	30.00	1566
Age (years)	46.52	12.35	18.00	83.00	1566
How many ppl above age 65 in home	0.14	0.48	0.00	8.00	1566
# People below age 14 in home	2.52	1.89	0.00	15.00	1566
How many ppl below age 5 in home	1.11	1.19	0.00	13.00	1566
Female	0.17	0.37	0.00	1.00	1566
Asset index	3.27	1.57	0.00	11.00	1566
Some/completed primary school	0.56	0.50	0.00	1.00	1566
Some/completed secondary school	0.24	0.43	0.00	1.00	1564
Earns income from land	0.99	0.10	0.00	1.00	1566
Top 3 income source: agriculture	0.94	0.24	0.00	1.00	1566
Top 3 income source: livestock	0.76	0.42	0.00	1.00	1566
Top 3 income source: charcoal	0.12	0.33	0.00	1.00	1566
Sell charcoal or charcoal trees	0.27	0.44	0.00	1.00	1566
Mt Elgon region	0.37	0.48	0.00	1.00	1566
Central region	0.33	0.47	0.00	1.00	1566
Land characteristics					
Acres farm/grazing land access	12.30	31.23	0.10	650.00	1566
Acres farm/grazing land owned	8.23	16.78	0.00	200.00	1562
Acres area of forest to access	18.43	84.67	0.00	1000.00	1566
Forest land: mailo	0.14	0.35	0.00	1.00	1566
Forest land: customary	0.26	0.44	0.00	1.00	1566
Forest land: private	0.50	0.50	0.00	1.00	1566
Forest land: reserves	0.10	0.30	0.00	1.00	1566
Forest land shared, communal	0.20	0.40	0.00	1.00	1559
Forest land shared, mailo	0.02	0.14	0.00	1.00	1559
Forest land shared, by permission	0.17	0.38	0.00	1.00	1559
% forest, 2019	44.36	16.80	12.72	80.48	1566
% deforested, 2000-2019	4.14	3.66	0.28	18.83	1566
Forested land					
Forest land fully covered with forest	0.24	0.43	0.00	1.00	1566
Forest land more than half but not fully covered	0.39	0.49	0.00	1.00	1566
Forest land also used for: farming	0.72	0.45	0.00	1.00	1564
Forest land also used for: grazing	0.63	0.48	0.00	1.00	1564
Forest land also used for: people to live on	0.30	0.46	0.00	1.00	1564
Forest has decrease in past 5 yrs	0.58	0.49	0.00	1.00	1566
Km to gather firewood increased past 5 yrs	0.42	0.49	0.00	1.00	1566
Forest decreased from charcoal	0.23	0.42	0.00	1.00	902
Forest decreased from ag/pasture	0.24	0.42	0.00	1.00	902
Forest decreased from housing	0.23	0.42	0.00	1.00	902
Forest decreased from firewood	0.27	0.44	0.00	1.00	902

Table A2: Balance table across experimental arms

	Individual		Norm	Shared		Norm
	A	Q	diff	A	Q	diff
Accepted bid	0.55	0.55	-0.01	0.54	0.44	-0.15
Offer amount	339.21	304.88	-0.05	334.52	337.19	0.00
Mt Elgon region	0.32	0.33	0.02	0.51	0.62	0.16
Central region	0.36	0.35	-0.03	0.23	0.18	-0.10
Southwest region	0.32	0.32	0.01	0.26	0.20	-0.10
Forest land: reserves	0.02	0.01	-0.05	0.38	0.47	0.14
Forest land: mailo	0.17	0.17	0.01	0.05	0.04	-0.04
Forest land: customary	0.19	0.22	0.05	0.55	0.41	-0.20
Household size	7.25	7.19	-0.01	6.91	6.51	-0.08
Some/completed primary school	0.55	0.55	-0.00	0.58	0.64	0.08
Asset index	3.33	3.45	0.05	2.83	2.77	-0.03
No access to savings or finance	0.38	0.37	-0.00	0.35	0.37	0.03
Num. hh ask for support	3.42	3.34	-0.01	3.22	3.02	-0.05
Top 3 income source: agriculture	0.94	0.94	0.02	0.93	0.92	-0.03
Top 3 income source: livestock	0.77	0.77	-0.00	0.74	0.75	0.01
Top 3 income source: charcoal	0.11	0.12	0.01	0.13	0.16	0.07
Sell charcoal or charcoal trees	0.25	0.25	0.00	0.31	0.32	0.01
Female	0.18	0.15	-0.05	0.19	0.14	-0.11
Acres farm/grazing land access	11.94	10.73	-0.04	14.37	17.65	0.04
Acres farm/grazing land owned	9.92	9.04	-0.03	3.39	3.23	-0.02
Acres area of forest to access	12.21	9.22	-0.04	33.85	62.45	0.13
Num. people with forest access	7.05	7.72	0.04	22.42	24.16	0.04
Yrs accessing forest	22.80	22.09	-0.04	17.80	17.10	-0.04
Risk	2.30	2.26	-0.02	2.19	2.22	0.01
Patience	6.15	6.21	0.00	6.50	6.17	-0.02
Trust	1802.88	1870.61	0.05	1892.62	1934.13	0.03
Observations	624	626	1566	149	167	1566

Table A3: Characteristics by official tenure category

	Private	Customary	Mailo	Reserves
Accepted bid	0.54	0.61	0.46	0.43
Offer amount	321.37	342.35	332.25	286.33
Mt Elgon region	0.33	0.56	0.00	0.62
Central region	0.21	0.25	0.99	0.14
Southwest region	0.46	0.19	0.00	0.24
Household size	7.43	6.51	7.02	7.28
Some/completed primary school	0.56	0.52	0.54	0.66
Asset index	3.43	2.86	3.97	2.60
No access to savings or finance	0.34	0.43	0.36	0.40
Num. hh ask for support	3.67	2.86	2.91	3.46
Top 3 income source: agriculture	0.93	0.94	0.99	0.91
Top 3 income source: livestock	0.79	0.75	0.74	0.73
Top 3 income source: charcoal	0.09	0.17	0.13	0.13
Sell charcoal or charcoal trees	0.26	0.27	0.28	0.28
Female	0.15	0.16	0.26	0.17
Acres farm/grazing land access	13.66	9.30	8.64	18.47
Acres farm/grazing land owned	11.95	3.73	6.93	3.47
Acres area of forest to access	10.87	7.00	10.00	96.51
Num. people with forest access	8.38	5.47	10.07	52.12
Yrs accessing forest	21.81	20.60	25.59	15.89
Risk	2.31	2.26	2.23	2.12
Patience	5.40	7.32	7.50	5.51
Trust	1826.03	1906.86	1887.89	1792.45
Observations	776	408	223	159

B WTA estimation equations

Table B4: WTA: No covariates estimation

	Individual			Shared		
	Both	Annual	Quarter	Both	Annual	Quarter
	(1)	(2)	(3)	(4)	(5)	(6)
Accepted price offer						
Ln(WTA offer, USD)	0.200***	0.226***	0.175***	0.240***	0.212***	0.264***
	(0.025)	(0.035)	(0.035)	(0.051)	(0.075)	(0.069)
Quarterly	0.003			-0.250*		
	(0.072)			(0.145)		
Constant	-0.809***	-0.928***	-0.689***	-1.055***	-0.919**	-1.418***
	(0.125)	(0.170)	(0.167)	(0.267)	(0.378)	(0.345)
Observations	1250	624	626	316	149	167

Estimates are coefficients from a probit (not marginal effects). * p <.10, ** p< .05, *** p<.01.

Table B5: WTA: Parsimonious estimation

	Individual			Shared		
	Both	Annual	Quarter	Both	Annual	Quarter
	(1)	(2)	(3)	(4)	(5)	(6)
Accepted price offer						
Ln(WTA offer, USD)	0.199***	0.230***	0.174***	0.236***	0.167**	0.318***
	(0.025)	(0.035)	(0.035)	(0.052)	(0.082)	(0.075)
Quarterly	-0.010			-0.240		
	(0.074)			(0.153)		
Forest land: mailo	0.104	0.054	0.128			
	(0.125)	(0.176)	(0.181)			
Forest land: customary	0.269***	0.323**	0.258*	0.266*	0.281	0.307
	(0.099)	(0.146)	(0.137)	(0.153)	(0.222)	(0.228)
Mt Elgon region	0.354***	0.205	0.476***	-0.200	0.181	-0.633**
	(0.103)	(0.150)	(0.144)	(0.208)	(0.289)	(0.316)
Central region	-0.190*	-0.366**	-0.008	-0.700***	-0.406	-1.286***
	(0.108)	(0.151)	(0.157)	(0.250)	(0.346)	(0.400)
Household size	0.023**	0.002	0.045***	0.046**	0.033	0.054*
	(0.011)	(0.016)	(0.016)	(0.022)	(0.031)	(0.033)
Some/completed primary school	0.128*	0.084	0.185*	-0.040	-0.044	-0.026
	(0.075)	(0.107)	(0.107)	(0.162)	(0.236)	(0.241)
Top 3 income source: livestock	0.104	0.070	0.151	0.515***	0.907***	0.267
	(0.089)	(0.126)	(0.125)	(0.182)	(0.278)	(0.252)
Sell charcoal or charcoal trees	-0.046	0.039	-0.100	0.240	0.298	0.298
	(0.088)	(0.126)	(0.125)	(0.175)	(0.280)	(0.242)
Asset index	0.003	0.006	0.003	-0.077	-0.138*	-0.023
	(0.027)	(0.039)	(0.038)	(0.059)	(0.082)	(0.090)
Constant	-1.227***	-1.090***	-1.434***	-1.448***	-1.429**	-1.766***
	(0.196)	(0.273)	(0.275)	(0.425)	(0.599)	(0.616)
Observations	1250	624	626	316	149	167

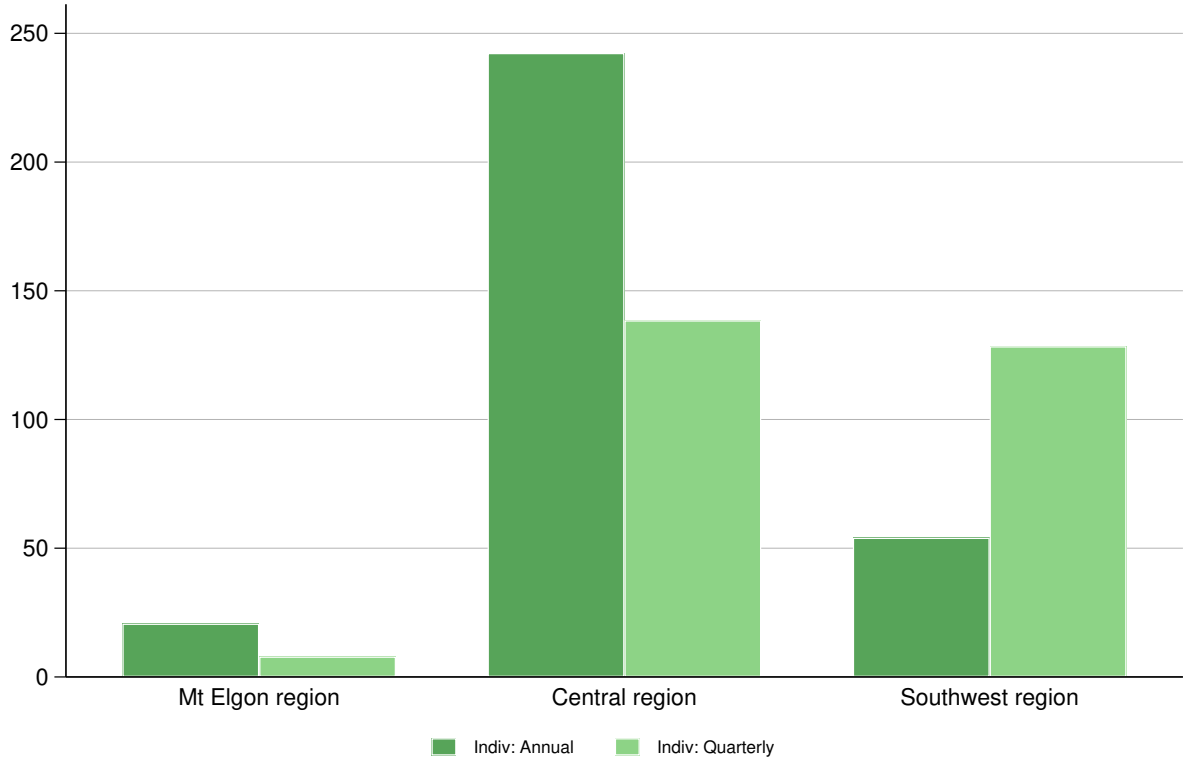
Estimates are point estimates from a probit. * p <.10, ** p< .05, *** p<.01.

Table B6: WTA: Estimation with full covariates

	Individual			Shared		
	Both	Annual	Quarter	Both	Annual	Quarter
	(1)	(2)	(3)	(4)	(5)	(6)
Accepted price offer						
Ln(WTA offer, USD)	0.198***	0.227***	0.174***	0.243***	0.172**	0.310***
	(0.025)	(0.036)	(0.036)	(0.053)	(0.083)	(0.077)
Quarterly	-0.003			-0.262*		
	(0.074)			(0.156)		
Forest land: mailo	0.107	0.085	0.103			
	(0.126)	(0.179)	(0.183)			
Forest land: customary	0.261***	0.304**	0.259*	0.117	0.156	0.124
	(0.100)	(0.149)	(0.139)	(0.186)	(0.269)	(0.275)
Mt Elgon region	0.363***	0.250	0.452***	-0.206	0.086	-0.568*
	(0.121)	(0.174)	(0.171)	(0.227)	(0.333)	(0.339)
Central region	-0.234**	-0.401**	-0.059	-0.725***	-0.518	-1.198***
	(0.116)	(0.165)	(0.166)	(0.264)	(0.371)	(0.413)
Household size	0.018	-0.003	0.042**	0.044**	0.034	0.053
	(0.011)	(0.016)	(0.017)	(0.022)	(0.031)	(0.035)
Some/completed primary school	0.145*	0.117	0.180*	0.001	-0.054	-0.006
	(0.076)	(0.109)	(0.109)	(0.165)	(0.242)	(0.251)
Female	0.123	0.080	0.182	0.033	0.083	-0.267
	(0.101)	(0.140)	(0.149)	(0.209)	(0.290)	(0.342)
Asset index	-0.007	-0.008	-0.005	-0.087	-0.146*	-0.037
	(0.028)	(0.040)	(0.038)	(0.061)	(0.084)	(0.095)
Top 3 income source: livestock	0.082	0.037	0.139	0.552***	0.877***	0.242
	(0.091)	(0.131)	(0.128)	(0.188)	(0.290)	(0.269)
Sell charcoal or charcoal trees	-0.075	-0.011	-0.120	0.249	0.325	0.280
	(0.089)	(0.130)	(0.127)	(0.179)	(0.289)	(0.252)
Ln(Farmland area, acres)	0.106*	0.109	0.094	0.018	0.044	0.018
	(0.054)	(0.074)	(0.082)	(0.065)	(0.105)	(0.092)
Ln(Forest access area, acres)	-0.051	-0.025	-0.075	-0.044	-0.069	-0.020
	(0.054)	(0.071)	(0.083)	(0.057)	(0.098)	(0.074)
Missing forest or ag land area	0.221	0.284	0.187	-0.240	-0.033	-0.510
	(0.328)	(0.530)	(0.427)	(0.230)	(0.349)	(0.335)
Risk	0.042*	0.036	0.044	0.023	0.016	0.006
	(0.024)	(0.034)	(0.035)	(0.050)	(0.074)	(0.073)
Patience	0.015***	0.016***	0.012**	0.010	0.021*	-0.004
	(0.004)	(0.005)	(0.006)	(0.008)	(0.012)	(0.011)
Trust	-0.031	0.001	-0.058	0.124	0.025	0.257*
	(0.039)	(0.057)	(0.055)	(0.087)	(0.124)	(0.135)
Constant	-1.379***	-1.326***	-1.476***	-1.649***	-1.407*	-1.991***
	(0.225)	(0.315)	(0.317)	(0.522)	(0.782)	(0.734)
Observations	1247	621	626	316	149	167

Estimates are point estimates from a probit. * p <.10, ** p< .05, *** p<.01.

Figure B1: Variation in individual payments across regions and frequency

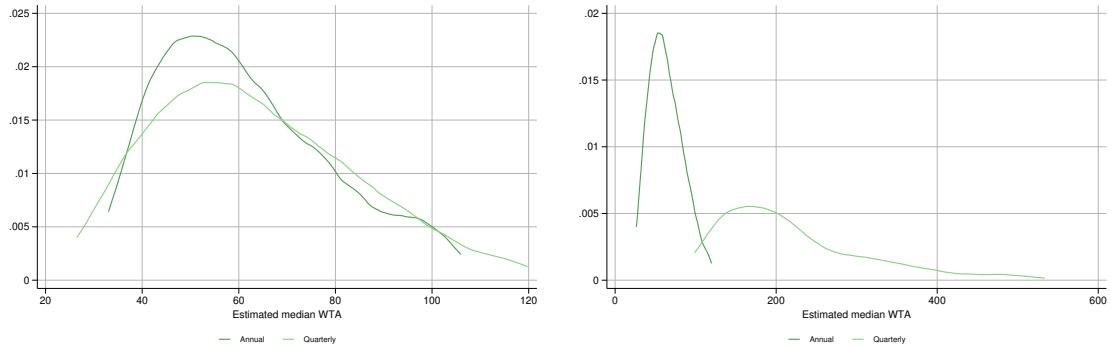


Estimates show results of median estimated value of WTA for individual payments across regions and frequency using the parsimonious set of controls.

Figure B2: Bootstrapped median WTA estimates by forest access regime and experimental arm

(a) Individual forests

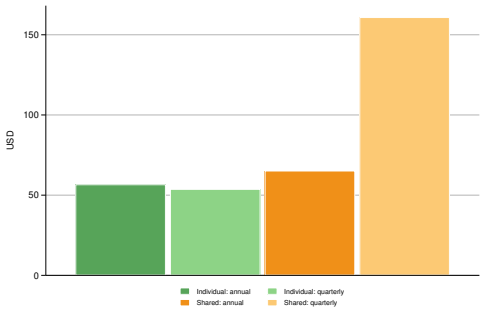
(b) Shared forests



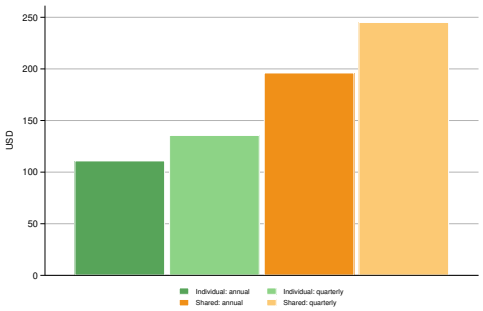
Estimates show results from 1000 estimates of median WTA drawn from a 75% sample of the data. The left panel shows individually managed forest results and the right shared forests. Lighter lines indicate quarterly estimates and darker annual.

Figure B3: WTA estimations dropping key groups of observations

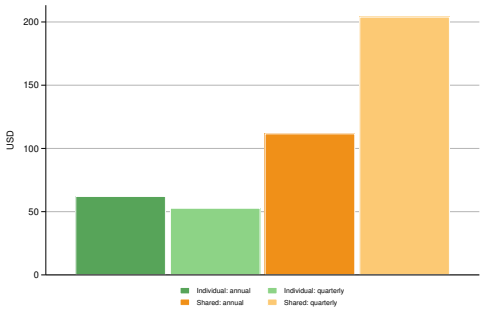
(a) Forest reserves



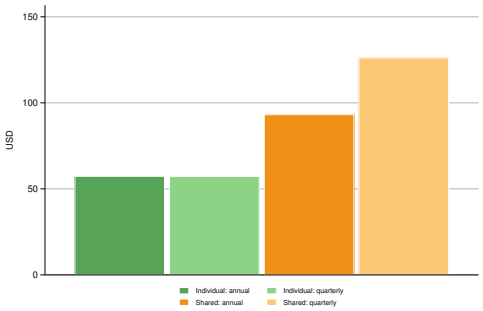
(b) Mt. Elgon



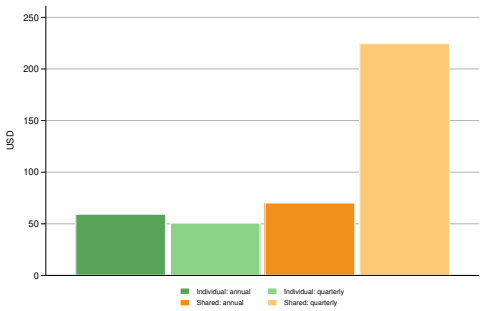
(c) Force exact same distribution of offers



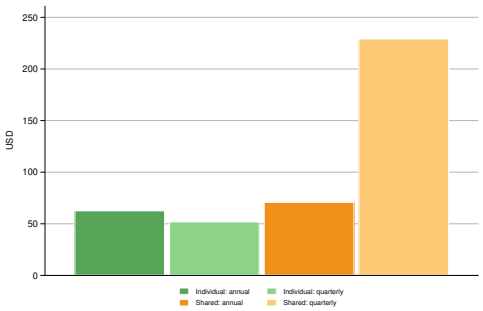
(d) Low trust in trust game



(e) More than 100 acres of forest



(f) Less than 2 years using this forest



Estimates show WTA for simple (no covariates) for individual (green) and shared (orange) forest tenure. Subtitles indicate the group of observations that is *dropped* from the estimation. Figure (c) randomly drops observations such that the number of offers of the same level is equal across all offers and across both arms.

Table B7: Land tenure

	Mean	SD	Min	Max	Count
Institutionnal arrangements					
Customary land access is granted at birth	0.08	0.28	0.00	1.00	404
Customary land access is granted through marriage	0.21	0.41	0.00	1.00	404
Customary land access is granted when the respondent is mature	0.61	0.49	0.00	1.00	404
Customary land access is granted when the elders deem the respondent is suitable	0.10	0.30	0.00	1.00	404
Customary: the income from land is shared	0.23	0.42	0.00	1.00	405
Customary: the income shared is split equally among those with access	0.45	0.50	0.00	1.00	91
Customary: the income shared is split equally among who worked	0.30	0.46	0.00	1.00	91
Customary: the income shared is split and distributed by the head of the family/	0.25	0.44	0.00	1.00	91
Customary land access is taxed	0.04	0.19	0.00	1.00	406
Customary land access fee paid to the local authority	0.81	0.40	0.00	1.00	16
Customary land access fee paid to the national government	0.13	0.34	0.00	1.00	16
Customary land access fee amount, USD	30.06	72.97	1.37	273.30	14
Customary land access fee paid annually	1.00	0.00	1.00	1.00	14
Lease-hold land	0.01	0.11	0.00	1.00	776
Free-hold land	0.99	0.11	0.00	1.00	776
Lease-hold land access fee, USD	227.75	110.23	27.33	355.29	6
Lease-hold fee paid annually	0.67	0.52	0.00	1.00	6
Lease-hold: only the respondent makes land use decisions	0.60	0.52	0.00	1.00	10
Lease-hold: many people make land use decisions, including the respondent	0.20	0.42	0.00	1.00	10
Lease-hold: someone else makes land use decisions, not including the respondent	0.20	0.42	0.00	1.00	10
Free-hold: the respondent purchased the land	0.67	0.47	0.00	1.00	760
Free-hold: year the land was purchased	2001.79	12.21	1950.00	2023.00	494
Free-hold: amount paid for land, USD	1594.03	2397.44	0.00	13664.94	389
Free-hold: land paid with cash	0.89	0.31	0.00	1.00	525
Free-hold: land paid with animals	0.07	0.26	0.00	1.00	525
Free-hold: land paid with installment loan	0.01	0.08	0.00	1.00	525
Free-hold: land was customary	0.89	0.32	0.00	1.00	245
Year customary became free-hold	2001.67	13.25	1963.00	2022.00	214
Free-hold: only the respondent makes land use decisions	0.68	0.46	0.00	1.00	765
Free-hold: many people make land use decision, including the respondent	0.28	0.45	0.00	1.00	765
Free-hold: many people make land use decision, not including the respondent	0.02	0.13	0.00	1.00	765
Free-hold: the landowner makes land use decision	0.01	0.12	0.00	1.00	765
Respondent is the owner of Mailo land	0.28	0.45	0.00	1.00	222
Respondent is the tenant of Mailo land	0.72	0.45	0.00	1.00	222
Mailo land has access fees (for tenant)	0.75	0.44	0.00	1.00	159
Mailo land access fee paid by the tenant, USD	5.16	6.12	1.37	40.99	114
Mailo tenant pay access fee annually	0.98	0.13	0.00	1.00	116
Mailo owner collect fee	0.27	0.45	0.00	1.00	63
Mailo land access fee collected by the owner, USD	29.29	64.53	0.55	273.30	17
Mailo owner collect fee annually	0.71	0.47	0.00	1.00	17
Mailo: only the respondent makes land use decisions	0.76	0.43	0.00	1.00	223
Mailo: many people make land use decision, including the respondent	0.18	0.39	0.00	1.00	223
Mailo: many people make land use decision, not including the respondent	0.04	0.19	0.00	1.00	223

C Predicted deforestation risk

We used the basic Lasso routine in Stata to choose a set of covariates that best predicted the percent area deforested between 2000 and 2019. We set the cross-validation for 10 folds with 100 lambdas. The final out of sample R-squared was 0.23 with a mean CV prediction error of 10.025. A linear regression using the selected variables is shown below. We then used these coefficients to create a linear prediction updated to use the 2019 forest area as the input for baseline forest. This linear prediction is used to assess deforestation risk at the village level.

Table C8: Village level deforestation risk

	(1)
Baseline forest percent	-0.084***
	(0.031)
Central region	5.517*
	(2.782)
Southwest region	8.524***
	(2.519)
Mean elevation	0.011**
	(0.005)
SD elevation	0.007
	(0.021)
SD slope	0.544
	(0.478)
Km to Kampala	-0.000
	(0.000)
Soil productivity	0.258
	(0.360)
Proportion mailo tenure	2.137
	(2.858)
Proportion producing charcoal	3.668
	(2.556)
Constant	-13.855**
	(5.832)
Observations	93

Estimates are coefficients from an OLS regression based upon the selected coefficients from a lasso regression. * p <.10, ** p< .05, *** p<.01.