Conservation Letters
A journal of the Society for Conservation Biology
Open Access

LETTER

Divergent Landowners' Expectations May Hinder the Uptake of a Forest Certificate Trading Scheme

Marta Lisli Giannichi[1,2], Martin Dallimer[2], Timothy R. Baker[1], Gordon Mitchell[1], Paula Bernasconi[3], & Guy Ziv[1]

[1] School of Geography, University of Leeds, Leeds, LS2 9JT, UK
[2] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK
[3] Instituto Centro de Vida (ICV), Cuiabá, Brazil

Keywords
Amazon; Cerrado; CRA; landowners; Mato Grosso; private-land conservation; tradable permits.

Correspondence
Marta Lisli Giannichi, School of Geography, University of Leeds, Leeds, LS2 9JT, UK.
Tel: +44 (0) 113 3433300.
E-mail: martagiannichi@gmail.com

Received
17 April 2017
Accepted
25 August 2017

Editor

doi: 10.1111/conl.12409

Abstract

A major challenge to reduce forest loss in the tropics is to incentivize conservation on private land in agricultural settings. Engaging private landowners in conservation schemes is particularly important along deforestation frontiers, such as in the southern Brazilian Amazon. While we know much about what motivates landowners to participate as providers, or sellers, of conservation schemes, understanding what motivates landowners who act as buyers, that is, those who require land to meet conservation obligations, remains lacking. Here we identify viewpoints of sellers and buyers of an emerging forest certificate trading scheme in Brazil and quantify the compatibility of their views to examine potential barriers to trade. Sellers and buyers could be divided into three groups, but only one group in each case was positive about participating in the scheme. A key concern of buyers was the desire for establishing contracts with a long duration; in contrast, price was a key issue for sellers. Addressing these concerns by defining minimum contract lengths and restricting the spatial scale of transactions will be essential if this scheme is to realise its potential to reduce rates of deforestation.

Introduction

The historical depletion of the natural environment (Gibbons *et al.* 2016) has led to the emergence of a wide variety of market-based conservation instruments. These schemes differ in rationale and implementation, but in essence attempt to create supply and demand for environmental goods (Lapeyre *et al.* 2015). Worldwide, forest conservation has often been the focus of such schemes, commonly based on Payment for Ecosystem Services (PES). Here, landowners receive payments from an institution (e.g., government, NGO, collective fund) to provide certain environmental goods or services, such as carbon storage/sequestration (Kosoy *et al.* 2008; Borner *et al.* 2017). Other recent schemes involve establishing markets for land, such as Tradable Development Rights, biodiversity offsets and habitat banking (Santos *et al.* 2015). These promote trade between private actors as "buyers" and "sellers" of environmental goods/services, potentially reconciling the trade-off between development and conservation (Ring *et al.* 2010). All such schemes rely on voluntary engagement of private landowners as an important factor to deliver long-lasting conservation gains (Kosoy *et al.* 2008; Yeboah *et al.* 2015).

In many conservation schemes, participation of rural landowners has been largely linked to sociodemographic factors: better-off, well-educated, and owners of larger plots of land are more inclined to participate, whereas age and gender are not determinant factors (Pagiola *et al.* 2010; Ma *et al.* 2012; Lastra-Bravo *et al.* 2015). Less is known, however, about how programme-specific factors influence landowners' participation (Greiner & Gregg 2011; Yeboah *et al.* 2015). Additionally, the possibility that sellers and buyers might have different perceptions on programme-specific factors and be influenced by them in different ways is typically disregarded in the

analysis of conservation schemes (Bastian *et al.* 2017; Zabala *et al.* 2017). For instance, long contracts and lack of information tend to be obstacles for sellers (Page & Bellotti 2015; Yeboah *et al.* 2015). In contrast, a scheme that has clear conservation potential often encourages the participation of those landowners who have a positive environmental attitude (Greiner & Gregg 2011; Bremer *et al.* 2014; Kwayu *et al.* 2014). High payment value can also encourage landowners to participate and forgo opportunity costs, but it is not always the main reason for their enrolment (Kosoy *et al.* 2008; Bremer *et al.* 2014; Page & Bellotti 2015). Overall, understanding the influence of these programme-specific factors on the uptake of conservation schemes is important, as they can be modified by policy interventions.

Accounting for the perceptions of buyers and sellers within conservation schemes is particularly urgent in areas under high and increasing deforestation pressure and land-use change, such as at the deforestation frontier in tropical forest landscapes (Nordhagen *et al.* 2017; Zabala *et al.* 2017). Some tropical countries have incorporated conservation incentives into their environmental policies through protection of forest within private land (Borner *et al.* 2016). For example, Brazil, with the world's largest tropical forest, has invested in a variety of strategies to halt deforestation, which resulted in a 70% decline in forest loss from 2005 to 2013 (Nepstad *et al.* 2014), although deforestation has risen more recently (Tollefson 2016). In particular, the Brazilian Forest Code has introduced a promising strategy—the Environmental Reserve Quota (Portuguese acronym, CRA; see SI for details)—that could potentially avoid the deforestation and degradation of native vegetation across a wide range of biomes (Soares-Filho *et al.* 2016). The CRA is a mechanism of tradable forest certificates in which private landowners can trade hectares of native standing forest (Bernasconi *et al.* 2016). This article aims to explore the diversity and agreement between potential sellers and buyers' perceptions of programme-specific factors within CRA (e.g., contract length, price, intermediaries, trust, information) and identify factors that result in sharp divergences between sellers and buyers that could potentially affect trade.

Methods

The Brazilian Forest Code states that private landowners must set aside areas of native vegetation within their farmland. Those who have deforested these set-aside areas (hereafter "Legal Reserve"; LR) above the maximum permitted may compensate for their deficit by acquiring hectares from landowners who have LR surplus. Noncompliant landowners are also given other options, such as: (1) buy and/or register another property with LR surplus; (2) acquire private areas pending tenure regularization inside publically owned protected areas and donate to the Environmental Agency; (3) allow natural recovery or reforestation of the area (Brasil 2012). Another key piece of the Forest Code that will help monitor CRA trades is the rural registry system, which is still to be finalized. Under this system, landowners must register and georeference their land, to promote transparency and compliance (May *et al.* 2015).

Study location

Mato Grosso is the third largest state in Brazil and has extensive coverage by the Amazon, Cerrado and Pantanal biomes (Figure 1). Since the early 1990s, Mato Grosso has experienced high rates of deforestation, mainly driven by expansion in pasture and soybean plantations (Brando *et al.* 2013). Private properties in Mato Grosso occupy 73 (of 90) Mha and nearly 22% (16 Mha) of native vegetation was cleared between 1990 and 2012 (Brando *et al.* 2013). Across the state as a whole, around 5.6 Mha of native vegetation within private land have been deforested above the maximum permitted (Soares-Filho *et al.* 2014). There should, therefore, be considerable demand from landowners to "buy" forest credits in order to meet their legal obligations (Soares-Filho *et al.* 2014). Nevertheless, there are also landowners who retain set-aside areas which exceed the minimum required who could, therefore, act as sellers. This makes Mato Grosso a large potential market for CRA trades (Soares-Filho *et al.* 2016), once the Forest legislation is fully enforced and the CRA is regulated.

Assessing willingness to participate in CRA

We used Q-methodology to explore the diversity of opinions of buyers and sellers regarding the CRA programme (details in SI). Q-methodology identifies and clusters individuals according to distinct perceptions of a topic (Watts & Stenner 2012). Our main objective was to assess different opinions on CRA, and Q-methodology enables an exploratory narrative of these opinions via a systematic and quantitative analysis (Zabala & Pascual 2016).

Between June and August 2016 we contacted farmers within the sampled municipalities (Figure 1) via local organizations that could facilitate communication by providing local landowners contacts (e.g., rural unions, cooperatives, local NGOs and Municipal Agricultural and Environmental Agencies). Of the 113 farmers invited to participate, 59 agreed to be interviewed (52.2% response rate), comprising 35 potential sellers (landowners who stated they have LR surplus) and 24 potential buyers (stated LR deficit). Participants were shown

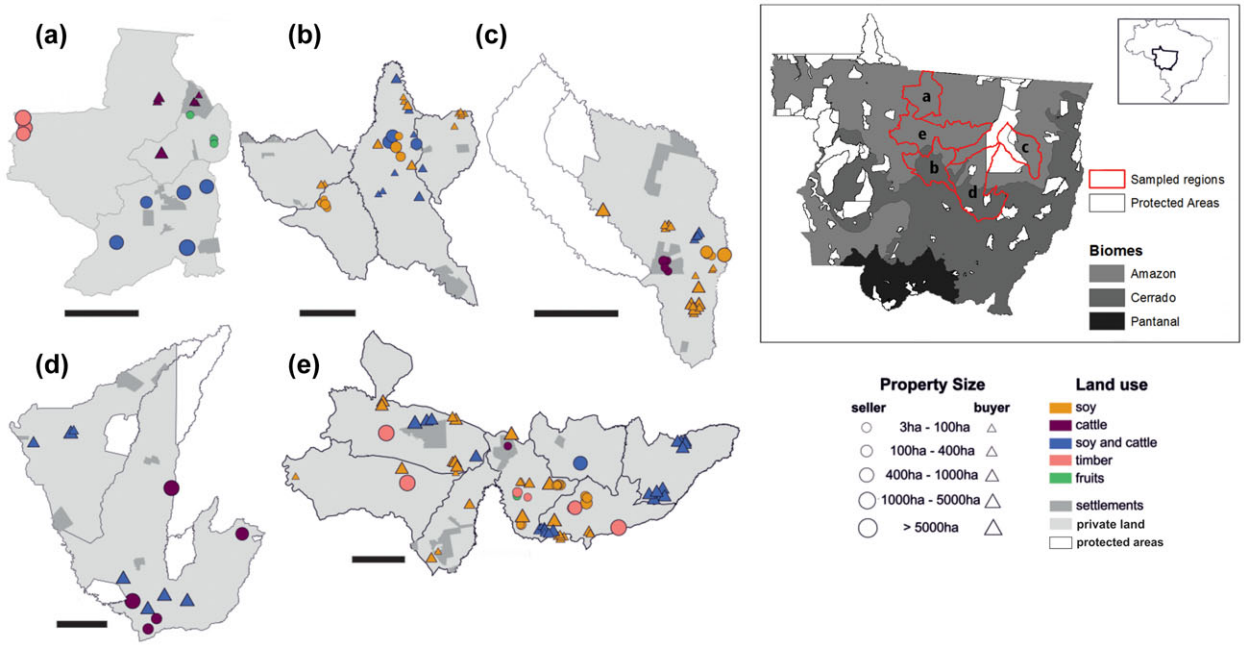

Figure 1 **Inset**: location of municipalities sampled in Mato Grosso (MT). Dark grey shades indicate the biomes in MT and the white areas are conservation units or indigenous lands. **Main figure**: Panels (a)–(e) show the municipalities where buyers and sellers have plots (a single landowner can own several plots of land): (a) Alta Floresta, Carlinda and Nova Canaã do Norte; (b) Tapurah, Lucas do Rio Verde, Sorriso and Vera; (c) Querência; (d) Paranatinga and Nova Ubiratã; and (e) Tabaporã, Ipiranga do Norte, Sinop, Cláudia, União do Sul and Santa Carmem. White areas represent the same conservation units or indigenous lands in the inset; grey areas area settlements and lighter grey shading represents area covered by private land. Different symbols represent buyers or sellers, symbol size is proportional to property size and each colour represents a different land-use. Black solid bars represent 50 kilometers in each of the (a)–(e) panels to give an indication of scale.

39 statements representing possible opinions on CRA programme-specific factors and asked to sort these onto a grid which represents their level of disagreement or agreement, namely Q-sort (Figure SI1). Twenty-seven statements were identical to both groups, five were similar with opposing meanings (Table 1) and seven were specific to either sellers or buyers (Tables 2 and 3). We built statements and thematic categories (contract length, price, intermediaries, trust, transaction costs, payment vehicle, information, ecoeffectiveness and demotivation) based on literature review and interviews with key actors (details in SI). All statements were pilot-tested with six landowners prior to application with participants. Besides the application of Q methodology, socio-demographic and farm-specific information were collected.

In spite of our efforts to cover a variety of land-uses, farm sizes, and demographic profiles (Table 4), landowners who are remotely-based and nonaffiliated to any organization are likely undersampled. However, our final sample reflects the main characteristics of Mato Grosso's agriculture: large landholdings (>1,000 ha) dominated by pasture and soybean (DeFries *et al.* 2013; Godar *et al.* 2015).

Data analysis

Q-sorts from buyers and sellers were analyzed separately using Principal Component Analysis (PCA) and varimax rotation in R package "qmethod" (Zabala 2014). The analysis provides representative groups of participants who share similar views about CRA. The final product of the analysis is an idealized sorting distribution of statement scores (hereafter "normalized factor scores") ranging between –4 (strongly disagree) and +4 (strongly agree), corresponding to the view of a hypothetical best representative participant of each group; and the statements that are statistically distinguishable to groups of sellers or buyers for $p < 0.05$ (Zabala 2014). To ease subsequent calculations, we negate the buyers normalized factor scores for statements with opposing meaning between the two groups (Table 1).

Measuring trade compatibility between buyers and sellers

To assess whether buyers and sellers have similar views about programme-specific factors that could indicate a

Table 1 Sellers and buyers statements and respective programme-specific factors, including the normalized factor scores for each group (group definitions given in Table 4 caption). Differences between groups significant at $^{*}p < 0.05$ and $^{**}p < 0.01$. Sentences in bold are consensus statements among either sellers or buyers.

Thematic categories	Statement number	Statement	Sellers			Buyers		
			A	B	C	D	E	F
Contract	S1/B1	Five years is the maximum period I'd contract CRA.	−1**	1**	−2*	0**	−3	−3
Contract	S2/B2	I think a 10-year contract is good length to guarantee stability and a fair price for contracting CRA.	3**	−1	−3	0**	−2	−1
Contract	S3/B3	I'd rather sign long-term contracts, from 15 years onward.	−1	−3**	0	−2*	0**	2**
Ecoeffectiveness	S4/B4	The CRA scheme will significantly help animal and plant conservation.	4**	3**	−1**	2**	4	3
Ecoeffectiveness	S5/B5	The CRA scheme will help protect forested areas.	4**	1**	−2**	1	−1	3**
Ecoeffectiveness	S6/B6	I'd deforest all native vegetation on my property if the Forest Code allowed.	−4	−4	−1**	−2	−4**	−2
Information	S7/**B7**	**Before this interview, I already had a good knowledge of the regulations and requirements in the new Forest Code.**	0	2**	0	**2**	**1**	**2**
Information	S8/B8	Before this interview, I was well-informed of the possibility to trade forest credits (CRA).	−4	−1*	−2	−1	−1	0*
Information	S9/B9	I think the CRA rules are too complicated.	0	−1	3**	−1	1**	−1
Information	S10/B10	I think CRA will not work.	−2**	0*	1**	−3**	1**	−3*
Information	S11/B11	I know intermediaries institutions of CRA such as BVRio and Biofilica.	−2	−2	−4**	0**	−2**	−4**
Information	**S12/B12**	**I don't know what my responsibilities are as a seller/buyer.**	**2**	**3**	**1**	**0**	**−1**	**0**
Intermediary	S13/B13	I would be willing to pay an annual fee for an intermediary institution that monitor the contract yearly.	1**	0**	−2**	−3	−2	1**
Intermediary	S14/B14	Having an intermediary makes the whole process more expensive.	0**	2	3	1**	2**	−1**
Intermediary	S15/B15	To me it would be impossible to go through all the CRA process without an intermediary.	1**	−1**	2**	1	−2**	0
Intermediary	S16/B16	I do not know where to find buyers and I need somebody to do that for me.	2	2	0**	0	0	1**
Intermediary	S17/B17	I prefer to negotiate CRA contract with a buyer/seller myself, without intermediaries.	−1*	0*	2**	1	1	−2**
Payment vehicle	S18/B18	I prefer to receive/pay annual payments for the duration of the contract.	0	2**	−1	−1	0	−2*
Payment vehicle	S19/B19	I only feel safe to receive/ pay the payment via an intermediary.	1	−3**	1	−2	−2	0**
Price	S20/B20	The price will depend on my land-use.	1**	−1**	4**	1*	0	1
Transaction costs	S21/B21	The associated expenses (negotiation, fencing [as seller] etc.) are a significant barrier for me to participate in CRA	0	−1	2**	0	0	−1**
Trust	S22/B22	I would trust an unknown landholder to proceed with a CRA contract.	−2**	−3	−2	0	−4**	0
Trust	S23/B23	I would visit the property of the seller/buyer, no matter how far it is, before selling credits.	1**	−2	−1	−4**	3**	1**
Demotivation	S24/B24	I do not see any real incentive for me to sell/compensate my exceeding Legal Reserve.	−2**	4**	−1*	1*	2**	−1**
Demotivation	S25/B25	I think the Forest Code will change again, so will wait and do nothing in the next few years.	0**	1	1	−1	2**	0
Contract	S26/B26	I would only sell/buy CRA for perpetuity.	−3	−4	−1**	−2**	2**	4**
Transaction costs	**S27**/B27	**CRA must have a fiscal incentive for aiming at conservation.**	**2**	**3**	**4**	3**	3	2
Price	S28	The per-hectare price of CRA should be at least how much I would get renting my land	3	1**	3	NA	NA	NA
Price	B28[†]	The per-hectare price of CRA should be at most how much I make per hectare	NA	NA	NA	(+)−3**	(+)−1**	(−)2**
Price	S29	The per-hectare price of CRA should be at least how much I would get selling my land	−2*	−2**	1**	NA	NA	NA

Continued

Table 1 Continued

Thematic categories	Statement number	Statement	Sellers			Buyers		
			A	B	C	D	E	F
Price	**B29**	**The per-hectare price of CRA should be at most how much I would pay purchasing vegetated land in my region.**	NA	NA	NA	**3**	**3**	**2**
Price	S30	For a higher price, I would sell to any landowner regardless of his location in my state.	−3	−2	−4**	NA	NA	NA
Price	B30†	For a lower price, I would buy from any landowner regardless of his location in my state.	NA	NA	NA	(+)−1	(+)−1	(−)1*
Demotivation	S31	CRA will only be attractive for who has Legal Reserve well above the minimum.	−1**	0	1	NA	NA	NA
Demotivation	B31†	CRA will only be attractive for who has Legal Reserve well below the minimum.	NA	NA	NA	(+)−1**	(−)2**	(+)−3**
Price	S32	The longer the contract the higher the price should be.	−1*	0**	2**	NA	NA	NA
Price	B32†	The longer the contract the lower the price should be.	NA	NA	NA	(−)3	(−)1	(−)4*

†The normalized factor scores of these statements were negated to ease calculations using Equation (1).

potential trade, we develop a Trade Compatibility Index (TCI) for each combination of buyer and seller category across all statements (details in SI), based on significant differences in normalized factor scores. TCI is calculated for a particular pair of sellers and buyers as derived from the PCA analysis. The lower the TCI, the more compatible a pair is in their perceptions (i.e., more similar Q-sort). More formally, we define TCI as:

$$\mathrm{TCI}(\{s\}) = \frac{\sum_{i \in s} |S_i - B_i| \; p_i^S p_i^B}{C \times \sum_{i \in s} \; p_i^S p_i^B}, \qquad (1)$$

where S_i is the normalized factor score for statement i for sellers and B_i is the normalized factor score for statement i for buyers. p_i^X equals 1 if the respective statement was given a significantly different score ($p < 0.05$) by a group, when pairwise compared to scores given by other groups. If not significant, p_i^X equals 0. This is to ensure that only statements that were distinct to define how a group "thinks" were included in the calculations. The constant C ensures TCI range from 0 to 1 (here $C = 8$; C is the sum of minimum and maximum absolute values of normalized factor scores). We calculated TCI for each pair of sellers and buyers, starting with statements set $\{s\}$ belonging to the contract thematic category, and added other thematic categories to the statements set in a stepwise fashion (details in SI).

Table 2 Sellers' only statements and respective programme-specific factors, including the normalized factor score for each group (group definitions given in Table 4 caption). Differences between groups significant at *$p < 0.05$ and **$p < 0.01$. Sentences in bold are consensus statements among sellers.

Thematic categories	Statement number	Statement	Sellers			Buyers		
			A	B	C	D	E	F
Ecoeffectiveness	S33	I wouldn't deforest my exceeding Legal Reserve.	3	4	−3**	NA	NA	NA
Information	S34	I see CRA as an investment so I will definitely be part of this market.	2**	−2	−3	NA	NA	NA
Intermediary	S35	An intermediary institution as a mediator reduces the risk of default.	2**	0	0	NA	NA	NA
Transaction costs	S36	The requirement of fencing makes CRA unattractive to me.	−1**	1	0	NA	NA	NA
Transaction costs	**S37**	**The costs for travelling, documentation, certificates and other associated expenses must considered as part of the CRA price.**	**1**	**2**	**0**	NA	NA	NA
Demotivation	S38	My exceeding LR is not significantly large so I wouldn't be willing to issue CRA.	−3**	1	2	NA	NA	NA
Demotivation	S39	Only CRA credits are not enough to make up the effort I made to conserve my exceeding Legal Reserve.	0*	0	0	NA	NA	NA

Table 3 Buyers' only statements and respective programme-specific factors, including the normalized factor score for each group (group definitions given in Table 4 caption). Differences between groups significant at $^{*}p < 0.05$ and $^{**}p < 0.01$.

Thematic categories	Statement number	Statement	Sellers			Buyers		
			A	B	C	D	E	F
Ecoeffectiveness	B33	If buying from another private landholder I'd like it to be from a conservation priority area.	NA	NA	NA	2**	0	1
Price	B34	I am very afraid of getting fined for noncompliance with the Forest Code.	NA	NA	NA	2**	−1	0
Trust	B35	I am afraid to run the risk of the sellers not keeping their obligations to preserve the land appropriately.	NA	NA	NA	−2	1**	−1
Demotivation	B36	I would prefer to buy vegetated land from another private landholder to be in compliance as opposed to renting CRA.	NA	NA	NA	2**	4**	−4**
Demotivation	B37	I would prefer to buy a land within a protected area and donate to the government as opposed to renting CRA.	NA	NA	NA	4**	0	1
Demotivation	B38	I prefer natural regeneration than buying CRA.	NA	NA	NA	−4**	−3	−2
Demotivation	B39	To reforest my deficit is my least option.	NA	NA	NA	4**	−3**	3**

Results

PCA analyses revealed three groups of sellers and three of buyers (total explained variance 44% and 46%, respectively). Q-methodology is designed to capture the diverse viewpoints from a relatively small sample size (Zabala & Pascual 2016). Thus, the number of assigned sellers and buyers to each group (Table 4) cannot be used as an accurate measure of their relative proportion within the overall landowners population. Of the 35 potential sellers interviewed, four were not representative of any of the three groups, while of the 24 potential buyers, only one was not representative (all identified via automatic flagging; details in SI). Hence, they were not considered in subsequent analyses.

Sellers

A lack of awareness about their responsibilities (statement 12 for sellers, hereafter denoted S12) was a consensus statement among sellers. Sellers also collectively agreed that transaction costs should be included in CRA price per hectare (S37) and that CRA should have a fiscal incentive (S27). Beyond these areas of consensus, three groups of sellers were identified.

Independent conservationists (group A)

Ideas of conservation provoked strong feelings for these landowners. They not only agreed that CRA can be a good conservation scheme to significantly protect forests at a large scale (S4, S5), but are also eager to conserve regardless of an economic incentive (S6). Predominantly composed of small landowners, 29% rely exclusively on growing fruits and vegetables as their main land-use (Table 4).

Their mean LR is the lowest of the sellers (Table 4), but this does not alter their perception that CRA could be a way to receive income for their LR (S34). Price (S28) was important, and for them it should vary according to forgone opportunity costs, even though they do not wish to deforest their land. "With or without CRA the forest must be preserved. Our consciousness does not let us do any type of deforestation," said one *independent conservationist* in his interview.

This group was strongly motivated to take part in CRA as they disagreed with statements on potential barriers (S24, S31). However, they require more information to facilitate their engagement (S8). They do not anticipate deforesting their LR surplus in the near future (S33) and consider a 10-year contract period to be a good option (S2).

Environmental disbelievers (group B)

Although attributing importance to conservation (S4, S33), this group does not believe that CRA will help protect forests (S5). They distrust negotiation with other landholders (S22) and do not wish to create opportunities to build trust (S23), indicating reluctance to be involved at all. Even a higher price (S30) per hectare did not influence their distrust in CRA, or in other landowners. Additionally, they do not see any reason to participate (S24). They recognize the importance of intermediaries in facilitating trade (S16) and are aware that this can have an impact on pricing (S14) but were unconcerned about the other roles intermediaries might have (S13, S17, S35). Long-term and perpetual contracts are unthinkable (S3, S36) and the potential CRA returns were not important (S20, S28, S32).

Table 4 Summary information about sellers and buyers (covering landholder and farm characteristics) and respective explained variances for each grouping identified as part of the Q analysis: **A** represents independent conservationists; **B** environmental disbelievers; **C** willing deforesters; **D** CRA outsiders; **E** cautious buyers; and **F** compensation seekers.

		Sellers			Buyers		
		A	B	C	D	E	F
		$n = 14$	$n = 10$	$n = 7$	$n = 8$	$n = 10$	$n = 5$
	Explained variance (%)[a]	20	14	10	19	17	10
Landholder							
	Average age	46	53	55	49	51	46
	Education						
	Primary school (%)	28	20	40	25	20	0
	Secondary school (%)	29	20	0	37	10	40
	Technical (%)	7	0	20	0	0	20
	University (%)	36	60	40	38	70	40
Farm							
	Mean farm size (ha)[b]	2,224	7,119	3,768	12,931	6,186	2,740
	Mean arable area (ha)	811	1,154	993	6,611	3,621	1,100
	Mean Legal Reserve (ha)	1,417	5,957	2,604	5,890	911	920
	Land-use						
	Pasture (%)	50	50	28	12	10	20
	Agriculture (%)	14	20	28	50	60	80
	Pasture + agriculture (%)	0	20	30	38	30	0
	Timber (%)	7	10	14	0	0	0
	Fruits (%)	29	0	0	0	0	0
	Biome						
	Cerrado (%)	36	50	43	25	30	20
	Amazon (%)	64	50	57	75	70	80

[a]Altogether, the three factors extracted explained 44% of the study variance. Factor analysis considers as a reasonable solution an explained variance above 35% (Howard *et al.* 2016).

[b]Most of the areas registered in CAR (rural database system) for MT are greater than 1,000 hectares (Godar *et al.* 2015).

Willing Deforesters (group C)

Price is all that matters to this group. CRA should provide the same financial return as productive land (S20, S28), regardless of its potential to protect native standing forests (S4, S5). How this potential monetary return will reach them does not matter (S18, S19). They do not perceive that complete deforestation is necessarily a poor outcome (S6) and would be willing to deforest their LR surplus (S33), suggesting they have no intrinsic motivation to conserve. They see CRA rules as too complicated (S9) and limited to specific groups of landowners (S31, S38). Interestingly, they were neutral about long-term and perpetual contracts (S3, S26). CRA is simply not seen as a profitable investment (S34). This will act as a barrier to them entering the market as they will favour more profitable land-uses, such as cattle or agriculture.

Buyers

Lack of awareness about their responsibilities was also consensus among buyers (B12) and, in general, buyers did not attribute much importance to being uninformed about CRA. It was also a consensus that CRA prices per hectare should not be higher than non-productive land prices (B29).

CRA outsiders (group D)

This group wants to be exempted from their environmental liability for a competitive price, preferably without any responsibilities for land management (statement 37 for buyers, hereafter denoted B37). They are very production-driven and would not promote any sort of environmental conservation activity if it meant a loss of productive land (B38, B39). CRA seems to be an odd and unfair compensation strategy to them. It involves making regular payments for a forest certificate that will never be theirs and has an "expiry date." Interestingly, from our interviews with them, we learned that half of this group had recently acquired private land in areas designated by the government for conservation—the so called public conservation units. For them, to have somebody (the seller) managing a forested land for them is not a rational decision. They prefer to delegate this

responsibility to the government (B36, B37) and are not prepared to consider any of the contract lengths proposed (B1, B2, B3, B26). In their own words: "The whole society should pay to maintain forest inside farms as the big urban centres also depend on clean air and water. To make this as an exclusive expense on the farmer is unfair."

Cautious buyers (group E)

As opposed to the other buyers, this group understands the conservation value of their LR (B6). They believe CRA has conservation potential (B4) but not at a large scale (B5). To ensure reliable negotiations they like to take the lead and are unwilling to go through intermediaries (B15). This is illustrated by their preference to visit a seller's property to minimize risks (B23) and to engender trust in the negotiation (B22). Perpetual contracts are the only contract duration that would be agreeable (B26). They are concerned about the longevity of CRA and stability of the Forest Code (B25), leaving them disinclined to participate (B24). They did not think they would participate in the market as: (i) they would rather acquire another forested farm in order to meet their obligations, rather than use CRA (B36) and (ii) in contrast with other buyers, they feel that active reforestation on their own land remains a possible strategy to recover their forest deficit (B39).

Compensation seekers (group F)

This group was the most willing to enter in CRA market, but their participation would be conditional on long-term contracts (B1, B2, B3, B26). They declined other compliance options (B36, B38, B39) and are indifferent about acquiring land in conservation units (B37). They see the conservation potential in CRA (B4, B5) and are positive about the success of the scheme (B10). However, a competitive price is important to guarantee their long-term participation (B28, B32). As they are seeking a perpetual contractual commitment, they seek the lowest price per hectare and trusting an unknown landowner is not an issue (B22, B23, B35).

Trade Compatibility Index (TCI)

Pairs of buyers and sellers were not substantially incompatible regarding CRA programme-specific factors (Figure 2). The overall TCI (i.e., including all thematic categories) for the most compatible pair (*independent conservationists* and *compensation seekers*: AF) was 0.167 on the scale of 0–1 (low TCI values indicate strong agreement; high values indicate strong disagreement for all

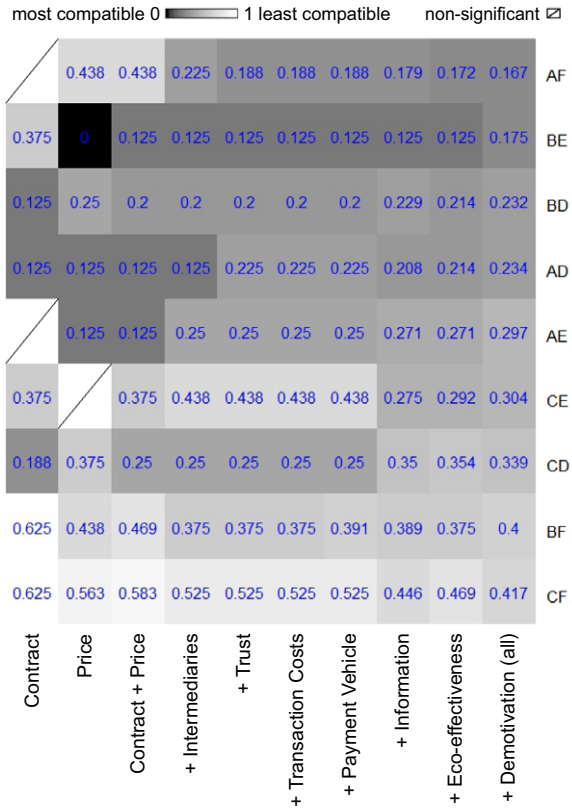

Figure 2 Trade Compatibility Indexes (Equation (1)) for each pair of sellers and buyers. The darker the cell, the more compatible the pair. The thematic categories were included in the model step-wise left to right. For **A**–**F** titles, see caption in Table 4. To assess overall compatibility, sorting was made according to right-most column, which is the one including all thematic categories.

statements in common). The most incompatible pair, *willing deforesters* and *compensation seekers* (CF), had a TCI of 0.417. TCI overall results suggest that *willing deforesters*, as the most incompatible group of sellers, is unlikely to engage in a trade. Although *environmental disbelievers* (B) showed high compatibility with two groups of buyers (TCI = 0.175 and 0.232), they clearly stated their disinterest in CRA. Apart from pairing up successfully (TCI = 0.167) with *independent conservationists*, *compensation seekers* were the most incompatible group of buyers (TCI range = 0.4–0.417). Ironically, they were the only group of buyers who considered participating in CRA.

Analysing how TCI values vary among different categories of factors allows us to identify the causes of particularly high agreement or disagreement between groups. For example, TCI values for contract length only are particularly high (e.g., TCI = 0.625) between *environmental disbelievers* and *compensation seekers* (BF), and the latter and *willing deforesters* (CF), as *compensation seekers* have a strong preference for long or perpetual contracts. For

independent conservationists and *compensation seekers* (AF), contract length was not significant, in spite of independent conservationists' disagreement with perpetual contracts (S26). However, when the TCI values were based only on price, AF had a relatively high TCI (0.438). When statements about other thematic categories were included, the incompatibility decreased suggesting price was the main point of disagreement between them.

Discussion

Differences among landowners must be considered in the design of market-based conservation instruments as we show that perceptions of programme-specific factors vary widely among potential groups of sellers and buyers. In the case of CRA, not all sellers were equally inclined to participate and not all buyers saw CRA as a good compensation strategy. Two programme factors in particular played a major role in determining compatibility between buyers and sellers: contract length and price.

Sellers prefer short-term contracts, as they associate long-term agreements with land management restrictions and the potential to miss future advantageous opportunities. In analogous programmes, such as PES and conservation easements, long-term and perpetual contracts discouraged the participation and permanence of sellers (Sorice *et al.* 2013; Yeboah *et al.* 2015; Bastian *et al.* 2017). Our results corroborate these findings as potential CRA sellers are reluctant to accept long-term contracts. In contrast, we found that buyers have a strong preference for long-term or perpetual agreements. Many buyers, therefore, might choose to acquire and donate private land inside conservation units. In Mato Grosso, these areas represent 800,000 ha in the Amazon and 50,000 ha in Cerrado (Andrade *et al.* 2013), which would cover a portion of the estimated LR deficit of 3.9 and 1.6 Mha in Amazon and Cerrado, respectively (Soares-Filho *et al.* 2014).

Despite the fact that some buyers, such as *CRA outsiders,* are likely to meet their Forest Code obligations by purchasing land in conservation units, Amazon and Cerrado would still have 3.1 and 1.1 Mha of demand left, respectively, which could result in successful CRA trades. Sellers willing to participate, such as *independent conservationists*, are well-placed to trade with *compensation seekers*, if issues around contract length can be resolved. To encourage this match, CRA regulation could set a minimum of 10 to 15-year contracts to ensure medium-term supply of forest certificates and to provide a middle-ground for sellers and buyers. This time-frame is widely adopted in analogous schemes (Lennox & Armsworth 2011) and contributes to an increased likelihood of future re-enrolment (Ando & Chen 2011).

Another important issue policy-makers need to address is how to make CRA more attractive to unwilling sellers like *willing deforesters*—landowners who clearly stated an intention of legally deforesting their LR surplus. If this land could be brought into CRA, the potential gains for the area of land under protection could be huge. In Mato Grosso, nearly 1.6 and 4 Mha, in the Amazon and Cerrado, respectively, could face legal deforestation. For *willing deforesters*, who are more profit-driven, price will likely play an important role. Because their parcels are located in regions of high opportunity costs, buyers will prefer trading with low-cost areas under no imminent deforestation pressure. A potential strategy to address issues around price is to restrict the spatial scale of trade (May *et al.* 2015). If trade could be constrained subregionally within the state, potentially restricted to areas under similar deforestation pressure, surpluses owned by *willing deforesters* could be brought into the market. Spatially restricted trade appears as an effective measure to achieve conservation gains both in CRA (Bernasconi *et al.* 2016) and in PES schemes (Sattler *et al.* 2013; Grima *et al.* 2016).

Our findings provide empirical evidence of how different perceptions on programme-specific factors can become substantial barriers to sellers and buyers engaging in trading land. To overcome these barriers, we suggest (1) establishing minimum contract durations and (2) restricting the spatial scale of trade to resolve issues around price and target specific landowner groups, are important policy recommendations that could minimize barriers to trade and improve chances of success. In addition, law enforcement and transparent monitoring should not be overlooked by regulators.

This study provides insights that are generally applicable in contexts where peer-to-peer schemes are promoted to avoid further forest conversion. In settings that provide similar preconditions in terms of environmental policies and land tenure, it is likely that many buyers will also prefer perpetual solutions, whereas sellers will prefer short-term contracts to avoid long-term commitments. In addition, landowners' heterogeneous perceptions about a given scheme should be considered, in order to target policy interventions to specific groups that are not likely to participate. The Trade Compatibility Index, as a novel and generally applicable methodological step, allows a systematic comparison between groups, emphasizing trade potentialities and key programme-specific factors that could be points of concern. Designing policies that are sensitive to the intended audience is likely to be critical to ensure that conservation interventions achieve their goals.

Acknowledgments

We thank the participants who voluntarily contributed to this study; Alfredo Filho for invaluable assistance with data collection; experts who assisted us with the statements and comments from two anonymous reviewers. MLG is supported by a PhD scholarship [205774/2014-8] from National Counsel of Technological and Scientific Development – Brasil (CNPq); TB is partially supported by NERC grant "Niche Evolution of South American Trees" (NE/I028122/1).

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

Figure S1: Diagram of methodological steps taken in this study. Each box corresponds to a section in the SI.

Figure S2: Grid distribution used in this study. Strong disagreement is denoted by –4 and strong agreement +4.

Table S1: Contacted local and regional organizations in base-municipalities

Table S2: Original Portuguese version of the statements and their correspondent translated version in English

Table S3: Loadings of sellers' groups. (A) The *independent conservationists*; (B) the *environmental disbelievers*; (C) the *eminent deforesters*. Asterisks indicate the loadings kept for calculations

Table S4: Loadings of buyers' groups. (D) The *CRA outsiders*; (E) the *cautious buyers*; (F) the *compensation seekers*. Asterisks indicate the loadings kept for calculations

Table S5: Z-scores of statements identical to both groups of sellers and buyers

Table S6: Comparison of TCI results robustness check using Spearman correlation test using z-scores and normalized factor scores

Table S7: Trade Compatibility Indexes (TCI) values for pairs of sellers and buyers. Set of statements corresponding to each thematic category were added step-wise in the calculations. The column "Demotivation (all)" includes all statements. Shaded cells correspond to nonsignificant TCI values.

References

Ando, A.W. & Chen, X.X. (2011). Optimal contract lengths for voluntary ecosystem service provision with varied dynamic benefit functions. *Conserv. Lett.*, **4**, 207-218.

Andrade, J., May, P.H. & Bernasconi, P. (2013). A policy mix to finance protected areas in Mato Grosso, Brazil. Pages 379-394 in M. Roldan, L. Rival, editors. *Governing the provision of ecosystem services*. Springer, Dordretch.

Bastian, C.T., Keske, C.M.H., McLeod, D.M. & Hoag, D.L. (2017). Landowner and land trust agent preferences for conservation easements: Implications for sustainable land uses and landscapes. *Landsc. Urban Plan.*, **157**, 1-13.

Bernasconi, P., Blumentrath, S., Barton, D.N., Rusch, G.M. & Romeiro, A.R. (2016). Constraining forest certificate's market to improve cost-effectiveness of biodiversity conservation in Sao Paulo State, Brazil. *PloS one*, **11**, 1-18.

Borner, J., Baylis, K., Corbera, E. *et al.* (2016). Emerging evidence on the effectiveness of tropical forest conservation. *PloS one*, **11**, 1-11.

Borner, J., Baylis, K., Corbera, E. *et al.* (2017). The effectiveness of payments for environmental services. *World Dev.*, **96**, 359-374.

Brando, P.M., Coe, M.T., DeFries, R. & Azevedo, A.A. (2013). Ecology, economy and management of an agroindustrial frontier landscape in the southeast Amazon. *Philoso. Transact. R. Soc. Lond. Ser. B, Biol. Sci.* **368**, 20120152.

Brasil. (2012). Forest Code. Lei No 12727 (October 17, 2012).

Bremer, L.L., Farley, K.A. & Lopez-Carr, D. (2014). What factors influence participation in payment for ecosystem services programs? An evaluation of Ecuador's SocioPáramo program. *Land Use Policy*, **36**, 122-133.

DeFries, R., Herold, M., Verchot, L., Macedo, M.N. & Shimabukuro, Y. (2013). Export-oriented deforestation in Mato Grosso: harbinger or exception for other tropical forests? *Philos. Transact. R. Soc. B-Biol. Sci.*, **368**, 20120173.

Gibbons, P., Evans, M.C., Maron, M. *et al.* (2016). A loss-gain calculator for biodiversity offsets and the circumstances in which no net loss is feasible. *Conserv. Lett.*, **9**, 252-259.

Godar, J., Gardner, T.A., Tizado, E.J. & Pacheco, P. (2015). Actor-specific contributions to the deforestation slowdown in the Brazilian Amazon (vol 111, pg 15591, 2014). *Proc. Nat. Acad. Sci. U.S.A.*, **112**, E3089-E3089.

Greiner, R. & Gregg, D. (2011). Farmers' intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: empirical evidence from northern Australia. *Land Use Policy*, **28**, 257-265.

Grima, N., Singh, S.J., Smetschka, B. & Ringhofer, L. (2016). Payment for ecosystem services (PES) in Latin America: analysing the performance of 40 case studies. *Ecosyst. Serv.*, **17**, 24-32.

Howard, R.J., Tallontire, A.M., Stringer, L.C. & Marchant, R.A. (2016). Which "fairness", for whom, and why? An empirical analysis of plural notions of fairness in Fairtrade Carbon Projects, using Q methodology. *Environ. Sci. Pol.*, **56**, 100-109.

Kosoy, N., Corbera, E. & Brown, K. (2008). Participation in payments for ecosystem services: case studies from the Lacandon rainforest, Mexico. *Geoforum*, **39**, 2073-2083.

Kwayu, E.J., Sallu, S.M. & Paavola, J. (2014). Farmer participation in the equitable payments for watershed services in Morogoro, Tanzania. *Ecosyst. Serv.*, **7**, 1-9.

Lapeyre, R., Froger, G. & Hrabanski, M. (2015). Biodiversity offsets as market-based instruments for ecosystem services? From discourses to practices. *Ecosyst. Serv.*, **15**, 125-133.

Lastra-Bravo, X.B., Hubbard, C., Garrod, G. & Tolón-Becerra, A. (2015). What drives farmers' participation in EU agri-environmental schemes?: Results from a qualitative meta-analysis. *Environ. Sci. Pol.*, **54**, 1-9.

Lennox, G.D. & Armsworth, P.R. (2011). Suitability of short or long conservation contracts under ecological and socio-economic uncertainty. *Ecol. Model.*, **222**, 2856-2866.

Ma, S., Swinton, S.M., Lupi, F. & Jolejole-Foreman, C. (2012). Farmers' willingness to participate in payment-for-environmental-services programmes. *J. Agric. Econ.*, **63**, 604-626.

May, P.H., Bernasconi, P., Wunder, S. & Lubowski, R. (2015). Environmental reserve quotas in Brazil new forest legislation: an ex ante appraisal. Occasional Paper 131 Bogor, Indonesia: CIFOR.

Nepstad, D., McGrath, D., Stickler, C. *et al.* (2014). Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science*, **344**, 1118-1123.

Nordhagen, S., Pascual, U. & Drucker, A.G. (2017). Feeding the household, growing the business, or just showing off? Farmers' motivations for crop diversity choices in Papua New Guinea. *Ecol. Econ.*, **137**, 99-109.

Page, G. & Bellotti, B. (2015). Farmers value on-farm ecosystem services as important, but what are the impediments to participation in PES schemes? *Sci. Total Environ.*, **515–516**, 12-19.

Pagiola, S., Rios, A.R., & Arcenas, A. (2010). Poor household participation in payments for environmental services: lessons from the Silvopastoral Project in Quindío, Colombia. *Environ. Resour. Econ.*, **47**, 371-394.

Ring, I., Drechsler, M., van Teeffelen, A.J.A., Irawan, S. & Venter, O. (2010). Biodiversity conservation and climate mitigation: what role can economic instruments play? *Curr. Opin. Environ. Sustain.*, **2**, 50-58.

Santos, R., Schrotter-Schlaack, C., Antunes, P., Ring, I. & Clemente, P. (2015). Reviewing the role of habitat banking and tradable development rights in the conservation policy mix. *Environ. Conserv.*, **42**, 294-305.

Sattler, C., Trampnau, S., Schomers, S., Meyer, C. & Matzdorf, B. (2013). Multi-classification of payments for ecosystem services: how do classification characteristics relate to overall PES success? *Ecosyst. Serv.*, **6**, 31-45.

Soares-Filho, B., Rajao, R., Macedo, M. *et al.* (2014). Cracking Brazil's Forest Code. *Science*, **344**, 363-364.

Soares-Filho, B., Rajao, R., Merry, F. *et al.* (2016). Brazil's market for trading forest certificates. *PloS One*, **11**, 363-364.

Sorice, M.G., Oh, C.O., Gartner, T., Snieckus, M., Johnson, R. & Donlan, C.J. (2013). Increasing participation in incentive programs for biodiversity conservation. *Ecol. Appl.* **23**, 1146-1155.

Tollefson, J. (2016). Deforestation rates spike in Brazil. *Nature* **540**, 182-182.

Watts, S. & Stenner, P. (2012). *Doing Q-methodological research: theory, method & interpretation*. SAGE Publications Ltd., London.

Yeboah, F.K., Lupi, F. & Kaplowitz, M.D. (2015). Agricultural landowners' willingness to participate in a filter strip program for watershed protection. *Land Use Policy*, **49**, 75-85.

Zabala, A. (2014). qmethod: a package to explore human perspectives using q methodology. *R J.*, **6**, 163-173.

Zabala, A. & Pascual, U. (2016). Bootstrapping Q methodology to improve the understanding of human perspectives. *PloS One*, **11**(2): e0148087.

Zabala, A., Pascual, U. & García-Barrios, L. (2017). Payments for pioneers? Revisiting the role of external rewards for sustainable innovation under heterogeneous motivations. *Ecol. Econ.*, **135**, 234-245.

