Timber or Carbon? Evaluating forest conservation strategies through a discrete choice experiment conducted in northern Guatemala

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Introduction

There is continuing concern about losses of tropical forests in developing countries due to potential carbon emissions (e.g., Baccini et al.,2017) and biodiversity losses (e.g., Giam, 2017). Conserving many of these tropical forests, however is not an easy task because communities located in or near the forest may depend on extracting forest resources as a source of income. For example, while timber concessions provide income from the landscape, a large share of the carbon losses in tropical forests result from forest degradation, including harvesting activities (Baccini et al., 2017). As Roopsind et al. (2018) points out, timber management can be changed to reduce emissions, but emissions will still occur as harvesting occurs, even with reduced impact logging. While there is a growing literature addressing whether and how reduced impact logging could be implemented more broadly, no studies to date have examined the willingness of local groups to replace sustainable logging practices with programs that would pay for carbon storage.

This paper examines the tradeoff between timber production and carbon storage in a tropical developing country context. Specifically, we examine whether individuals living in and around forest concessions in the Maya Biosphere Reserve (MBR) in northern Guatemala are willing to accept payments to reduce timber harvesting and increase carbon sequestration. The sampled group of over 700 individuals includes members of the concessions and non-members living in the area. We chose to administer this experiment to communities in the MBR because households generally depend on the forest resources for their livelihoods. Also, programs that would provide payments for avoided deforestation to households in forest-dwelling communities have been piloted in the region, however few households have actually received the benefits from these programs (GuateCarbon, 2017; Hodgdon et al, 2012). We control for other activities

the concessions could also undertake, including harvesting non-timber forest products and participating in tourism activities in and around the area, as well as the contract length and payment vehicle. The results of the analysis suggest a strong willingness by local residents in this region to engage in carbon sequestration services, even if timber revenues decline. Not surprisingly, there is large heterogeneity amongst the respondents, depending on their group affiliation and other factors.

This paper builds on a number of studies that have considered whether payments for ecosystem services, PES, can be deployed in the tropics to conserve forests (e.g., Jayachandran et al, 2016; Wunder et al, 2008; Wunder and Albán, 2008; Zabel and Holm-Müller, 2008; Liu et al, 2007; Pagiola et al, 2005). Several PES programs have thus far been successful in achieving conservation and development objectives. For instance, the PROFAFOR initiative in Ecuador improved carbon sequestration and it improved PES recipients' welfare (Wunder and Albán, 2008). In western Uganda, a PES program was implemented as a randomized trial in 121 villages. After two years, tree cover declined by less of an extent in villages that received the PES programs than in villages that did not receive a payment to reduce deforestation and forest degradation (Jayachandran et al, 2016). Similarly, the Natural Forest Conservation Program and Grain to Green Program in China have been successful in increasing carbon sequestration, increasing vegetation cover, controlling soil erosion, and promoting economic development (Liu et al, 2007). Despite these successes, concerns have been raised about the effectiveness of PES programs in Costa Rica (Pagiola et al, 2005; Pagiola, 2006) and conservation policies in Zambia (Richardson, 2011) and Zimbabwe (Frost and Bond, 2008).

Some forest conservation proposals aim to provide payments to already successful conservation institutions for avoided deforestation. Often, these proposals provide additional

payments for existing forest conservation strategies such as sustainable timber harvesting or payments for strict conservation. For example, one of the goals of the current GuateCarbon program is to provide payments for carbon credits earned by preventing deforestation that would have occurred if the community forest concessions in the Maya Biosphere Reserve were not in place. Although the current community forestry model in the MBR prevents deforestation (Fortmann et al, 2017), the payments from GuateCarbon would help the concessions improve existing sustainable forest management plans and conduct additional surveillance to mitigate illegal logging (GuateCarbon, 2017). The results of our study suggest that households are receptive to this initiative and would even be willing to reduce the amount of timber harvested in order to receive more payments for carbon.

The conclusion we reach from the existing studies on sustainable timber harvesting and PES programs is that success ultimately depends on the willingness of individuals, communities, and governments to cooperate and implement the conservation strategy. As society considers whether to adopt PES for forest conservation in developing countries, the question of whether these payments are sufficient to convince individuals who may already have rights to land remains. This study expands on existing PES studies because it evaluates the tradeoff between carbon storage and timber harvesting. Importantly, this tradeoff considers property rights. To harvest timber in the Maya Biosphere Reserve, concession members are given exclusive land use rights to an area of land within the reserve. The land use rights also include exclusive rights to non-timber forest product harvesting and ecotourism within the boundaries of the concession. In order to get paid for carbon storage by reducing timber harvesting, however, communities would have to give up a portion of their land use rights and an external agency or government would have permission to monitor the area. In principle, people should be willing to trade these rights in

return for payments, but since the payments for carbon typically come from government sources (either nationally or internationally), it is not obvious that those with tenure rights will trust government agencies to pay for the carbon, especially when they must give up a fairly secure private stream of revenue from timber.

An additional contribution of this study is that it values other attributes associated with carbon contracts and household usage of the forest. One of these attributes is allowing for non-timber forest product harvesting and ecotourism in the PES contract. Non-timber forest product harvesting and ecotourism are important sources of income for communities that live around the forest (Bocci et al. 2018; Radachowsky et al. 2012). Although they may have a small impact on deforestation, the value of allowing these activities in a PES contract is about 30,000 quetzals for non-timber forest products and 20,000 quetzals for ecotourism per household on average. This shows that there could be large welfare gains if contracts were to allow households to participate in these low-impact activities.

Another attribute this study evaluates is whether to pay households individually or as a group. The results show that households would be willing to accept less money for an individual payment. The group payment attribute in this experiment explained that the payment would go to the community and community representatives would decide how to allocate the payment. This result has important policy implications because many PES programs have distributed the payment to a community organization or governing board who then decides how to allocate the payments to the community members who participated in the program (Frost and Bond, 2008; Pagiola, 2006). If instead the payment is distributed directly to the households that participated in the program, there could be significant welfare gains. A third contribution of this study to the existing valuations for PES programs is valuing contract length. Our results show that

households tend to value longer contracts over shorter contracts. This is an important result because it shows that households in this area value steady work and are willing to accept less money per year in exchange for a longer contract.

The next section of this study contains background information on the Maya Biosphere Reserve. The subsequent section describes the attributes, data, and methods of the choice experiment followed by the model specification. The final sections describe the results of the analysis and provide a brief discussion of their policy implications.

Maya Biosphere Reserve Background

Since the Guatemalan government does not have sufficient resources to strictly protect the entire reserve, the MBR was divided into three zones: the core zone, buffer zone, and multiple-use zone (MUZ). The core zone contains high-priority preservation areas such as Tikal and el Mirador. These areas receive strict protection and resource extraction is forbidden. The buffer zone surrounds the core zone and is meant to divert land use pressure away from protected areas of the MBR. The multiple-use zone is where sustainable resource extraction is permitted in the form of a forest concession that is either an industrial concession managed by a private company or a community concession managed jointly by concession members in a community. In order to be granted a forest concession, the company or concession members must partner with a participating NGO of their choosing and develop a sustainable forest management plan and apply for land-use rights in the MUZ from the National Council for Protected Areas (CONAP). To maintain active concession status, all concessions must be certified by the Forest Stewardship Council (FSC) and maintain their FSC certification status. From 1994 to 2002, CONAP granted twelve communities and two companies forest concessions. However, since 2009, three of these concessions have been cancelled or suspended because they did not abide by

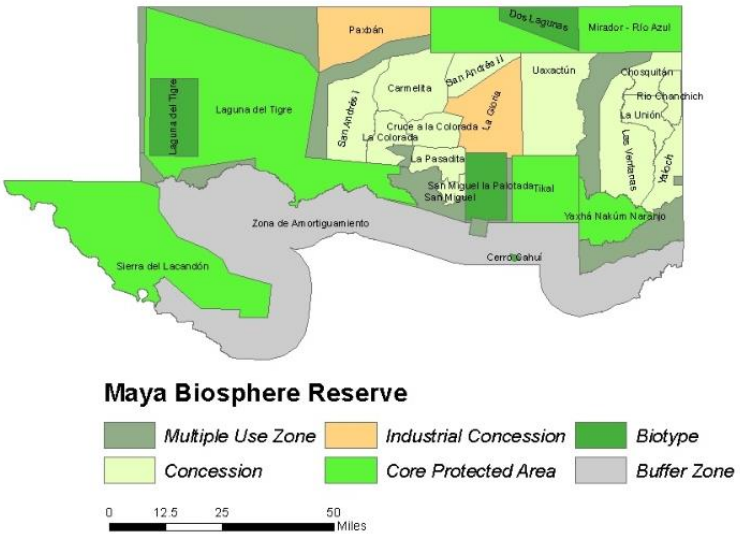
FSC standards (Radachowsky et al, 2012). The different characteristics of the community and industrial forest concessions are shown in Table 1 and the different zones of the MBR are shown in Figure 1.

Table 1. Community and Industrial Concession Characteristics

Management Unit	Organization Name	Concession Type	Size (ha)	Year Formed	No. of Members
Carmelita	Cooperativa Carmelita	Long-inhabited	53,797	1997	174
Uaxactún	Sociedad Civil Organización, Manejo y Conservación Uaxactún (OMYC)	Long-inhabited	83,558	2000	280
San Miguel la Palotada (cancelled/ suspended)	Asociación Forestal San Miguel La Palotada	Recently-inhabited	7,039	1994	39
La Pasadita (cancelled/ suspended)	Asociación de Productores La Pasadita	Recently-inhabited	18,817	1997	122
Cruce a la Colorada	Asociación Forestal Cruce a la Colorada	Recently – inhabited	20,469	2001	65
La Colorada (cancelled/ suspended)	Asociación Forestal La Colorada	Recently - inhabited	27,067	2001	48
Río Chanchich	Sociedad Civil Impulsores Suchitecos	Nonresident	12,117	1998	22
Chosquitán	Sociedad Civil Laborantes del Bosque	Nonresident	19,390	2000	74
San Andrés	Asociación Forestal Integral San Andrés	Nonresident	51,940	2000	170
Las Ventanas	Sociedad Árbol Verde	Nonresident	64,973	2001	309
La Unión	Sociedad Civil Custodios de la Selva (CUSTOSEL)	Nonresident	21,177	2002	85
Yaloch	Sociedad Civil El Esfuerzo	Nonresident	25,386	2002	39
Paxbán	GIBOR, S.A.	Industrial	65,755	1999	N/A
La Gloria	Baren Comercial Ltda.	Industrial	66,548	1999	N/A

Source: Maas and Cabrera (2008) and Gómez and Méndez (2007)

Figure 1. Maya Biosphere Reserve Zones



The communities that manage the concessions have historically been classified as nonresident, long-inhabited, or recently-inhabited because of the different income-earning characteristics of the households that reside within the communities (shown in Table 2). Nonresident concessions are managed by communities that reside in the buffer zone of the MBR. They are comprised of wealthier households that typically have jobs outside of forestry. Long-inhabited communities were established in the MUZ long before the MBR was created and have traditionally depended on harvesting timber and non-timber forest products for their livelihoods. Recently-inhabited communities are made up of recent migrants that moved to the MBR around the time it was created. These households typically have backgrounds in agriculture. In addition to the concession communities, there are also several communities in the western half of the MBR that reside in the MUZ or buffer zone, but do not manage a forest concession. (Bocci et al, 2018; Fortmann et al, 2017; Radachowsky et al, 2012)

Data

The discrete choice experiment we administered to 716 households in the MBR had five attributes: level of carbon storage, contract length, payment per year of the contract, whether non-

timber forest product harvesting or ecotourism is permitted, and whether the payment is at the community or individual level. The attributes and levels are shown in Table 2 and were selected based on information from focus groups and the results from a test community.

Table 2. Choice experiment levels and attributes

Attribute	Levels
Carbon Stored	Increase carbon storage by 30% and decrease timber harvesting by 30%
	Decrease carbon storage by 30% and increase timber harvesting by 30%
	Keep timber harvesting levels the same and get paid for carbon storage
Contract length	5, 10, or 20 years
Other permitted activities	Only permit NTFP harvesting
	Only permit tourism
	Permit both NTFP harvesting and tourism
	Prohibit NTFP harvesting and tourism
Payment level	Individual
	Group
Payment amount	800, 2000, 3200, 4800, 10000, or 20000 quetzals

One U.S. dollar equals about 7.64 quetzals. The average annual income for MBR households is about 28000 quetzals so the payment amounts ranged from 2.86% to 71.43% of the average income.

The main attribute of interest is the amount of carbon stored. The three levels of this attribute represent the types of programs that have been implemented or proposed in the MBR or other areas. Increasing carbon storage and decreasing timber harvesting by 30% represents payments given to households that prevent additional deforestation. In other words, there is a baseline of forest and a baseline rate of annual deforestation. To receive a payment, households need to maintain the existing forest and decrease the annual deforestation rate by a given amount. This can be done by increasing protection of the existing baseline forest, planting additional trees, or a combination of reforestation and increased forest protection. Decreasing carbon storage and increasing timber harvesting represents payments for increasing sustainable timber harvesting.

Current programs to promote sustainable harvesting practices allow forest-dwelling households to extract for resources as a source of income if they agree to participate in sustainable forest management. Often, the sustainably harvested products are FSC certified and households are able to work with institutions to sell the products. By choosing the option to increase timber harvesting by 30% and decrease carbon storage by 30%, the participant chooses to earn their payment through increased timber sales rather than conservation. The option to keep the amount of timber harvesting the same, but receive a payment for avoided deforestation represents payments for avoided deforestation through existing harvesting practices. For example, in the MBR, concessions already prevent deforestation relative to similar areas that are not under concession management (Blackman, 2012; Fortmann et al, 2017). This option in the choice experiment would provide payments for avoiding the deforestation that would have happened if the concessions did not exist in the MBR.

The contract length attribute described the amount of years the household would have to agree to abide by the restrictions in the contract. Participants were told they would receive the payment shown for each year of the contract and be subjected to strict enforcement and monitoring of the regulations. The other activities that are currently permitted within the concessions in the MBR are ecotourism and non-timber forest product harvesting. While some of the proposed contracts allowed for both ecotourism and non-timber forest product harvesting, many limited these activities. The purpose of including contract attribute levels that limited these activities was to represent a strict monitoring situation that households would be subjected to if they chose to sign a carbon or sustainable timber harvesting contract. The payment level attribute represents the payment going directly to the household or as an investment to community improvements.

We find the results for complete sample of communities we surveyed in the MBR as well as separate results for concession members, nonmembers, nonresident concession communities, communities located within the forest, and communities that are not associated with a concession. We find the results for these subsets of the sample because households within each community classification exhibit similar characteristics (Bocci et al. 2018). The nonresident concession communities we surveyed were Melchor de Mencos, San Andrés, San José, El Porvenir, Caoba, El Naranjo, Macanche, El Remate, Ixlu, El Zapote, Las Viñas, and Zocotzal. They are located in the buffer zone of the MBR and households are generally wealthier and have jobs outside of timber and non-timber forest product harvesting. The communities located within the forest we surveyed were Carmelita, Cruce a la Colorada, Uaxactún, and Laguna Perdida. Households in these communities are typically not as wealthy as communities located in nonresident concession communities and traditionally have depended on agriculture or forestry for their livelihoods. The communities we surveyed that are not associated with a concession were Sacpuy, Laguna Perdida, and Corozal. Sacpuy and Corozal are located in the buffer zone of the MBR and Laguna Perdida is located inside of the MUZ of the MBR. Households in these communities are typically wealthier and depend on agriculture for their livelihoods. The wage-earning activities of each community classification are shown in Table 3.

Table 3. Annual Income From Wage-Earning Activities

	All households	Long-inhabited	Recently-inhabited	Nonresident	Concession Communities	Nonconcession Communities
Forest-related work	25,342.00	24,896.24	17,780.07	30,155.97	25,342.07	N/A
	(15,973.93)	(15,149.59)	(15,010.17)	(15,864.94)	(15,973.93)	N/A
Total workers	195	82	41	72	195	0
Daily work in agriculture	21,204.27	41,288.00	29,238.12	14,273.63	22,472.87	17,622.35
	(31,530.72)	(62,304.99)	(48,131.86)	(9,068.66)	(36,485.26)	(6,024.69)
Total workers	130	10	35	50	96	34
Domestic work	12,602.04	14,100.00	N/A	12,078.57	12,752.38	11,700.00
	(8,441.66)	(13,589.70)	N/A	(7,020.23)	(9,095.06)	(3,818.38)
Total workers	14	4	0	8	12	2
Small business	23,014.03	N/A	N/A	22,615.43	22,615.43	27,000.00
	(13,148.75)	N/A	N/A	(13,443.31)	(13,443.31)	(12,727.92)
Total workers	22	0	0	20	20	2
NGO work	50,320.00	50,800.00	N/A	49,745.45	49,971.43	55,200.00
	(29,857.26)	(22,967.80)	N/A	(33,759.750	(30,952.65)	N/A
Total workers	15	3	0	11	14	1
Government work	38,953.16	37,541.00	22,392.00	38,964.50	38,023.66	52,152.00
	(16,801.41)	(13,704.89)	(18,616.90)	(17,054.43)	(16,708.25)	(13,205.89)
Total workers	76	12	3	56	71	5
Self-employed	23,203.69	23,837.14	10,800.00	23,665.69	22,948.16	2,700.00
	(19,402.06)	(22,289.32)	(6,616.34)	(18,772.50)	(18,956.18)	(26,736.49)
Total workers	111	15	6	83	104	7
Carpenter or artisan	34,522.96	33,487.50	N/A	36,460.15	35,579.37	6,000.00
	(26,735.73)	(25,618.93)	N/A	(27,700.62)	(26,642.86)	N/A
Total workers	28	8	0	19	27	1
Professional Career	37,313.47	38,400.00	N/A	43,917.60	39,364.67	392.00
	(25,244.00)	(17,852.73)	N/A	(26,670.81)	(24,292.03)	N/A
Total workers	19	7	0	10	18	1
Tourism work	41,793.84	45,401.02	N/A	32,325.00	41,793.84	N/A
	(41,178.41)	(47,487.35)	N/A	(14,076.50)	(41,178.41)	N/A
Total workers	29	21	0	8	29	0
Selling agricultural products	29,760.00	N/A	18,000.00	36,000.00	27,000.00	35,280.00
	(10,190.82)	N/A	N/A	N/A	(12,727.92)	N/A
Total workers	3	0	1	1	2	1
Selling food or clothing	17,105.89	12,402.00	7,200.00	20,463.64	17,123.88	16,800.00
	(12,836.13)	(20,444.50)	(3,394.11)	(12,487.94)	(13,230.95)	N/A
Total workers	18	3	2	11	17	1
Selling other products	27,714.29	24,000.00	N/A	28,333.33	27,714.29	N/A
	(10,202.52)	N/A	N/A	(11,031.35)	(10,202.52)	N/A
Total workers	7	1	0	6	7	0
Temporary work	10,898.25	4,388.89	4,000.00	12,660.00	10,898.25	N/A
	(11,777.41)	(2,044.60)	N/A	(12,725.44)	(11,777.41)	N/A
Total workers	19	3	1	15	19	0
Construction-related work	25,286.50	28,800.00	N/A	23,315.33	24,312.55	36,000.00
	(11,239.47)	(10,182.34)	N/A	(11,786.99)	(11,244.42)	N/A
Total workers	12	2	0	9	11	1
Other	35,963.32	33,099.12	32,834.29	39,471.60	36,621.08	24,342.86

	(48,758.64)	(48,482.76)	(34,453.01)	(53,445.70)	(49,958.02)	(13,975.37)
Total workers	112	37	10	59	106	6

Model Specification

The indirect utility level V_j for individual i is represented by equation (1)

$$V_{ij} = v_{ij} + \varepsilon_{ij} \qquad (1)$$

V_{ij} represents the observable utility component respondent i receives by choosing alternative j and ε_{ij} represents the random error component. We assume the respondent maximizes their utility when making a choice among the alternatives presented to them. Hence, if respondent i chooses alternative j over another alternative (k), we assume $V_{ij}>V_{ik}$. The probability of respondent i choosing alternative j over alternative k in choice set c is shown in equation (2).

$$p_i\left(\frac{j}{c}\right) = p(V_{ij} > V_{ik}) = p\left[(v_{ij} + \varepsilon_{ij}) > (v_{ik} + \varepsilon_{ik})\right],\ j \neq k \qquad (2)$$

We estimate the probability of individual i choosing an alternative in the choice c (equation (2)) with a mixed logit. A mixed logit is more flexible than a standard logit because it allows for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (McFadden and Train, 2000). Equation (3) shows the estimation of p_{ij} based on observables covariates of the individual (Z_i) and observable characteristics of the choice set from which individual i chooses alternative j (X_{ij}).

$$p_{ij} = \int \frac{\exp(\propto + \beta_i X_{ij} + \gamma Z_i)}{\sum_{k=1}^{K} \exp(\propto + \beta_i X_{ij} + \gamma Z_i)} f(\beta|\theta) d\beta \qquad (3)$$

From equation (3), we estimate the respondent's willingness to accept for each attribute described in Table 3. This value represents the amount of money that must be given to a person in order for them to be just as well off as they were before changing their behavior (Haab and McConnell, 2002, Casey et al, 2008). If the respondent, for example, engages in 1% more sustainable timber harvesting, they are changing their behavior by exerting additional effort to

harvest more timber and must be compensated accordingly. Assuming V_{ij} is linear and additive, we estimate the indirect utility function shown in equation (4).

$$V_{ij} = \propto + \beta X_{ij} + f(\beta) X_{ij} + \gamma Z_i + \varepsilon_{ij} \qquad (4)$$

The willingness to accept can then be represented as the ratio of each β for each attribute a over the β for the payment attribute (equation (5)).

$$WTA = -1\left(\frac{\beta_{attribute}}{\beta_{payment}}\right) \qquad (5)$$

Results

The results shown in Table 4 are for concession members in Melchor de Mencos, San Andrés, San José, el Porvenir, Caoba, El Naranjo, Macanche, El Remate, Ixlu, El Xapote, Las Viñas, Zocotzal, Cruce a la Colorada, Uaxactún, and Carmelita. Concession members have access to an area of forest to harvest timber so the results represent the value of storing an additional 1% of carbon in their concession area by decreasing timber harvesting by 1%. In other words, the results show that increasing carbon storage by decreasing timber harvesting is equivalent to a payment of about 103 quetzals per person on average. This suggests that a PES scheme that provides concession members with a payment for carbon instead of timber could have welfare benefits.

One way to assess the welfare gains of providing payments for increased carbon storage is to consider the amount of timber harvesting revenue households would forgo by decreasing timber harvesting by 1% to store carbon. For the concessions in the MBR, decreasing timber harvesting by 1% would decrease concession timber profit by about 256 quetzals per person[1]. Assuming markets clear and marginal labor costs (wages) are equal to marginal revenues, paying members the 103-quetzal payment for carbon would only comprise about 40% of the labor costs

[1] See Appendix 1 for an explanation on how we derived the average concession timber profit

of timber harvesting to the community. The Petén community average CO_2 emissions is about 35.4 tCO_2 per person per year from 2000-2016 (see Stults, 2018). Hence, the marginal cost of storing an additional 1% of carbon is about 7.2 quetzals per tCO_2 (Q256 per person per year /(35.4 t CO_2/person/year)), which is about \$1/tCO_2. This result implies there are large gains for the communities for a carbon payment scheme.

Table 4. Mixed Logit and WTA Results

	(1) Concession Members	WTA	(2) Nonmembers	WTA
Payment Amount	4.59e-05***	---	3.23e-05***	---
	(5.94e-06)		(5.56e-06)	
Inc. Carbon	0.00476***	103.7756***	0.00977***	302.3684***
	(0.00183)		(0.00164)	
Std. Dev.	0.0183***		0.0162***	
	(0.00276)		(0.00241)	
Contract length (years)	0.0205***	446.4967***	0.0174***	538.5232***
	(0.00628)		(0.00485)	
Std. Dev.	0.0463***		-0.00981	
	(0.0122)		(0.0635)	
Allow NTFP harvesting	1.587***	34,568.1481***	0.864***	26,755.0124***
	(0.147)		(0.0956)	
Std. Dev.	0.961***		-0.203	
	(0.197)		(0.431)	
Allow Tourism	1.018***	22,169.0196***	0.621***	19,240.8204***
	(0.108)		(0.0832)	
Std. Dev.	0.902***		0.701***	
	(0.158)		(0.138)	
Group Payment	-0.107	-2,324.7756	-0.303***	-9,390.5108***
	(0.106)		(0.0836)	
Std. Dev.	1.087***		0.718***	
	(0.168)		(0.139)	

Status Quo	-4.570***	-99,564.9237***	-4.321***	133,790.9907***
	(0.499)		(0.428)	
Std. Dev.	4.793***		3.778***	
	(0.482)		(0.388)	
Observations	6,399		6,411	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Results are in quetzals. 1 U.S. dollar was equal to about 7.33 quetzals when the experiment was administered. WTA results are calculated with the marginal effects.

Unlike concession members, nonmembers typically do not harvest timber since they are not part of a concession. Of those nonmembers that harvest timber, few have steady jobs harvesting timber or working in the concession. Therefore, the WTA value for increasing carbon storage by 1% is interpreted as the value of storing an additional 1% of carbon in the Maya Biosphere Reserve by decreasing the time spent timber harvesting or doing other wage-earning or leisure activities. The results in Table 4 show that increasing carbon storage by 1% by devoting less time to other activities is equivalent to a payment of about 302 quetzals per person.

The willingness to accept results for the different community groups are shown in Table 5. The results show that for all communities on average, households would have to be paid 190.614 quetzals less to store an additional 1% of carbon instead of increase sustainable timber harvesting by 1%. In other words, to increase sustainable timber harvesting by 1%, households need to be paid 190.614[2] quetzals more, on average, than if they were paid to store carbon.

There are preference differences among the community groups. For example, increasing carbon storage by 1% by devoting less time to other activities is equivalent to a payment of about 300 quetzals for households in communities not associated with a concession while the payment for households in nonresident concession communities is about 249 quetzals less. One explanation for the higher value for carbon storage for communities not associated with a

[2] We believe 190.614 quetzals is a reasonable willingness to accept to increase timber harvesting by 1%. Based on information collected from concession balance sheets, increasing timber harvesting by 1% would increase timber revenues on average by about 256 quetzals per person (see Appendix 1).

concession is that these communities do not currently have many forest-related job opportunities because they are not permitted to extract resources from the multiple-use zone of the MBR. Since they currently do not have a contract, they may receive a higher utility for any contract they are offered.

The results for the willingness to accept to harvest non-timber forest products are large and significant across all groups. Harvesting non-timber forest products has been an important source of income in MBR communities and is an attractive economic activity for households. Xate harvesting, for example, requires almost no initial time or capital investment since the xate plants grow in the MBR and are ready to be harvested. Xate fields are also close to forest-dwelling communities and there is no expensive equipment needed to harvest the leaves since most can be cut with a small knife. Additionally, xate harvesting gives women and children the opportunity to participate in the labor force on their own schedules since xate harvesters are typically paid per bundle of leaves and can be harvested for a few hours after doing household chores or attending school and sell the bundles they collect as a supplemental source of income (Nesheim and Stølen, 2012).

Although income for xate harvesters is lower on average than income earned from other forest activities[3], harvesting non-timber forest products such as xate provides a stable source of income for the region and it is possible that households in MBR communities are willing to take a pay cut to have a stable job. This is also shown by the strong preference for longer contracts in Table 5. On average, households in all MBR communities value longer contracts at an equivalent payment of 462.987 quetzals per year. Although some economic activities provide an above-

[3] The results from a 2017 survey of MBR communities show that the average income for a NTFP harvester is between 50 to 100 quetzals per day while the average income for a timber harvester or tourism worker is between 200 and 300 quetzals per day.

average income for households, there is a high degree of risk associated with these activities since employees are not guaranteed a salary for the entire year. Thus, it is possible that households in this region are risk averse and value a stable income for a longer time period[4].

The coefficient on "more carbon" is positive for all community groups, however the results for the resident communities is insignificant. One explanation for this is that households from Uaxactún and Carmelita have traditionally depended on harvesting non-timber forest products for their livelihoods (Primack, 1998). This is reaffirmed by the large coefficient on non-timber forest product harvesting and the high these communities place on non-timber forest product (NTFP) harvesting in the potential contracts shown in Table 5. Hence households that reside inside of the MUZ may have not made their decisions based on timber harvesting, but rather on the restrictions on NTFP harvesting. In contrast, preferences for non-timber forest products are weakest in the communities not associated with a concession, although these communities would likely still need to be compensated to not engage in non-timber forest product harvesting since the willingness to accept is positive and significant.

Discussion

The results presented in this analysis have several important policy implications. First, providing households payments for increasing carbon storage could be more economical than increasing the amount of timber harvested sustainably. Second, the willingness to accept for a group payment is negative and significant in all of the community groups except the nonresident concession communities where it is negative and insignificant. This has important policy implications because an investor would have to pay households less to participate in one of these contracts if they could pay each household directly rather than give the money to an organization

[4] About 53% of the respondents in a 2017 MBR household survey felt that having access to stable work opportunities was more important than receiving annual dividends or in-kind benefits from a forest concession.

Table 5. Mixed Logit and Willingness to Accept Values for Community Groups

	All communities		Nonresident communities		Resident communities		Nonconcession Communities	
	Marginal effect	WTA	Marginal effect	WTA	Marginal effect	WTA	Marginal effect	WTA
Payment amount	0.0000399***	---	0.0000436***	---	0.0000378***	---	0.0000617***	---
	(0.0000000)	---	(0.00001)	---	(0.00001)	---	(0.00002)	---
Carbon instead of timber	0.0076055***	190.614	0.0108555***	248.97936	0.0026082	69	0.0184941***	299.742
	(0.00123)		(0.00171)		(0.0019)		(0.00567)	
Longer Contract	0.0184732***	462.987	0.0222984***	511.43119	0.0167769**	443.833	0.0153374	248.58
	(0.00392)		(0.00528)		(0.00676)		(0.01772)	
NTFP harvesting	1.201749***	30,119.02	0.8774754***	20,125.583	1.850756***	48,961.8	0.5976163**	9,685.84
	(0.08243)		(0.0962)		(0.1681)		(0.30041)	
Tourism	0.812885***	20,373.06	0.6760838***	15,506.509	1.110337***	29,374	0.1229789	1,993.18
	(0.06861)		(0.08454)		(0.12174)		(0.24342)	
Group payment level	-0.2236375***	-5,604.95	-0.0484453	1111.13073	-0.3908246***	-10,339.28	-0.8105378***	-13136.76
	0.06666		0.08611		0.11745		0.29621	
Status quo	-4.46528***	-111,911.78	-4.302763***	98,687.2248	-5.320624***	-140,757.2	-3.826915***	-62,024.55
	0.32841		0.46519		0.58919		1.15189	

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. WTA results are calculated with the marginal effects. Results are in quetzals. 1 U.S. dollar was equal to about 7.33 quetzals when the experiment was administered. The WTA values were calculated using the marginal effects.

or community. Finally, households in this area generally value harvesting non-timber forest products and engaging in ecotourism highly. The preference for engaging in these activities combined with the willingness to accept coefficient on contract length highlights the risk aversion of the households since NTFP harvesting and tourism have traditionally been stable sources of income for the region.

Appendix 1

Table 6. Concession Timber Revenue

	Revenue	Expenses	Profit	Concession Members	Revenue of 1%increase in timber per person	Weighted 1% increase in timber per person
Cruce	3,488,726	979,460	2,509,266	65	386.041	20.60153
Carmelita	6,067,948	1,467,605	4,600,343	174	264.3875	37.76965
Yaloch	3,400,179	1,130,158	2,270,021	39	582.0566	18.63728
Laborantes	9,540,447	893,205	8,647,243	74	1168.546	70.99543
Arbol Verde	6,524,507	2,554,911	3,969,596	309	128.4659	32.5911
Suchitecos	2,870,981	1,308,588	1,562,393	22	710.1785	12.82753
San Andres	6,982,966	3,051,697	3,931,270	170	231.2512	32.27643
Uaxactun	3,250,544	760,875	2,489,669	280	88.91674	20.44063
Custocel	2,050,897	830,515	1,220,382	85	143.5744	10.01956
Average						256.1591

Table 6 contains the values for timber revenue and expenses from concession balance sheets. The values are from the most recent year reported by each concession, which ranges from 2011 to 2017. The results are in quetzals and the average is weighted by the amount of concession members.

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