Assessing Factors that Contribute to Reduced Deforestation and Successful Community Forest Management in Guatemala's Maya Biosphere Reserve

DISSERTATION

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ABSTRACT

The community forest concessions in Guatemala's Maya Biosphere Reserve provide a unique opportunity to investigate different aspects of community forest management. This dissertation examines the concessions in-depth and assesses the effectiveness of the concession policy in reducing deforestation, as well as how the preferences among concession members and non-members differ over various attributes of the concessions. The first chapter goes over the background and formation of the Maya Biosphere Reserve and the community forest concessions, which provides important context for the empirical analyses that follow.

The second chapter examines how the heterogeneity of the concessions and their members affect deforestation in the reserve using matched difference-in-differences methods. The results indicate that the concession policy was effective in reducing deforestation among all types of concessions, although leakage was an issue in concessions comprised of recent immigrants that come from primarily agricultural backgrounds. The third chapter builds off the first by estimating selection bias due to the non-random assignment of areas into concession management that may not be controlled for in the matching process. This is possible due to the staggered timing of the formation of the concessions, where the treatment group is made up of the first concessions and the control group is comprised concessions that were created later. The results indicate that

selection bias is present based on comparing the policy treatment effect using the later-formed concessions as a control group, with the treatment effect of a more traditional control group of adjacent forest areas.

The fourth chapter uses data from a choice experiment conducted as part of a household survey of concession members and non-members. The experiment was designed to assess preferences over different attributes of the concessions, including the allocation of land to members, concession activities (ecotourism or non-timber forest product collection), the distribution of profits (cash dividends or in-kind), and membership fees. The results of the random parameters logit model indicate that concession members have heterogeneous preferences with regards to land allocation and concession activities based on whether they live inside the reserve or outside, in larger towns and villages. Both members and non-members prefer in-kind benefits to cash dividends, and non-members are more likely to join a concession if land is allocated to the members, while older individuals and males, on average, are more likely to select the status quo option and not join a concession.

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LIST OF ACRONYMS AND ABBREVIATONS

ACOFOP	Association of Forest Communities of the Petén
BIOFOR	Biodiversity and Sustainable Forestry Project
CEMEC	Center for Monitoring and
CFE	Community Forest Enterprise
CFM	Community Forest Management
CONAP	National Council of Protected Areas
DID	Difference-in-Differences
FAO	Food and Agriculture Organization
FORESCOM	Community Forestry Concessions Enterprise
FSC	Forest Stewardship Council
FYDEP	Promotion and Economic Development of Petén
ICDP	Integrated Conservation and Development Project
MBR	Maya Biosphere Reserve
NGO	Non-governmental Organization
NTFP	Non-Timber Forest Product
RFA	Rainforest Alliance
RPL	Random Parameters Logit
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
ZUM	Multiple-use Zone (*Zona de Usos Múltiples)*

Introduction

Forests make up over 31 percent of total land area worldwide, which was estimated by the Food and Agriculture Organization (FAO) to be about four billion hectares in 2010. However, in the past decade approximately 13 million hectares per year of forest have been lost due to illegal logging, agricultural expansion, or natural causes (FAO 2010). Multiple strategies for protecting the forests have been implemented in an effort to reduce deforestation, particularly in tropical forests in developing countries. While strict protection through the creation of national parks and reserves has historically been the most widespread approach, community forest management has gained increasing attention as a way to promote local, and often indigenous, populations and provide a means of income for people who depend on the forest and its resources for their livelihoods. While community forest management has been the focus of many studies, the results have been somewhat inconclusive due insufficient methods of analysis and lack of consistent measures to compare across study areas (Bowler et al. 2009). As REDD (Reducing Emissions from Deforestation and Forest Degradation) negotiations continue to play a more prominent role in efforts to mitigate climate change, more research is needed to identify which strategies are the most effective and efficient when it comes to limiting deforestation, while at the same time acknowledging the roles and rights of local populations. This thesis takes an in-depth look at one type of community forest management strategy in Guatemala and addresses some of the previous concerns in the literature by applying a more rigorous approach to assessing the effectiveness of a group of community forest concessions in the Maya Biosphere Reserve.

The Maya Biosphere Reserve covers over 2.1 million hectares of tropical forests and wetlands in the northern department of the Petén in Guatemala. Due to mounting pressure from international conservation groups and growing dissatisfaction among resident populations, the reserve was established in 1990 under the direction of the National Council of Protected Areas (CONAP) (Nittler and Tschinkel 2005; Gómez and Méndez 2007). CONAP divided the reserve into three zones, each with different management strategies. The core zone includes national parks and reserves and is under strict protection. The buffer zone runs along the southern border of the reserve and was created to deflect land-use change from the core zones. The multiple-use zone makes up the center of the reserve and is home to the community forest concessions. Between 1994 and 2002, 12 of these concessions were established in the reserve. In order to gain rights to a concession, a group of community members had to gain legal status as an association and create a sustainable management plan for the proposed forest area. Once the plan was approved, the community was granted property rights to the forest and allowed to extract timber and non-timber forest products (NTFP) as long as the management plan was followed. While the concessions were all established under the same legal framework, the members themselves come from a wide range of backgrounds with varying degrees of forest experience. The forest concessions also vary regarding size, remoteness, and association bylaws. These differences among the concessions and their members are a primary focus of this research.

This thesis is constructed as follows. The first chapter provides a detailed overview of the Maya Biosphere Reserve, including the institutional history of land-use and management in the Petén over the past several decades, the development of the community forest concessions, and the internal and external challenges they have faced. This information provides important background for understanding the empirical analyses that follow.

The second chapter assesses the effectiveness of the community forest concessions using land-use data from the reserve from 1990 through 2009. The concessions are distinguished based on the residential status of the communities (within the reserve or outside) and the length of time the community has been established in the region. I apply a matched difference-in-differences approach to estimate the effectiveness of the community forest concession policy in reducing deforestation, taking into account differences among the concession communities. The results indicate that the concession policy reduced deforestation, but the amount varies across community types. I also find evidence of leakage associated with the policy, but only in concessions comprised of recent migrants. In concessions with non-residents or long-inhabited populations, the concessions reduced deforestation with no evidence of leakage.

The third chapter builds on the second chapter and examines issues with selection bias due to the non-random assignment of areas into community forest concession management. Selection bias occurs if there are unobservable factors that affect selection into the treatment group and the outcome of interest (deforestation in this case) that are different from the control group. In studies assessing the effectiveness of different forest management strategies, control groups are typically made up of surrounding forest areas not under protected area status or community management. Many of these studies use matching methods, such as propensity score matching, to account for the non-random selection of areas into the treatment group. In order for matching to eliminate selection bias, however, all of the factors that affect selection into the treatment group and deforestation must be controlled for in the matching process, which is a strong assumption. The staggered timing in the formation of the community forest concessions provides a unique opportunity to minimize selection bias in the analysis by comparing the treatment group (forest concession areas) with a control group that is also selected for treatment, though at a later date. The results of the matched difference-in-differences (DID) analysis indicate that there is a degree of selection bias present in the estimated policy effects, where the community concession policy had a larger treatment effect of reduced deforestation when comparing the early-formed concession areas to a control group of non-concession areas in the multiple-use zone as opposed to the control group of future concession areas, where the difference between the two effects is the estimate degree of selection bias.

The fourth chapter examines the preferences of concession members and non-members regarding different attributes of the concessions using data from a household survey of local residents living in and around the Maya Biosphere Reserve that was conducted during the fall of 2012. The survey includes a choice experiment in which survey respondents were shown two types of concessions, each with different attributes, and asked which concession they would rather join if given the opportunity. The four attributes of interest are: membership fee, allocation of land to members, concession activities including ecotourism or the collection non-timber forest products (NTFP), and whether concession profits are distributed as cash dividends or as in-kind benefits such as life insurance or local community enhancements.

The results of the random parameters logit (RPL) model indicate that members and non-members have varying preferences over the concession attributes. Whether or not the members live within the reserve also influences their preferences, particularly for land allocation. Members of resident concessions are more likely to join a concession if land is provided to the members, while people who live outside the reserve are less likely to join a concession that gives land to its members.

The results of the analyses here provide evidence that community forest concessions can be a viable means of reducing deforestation while also generating potential livelihood benefits to local populations. They further highlight areas of potential concern when assessing different approaches to forest management, such as the potential for selection bias. The results of the choice experiment offer insight into factors that increase the likelihood of participation in a concession and how preferences vary among members and non-members. While community-based forest concessions are a relatively new model of forest management and most of the world's timber concessions are privately held and operated, there is a trend towards more collaborate approaches that promote both sustainable forest management and local community development (Bowler et al 2009; Mollnar et al. 2011), which will likely continue as climate change moves up the policy agenda. Community forest concessions are one approach that has the potential to achieve both of these goals.

Chapter 1: The Development and Progression of the Community Forest Concessions in Guatemala's Maya Biosphere Reserve

1.1 Introduction

The Maya Biosphere Reserve (MBR) is a tropical forest area in the northern Petén region of Guatemala covering over two million hectares. It is home to many important archeological sites - including Tikal National Park, a UNESCO World Heritage Site, that was one of the major cities of the Mayan Civilization. The region has a long history of selective logging of mahogany and cedar and the extraction of *chicle*, which is a traditional ingredient in chewing gum. The MBR was established in 1990 under the direction of the National Council of Protected Areas (CONAP) in an effort to conserve the natural resources of the Petén under increasing pressure from an influx of domestic migrants, agricultural expansion, and illegal drug trafficking (Gómez and Méndez 2007). The Maya Biosphere Reserve was divided into three zones, each with different land use goals and management strategies, including a core zone, buffer zone, and multiple-use zone (*zona de uso multiple*, ZUM). The ZUM covers about 40% of the total reserve and is home to 12 community forest concessions. In order to gain concession status, the community groups must submit forest management plans to gain legal property rights over the forest area for a renewable period of 25 years. CONAP is the central authority overseeing the concessions, and is responsible for establishing rules, granting concession status, and monitoring and compliance (Primack 1998).

Since the establishment of the concessions, a number of local and international non-governmental organizations (NGOs) and international aid organizations have worked together with the communities of the MBR in the multiple-use zone to provide technical assistance and develop the communities' forest management skills to enable them to gain concession status. Since their creation, the concessions have faced a number of internal and external challenges related to governance, business management, organizational capacity, and cooperation among members, but they have also had many achievements. They formed the Association of Forest Communities of the Petén (ACOFOP) which is a local organization that was established to represent their common interests and increase their bargaining power and market share. ACOFOP has also helped the concession communities progress from selling raw timber to processing it themselves in sawmills along with other value-added product enhancements. However, there are still issues regarding transparency and equity among and within the concessions, and incorporating new forest products into management schemes. The sustainability and success of the concessions in the future will likely depend on their ability to diversify and adapt to changing environments (Taylor 2010).

1.2 Maya Biosphere Reserve

The Petén is in the northern-most part of Guatemala and is the largest department in the country, accounting for about one third of the national territory. Until the mid 1950s, the Petén was an isolated forest region with a population of about 25,000 (Gómez and Méndez 2007). These Peteneros spent the majority of their working hours extracting forest products, such as the *chicle* used in natural chewing gum, and high value timber species, such as mahogany and cedar (Gretzinger 1998). Agriculture was done on a small scale, with fields cultivated for two to three years before lying fallow for an extended period to maintain soil fertility. This system maintained the forests and limited the amount of agriculture and land clearing in the Petén, which was ideal since only about 30 percent of the soil there is suitable for farming (Schwartz 1990; Gretzinger 1998).

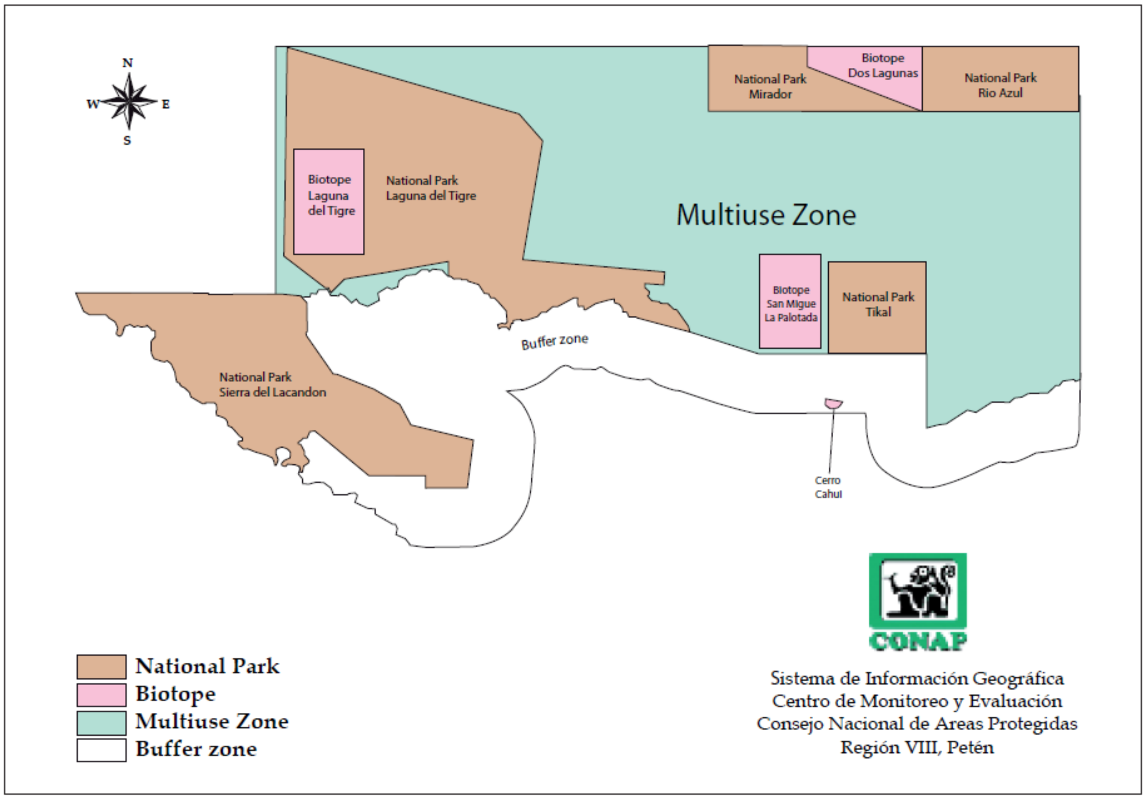
In 1955, ten national parks were created in the Petén by the national government, including Tikal and Río Dulce National Parks. However, due to the inability of the government to monitor and enforce regulations in these remote regions, the majority of the parks, except for Tikal, were subjected to deforestation and degradation (Ponciano 1998). The stability of the forests and resident populations of the Petén was further challenged when the government started promoting the region as a place for rural migrants to settle. In 1959, the Enterprise for the Promotion and Development of the Petén (*Fomento y Desarrollo del Petén* [FYDEP]) was created with support from the United States Agency for International Development (USAID). From the time of its creation to 1987, FYDEP, which was closely tied to the Guatemalan military, was the only governmental presence in the Petén. Its objectives centered on promoting rural colonization policies, which resulted in large numbers of landless farmers moving into the region in search of arable lands. Many of these newcomers formed agricultural cooperatives and were granted tracts of land from FYDEP. In addition to the cooperatives, FYDEP sold an estimated 1.9 million ha to 39,000 beneficiaries (Elías et al. 1997) with the majority of the land being granted to people associated with the military or of the middle- and upper- classes (Schwartz 1990; Gómez and Méndez 2007; Monterroso and Barry 2007). Forest policies were also changing during this period.

FYDEP, along with the United Nations Food and Agriculture Organization (FAO) conducted a forest inventory in 1969, determining that 92 percent of the Petén was covered with primary forests. Subsequently, FYDEP granted sizable forest concessions (approximately 50,000 ha) to logging companies with the objective of extracting mahogany and Spanish cedar (Ponciano 1998). During this period, the Petén went from being an isolated region to a hotspot of competing interests, political instability, and illegal drug activity, all of which placed increasing pressure on the land and its resources (Cronkleton et al. 2008).

Growing concern for the southern forests of the Petén, which were being lost to agriculture, ranching, illegal logging, and forest fires (Nittler and Tschinkel 2005), along with increased conservation awareness among international organizations led to the creation of CONAP in 1989. The Maya Biosphere Reserve was established shortly after in 1990 (Nations 2006). With the creation of the reserve, CONAP set out to regain control of the region by putting a halt to illegal harvesting and the advancement of the agricultural frontier, protect and preserve archeological sites, and control illegal drug trafficking (Nittler and Tschinkel 2005) through a mix of policies and property rights regimes.

CONAP divided the MBR into three zones each with different land use goals, management strategies, and property rights. The core zone includes national parks, Mayan ruins, and biological habitats (biotopes), and is under strict protection by the government. The buffer zone runs along the southern border of the reserve and was designed to reduce negative impacts on the core zone and allows private land ownership. The multiple-use zone is managed under a common property regime and allows for the extraction of timber and other forest products by assigning forest concessions to community groups with approved management plans.

Figure 1: Zones in the Maya Biosphere Reserve



Source: CEMEC-CONAP from Gómez and Méndez (2007)

1.3 Development of the Concessions

While the establishment of the MBR represented a step toward protecting the Petén from widespread degradation, changes in government initially did little to stem the rampant illegal logging and deforestation, which began during the 1980s due to lack of government enforcement and an increase in illegal drug trafficking. In 1992, six million board feet of illegally cut timber was confiscated in the reserve near the border of Belize (Ponciano 1998). CONAP met further resistance by communities that had been established in the Petén beginning in the 1930s and were not used to government interference. Although the lands are state owned and under the control of the government, many of the communities that had been living in the region for multiple generations had built up roads and infrastructure such as schools, churches, and clinics all within the borders of the more recently established MBR (Gretzinger 1998). The community residents were afraid of being displaced from the land and felt that the establishment of the MBR threatened their livelihoods, which resulted in violent outbreaks against CONAP in 1990 and 1991 (Ponciano 1998). As a result, for the first couple of years after the MBR was created, CONAP was primarily focused on the core zone and slowing deforestation rates in these areas (Chemonics 2006).

The creation of community forest concessions was not included in the original plan for the MBR and initially provoked controversy particularly among environmental groups that were advocates for strict conservation. However, a prime motivation for promoting the concessions was to provide the local populations income through sustainable forest management. A further contributing factor to the creation of community concessions was that this was a more desirable option for environmental and conservation groups, which did not want to see the concessions fall into the hands of the private logging industry and thought community forest management was the lesser of the two evils (Gómez and Méndez 2007). The Petén was also receiving pressure from the government as a place for landless peasants to relocate, which accelerated after 1996 with the signing of the Peace Accords ending the civil war and calling for land and resources to be granted to returning refugees and war combatants (Nittler and Tschinkel 2005; Taylor 2010).

Establishing a framework for the concessions was a long and complicated process, which took over a year to complete (Nittler and Tschinkel 2005). In 1993, a group of foresters put forth a proposal for the establishment of forest concessions (Nittler and Tschinkel 2005) and in 1994 an environmental assessment of the proposed concession areas was completed (Maas and Cabrera 2008). Along with this was a proposal for a pilot concession, which was established in 1994 in the community of San Miguel, including 33 families and about 7,000 ha of land, with a little over 5,000ha allocated toward forest production (Gretzinger 1998; Nittler and Tschinkel 2005). USAID played a key role in developing the concession framework and was the primary financial backer, contributing almost US$ 9 million to the process (Nittler and Tschinkel 2005). After much deliberation over how the rest of the concession areas should be allocated and who should receive the rights for managing them, two main types of forest concession units were recognized, industrial and community.

Two industrial concessions were granted to Paxbán and La Gloria, which were both established timber companies in the Petén. Including the pilot concession of San Miguel, there were twelve community concessions created between 1997 and 2002. Six were allocated to resident communities living inside the boundaries of the MBR, and six to non-resident communities living outside (see Table 1 below). Eight cooperatives, primarily located in the buffer zone, were also established during this same period (Chemonics 2006).

Table 1: Community and Industrial Concession Characteristics

Management Unit	Organization Name	Size (ha)	Authorization Year	No. of members
San Miguel La Palotada	Asociación Forestal San Miguel La Palotada	7,039	1994	30
Carmelita	Cooperativa Carmelita	53,797	1997	122
La Pasadita	Asociación de Productores La Pasadita	18,817	1997	110
Río Chanchich	Sociedad Civil Impulsores Suchitecos	12,117	1998	27
La Gloria	Baren Comercial Ltda.	66,548	1999	N/A
Paxbán	GIBOR, S.A.	65,755	1999	N/A
San Andrés	Asociación Forestal Integral San Andrés (AFISAP)	51,940	2000	174
Chosquitán	Sociedad Civil Laborantes del Bosque	19,390	2000	78
Uaxactún	Sociedad Civil Organización, Manejo y Conservación Uaxactún (OMYC)	83,558	2000	244
Las Ventanas	Sociedad Civil Árbol Verde	64,973	2001	364
Cruce a la Colorada	Asociación Forestal Cruce a la Colorada	20,469	2001	65
La Colorada	Asociación Forestal La Colorada	27,067	2001	39
La Unión	Sociedad Civil Custodios de la Selva (CUSTOSEL)	21,177	2002	96
Yaloch	Sociedad Civil El Esfuerzo	25,386	2002	39

Source: Maas and Cabrera 2008 and Gómez and Méndez 2007. Concessions highlighted in blue have resident populations, white have non-resident populations, and industrial concessions are in red.

The concession arrangement in the MBR is different from other forest concessions since agricultural lands are allowed within the boundaries as long as the standing forest remains intact (Gretzinger 1998). This coincides with how communities traditionally have managed land, allowing for some agricultural activities while the primary focus is on extracting forest products. The collection of non-forest timber products (NTFPs) was originally separate from the extraction of timber in the concessions. These activities were not included in the original annual operating plans, and while concession status grants rights to collect NTFPs, collection is also allowed on a permit basis through CONAP based on historical extraction. Traditional extractors are able to apply for permits to extract NTFPs even if they are not members of the concessions (Nittler and Tschinkel 2005; Larson et al. 2008), which has been a source of management problems in the concessions discussed further below. More recently, concessions have been making management plans for NTFPs in addition to timber (Taylor 2010).

In order for a community group to gain concession status and be recognized as a Community Forest Enterprise (CFE), it must first be recognized as a legal entity and backed by an NGO that has agreed to provide technical and financial support (Nittler and Tschinkel 2005). A community group seeking a concession must also establish internal regulations and formal by-laws (Larson et al. 2008). With the help of NGOs, each concession group had to map out the proposed concession boundaries to be approved by CONAP. After the concession area was approved, the group was required to conduct a forest inventory and submit technical documents outlining the demarcation and management of the concession area (Gretzinger 1998; Maas and Cabrera 2008). Once CONAP granted the group concession status, which included legal property rights to the concession area for a renewable period of 25 years, it had three years to obtain certification through the Forest Stewardship Council (FSC). Concessions status may be revoked by CONAP if a group fails to get certified, violates its management/operating plan, or for any other breach of contract (Gretzinger 1998). A typical management plan for a tract of forest within the concession might involve dividing the concession area into

25 sections, and then extracting timber from one part each year (Maas, R. Personal interview, 22 Aug. 2011). The extraction of timber and NTFPs is done year-round, starting with timber from January to May or June, allspice from July to September, *chicle* from September to January. *Xate*, which is a palm frond used in floral arrangements, is collected throughout the year (Pinelo, M. Personal interview, 22 Aug. 2011).

1.4 Concession Populations

The composition of membership across the concession groups varies greatly and includes a wide range of skill sets and forestry experience. Five villages that are located within the multiple-use zone had been established prior to the MBR, including Carmelita, Cruce a Dos Aguadas, La Pasadita, San Miguel, and Uaxactún. These villages did some timber harvesting, but mainly relied on the extraction of NTFPs, including *chicle, xate*, and allspice (Schwartz 1990; Gretzinger 1998). Other communities in the MBR formed in the 1980s as a result of increased migration to the Petén. Concession groups were initially created based on groups from small towns, or alliances that formed from recently established communities (Nittler and Tschinkel 2005). Many of these new groups did not have strong ties to the forest and formed solely to gain concessions status. Gómez and Méndez (2007) and Elías et al. (1997) identified three different types of settlements in the Petén:

- *Petenero* communities that moved into the region between the 1920s and 1950s to extract *chicle* (including Carmelita, Uaxactún and Melchor de Mencos),

- Peasants of indigenous and *mestizo* origin, who moved to the area during the promotion of rural colonization under FYDEP from 1954 to 1986, and
- Indigenous communities of various ethnic backgrounds that returned to the Petén in the 1990s after being displaced by the war.

The *Petenero* communities have been living in the Petén the longest and have the most experience in forestry and the extraction of NTFPs. Carmelita and Uaxactún are the oldest communities to form concessions and were established 100 and 90 years ago respectively (Nittler and Tschinkel 2005). Uaxactún, was traditionally focused primarily on extraction of NTFPs, but began extracting timber as an alternative source of livelihood as NTFPs were depleted in the area. Due to their location near the Mayan cities of Tikal and Calakmul, residents also participate in tourism and archeological activities. While the community participates in forest management and timber extraction, a "logging culture" has yet to develop there (Gómez and Méndez 2007). Around Mechor de Mencos, prior to the 1990s, Mexican and Belizean companies often hired residents from this area, which provided them with forestry experience. These residents went on to form four concessions groups, including: Impulsores Suchitecos, Laborantes del Bosque, El Esfuerzo, and Custodios de la Selva (Gómez and Méndez 2007).

The second type of settlement community includes five of the concessions that formed along the road to Carmelita that have traditionally extracted NTFPs and participate in subsistence agriculture and cattle ranching on a small scale. These include La Colorada, Cruce a la Colorada, La Pasadita, San Andrés, and San Miguel. The concession of Arbol Verde is also included in this group, but has members with a wider range of backgrounds. The residents of this concession have a variety of occupations including farming, cattle ranching, wood artisans, carpenters, and public employees (SmartWood Program 2003c; Gómez and Méndez 2007). Members of Arbol Verde have not traditionally been involved in forest activities and live outside the concession in nine different towns spread out over 80 km (Larson et al. 2008).

The third settlement type includes the communities that returned to the Petén after being displaced during the civil war. Many of these groups formed cooperatives, which are located mainly in the buffer zone. These communities are focused primarily on agriculture and ranching, and have some experience extracting NTFPs, but forest management is relatively new to them (Gómez and Méndez 2007).

Researchers at the University Rafael Landívar conducted an evaluation of the MBR (Maas and Cabrera 2008) and also identified differences among the concessions in terms of their backgrounds and forest experience. They first divided the concession populations into two categories, resident and nonresident, with additional subcategories based on historical backgrounds. Sub-categories for the resident concessions are *silvicultural collectors*, which includes people who have been living in the forests of the Petén for more than five decades, and *agrarian immigrants*, which include groups that have migrated to the Petén within the past 50 years in search of land for agricultural development. Sub-categories for the non-resident concessions are *foresters*, which includes people who have historically worked with timber, and a *heterogeneous composition* group, which includes two concessions with mixed populations that could not be placed into one of the above sub-categories. They note that these heterogeneous populations tend to have higher levels of education but limited-to-no timber backgrounds.

Table 2: Forest Concession Categorizations

Concession	Sub-Category	Category
Carmelita	Silvicultural Collectors	With Resident Population
Uaxactún		
San Miguel	Agrarian Migrants	
La Pasadita		
Cruce a la Coloradas		
La Colorada		
Yaloch	Foresters	Without Resident Population
Chosquitán		
La Unión		
Chanchich River		
Las Ventanas	Heterogeneous Composition	
San Andrés		

Source: Cabrera (2008)

1.5 Internal Challenges for the Concessions

The NGOs played a large role in the development of the concessions, since in some cases communities were initially not interested in the idea. The NGOs promoted the concessions within the communities and drafted the necessary paperwork, often with little buy in from the community (Nittler and Tschinkel 2005; Beavers, J. Personal interview, 2 Oct. 2011). However, the pilot concession of San Miguel was initially considered a success, where the community was able to increase its profits from 1994 to 1995 and provide 879 person-days of employment by processing the lumber rather than just selling roundwood (Gretzinger 1998). This prompted other communities to form groups and start applying for concessions. As a result, many of the concessions were formed quickly and the members did not fully understand the complicated statutes associated with legal concession status.

One ongoing issue has been the legal designation of the community groups as for-profit or non-profit, which in the latter case restricts the division of profits to its members through dividend payments (Nittler and Tschinkel 2005). Due to this restriction, many of the concessions that are registered as non-profit associations provide benefits by giving members land outside of the MBR or paying school and medical fees (Maas, R. Personal interview, 22 Aug. 2011; Pinelo, Personal interview, 22 Aug. 2011). Other communities that registered as cooperatives, such as Carmelita, are allowed to distribute dividends to their members

Nittler and Tschinkel (2005) contend that the division of members and non-members within communities and restrictions on new members joining is another source of conflict. The strict regulations imposed on the community groups in the process of gaining legal property rights resulted in situations where not all of the people living in a community were necessarily members of the forest concession group (Larson et al. 2008). In the beginning, communities had to form legally recognized groups to apply for concessions, which were generally subsets of communities because people either did not want to join or were excluded. Or conversely, as Beavers notes (Personal interview, 2 Oct. 2011), some members were forced or coerced into joining due to community pressures. The division between concession members and non-members has been a growing source of conflict. As the concessions began to turn profits, more people wanted to join, but since the area for forest extraction within the concessions is limited, current members did not want to increase membership size since it would take away from their individual benefits, which has caused resentment among non-members. The current concession members also argue that they have invested time and money and taken on risks in effort to develop the concessions into profitable enterprises. One ACOFOP leader stated in an interview with Taylor (2010) “It would be nice to have everybody inside the system, but that would mean someone could come along later and eat the same amount of cake. It's not fair to require that." To make up for not allowing new members into the concession, some groups designate that part of their profits go toward community enhancements such as improvements to local schools or health clinics (Nittler and Tschinkel 2005; Maas, R. Personal interview, 22 Aug. 2011).

Currently, the rules regarding new membership vary across concessions. Carmelita originally had 34 members, but has grown due to its membership policy which allows people living in the community prior to the concession being established to join (Barillas, J., Personal Interview, 7 March 2012). This has resulted in about 80 percent of the community joining the concession, which now has over 100 members (Larson et al. 2008). On the other hand, Arbol Verde, which is already the largest community forest enterprise, restricts its membership and only allows new members if current members sell or trade their rights (Larson et al. 2008). Residents that were living in communities within the MBR before the multiple-use zone was established, in Carmelita or Uaxactún for example, but are not concessions members have the 'Rights to Remain' on the land and are granted use-rights to a little over 28 ha of land per family for 25 years, which are renewable as long as the family complies with regulations (Larson et al. 2008).

A further challenge is the lack of business management skills within the concession groups. This may be attributed to the influence of the NGOs that played a large role in the development and management of the concessions. These groups tend to be more focused on conservation and technical skills, as opposed to business and marketing strategies. Consequently, the concessions often have find made poor decisions when it came to business management (Nittler and Tschinkel 2005; Chemonics and IRG 2000). Each concession is typically managed by a board of directors ranging from five to seven people who are elected by other concession members for a one-year term. The elected members may serve a maximum of two consecutive terms. The board typically takes on the management of the community enterprise, even though it is subject to frequent turnover, which prevents stable management and the ability to learn from mistakes over time. The boards have also been resistant to hiring managers for day-to-day operations and thus are typically responsible for making all the minor decisions for the enterprise. This type of management structure within the concessions has resulted in corruption among the board members and some significant financial losses due to poor decision-making. Nittler and Tschinkel (2005) elaborate on some of these outcomes, stating:

> *The incompetence inherent in such a defective system has resulted in expensive, mistaken decisions such as the purchase of antiquated "cheap" machinery, the proliferation of sawmills, the distribution of benefits and failure to reserve sufficient working capital, and the obsession with obtaining the highest price for wood rather than the development of a long-term client relationship. (p.9)*

A lack of trust among the communities has also led to inefficiencies when it came to the purchase and sharing of equipment. While the communities have made great strides in adding value to their products to increase their sales margins, there have been many cases in which communities have invested money in their own sawmills and heavy machinery rather than sharing equipment and reducing costs (Nittler and Tschinkel 2005). Corruption within the groups has also taken its toll on the ability of the concessions to function as profitable enterprises and collaborate with other concession. Some efforts to reduce corruption are being made, including better accounting systems, increased transparency, and internal and external audits. However, there have been few efforts in training and education to promote long-term sustainability and efficient management, where the training that has taken place has been disjointed and *ad hoc*. Furthermore, the governing boards are typically dominated by middle-aged males and efforts to educate younger populations, who will eventually take over management of the enterprises, have been neglected.

The role of international aid has been a major factor in the development of the concessions, which would not have been possible without such support. Gómez and Méndez (2007) estimate that between 1989 and 2003, over US$ 92 million was invested for projects in the Maya Biosphere Reserve. The primary funders included USAID, the Inter-American Development Bank (IDB), and a German organization, Forestry, Work, and Technology (KWF). A significant portion of the USAID funding went toward creating CONAP and providing the technical support and training necessary to develop the concessions. However, the majority of funding was assigned to national and international NGOs that worked with the concessions, rather than going directly to the communities. This developed a culture of dependence on NGOs among the concessions, as well as perverse incentives for the NGOs to maintain this dependency in order to retain funding streams (Gómez and Méndez 2007). The NGOs also failed to acknowledge the heterogeneity among the concession groups and despite the wide range of backgrounds and experiences, the general approach by NGOs for providing training and technical support was the same across all groups (Gómez and Méndez 2007).

Due to conflicts between the concessions and their NGO counterparts, in 1999, CONAP changed the regulation requiring that each concession be backed by an NGO and instead let the concessions and cooperatives choose a certified forest agent (*regente*) to represent the group, or in some cases, one agent may work with multiple concessions (Nittler and Tschinkel 2005). The forest agents took over many of the roles of the NGOs, assisting the concessions with developing their Annual Operating Plans and general oversight of forest activities.

1.6 Progression of the Concessions as Community Forest Enterprises

The concession groups made much progress from the initial days of cutting and selling standing timber to logging companies, to the present where they now process the timber and are able to sell directly to the buyers at much higher profit margins. In 1995, when CONAP was still deciding whether to grant the concessions to the local communities or industrial organizations, a group of community leaders came together to form the Consultative Council of Forest Communities of Petén (CONCOFOP). CONCOFOP was formed as a political organization, based on the need for more collaboration among the concession groups to promote their interests and gain increased support for their role in forest management in the Petén (Gómez ad Méndez 2007; Taylor 2011). In 1997, when the organization gained legal status, its name was changed to the Association of Forest Communities of the Petén (ACOFOP). ACOFOP represents about 14,000 individuals from 13 concessions and 9 cooperatives, which allows the organization to gain a larger share of the market and increases its bargaining power (Nittler and Tschinkel 2005). Since its creation, ACOFOP has continued to expand its scope from an advocacy group to a more comprehensive organization that serves as a common forum for all the community enterprises to work together.

While the concessions have made progress in many areas, financial planning and distribution of benefits are continuing challenges for the community enterprises, especially if they are heavily dependent on advances from their buyers (Beavers, J. Personal interview, 2 Oct. 2011). Marvin Oswaldo (Personal interview, 23 Aug. 2011) reported that Rex Lumber provides concessions with advances of US$ 50,000-80,000 for harvesting expenses. However, in the past, the groups generally have chosen not to manage their funds and reinvest profits each year, but instead have succumbed to pressure to redistribute the benefits to members.

Thus far, most of the profits made in the concessions have been from the harvesting and selling of the most valuable species. In 2004, the majority of the concessions harvested and sold three to five high-value species, including mahogany (Swietenia macrophylla), which is the most profitable and was the most abundant species harvested, as well as Spanish cedar (*Cedrella odorata*), "jobillo" (*Astronium graveolens*), and "chichipate" (*Sweetia panamensis*). Two companies in the United States are the main buyers: American Wood Products Co. and Rex Lumber, which together buy approximately 80% of the high grade mahogany (Maas, R. Personal interview, 22 Aug. 2011). Mexico and the Dominican Republic buy the majority of lower grade mahogany and Spanish cedar, and many of the lesser known species that are harvested are sold domestically (Nittler and Tschinkel 2005).

The financial viability of the concessions is heavily dependent on the continued abundance of mahogany. The concessions initially chose to harvest tracts of land with a high density of mahogany, so the continued profitability will largely rest on the inventory of the highest value species in the years to come. Efforts to promote and market lesser known species and to continue increasing valued added processes to the timber will also help increase financial security for the concessions in the future.

1.7 External Challenges to the Concessions

One ongoing challenge for the concessions has been the lack of authority and stability of CONAP, the main oversight agency of the forest concession groups. CONAP is responsible for monitoring the concessions for compliance with their management plans and conducting on-site inspections. However these inspections are not as frequent or rigorous as they should be, which is in part due to lack of sufficient funding. While the Petén is the largest department in Guatemala, it receives the least financial support, which limits the capacity of its government agencies (Ponciano 1998). USAID and the Forest Stewardship Council also periodically carry out inspections of logging activities in the concessions areas. However, these multiple sources of monitoring and inspection have proved burdensome and inefficient for the concessions groups (Nittler and Tschinkel 2005).

Another issue in the external governance of the concessions is the inflexibility of the regulations in their contracts with CONAP. Nittler and Tschinkel (2005) advocate the need for a *series of escalating penalties* imposed on the concessions if they violate their contract. Under the current standards, if CONAP does not approve of the operating plans, their only option is to cancel or suspend the contract with the concession, which may result in extreme actions taken by the community leading to increases in forest fires, illegal logging, and deforestation for agriculture.

The concessions have also received pressures from conservation and archeological groups, which have put pressure on CONAP for stricter conservation policies in the Petén. One project in particular that gained international attention was the Mirador Basin Expansion Project, led by Richard Hansen and the Foundation for Anthropological Research and Environmental Studies (FARES). This project proposed expanding the Mirador-Rio Azul National Park in 2002 (Taylor 2010), which would have extended the park boundaries into five concessions and two industrial concessions. The concession of Carmelita would have been most affected by the proposed expansion, and the ongoing controversy has created conflict between concession members and non-members who support the project (Larson et al. 2008). The proposal was eventually overturned after a three-year process in which ACOFOP invested considerable time and resources, but there still remains support for strict conservation policies at the expense of the concessions and livelihoods of these forest communities (Lehnhoff, A. Personal interview, 26 Aug. 2011).

A growing source of conflict for the concessions close to the agricultural frontier in the buffer zone is the increasing pressure on the land for agricultural expansion and cattle ranching. The problem is exacerbated by controversial land grants made by the government under the 1996 Peace Accords, where land was granted to former guerillas that overlapped with the boundaries of the protected areas in the MBR (Cronkleton et al. 2008). This is seen particularly in the municipality of San Andrés, which includes five concessions within its boundaries. Four of these concessions border the frontier. These communities face further challenges because they were established, have no history of forest management, and possess less land with lower-value forests (Larson et al. 2008).

Petroleum exploration and extraction have also been sources of conflict in the Petén. Under FYDEP, oil exploration began where two national parks are now established, Laguna del Tigre and Sierra del Lacandón, in the western part of the MBR (Gómez and Méndez 2007). Petroleum concessions were later established in the same setting. The Ministry of Energy and Mines offered these concessions to international corporations for resource extraction from 1983 to 1993, which led to more infrastructure development and an influx of workers into these areas. Since the state retains the subsoil rights to the forest concession lands some of the concessions, such as Carmelita, have also had to fight against pressures for petroleum exploration on their land (Larson et al. 2008). The oil concession grants expired in 2010, but were renewed by the Guatemalan President in 2011 (Robles, T. Personal interview, 22 Aug. 2011).

Drug trafficking also continues to be an issue in the reserve, where the Petén is a major route for drug smuggling up through Mexico and on to the United States. CONAP (2007) reported that some areas within the reserve have come under control of *narcos* who have expanded their operations to include illegal land sales. These problems primarily fall on CONAP and ACOFOP as the responsible agencies for monitoring and regulating illegal activities in the Petén (Monterroso and Barry 2007).

1.8 The Role of Non-forest Timber Products

Non-timber forest products (NTFPs), such as *chicle* gum, *xate* palm, and allspice, have long been a source of income and a means of livelihood for populations living in the Petén. The resident communities of Carmelita and Uaxactún, in particular, have long histories of traditionally extracting and managing *chicle* and *xate* (Taylor 2011). In the past, individual contractors and subcontractors managed *chicle* and *xate* collections, where they would hire extractors to go into the forest for harvesting. In 1992, the three most important NTFPs listed above generated an estimated US$ 4 to 7 million in export revenues, and provided employment (full and part-time) for as many as 7,000 people (Nations 1992).

Chicle, which has great cultural and historical importance in the Petén, was the central economic focus of the region from 1890 to the early 1970s (Schwartz 1990). As synthetic materials became more common in chewing gum manufacturing, *chicle* exports decreased, but there has been some revival due to renewed interests in natural products (Schwartz 1990). In 1998, *chicle* production in Guatemala employed about 2,000 people seasonally and was worth about US$ 1.4 million (Dugelby 1998; Taylor 2011). *Chicle* extraction requires some skill and is potentially dangerous, compared to other NTFPs, such as *xate* collection, which generally requires little investment and few resources (Taylor 2011).

Xate, which is used in floral arrangements, has become an increasingly large source of revenue in the Petén. In 2004, *xate* exports from the MBR were estimated to be more than US$ 4 million. This figure is comparable to the value of commercialized timber, which is estimated at US$ 3.5 to 5 million (Bridgewater et al. 2006; Taylor 2011). The extraction and processing of *xate* also has the potential to provide year-round employment for 6,000 to 10,000 people, and daily wages for harvesting are generally higher, at US$ 7.70-10.30, than the minimum wage, which ranges from US$ 5-8 (Bridgewater et al. 2006; Taylor 2011).

In the past, *xate* collection has been sustainable, with the harvesting of palms in three month rotations if the number of leaves taken from the plants is limited (Nations 1992). However, recent problems with over harvesting have raised concerns about its continued sustainability. Typically, *xate* extractors have been paid for quantity, rather than quality of the palms, which along with low prices has contributed to over harvesting (Taylor 2011). Rainforest Alliance has been working with ACOFOP to promote sustainable harvesting of *xate* palms. In 2005, extension agents began training *xate* collectors in Carmelita and Uaxactún to cut only high quality leaves and pay the collectors based on quality rather than quantity (Taylor 2011). Five communities are now certificated for *xate* extraction and ACOFOP has also made efforts in the processing and marketing of *xate*. ACOFOP maintains a cold room in San Benito to store the *xate* palms, and has developed a relationship with a floral firm in San Antonio, Texas, Continental Floral Greens, which is one of their main buyers (Pinelo, Personal interview, 22 Aug. 2011). These efforts by ACOFOP have proven successful and the market size for *xate* increased from US$ 58,000 in 2005 to almost US$ 210,000 in two years (Taylor 2010).

The extraction of NTFPs within the concessions has provided an additional source of income generation for the community groups; however it has also led to conflicts between the concession groups and traditional extractors. Legal rights to harvest timber are limited to the community organizations, but NFTP extraction is not limited to concession members. Traditional extractors can file for permits through CONAP to gain rights to extract *chicle* or *xate* in concession lands. This has caused tension between the two groups because the extractors are not bound to the same forest practice standards as the community groups, which have to uphold high standards to ensure forest quality and maintain certification and concession status (Larson et al. 2008). While CONAP is responsible for regulating the extractors who are granted permits, it lacks the institutional capacity necessary, which leaves the responsibility to the concession groups. As a result, Carmelita started issuing its own permits for NTFP extraction to facilitate monitoring, even though the permits have no legal standing (Larson et al. 2008).

ACOFOP has extended its purview to include NTFPs such as *chicle* and *xate* management and more recently, there have been efforts to increase the production and market for Brazil nuts, which are used in flour and for baking, but so far projects have only been done on a local scale (Robles, T. Personal interview, 22 Aug. 2011). The efforts made by ACOFOP to extend its scope to NTFPs are also a way to incorporate non-concession members and provide them a means of income generation not directly related to timber extraction. By expanding its representation within the forest communities, ACOFOP will be able to increase both its internal and external legitimacy (Taylor 2011). However this has also presented new challenges as the scope and range of management objectives has become more complex and diversified. The management and distribution of benefits from NTFP activities has been a source of internal conflict, along with resistance from traditional NTFP contractors, who feel threatened by the concessions' move to engage in these activities (Taylor 2011).

1.9 Are the Concessions Successful?

The success of the concessions has yet to be determined. Success could be considered on multiple fronts, including decreased rates of deforestation and forest cover change due to reductions in logging, agriculture, and forest fires, as well as the financial stability and profitability of the community forest enterprises. With regards to deforestation, the concessions have experienced less forest cover change compared to the core zones and buffer zone, based on results from a USAID evaluation by Maas and Cabrera (2008). They found that the multiple-use zone had the smallest change in forest cover from 1986 to 2004, with 97% remaining intact, compared to 94% and 64 % in the core zones and buffer zone respectively. Their analysis was done using Landsat data from the years 1985 and 2005, developed by the Center for Monitoring and Evaluation (CEMEC), under CONAP. Within the concessions, the amount of forest cover change during the same period of time ranged from 11.5% forest loss to 0.01%, with an average of 1.8% loss for the 14 concessions. Another report by Rainforest Alliance (Rosales 2010) looked at the impact of forest certification on deforestation rates and incidence of forest fires in the MBR. The authors found that concessions that were certified had significantly lower rates of deforestation and wildfires. These results indicate that community forest management and the distribution of common property rights can be a successful strategy for reducing deforestation.

While the concessions have experienced less deforestation than the protected areas, their financial viability as community forest enterprises is yet to be determined. The concessions have been heavily dependent on donor aid, which has been abundant over the course of their development. Weaning them off aid money and making them financially self-sufficient may be a true test of their success. Nittler and Tschinkel report as of 2005, that the more successful concessions cover about 95 percent of their costs, while other concessions cover about 80 percent.

The estimates for the individual incomes of members working in the forest concessions is large relative to national averages, where the potential income during a harvesting period lasting two to three months is US$ 1,140. However, these estimates assume no corruption or poor management in financial decisions, which have been ongoing problems in many of the concessions (Nittler and Tschinkel 2005). The daily salaries for concession work are higher than the minimum wage, which is about 64Q per day (about US$ 8.20) compared to concession salaries of 75-100Q per day (about US$ 9.60-12.00) (Pinelo, Personal interview, 22 Aug. 2011; Oswaldo, Personal interview, 23 Aug. 2011). However, the wage distribution among the concessions varies.

In 2003, the 14 concessions (including two industrial concessions) generated 51,309 person-days of work; however, the distribution of work was not evenly spread out among the concession groups. The top three concessions averaged 63 to 162 work days per year for members, and the lowest three generated less than 10 days per year (Nittler and Tschinkel 2005). Processing the wood largely contributes to the number of work days generated for concession members, where the lowest three groups sold more unprocessed wood and have smaller areas of forest per concession member. Complimenting timber production with value-added processes could increase the incomes of concession members by increasing work days, as well as garnering a higher market price for the processed timber. Overall, the concessions have created jobs for both members and non-members. Chemonics (2006) reported that in 2004, nine community forest enterprises generated 24,338 permanent jobs and 46,692 temporary jobs

Looking at the success of individual concessions, Gómez and Méndez (2007) separate the member organizations of ACOFOP into two groups, “more advanced” and “less developed” (see Table 3 below). The more advanced concessions tend to have a more active role in ACOFOP and account for the majority of total concession land (77 percent). These groups also have higher levels of social and human capital, where 80 percent of the members of the more advanced concessions are literate, compared to less than 60 percent in the less developed concessions. The more advanced concessions also depend on the forests more, where forest management makes up 70 percent of their livelihoods compared to the less developed organizations where agriculture and livestock make up 80 percent of their livelihoods.

The weaker concessions have struggled with organizational problems and internal conflicts, which have led to increased deforestation and violations of their management plans due to illegal logging, burning, and expansion of cattle ranching by third parties (Chemonics 2006; Bray et al., 2008; Taylor 2010). The four weakest concessions consist of resident communities made up of migrants with little forest background, and the majority of the residents of these communities were involved in agricultural activities at the time the concessions were established. Only a minority of people were interested in forestry, however, once they were granted the concessions, they were responsible for maintaining the entire tract of forest area. Part of these problems can also be attributed to outside actors, such as powerful landowners, where the concession groups are still held responsible for the management of the land within their concession boundaries even if, in some cases, it may be beyond their control (Taylor 2011). La Pasadita is one concession that has experienced these problems. The concession were certified in 1999, but was suspended in 2004 “due to internal problems and the advancement of the agricultural frontier into the concessions” (Chemonics 2006).

Table 3: Concession Rankings and Level of Organizational Development

ACOFOP	Concession	Gómez & Méndez
Top	Asociación Forestal Integral San Andrés (AFISAP)	Most Developed
Top	Sociedad Civil Árbol Verde (Las Ventanas)	Most Developed
Top	Sociedad Civil Custodios de la Selva (CUSTOSEL) (La Unión)	Most Developed
Top	Sociedad Civil Laborantes del Bosque (Chosquitán)	Most Developed
Top	Sociedad Civil Impulsores Suchitecos (Río Chanchich)	Most Developed
Mid	Cooperativa Carmelita	Most Developed
Mid	Sociedad Civil Organización, Manejo y Conservación Uaxactún (OMYC)	Most Developed
Mid	Sociedad Civil El Esfuerzo (Yaloch)	Most Developed
Mid	Asociación Forestal Cruce a la Colorada	Least Developed
Bottom	Asociación Forestal La Colorada	Least Developed
Bottom	Asociación de Productores La Pasadita	Least Developed
Bottom	Asociación Forestal San Miguel	Least Developed

Source: Gómez and Méndez (2007) and Interview with Mario Rivas of ACOFOP (2012). Management unit in parentheses if not part of association name.

Mario Rivas, who is the extension coordinator for ACOFOP, also ranked the concessions into three groups, top, middle, and bottom (Personal Interview. March 5, 2012). The top concessions have been the most successful in reducing deforestation and managing their community forest enterprise, and the three worst performing concessions have had their concession status revoked (San Miguel and La Colorada) or suspended (La Pasadita) (Personal Interview, 7 March 2012).

1.10 What the Future Might Hold

While the concessions have generally been considered a successful effort in community forest management, several challenges remain for these groups as they try to become self-sufficient enterprises, independent of the donor aid that has supported them for so long. Gómez and Méndez (2007) identify what some of the main issues that need to be addressed including strengthening human and social capital, and reducing infighting and cronyism which have been present in some of the weaker concessions. They believe that greater participation in ACOFOP could help strengthen these less developed concessions, which generally have lower participation levels.

The concessions have made some advances in accounting, estimating costs, and financial planning, which were identified as weaknesses in a USAID sponsored assessment of the concessions in 2000 (Chemonics and IRG 2000). Most of the concessions now generate quarterly financial statements and some are developing investment plans (Nittler and Tschinkel 2005). However, Pinelo (Personal interview, 22 Aug. 2011) stated that the biggest challenges moving ahead are improving internal governance within the concessions, institutional strengthening in CONAP, and better financial management so the concessions are not dependent on advances for capital investment each year.

CONAP has also been working to address some of the weaknesses identified in the concessions regarding internal organization, transparency, and equity in the distribution of benefits (Taylor 2011; Morales, Personal interview, 23 Aug 2011; Lehnhoff, A. Personal interview, 26 Aug. 2011). According to one CONAP official, starting in 2012, CONAP will require every community group to have a financial director and an investment plan. He said there is also work on an administrative manual, which each concession will be responsible for adopting (Morales, Personal interview, 23 Aug 2011).

A final issue is the education of the next generation of concession leaders and managers. When the concessions were first developed, many of the members did not have formal education and lacked the business and entrepreneurial skills required to manage the concessions in a sustainable and profitable manner. Ensuring the education and development of future leaders will greatly contribute to the future viability of the concessions (Chemonics 2006).

As the concessions continue to develop their business models and incorporate a wider range of activities into their forest management plans, they will need to be flexible enough to adjust to the changing markets and continue to build up the organizational structures already in place. Taylor (2010) believes that the future success of ACOFOP and the concessions depends on their ability to continually adapt to the changing conditions, while “maintaining adequate representativeness, equity, and legitimacy.”

Chapter 2: Do All Types of Community Forest Management Projects Actually Protect Forests?

2.1 Introduction

Various strategies have been employed to slow tropical deforestation, which amounts to approximately 13 million hectares per year worldwide (FAO 2010). The creation of national parks and reserves has been the most common approach, with over $5 billion invested in protected areas (Nelson and Chomitz 2011). More collaborative methods have also been implemented, such as payments for ecosystem services (PES), integrated conservation and development projects (ICDPs), and community forest management. These strategies are particularly appealing since they have the potential to meet dual objectives of environmental conservation and poverty reduction by providing sustainable livelihoods for local residents (Pagiola et al. 2005; Wunder et al. 2008). Among these strategies, community forest management has become an increasingly popular approach for managing tropical forests. The term community forest management can be used in a variety of contexts, but is broadly defined as a form of governance in which local populations are involved in the management decisions regarding the use of forest resources and obtain social or economic benefits from the forest while promoting sustainability (Bowler et al. 2010).

Although hundreds of community forest management projects are currently in operation worldwide, evidence regarding the impact of these programs on deforestation is inconclusive (Bowler et al. 2008). Some studies find positive results indicating that community-based management approaches are more successful at reducing deforestation compared to protected areas (Porter-Bolland et al. 2012) or areas not under community management (Gautam and Webb 2002). In contrast, findings from other studies are more ambiguous. Somanathan et al. (2008) find that village council-managed forests in the Himalayas had less forest cover than similar state-managed forests in certain areas and generally did no worse than state forests. Bray et al. (2008) compare deforestation rates in Mexico and Guatemala and find no significant differences in deforestation rates between protected areas and community forests.

Aside from the lack of consensus in the literature, overall, more rigorous estimation methods need to be employed to gain a better understanding of the effectiveness of community forest management. According to Bowler et al. (2010), one of the main shortcomings of existing studies is that they lack a suitable comparison group for the community forest areas, thereby creating a selection bias problem. Recent studies examining the role of protection on avoided deforestation address selection bias by applying matching methods (such as propensity score matching) to account for the nonrandom assignment of areas selected for national parks and reserves (Andam et al. 2008; Pfaff et al. 2009; Joppa and Pfaff 2009; Joppa and Pfaff 2010). These studies find that the effects of protection are overestimated when studies fail to control for nonrandom selection, in some cases by threefold or more (Andam et al. 2008). Only a limited number of studies use similar matching methods to analyze the effectiveness of community forest management on reducing deforestation (Somanathan et al. 2009; Nelson and Chomitz 2012).

In addition to the methodological issues that need to be addressed when assessing community forest management policies, accounting is needed for the impact of conservation outcomes on the background and socioeconomic status of the community members (Frito et al. 2009; Bray et al. 2008; Alix-Garcia 2007). To date, most research has focused on populations of long-term forest dwellers, including though not limited to indigenous populations (Nelson et al. 2001; Gautam et al. 2002; Kumar 2002; Somanathan et al. 2009; Nelson and Chomitz 2011). Across the world, however, communities living in and around local forests have varying characteristics that need to be taken into account when examining the impact of community-based management on forest conservation.

The community forest concessions in Guatemala's Maya Biosphere Reserve (MBR) provide a unique opportunity to assess the influence of various community characteristics on environmental outcomes. In this paper, I use land-use data from the reserve and apply a matched difference-in-differences approach to estimate the effectiveness of the community forest concession policy in reducing deforestation, taking into account differences among the participating communities. The concession policy was established as part of the management strategy for the Maya Biosphere Reserve. To gain concession status, a community had to register as a legal association and submit a sustainable management plan for a designated area of forest. Once the plan was approved, the community received property rights to the area by the local government and was allowed to harvest timber from the concession area as long as the management plan was followed. While all groups formed under the same legal framework, the communities themselves have many substantive differences in the cultural background and socioeconomic status of the members (Maas and Cabrera 2008; Bray et al. 2008; Radachowsky et al. 2011). Given the heterogeneity among the communities, the effectiveness of the different groups is also likely to vary with regards to managing the forest area and implementing the concession policy.

The findings indicate that community forest concessions can be a viable means of reducing deforestation, but the benefits vary across different types of communities. I find that the policy reduced deforestation within the concession boundaries across all groups, but the size of the effect varies based on the type of community group. As a robustness check, I test for evidence of local leakage due to the concession policy, where increased forest protection within the concession areas may shift deforestation to areas outside the concession boundaries. I find potential leakage in the concessions comprised of recent migrants. However, the increased deforestation in the surrounding buffer area that is attributed to leakage is less than the reduction in deforestation due to the policy. Overall, there has been a net reduction in forest loss. Leakage is not found to be an issue in the other concession groups.

I address previous shortcomings in the literature by applying a more rigorous estimation approach to control for the nonrandom selection of areas designated for concession management and to assess the before and after effects of the concession policy. This paper further contributes to the literature by estimating local leakage (or spillover) associated with the concession policy. To my knowledge, none of the existing studies that address the effectiveness of community forestry examine leakage. This is an important omission given the role that community forest management plays in discussions about REDD and REDD+ programs[1] (Hayes and Persha 2012) and the prevailing concerns regarding leakage and spillovers (Angelsen 2008).

In the section that follows, I review the background and formation of the community forest concessions, highlighting the differences among the three community groups. Next, I describe the sources of data and the variables used in the matching and regression analyses. After that, I provide an overview of the matching process and difference-in-differences estimation. I then review the findings and show the results from the robustness checks, including tests for unobserved bias (Rosenbaum 2002) and leakage. In the final section, I discuss implications of the findings and conclusions.

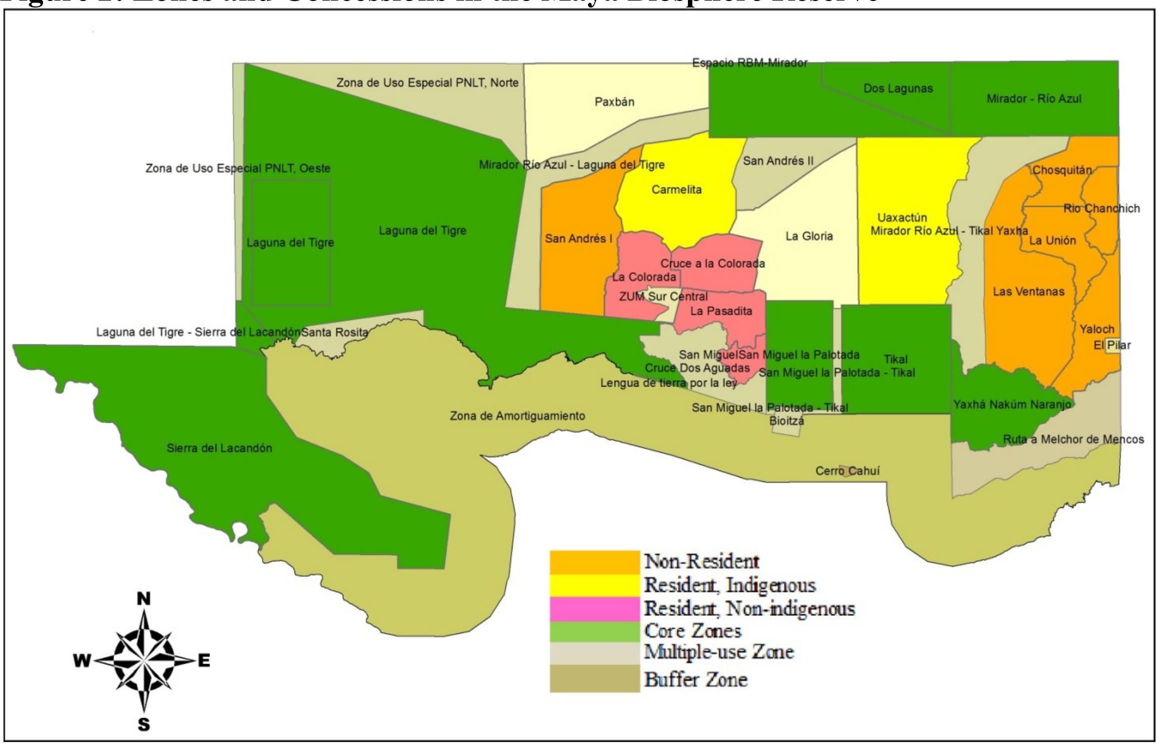
2.2 Background on the Community Forest Concessions

The community forest concessions were created as part of the forest management strategy for the Maya Biosphere Reserve in the northernmost department of Guatemala, called the Petén. The reserve covers over 2.1 million hectares and was established by the National Council of Protected Areas (*Consejo Nacional de Áreas Protegidas* [CONAP]) in 1990 in effort to stem deforestation and protect the cultural and historical resources found in the Petén, including Tikal National Park, which is an ancient Mayan city and UNESCO World Heritage site. When the reserve was formed, it was divided into three zones, each with different land use goals and management strategies. The core zones are protected areas that include national parks, Mayan ruins, and biotopes (areas of uniform habitat). These areas are under strict control of the government and the primary goal is

[1] REDD (Reducing Emissions from Deforestation and Forest Degradation) is a United Nations Initiative with the aim of creating economic value for carbon stocks in developing countries through a variety of projects. REDD+ goes beyond REDD to include conservation efforts and sustainable management practices. For more information see: http://www.un-redd.org/

conservation. The buffer zone runs along the southern border of the reserve. It was designed to promote sustainable land management and deflect pressure for land-use change away from the core zone. The multiple-use zone makes up the central part of the reserve and allows sustainable extraction of forest resources. It is home to the community forest concessions (CONAP 1996; Nittler and Tschinkel 2005; Gómez and Méndez 2007).

Figure 2: Zones and Concessions in the Maya Biosphere Reserve



Source: Land use data compiled by CEMEC, CONAP

The community forest concessions were not part of the original plan for the reserve and were created later under pressure both from conservation groups that wanted to keep the forests out of the hands of private logging firms and from local populations that wanted legal access to the forest resources in the reserve. To satisfy both groups, a system was set up in which a community worked with a non-governmental organizations

(NGO) on a sustainable forest management plan and an environmental impact evaluation, both of which had to be reviewed by CONAP (Nittler and Tschinkel 2005; Gómez and Méndez 2007). Once the plan and environmental evaluation were approval, CONAP granted the community property rights to a forest concession area for a renewable period of 25 years, where timber could be harvested and non-timber forest products collected. They also had to obtain Forest Stewardship Council[2] certification within three years of formation. The first pilot concession, San Miguel, was formed in 1994 and 11 other concessions were created between 1997 and 2002. One of the key components of the concession policy was the designation of property rights. Prior to the formation of the concessions, many of the resident communities living inside the reserve faced uncertainty about whether they would be able to continue living there. The assignment of property rights to concession communities secured the forest area for member use and provided legal grounds for the group to prevent outsiders from encroaching on the land (Nelson et al. 2001).

The community concessions can be separated into three groups based their location and the cultural and socioeconomic background of their members (Maas and Cabrera 2008; Bray et al. 2008; Radachowsky et al. 2011). Following Bray et al. (2008) I categorize the concessions into three groups: long-inhabited concessions, recently inhabited concessions, and non-resident concessions. The first two types of concessions (commonly referred to as resident concessions) are home to pre-existing, local populations that live within the concession boundaries. Long-inhabited concessions

[2] The *Forest Stewardship Council* is "an independent, non-governmental, not for profit organization established to promote the responsible management of the world's forests" (for more information see: us.fsc.org).

consist of *petenero*[3] communities that have lived in the area for multiple generations and originally came to extract *chicle* (ingredient for chewing gum) in the early 1900s (Schwartz 1990). These communities have a history of extracting timber and non-timber forest products and are largely dependent on the surrounding forest for their livelihoods. The recently inhabited concessions are comprised of recent migrant populations. The members come primarily from agricultural backgrounds and rely heavily on farming for their income. Non-resident concessions are more remote and the members live outside the concession area, typically in larger towns along major roads. The concession members travel seasonally to and from the concession areas to extract timber, while often maintaining other jobs, such as teachers or government workers. These other jobs often provide their main source of income throughout the year.

Table 4: Overview of the Three Types of Community Forest Concessions

Type	Concession Name	Year Formed	Overview of Membership
Long-Inhabited	Carmelita	1997	Members live within the concessions and have been for multiple generations. They are largely dependent on the forest for their livelihoods.
	Uaxactún	2000	
Recently Inhabited	San Miguel	1994	Members live within the concessions and primarily come from agricultural backgrounds. Many have migrated to the Petén from other regions in Guatemala
	La Pasadita	1997	
	La Colorada	2001	
	Cruce a la Colorada	2001	
Non-Resident	Suchitecos (Río Chanchich)	1998	Members live outside of the concessions in larger towns and cities. They have varied backgrounds and most have jobs outside of the concessions.
	Laborantes (Chosquitán)	2000	
	San Andrés (AFISAP)	2000	
	Arbol Verde (Las Ventanas)	2001	
	El Esfuerzo (Yaloch)	2002	
	CUSTOSEL (La Unión)	2002	

[3] Members of these communities are commonly referred to as *Peteneros* (Goméz and Méndez 2007)

While all of the groups had to meet the same requirements to gain legal rights to the concession areas, the circumstances under which they formed varied. Some groups, primarily in the non-resident concessions, were eager to enter into concession contracts to gain access to timber and non-timber forest products. On the other hand, the majority of the recently inhabited concessions formed under pressure from the government and NGOs. Many of the members were initially reluctant to join and only did so out of fear of being removed from the land they were currently settled on after the establishment of the reserve (Radachowsky et al. 2011). This reluctance to form groups and lack of interest in forestry, especially compared to the other concession groups, helps ensure that these groups were not endogenously selected (i.e., the members were not less likely to engage in deforestation regardless of the formation of the concession). If anything, they were more likely to deforest the surrounding land due to their background in farming and cattle ranching. Ultimately, these concessions struggled more than the other two concession groups and two of them were cancelled in 2009 due to failure to uphold their management plans (San Miguel and La Colorada).[4]

A 2012 survey (Fortmann et al. 2013) of the membership of the concessions further highlights some of the economic and social differences among the three groups of communities. Non-resident concession members are typically more educated, have higher income, and a larger percentage of members have jobs outside of farming and forestry. In the long-inhabited concessions, the members are more likely to do forest-related work

[4] In La Colorada, a number of the members illegally sold their land to cattle ranchers and fled the area. In May of 2009, a large area of clear cut forest was discovered and the concession was cancelled shortly (Radachowsky et al. 2011; WCS 2013).

and 76% of the members surveyed were born in the Petén compared to 52% and 29% in the non-resident and recently inhabited concessions, respectively. Among the recently inhabited groups, 86% of the members surveyed identified farming as their primary occupation. They also reported the lowest annual income, daily food expenditure, and education compared to the other two groups (see Table 5).

Table 5: Member Summary Statistics Separated By Concession Group

Variable	Non-resident	Long-Inhabited	Recently Inhabited
Age of Head	49.6	47.8	51.0
Educ. Of Head (years)	5.0**	4.1**	2.5***
Born in Petén	52%***	76%***	29%***
Daily Food Exp.[a]	$11.87**	$8.77	$7.41
Annual Income[a]	$7,928*	$3,867*	$2,413**
Own Land	47%***	76.8%**	82%**
Farmer	34.2%	37.1%	86%***
Forest job	7.9%**	25.8%***	1.7%**
Other job	52.6%**	35.5%**	10.5%***
Observations	152	62	57

Note. - Concession membership ranged from 20 members to more than 300. 20-25% of members were randomly selected for interviews. [a] Income and food expenditures are converted from Quetzales to USD based on October 2012 exchange rates (when the survey was conducted), Q1.00 = $0.1253, source: http://www.freecurrencyrates.com/exchange-rate-history/GTQ-USD/2012.
Significant difference from the other two groups on paired t-tests.* p<.10. ** p<.05. *** p<.01.

In addition to differences among the membership of the three types of communities, the concession areas also differ along on spatial and environmental characteristics. Five of the six non-resident concessions are located in the eastern half of the reserve, which is more isolated. Summary statistics show that these concessions are, on average, farther away from roads and villages compared to the resident concessions. Such factors influence the likelihood of deforestation, where more remote forests are under less pressure for land-use change (Pfaff 1999; Cropper et al. 2001; Man et al. 2013). These areas historically have had low rates of deforestation (less than 1%

annually), and they have continued to have the lowest rates of deforestation after the concessions were established (Maas and Cabrera 2008; Radachowsky et al. 2011). The central and western regions of the reserve are less remote and have experienced more development. This region is also home to a larger population of people who migrated to the Petén in search of land for farming and ranching. The recently inhabited concession areas tend to have higher elevation and steeper slopes on average. These environmental and geographic differences among the three concession groups need to be taken into consideration in order to control for selection effects and to create a suitable matched control group of similar forest areas for each type of concession area. By disaggregating the concessions into the three separate groups, I can focus on the differences among the concession communities and control for environmental and geographic variations among the forest concessions that may also impact deforestation.

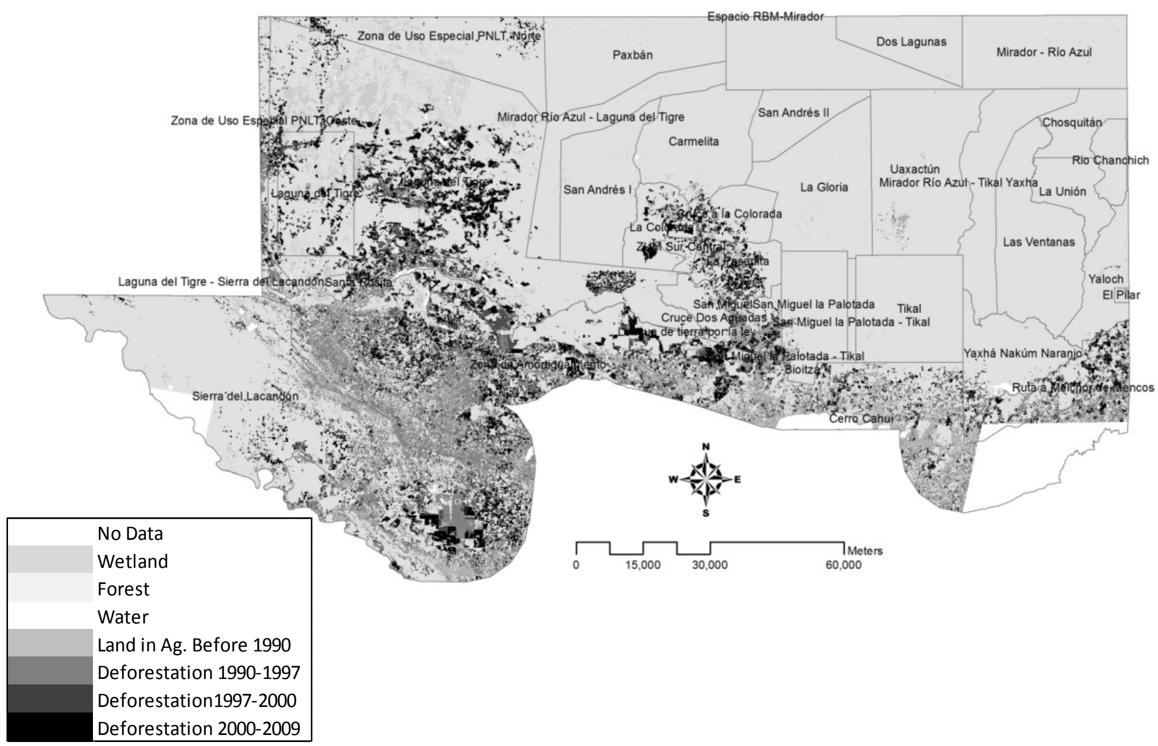
Table 6: Comparison of Summary Statistics for Forest Concession Groups

Variable	Non-resident	Long-Inhabited	Recently Inhabited
Road Distance (km)	21.4	8.8	6.6
Slope (degrees)	3.7	3.5	5.0
Elevation	194	226	230
Cleared Distance[a] (km)	9.4	5.7	1.6
City Distance (km)	49.5	69.5	51.6
pH	6.8	7.1	7.3
Archeo Distance[b] (km)	21.4	16.4	22.7
Aspect (degrees)	175	159	185
Village Distance (km)	25.3	13.1	5.1
Observations	2,157,303	1,484,183	734,509

Note. - Data from remote sensing satellite images. Observations are based on 30m x 30m parcels of land. See Data section for more details. All of the variables for each concession group are significantly different from the other groups at the 99% level for all covariates. [a] Cleared distance is the distance to the nearest pixel of land cleared prior to 1986. [b]Archeo distance is the distance to the nearest Mayan archeological site in the reserve.

A final consideration that is important when accounting for differences among the three concession groups is the presence of unobservable factors that are also likely to influence the probability of deforestation and land-use change. Not only is the western half of the reserve less isolated, it has also been the destination of a number of refugees that initially fled the area during the civil war and then returned to the area in the 1990s in search of land on which to settle (Gómez and Méndez 2007). The region also has a larger presence of drug trafficking (Radachowsky et al. 2011). As a result, the western region has been under a great deal more pressure for land conversion and deforestation than the eastern side. Figure 3 displays deforestation patterns in the reserve from 1986 to 2009, with the majority taking place in the western half.

Figure 3: Deforestation in the Maya Biosphere Reserve: 1990 - 2009



Source: Land use data compiled by CEMEC, CONAP

Given the differences evident among the three types of concession groups, these factors need to be taken into consideration when assessing the effectiveness of the community forest concessions as a policy for reducing deforestation. In this paper, I conduct analyses on the three separate forest concession areas, each comprising a different treatment group that will be matched with a control group of surrounding, non-concession forest areas in the multiple-use zone. While the core and buffer zones are of interest, they are not included in this analysis since they are under different management strategies and do not make a suitable control group for the concessions.

2.3 Description of Data

The land use data from 1986 through 2009 for the Maya Biosphere Reserve were compiled by the Center of Monitoring and Evaluation (CEMEC). The data are derived from satellite imagery obtained by CEMEC, which classified the images into various land uses at 30 meter resolution. Each 30m pixel is coded as "forest" if it remained forested from 1986 until 2009. If at some point it was determined that the area of land experienced forest disturbance based on satellite images, that pixel is given a code based on the year the disturbance took place. Reforestation of a parcel in later periods thus, is not accounted for in the data. A further limitation is that I am not able to ascertain the density or quality of the forest, only whether a parcel is considered forested or not based on satellite imagery (see Sader et al. 2001 for more details). As a result, the dependent variable of interest is binary, equal to "1" if the pixel of land was deforested during a given time period, "0" otherwise.

Environmental covariates used to match observations between the concession areas and the control areas include: elevation, slope, soil acidity (pH), and aspect. The slope and elevation measures come from digital elevation models (DEM) created by the Ministry of Agriculture, Livestock, and Food in Guatemala and are analyzed using ArcGIS. Data on distances to roads and settlements were obtained from the National Institute of Statistics in Guatemala. Location covariates used in the analysis include distances to the nearest road, pixel of land cleared prior to 1986, archeological site, major town, and medium-sized village. Major towns are defined as having a population over 10,000 people.[5] Medium-sized villages are defined as having a population greater than 200 people or existing within the reserve prior to its establishment in 1990 (Grunberg 1998).[6] Medium sized villages are included in the analysis since populations in these smaller villages are more likely to be involved in subsistence agriculture, and thus have different incentives for clearing land. Distance to the nearest major town serves as a proxy for transportation costs and distance to markets, where this distance is more likely to influence land use change on a commercial scale.

As previously discussed, a number of external influences may contribute to the selection of areas chosen for concessions that may also affect the probability of an area being deforested. To reduce the impact of unobservable factors, a regional dummy variable is included in the matching models based on whether the observation is in the eastern or western half of the reserve. For the four recently inhabited concessions, only

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[5] There are four towns in the Petén that meet this requirement, Flores, San Benito, Melchor de Mencos, and Poptun. However Poptun is located farther away from the reserve than the others, so no parcel of land included in the analysis is closer to this town than compared to the other major towns.

[6] Medium-sized and villages within the reserve prior to 1990 are based on a census report by Grunberg (1998) and correspondence with Dr. Norman Schwartz, an anthropologist and scholar of the Petén.

control observations in the western half of the multiple-use zone are included in the control group since all the concessions are located in this region.

Due to the large number of observations, I randomly selected 100,000 observations from each type of concession area to create three treatment groups, and 200,000 observations were randomly selected to make up the control groups.[7] The matching and difference-in-differences analyses are conducted using these randomly selected subsamples.

2.4 Methods

This paper uses a matched difference-in-differences approach to assess the effectiveness of the different community forest concession groups on deforestation in the Maya Biosphere Reserve. The final matched data sets used in the analysis are based on nearest neighbor matching without replacement, with Mahalanobis distance metrics and calipers set to a quarter of a standard deviation of each covariate to limit poor matches (Ho et al. 2011). I tested multiple matching specifications and use the samples with the best balance between the treatment and control groups for post-matching regression analysis (Ho et al. 2007; Arriagada et al. 2012).

2.4.1 Approach to Matching

The first part of the analysis involves matching treatment group observations from the three forest concession areas with control observations from the non-concession areas. Matching methods are based on the assumption that all of the factors that affect selection into the treatment group are observable and controlled for in the matching

[7] The total dataset including all observations in the concession and non-concession areas of the multiple-use zone contains 10,557,972 observations.

process; this is often referred to as selection on observables or the conditional independence assumption (Guo and Fraser 2009). Matching enables researchers to identify a set of observations in the control area that have characteristics similar to those of the observations in the treatment area. Thus when the treatment and control observations in the matched data set are compared, the resulting differences are driven by the treatment itself, in this case the change in land management due to the establishment of the community forest concession policy. Failure to minimize the differences between the two groups may lead to biased estimates of the treatment effect. The second necessary requirement for estimating causal effects is referred to as the stable unit treatment value assumption (SUTVA), which requires that the treatment of one unit does not impact the outcome of other units. Furthermore, the level of treatment should be the same for all units.

In the case of the Maya Biosphere Reserve, not taking the differences among the three types of concessions into consideration (i.e. treating all the concessions the same) would likely lead to bias since these differences may lead to variation in effectiveness of the concession policy (treatment effect). To reduce potential selection bias due to variation across concession areas and differences among the concession communities, I matched separately for each of the three groups under the assumption that the effectiveness of the concession policy varies based on the type of community implementing it. To satisfy SUTVA, the selection of forests into concession management would have to have no impact on deforestation in surrounding non-concession areas, which make up the control units in this case. This may not be the case if leakage is an issue, which occurs if increased management in one place results in deforestation shifting to non-protected areas. Given that leakage may be a potential issue, sensitivity analysis includes estimates of spillover (increased deforestation) after the policy was implemented in nearby buffer areas surrounding the concession boundaries.

Following Ho et al. (2007), I focus on nearest neighbor matching, which allows for post-regression analysis with the matched datasets (Guo and Fraser 2009). The final matched sample used in the DID analysis is based on nearest neighbor propensity score matching with Mahalanobis distance metrics. Propensity scores are estimated with a logit model that predicts the probability of treatment (being selected into one of the three concession areas) based on a set of environmental and demographic covariates (see Appendix A for Table 23). The propensity score is used to narrow down the range of possible matches between the treatment and control observations. For each treatment observation, only observations with propensity scores within a quarter of a standard deviation of the treatment score are eligible for matching. After the potential control observations are narrowed down, they are matched to the treatment observation with the smallest distance based on a vector of covariates.[8] As a robustness check, I also conduct bias-corrected (Abadie and Imbens 2002) and nonparametric kernel matching to compare differences in means between the treatment and control groups before and after the concession policy was established with the difference-in-differences estimates.[9]

[8] Mahalanobis distance metric is measured as $D(i,j) = (u-v)^T C^{-1} (u-v)$, where i and j are treatment and control observations respectively, and u and v are vectors of covariates for the treatment and control observation. C is the sample covariance matrix (Guo and Fraser 2010).

[9] Smaller sample sizes (50,000 rather than 300,000) were used for these matching estimators due to the computational complexity of the matching process. (See Appendix Tables 2A-2C).

Table 7: Comparison of Balance between Matched Data Sets

	Non-Resident				Long-Inhabited				Recently Inhabited			
	Unmatched		Matched		Unmatched		Matched		Unmatched		Matched	
Variable	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***
Dist. to road	6.86	6.75	1.81	1.72	-5.71	6.82	-0.03	0.67	-8.93	8.13	1.062	1.45
Dist. to city	-23.48	24.92	-0.96	6.60	-3.48	23.16	5.96	19.98	-14.98	21.95	5.20	6.86
Dist. to village	6.62	6.52	0.88	2.65	-5.60	6.60	-0.99	0.90	-9.66	10.11	0.48	0.81
Dist to village sq	305.9	217.7	32.06	71.17	-231.9	262.1	-40.10	21.99	-240.3	200.0	12.31	5.74
Dist. to clearing	1.90	2.10	-0.59	1.36	-1.80	1.34	-0.14	0.56	-8.68	10.67	0.86	0.19
Cleared dist sq	18.69	19.14	-19.24	27.82	-46.52	13.78	-5.32	3.91	-152.4	133.1	7.37	0.38
Dist. to archeo site	-0.86	5.22	-1.89	2.01	-5.85	3.27	-0.97	2.94	3.64	5.53	-3.19	2.87
Aspect	12.88	10.01	1.01	4.40	-2.60	6.34	-0.36	1.30	20.27	14.04	-4.02	4.07
pH	0.34	0.36	0.10	0.05	0.55	0.50	-0.09	0.00	0.51	0.36	-0.13	0
Elevation	29.90	48.25	12.22	11.00	62.14	69.00	-4.29	36.00	29.93	35.00	14.7	16
Slope (degrees)	0.57	0.87	-0.36	0.00	0.38	0.46	-0.11	0.00	2.20	1.90	-1.86	1.97
West (location dummy)	-0.29	0.29	0.00	0.00	-0.16	0.16	0.00	0.00	0.32	0.00	0.00	0.00
Observations	293248		90190		294208		94204		296262		43116	

Note. - Matching methods for all three data sets are nearest neighbor without replacement, with Mahalanobis distance metric for select variables. *Median values for the QQ plot differences are used for all ordinal covariates and the mean is used for categorical covariates (west). Matching is conducted in R using "MatchIt" (Ho et al. 2011)

Balance is assessed by measuring the difference in means between the treatment and control groups for each covariate and the median difference in the quantile-quantile (QQ) plots of the treatment and control group, where zero indicates that the empirical distributions are the same for each covariate (Ho et al. 2011). Table 7 shows the balance results comparing the treatment and control groups for the matched samples that are used in the post-matching regression analysis. The table shows the difference in means between the treatment and control groups and the median difference in the QQ plots for each covariate used in the matching process, and compares the results between the matched and unmatched samples for each concession group. If matching is effective, then the difference in means and the median difference in the QQ plots should be smaller in the matched sample compared to the unmatched sample, which is what we see in Table 7.

2.4.2 Difference-in-Differences

After matching the data, I conduct difference-in-differences (DID) regression analysis with two cross-sections of the matched data (for each concession group) to estimate the average treatment effect on the treated observations (ATT), which is defined here as the difference in deforestation in forest areas under community concession management compared to the deforestation that would have taken place had there been no concession policy.

The basic DID estimator compares differences in the outcome variable between the treatment and control groups before and after the policy was implemented. The regression equation can be written as:

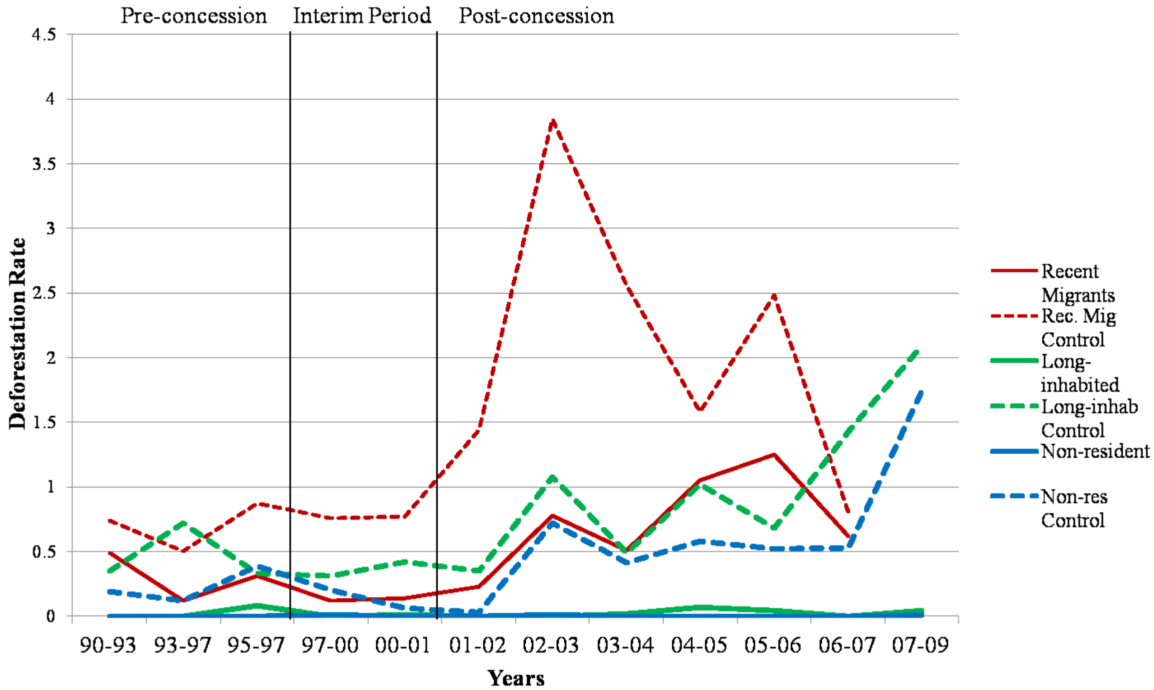
$$y_{it} = \beta_0 + \beta_1\, TREAT_{it} + \beta_2\, POST_{it} + \beta_3\, TREAT_{it}{*}POST_{it} + \beta_4\, X_{it} + \varepsilon_{it}$$

where *y* is a binary dependent variable equal to "1" if the pixel was deforested in a given period, *i* indexes the observed pixel of forest area, and *t* indexes the time period, "0" before the concessions, or "1" after the concessions were established. The coefficient of interest is β_3, the DID estimate, which can be interpreted as the impact of the concession policy on deforestation. An advantage of using DID is that the method controls for unobservable, time invariant factors that might affect the outcome of interest and selection into the treatment group.

The main assumption for this method is the parallel trends assumption, which requires that the trends in deforestation for treatment and control group areas would have been similar if the policy had never been implemented (Wooldridge 2002). Figure 3 shows the trends in deforestation for the matched treatment and control areas for each concession group from 1990 to 2009. The pre-policy time period used for this analysis is 1990 to 1997, after the reserve was created, but before the community groups were actively managing their concession areas. The post-policy period varies slightly based on the concession group. For the non-resident concessions the post-policy period is 2002 to 2009, so the analysis does not include the interim years when the concessions were being formed. For the long-inhabited concessions the post-policy period is 2000 to 2009, since Carmelita and Uaxactún were both established as of 2000. For the recently inhabited concessions, the post-policy period is 2000 to 2007. The analysis does not extend to 2009 for this group of concessions due to the fact that two of the concessions were cancelled

(San Miguel and La Colorada) and were no longer actively managing their concession areas in the two years prior to 2009 (Radachowsky et al. 2011; WCS 2013).

Figure 4: Annual Deforestation Rates in Matched Treatment and Control Groups



Source: Land-use data from CEMEC, CONAP

From 1990 to 2000, the data is limited and deforestation rates are only available for multiple-year periods. In Figure 4, the pre-policy period is from 1990 to 1997 for all three concession groups. While the deforestation rates are different, the matched treatment and control groups have generally similar trends for the pre-policy period, supporting the parallel trends assumption.

For my analyses, I use a linear probability model (with robust standard errors) since the dependent variable is binary, equal to "1" if the parcel of land was deforested in the period of analysis. I run a probit model and estimate marginal effects as a further robustness check. I start with a basic DID model and also run an extended model with a full set of covariates for a more robust estimation of the policy effect (Ho et al. 2007). The basic model includes dummy variables for "post" and "treat" and the interaction of "treat*post", which is the estimated effect of the concession policy.[10] The extended model is the same as the basic one but includes environmental and location covariates.[11]

2.5 Results

The main model upon which I focus includes the full set of covariates. The results indicate that the concession policy reduced deforestation rates in all three types of community concession areas (see Table 8). The results are robust to tests for unobserved bias using Rosenbaum's bounds (Rosenbaum 2002). The estimated treatment effect is the smallest in the non-resident concessions, with 3.3% less deforestation compared to the matched control group. This result is not surprising since these areas had the lowest deforestation rates to begin with. The long-inhabited concessions reduced deforestation by about 5% compared to the matched control group, and the recently inhabited concessions reduced deforestation by approximately 7.8%. The results from the basic model are similar to the extended model, and in almost all cases, the treatment effects for each concession group are negative and significant.[12] I can use the DID results to estimate the area of avoided deforestation that can be attributed to the concession policy in each of the concession areas. The non-resident concessions cover approximately

[10] For the basic model, the DID coefficient is the same as differencing the means of the treatment and control groups before and after the policy was in place, and then differencing those means between the two groups, where: $\hat{\beta}_3 = (\bar{y}_{11} - \bar{y}_{10}) - (\bar{y}_{01} - \bar{y}_{00})$.

[11] The covariates in the extended model include: road distance, road distance squared, major city distance, elevation, slope, cleared land distance, cleared distance squared, west dummy, aspect, village distance, village distance squared, archeological site distance, pH.

[12] The only model where the treatment effect is not negative is for the unmatched data for the resident, recently inhabited concessions.

194,157 ha of forest and the long-inhabited concessions approximately 133,576 ha. The resulting avoided deforestation is estimated to be 6,407 ha and 6,678 ha, respectively. In the recently inhabited concessions, avoided deforestation amounts to approximately 5,020 ha (based on 45,041 total ha).

Table 8: Results of Difference-in-Differences Analysis and Probit Marginal Effects

	Unmatched		Matched[a]	
Model	**Coeff.**	**S.E.**	**Coeff.**	**S.E.**
Non-resident				
Basic DID	-0.035***	0.001	-0.031***	0.002
Extended DID	-0.040***	0.001	-0.033***	0.002
Probit ME	0.003***	0.009	-0.014***	0.005
Observations	293248		90190	
Pseudo R2	0.1302		0.0976	
Long-inhabited				
Basic DID	-0.038***	0.001	-0.047***	0.002
Extended DID	-0.043***	0.001	-0.050***	0.002
Probit ME	-0.018***	0.003	-0.022***	0.003
Observations	294679		94204	
Pseudo R2	0.1317		0.109	
Recently Inhabited				
Basic DID	0.272***	0.001	-0.075***	0.004
Extended DID	0.026***	0.001	-0.078***	0.004
Probit ME	-0.001***	0.001	-0.040***	0.004
Observations	296262		43116	
Pseudo R2	0.0882		0.0881	

Note. - [a]Matched samples are based on nearest neighbor propensity score matching with Mahalanobis distance metric with calipers set to 0.25 standard deviations taken from the sample with 300,000 observations. Results based on a linear probability model where the dependent variable equals “1” if pixel is deforested., “0” otherwise. * p<.10. ** p<.05. *** p<.01.

As a robustness check for the DID results, I also compare mean deforestation rates before and after the concession policy was established for the treatment and control groups using data matched with kernel and bias-corrected matching estimators (Abadie and Imbens 2002).[13] The results are for the most part in line with the DID results (see Table 9). Kernel matching estimates indicate that deforestation was reduced by 1.1% and 11.1% in the non-resident and recently inhabited concessions, respectively (compared to 3.3% and 7.8% based on the DID estimates). Results from the bias-corrected matching show that the recently inhabited concessions reduced deforestation by 8.4%, and the long-inhabited concessions reduced deforestation by 8.5% (results for the non-resident concessions are not significant). The main discrepancy from the DID results is for the long-inhabited concessions, where the kernel-matched results indicate a reduction in deforestation by 13.5%, which is more than double the DID estimate. In all cases, the estimated treatment effects for the concessions are negative, further supporting the conclusion that the concession policy reduced deforestation in all three concession areas.

Table 9: Alternative Results from Matching Pre- and Post-Concession Policy

Concession Group	Time Period	Unmatched ATT	Unmatched S.E.	Kernel ATT	Kernel S.E.	Bias-Corrected ATT	Bias-Corrected S.E.
Non-resident	Pre	-0.036***	0.002	-0.004***	0.0005	-0.013***	0.0006
	Post	-0.070***	0.003	-0.015***	0.001	-0.015***	0.004
	Difference	-0.034***	0.003	-0.011***	0.001	-0.0015	0.004
Long-inhabited	Pre	-0.036***	0.002	-0.035***	0.009	0.0080*	0.004
	Post	-0.068***	0.003	-0.170***	0.027	-0.077***	0.009
	Difference	-0.032***	0.003	-0.135***	0.028	-0.085***	0.010
Recently Inhabited	Pre	0.0047***	0.001	0.004**	0.002	0.038***	.002
	Post	0.031***	0.002	-0.107***	0.012	-0.046**	.020
	Difference	-0.035***	0.002	-0.111***	0.012	-0.084***	0.020

Note. - Kernel matching performed in Stata 12 with "psmatch2". Bias-corrected performed in Stata using the "nnmatch" command. The number of observations for each sample vary, but are based on 50,000 total observations in the unmatched sample, then split up into 25k each for pre- and post- samples. ATT (Average Treatment effect on the Treated) estimates and standard errors for Kernel matching are based on bootstrapped S.E. for 50 repetitions.

[13] Smaller sample sizes (50,000 rather than 300,000) are used for these matching estimators due to the computational complexity of the matching process.

2.5.1 *Test for Unobserved Bias*

As a further robustness check, I test for unobserved or "hidden" bias that would change the significance of the treatment effect. This is particularly important since matching relies heavily on the assumption that there are no unobservable factors that simultaneously affect selection into the treatment group and the outcome variable of interest. Sensitivity to unobserved bias is commonly assessed using Rosenbaum's bounds (Rosenbaum 2002), where the test indicates how strong the unobserved bias would need to be in order to change the significance of the results. In other words, it tests how sensitive the results are to potential, unobserved factors not captured in the analysis. The test is based on different levels of Γ. When Γ=1, the presence of an unobservable factor has no effect on the estimated treatment effect. As Γ increases, the odds that the treated observations are less likely to experience deforestation due to an unobserved factor increase. For example, Γ=2 indicates that concession observations are twice as likely to not be deforested as matched control observations due to some unknown factor not accounted for in the analysis (Rosenbaum 2002; Becker and Caliendo 2007).

Table 10: Test for Unobserved Bias using the Mantel-Haenszel Test Statistic

	Non-Resident		**Long-inhabited**		**Recently Inhabited**	
Γ	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	12.2	21.5	10.3	15.1	6.2	4.4
2	17.4	30.3	14.8	21.6	11.1	13.1
3	21.3	36.9	18.3	26.5	14.6	18.8
4	24.6	42.4	21.2	30.6	17.4	23.2
5	27.5	47.2	23.8	34.2	19.8	26.9

Note. - Results were obtained using "mhbounds" in Stata 12 used for testing unobserved bias with binary dependent variables (see Becker and Caliendo 2007). Reported values are for the Mantel-Haenszel statistic Q+mh (assumption: overestimation of treatment effect) P-values for all test statistics are less than 0.001 and thus are not displayed in the table. Pre- indicates the pre-policy period from 1990-1997, post- indicates the post-policy period from 2000-2009. Γ is a measure of the degree of hidden bias required to change results of the estimated treatment effect from the kernel matching results (Table 9).

The results for unobserved bias follow the kernel-based matching estimation (see Table 9). The concession groups are split into subsamples, pre- and post- concession policy. Table 10 shows the results for the Mantel-Haenszel test statistic, which tests the null hypotheses that the treatment effect is overestimated for the given levels of Γ. I can reject the null hypothesis in all cases. The results are robust to unobserved bias for Γ up to five ($p < .001$).[14] Thus the significance of the treatment effect would not change even in the presence of a sizable unobserved, confounding variable.

2.5.2 Leakage Analysis

I also test for leakage or spillovers, which would occur if the concession policy results in illegal forest activities being moved to outside of the concession boundaries. If leakage occurs, then the gross measures of reduced deforestation calculated in the models in Table 7 will be smaller in net. Negative leakage could occur as well, if the implementation of the concession policy and improved forest management it brings discourages deforestation outside of the concession boundaries. Following Andam et al. (2008), to estimate leakage from the community concessions I create buffer areas around the outside boundaries of the three concession areas (2km, 5km, and 10km) and match random observations from within the buffer areas to observations outside the buffers, further away from the concession borders.[15]

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[14] The upper bounds on the significance levels for Γ are essentially zero ($p < 0.001$) for all levels of Γ, for all subgroups (not shown in the table).

[15] Andam et al. (2008) matched unprotected forest plots within a 2km buffer surrounding the protected area (treatment) with unprotected plots beyond the 2km radius (control), and compared deforestation in the two areas to test whether there were any spillover effects due to the designation of protected area status in Costa Rica.

Leakage is estimated based on the coefficient for a "buffer" dummy variable, indicating if an observation is within the designated buffer area in the post-concession policy period. I run a basic OLS regression model with a limited number of covariates, and an extended model with the full set of covariates. A positive "buffer" coefficient indicates that observations in the buffer zones had higher rates of deforestation compared to matched observations further away from the concessions during the period of analysis. This approach will primarily capture leakage on a local scale due to local residents involved in small scale agriculture. If the presence of the concessions discouraged large landowners and cattle ranchers from settling near concession boundaries, but they moved elsewhere in the region and deforested outside the buffer areas, then this method would underestimate the amount of leakage taking place due to the concession policy.[16]

Table 11: Leakage Estimates for the "Buffer" Coefficient for Recently Inhabited Concessions

	2 Km Buffer		5 Km Buffer		10 Km Buffer	
Model	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Basic	0.14***	0.14***	0.13***	0.072***	0.11***	0.033***
	(0.002)	(0.009)	(0.002)	(0.007)	(0.002)	(0.007)
Extended	0.089***	0.15***	0.08***	-0.057***	0.057***	0.039***
	(0.004)	(0.008)	(0.003)	(0.009)	(0.004)	(0.014)
Kernel	--	0.088***	--	0.03	--	0.14***
	--	(0.023)	--	(0.022)	--	(0.044)
Observations	96899	7230	97756	5582	98014	5004
Pseudo R2	0.20	0.28	0.18	0.28	0.17	0.17

Note. - Matched results are based on nearest neighbor matching without replacement with Malahanobis distance metrics. Matching was done in R using "MatchIt" (Ho et al. (2011). Kernel results are from Stata using "psmatch2". Standard errors are in parentheses. Dependent variable is binary, equal to "1" if observation is within the designated buffer zone.

[16] Our model only estimates leakage from activity shifting and not market based leakage that would occur if the size of the projects change any prices (we assume prices are exogenous). Other studies that estimate market leakage include Murray et al. 2004 and Sohngen and Brown 2004.

Based on the findings, leakage only occurred near concessions managed by recent inhabitants. The results for this concession group in Table 11 indicate that leakage varied across buffer distances and areas closer to the concession boundaries experience more deforestation compared to areas farther away. Focusing on the results from the extended model, deforestation inside the 2km buffer surrounding the recently inhabited concessions was 15% higher than in areas farther away from the boundaries. In the 5km and 10 km buffer areas, the magnitude and sign (positive or negative) of leakage varies, thus the extent of the leakage outside of the concessions beyond the 2 km buffer is not clear. Leakage estimates in the other two concession groups for all three buffer distances are, for the most part, negative or not significant (see Appendix A Table 27).

The presence of leakage in areas surrounding the recently inhabited concessions is not surprising. I would expect to see leakage in this area in particular given that the main source of deforestation in this region is due to land clearing for subsistence farming and cattle ranching. Furthermore, the local populations in this region have fewer alternatives to farming since they do not have backgrounds in forestry and they live inside the reserve, farther away from towns and cities that offer more job opportunities. Overall, I still find that the concession policy reduced deforestation in net. Taking into consideration the increased amount of deforestation in the 2km buffer area that is attributed to leakage, avoided deforestation still amounts to a net gain of 3,298 ha in the recently inhabited concessions.

Other studies estimating leakage surrounding protected areas or land enrolled in payment for ecosystem services (PES) programs found minimal leakage, that was if anything, negative. (Andam et al. 2008; Honey-Roses et al. 2011). The only paper that finds evidence of positive leakage is by Alix-Garcia et al. (2012). They examine slippage due to farmer enrollment in a PES program in Mexico that pays farmers to conserve forest land. They find that in more remote areas with high program enrollment and low road density, deforestation is higher in buffer areas surrounding enrolled land compared to areas that are less remote and have better access to markets. These results parallel the findings, where leakage is greater in areas where the residents live farther away from markets and have fewer alternatives to farming. Among the more robust studies that examine community managed forests, none of the papers address leakage in their analyses (Nelson and Chomitz 2011; Somanathan et al. 2008; Bowler et al. 2010)

2.6 Discussion

This paper examines how cultural and socioeconomic differences among the members of the community forest concessions in Guatemala influence the groups' effectiveness in reducing deforestation. The analysis is conducted using land-use data from the Maya Biosphere Reserve in northern Guatemala, where forest concessions have been granted to community groups that are responsible for managing the land sustainably. Applying a matched difference-in-differences approach, I show that the community concession approach has been successful in reducing deforestation in the reserve. Although all three types of concession communities were successful, the findings indicate that group type influenced the effectiveness of the concession policy. Specifically, the recently inhabited concessions, which were established in areas under the highest pressure of deforestation initially, experienced the largest treatment effects, while the non-resident concessions had the smallest treatment effects. This is a striking result since the recently inhabited groups were reluctant to form in the first place and were initially more focused on agriculture and cattle ranching. Furthermore, these residents faced greater external pressure and were less equipped to engage in forest activities due to their lack of experience and education.[17]

We also find evidence of leakage, but only in buffer areas outside the boundaries of the recently inhabited concessions. This finding is not surprising given that these areas are farther away from major towns and are more densely populated with recent migrants who primarily come from subsistence farming backgrounds. Despite findings of leakage in these areas, there were still positive, net gains in avoided deforestation, amounting to 3,298 ha in the recently inhabited concessions. The concession policy was more effective at reducing deforestation in the non-resident and long-inhabited concessions, which had no evidence of leakage. Avoided deforestation in these concessions amounts to 6,407 ha and 6,678 ha, respectively. These communities have higher levels of income and education compared to the recently inhabited concession groups. Alix-Garcia et al. (2012) similarly find that less slippage occurred in PES programs in areas with lower poverty and more market integration.

The results of this study have a number of implications for policy. First, the results indicate that the creation of community forest concessions can be an effective strategy for slowing deforestation. This approach may be exceedingly useful across large

[17] Members of resident non-indigenous concessions have an average of 2.5 years of education based on a survey of concession members. See Table 2 for a comparison of member summary statistics (Fortmann et al. 2013).

swaths of tropical forests where deforestation is a concern but countries do not have the resources required to provide strict protection of the forest. One reason why community based concessions work is that they establish property rights. When community concessions are granted, property rights are given to the group for a renewable period of 25 years, as long as they continue to uphold the management guidelines. This provides groups with the assurances they need to conduct sustainable forest management without concerns that the government with renege on the contract or that they will be forced off the land. Since community concessions require the allocation of property rights, this approach is most applicable for forests under state or government control. Currently in Latin America, Africa and Asia, approximately 140 million hectares are currently placed in timber concessions, though the majority of these are leased to private or industrial firms. Efforts are being made, however, to increase community involvement and management in forest concessions, particularly in Brazil and Indonesia (Molnar et al. 2011).

Second, the findings indicate that community-based concessions can be successful across a wide range of community types. In the study region, the three types of community groups that formed concessions vary substantially, but each reduced deforestation. Deforestation rates were initially higher in regions with recently inhabited populations, but the establishment of the concessions in these areas led to a significant reduction in deforestation in the areas under concession management. Given the various types of communities that currently live in forested areas in the tropics, the results suggest that establishing community concessions and assigning property rights may a potential strategy for slowing deforestation in many of these areas with similar conditions. My analysis also extends the current literature to include non-indigenous populations and finds that the concession policy can be successful in communities with no prior forest background. However, these types of communities will likely require more training and support in the initial stages of the program. Assessing the tradeoffs associated with implementation costs, avoided deforestation, and local economic development are important considerations and may be areas for future research.

A third policy implication, based on the findings, is that leakage may be a concern if implementing similar policies in other regions. However, certain types of communities appear to be more susceptible to leakage than others. Leakage was only a factor in recently inhabited concession areas with primarily migrant populations. This result is not surprising given the agrarian background of the local populations in this region. Furthermore, individuals in these concessions who were unsatisfied with the concession arrangement may have left the area and increased their landholdings outside the concession boundaries. Over time, one would expect the amount of leakage to subside. One way to reduce leakage on a local scale may be to increase the area under concession management.

Overall, I find that that the community forest concessions are successful in reducing deforestation, and may be a viable policy option for conserving the world's forests moving forward. Additionally, the potential welfare benefits associated with granting communities access to the forests, and creating a means of sustainable income generation, lends further support for the community forest concession policy.

Chapter 3: Detecting Selection Bias when Estimating Treatment Effects for a Community Forest Concession Policy

3.1 Introduction

While community forest management has become an increasingly popular strategy for decreasing deforestation worldwide, it is not clear that these programs actually reduce deforestation (Bowler et al. 2010; Gautam and Webb 2002; and Nagendra et al. 2008; Somanathon et al. 2009; Porter-Bolland 2011). One of the weaknesses with the current suite of studies is that many fail to control for potential selection bias in the designation of community forest areas (Bowler et al. 2010). When considering forest protection, it is often difficult to disentangle whether forests are protected due to the policy or if the forests would have remained relatively protected even without a change in management. For example, the effectiveness of a community forest management program may be overestimated if the areas selected for management are less likely to be deforested regardless of the level of protection (e.g. more remote areas farther away from roads and villages). In this case, simply comparing the community forests to nearby, non-protected areas would not result in an accurate estimate policy effectiveness.

Adjacent forests that are not under any specific management policy are most commonly used as counterfactuals, or control groups, when assessing the effectiveness of various forest management strategies on reductions in deforestation. However, given that the process for selecting forests for protection or specialized forest management is generally non-random, any area used for comparison will be subject to selection bias (Joppa and Pfaff 2009). Of late, many studies use matching methods, such as propensity score matching, to reduce selection bias and ensure that comparisons are being made between similar areas of forest (Andam et al. 2008; Pfaff et al. 2009; Joppa and Pfaff 2010; Nelson and Chomitz 2012; Somanathan et al. 2009; Fortmann et al. 2014). One shortcoming of matching methods, however, is the assumption of matching on observables (or conditional independence), which necessitates that all factors that affect selection be accounted for in the matching process. This is a somewhat strong assumption and requires that the selection of forest areas into the treatment group is completely based on observable covariates and that there are no underlying, unobservable factors that affect both selection and deforestation. If unobservable factors exist that are not accounted for, then the estimated treatment effect will be biased.

The staggered timing in the formation of the community forest concessions in northern Guatemala provides a unique opportunity to examine the effectiveness of the concession policy and assess to what degree, if any, selection bias influences estimates of a policy treatment effect. The concessions are a part of the Maya Biosphere Reserve, which covers more than two million hectares of forest in northern department of the Petén. The reserve and was created in 1990 in an effort to stem deforestation occurring in the region and to protect cultural and historical sites of importance. The community forest concessions were subsequently established as a way to grant local populations access to the forest, where many of the communities have been living in the reserve for multiple generations and depend on forest resources for their livelihood. In order to gain concession status, a community had to create a sustainable management plan for the proposed forest area. Once approved, the community was granted property rights to the forest concession and allowed to extract timber and non-timber forest products. Between 1994 and 2002, 12 community forest concession groups formed (Nittler and Tschinkel 2005; Goméz and Mendéz 2007). In this analysis, I exploit the staggered timing of the formation of the concession groups to create a treatment group of early formed concessions to compare with a control group of concessions formed in a later period. The focus of the analysis is on the central region of the reserve, which has been under the greatest pressure for land-use change and deforestation, and as a result, is also where the concession policy is likely to have the greatest impact.

To test for selection bias, I first apply a matched difference-in-differences approach using forest cover data from the reserve to estimate the reduction in deforestation due to the concession policy. The difference-in-differences analysis is based on comparing deforestation rates between a treatment and control group in the pre-policy period, prior to any of the concessions being formed, with deforestation rates in the post-policy period, after the first group of concessions was formed, but before the second group of concessions became active. The degree of selection bias present in the analysis is based on comparisons of two control groups, one made up of future concession areas, and a second, more standard control group comprised of surrounding forest areas not under concession management. The difference in treatment effects between analyses using the two control groups provides insight as to whether or not selection bias is an issue when assessing different forest management strategies, or if matching is enough to mitigate concerns about non-random selection and unobservables not accounted for in the data.

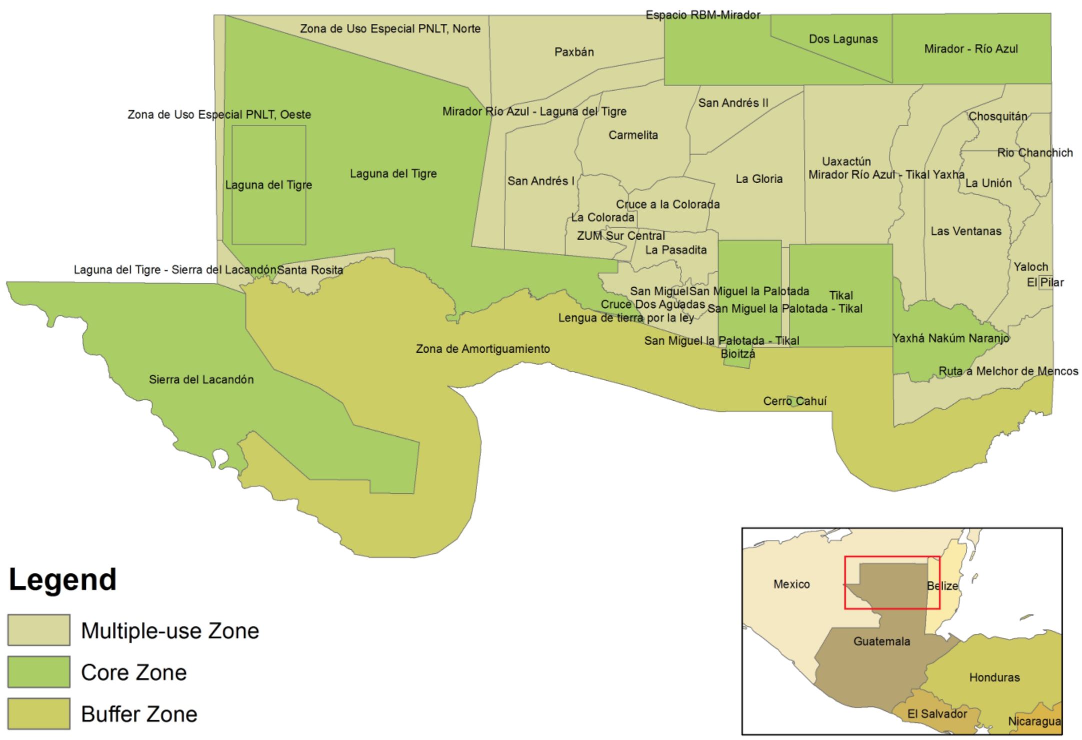
The results indicate that overall, the community concession policy did appear to be effective in reducing deforestation. However, there was a small degree of selection bias when comparing treatment effects between the two different control groups. When using the control group made of future concession areas, the concession policy reduced deforestation by 0.9 percent in the treatment concessions, compared to a reduction of 1.5 percent when using the non-concession control group. Analysis of potential leakage or spillover effects due to the establishment of the concessions indicates that leakage was not an issue. Leakage would occur if increased management due to the concession policy led to greater deforestation in surrounding areas outside of the concessions. When comparing deforestation rates in buffer areas around the concession boundaries with forest areas farther away, there is no significant difference in deforestation rates.

The remainder of the paper is organized as follows: in the next section I provide an overview of the study area and the community forest concessions. Section 3 describes the data used for the analysis. Section 4 explains the selection bias problem and the matched difference-in-differences approach used in this analysis. Section 5 goes over the results and Section 6 covers discussion and conclusions.

2.2 Study Area: Guatemala's Maya Biosphere Reserve

The community forest concessions are located in Guatemala's Maya Biosphere Reserve, which covers over 2.1 million hectares of tropical forests and wetlands in the northern department of the Petén. Growing concern for the southern forests of the Petén, which were being lost to farming, ranching, illegal logging, and forest fires, along with increased awareness for environmental conservation among international organizations led to the creation of the Maya Biosphere Reserve in 1990 (Nittler and Tschinkel 2005; Gómez and Méndez 2007). The reserve is under the direction of the National Council of Protected Areas (*Consejo Nacional de Áreas Protegidas* [CONAP]), which divided the area into three zones, each with different land use goals and management strategies. The core zone includes national parks, Mayan ruins, and areas containing similar habitat (i.e., biotopes). It is under strict control of the government, and the primary goal is conservation. The buffer zone runs along the southern border of the reserve and was designed to deflect land-use change from the core zone. The multiple-use zone (ZUM) allows sustainable extraction of forest resources and is home to the community forest concessions (see Figure 5).

Figure 5: Zones in the Guatemala's Maya Biosphere Reserve



Source: Land-use data from CEMEC-CONAP

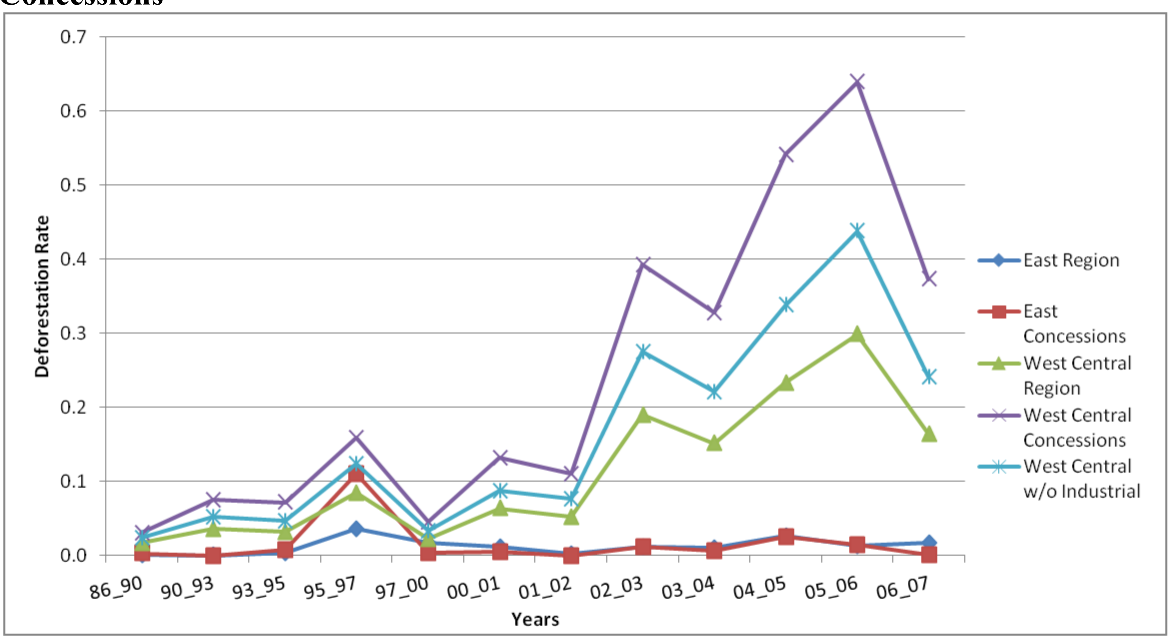
Initially after the reserve was created, the main focus was to control illegal logging primarily in the core zone. Then, as pressure increased from local communities and environmental conservation organizations, the community forest concessions were established as a way to grant local populations access to forest resources. The goal of the community concessions was to provide income and a means of livelihood for local populations through the sustainable extraction and sale of timber. In 1994, a legal system for the community concessions was established and a pilot concession was initiated in San Miguel (Monterroso and Barry 2012; Nittle and Tschinkel 2005). San Miguel was initially considered a success, and subsequently, 11 more community forest concessions were established in the multiple-use zone between 1997 and 2002. In order to gain access to a concession area, each community group had to obtain legal status as an organization, as well as create a sustainable forest management plan and conduct an environmental impact analysis. Once approved, the groups were granted property rights to a forest concession area for 25 years and were allowed to extract timber and non-timber forest products (Nittler and Tschinkel 2005; Radachowsky et al. 2012). Within the first three years of formation, the groups also had to obtain certification from the Forest Stewardship Council.[18]

The eastern and western halves of the reserve have experienced different land-use patterns since the establishment of the reserve in 1990. The eastern region is more

[18] The *Forest Stewardship Council* "is an independent, non-governmental, not for profit organization established to promote the responsible management of the world's forests" (for more information see: us.fsc.org).

remote, with fewer roads and population settlements.[19] Deforestation rates in the east have also been significantly lower than in the western region of the reserve. For the most part, rates were less than 0.1 percent prior to the creation of the reserve, and remained low through 2007. The western region, on the other hand, has been under a great deal more pressure for land-use conversion due, in part, to increased access to roads and higher population densities. Deforestation rates in the west have been steadily increasing since 1990, and the concession areas in this region have actually experience higher rates of deforestation in aggregate compared to other nearby areas in the multiple-use zone (see Figure 6).

Figure 6: Deforestation Rates in the Maya Biosphere Reserve by Region and Concessions



Note: Data comes from CEMEC-CONAP. The *East* and *West Central* regions include their respective groups of concessions in the total deforestation rates. The *West Central w/o Industrial* excludes the two privately owned concessions, Paxban and La Gloria.

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[19]Forest observations from the land-use data used in this analysis (30x30m pixels of land) are, on average, 17km from the nearest road and 25km from the nearest village in the eastern region of the reserve, compared to 13km and 11km in the west, respectively.

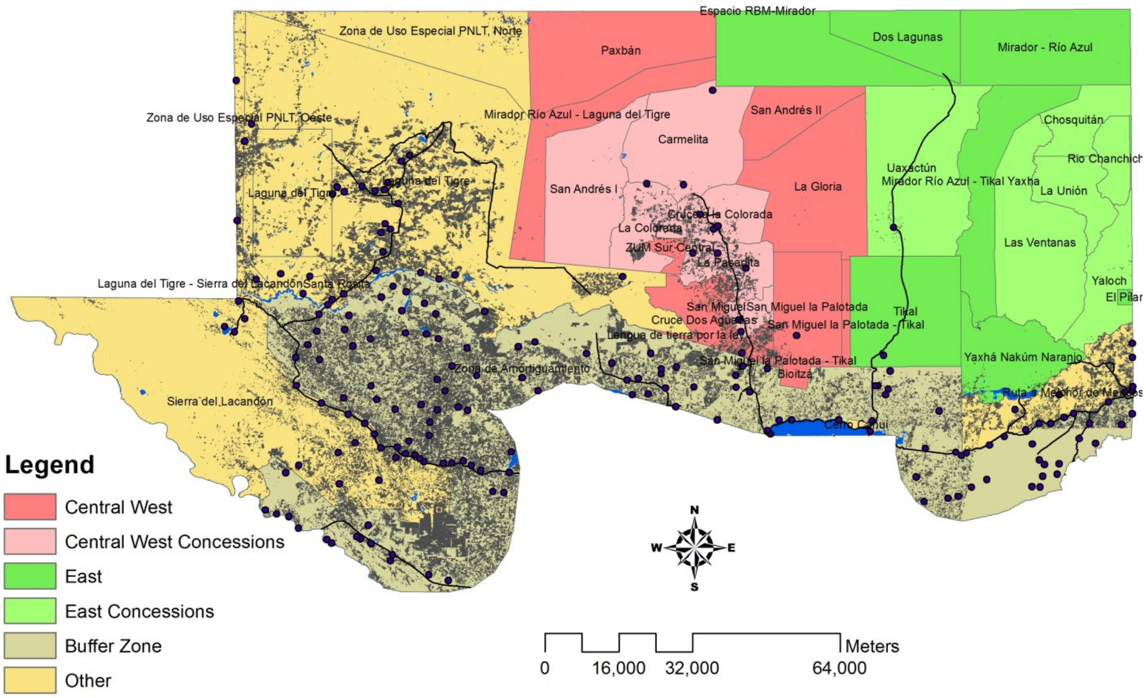
Given the differences between the eastern and western halves of the reserve, I separate the reserve into regions and focus on the central west area for this analysis. There are two reasons for this. First, the lack of forest disturbance in the eastern concessions prevents any meaningful analysis of changes in deforestation due to the implementation of the concession policy. For example, in the first eastern concession that was formed in 1997 (Rio Chanchich), there are no observations of deforestation from the period of 1986 to 1997, and from 1997 to 2000, only 0.002 percent of the forest was lost to deforestation.[20] Deforestation rates are similarly low for the other concessions in the eastern region that would serve as the treatment group, thus any changes in deforestation for the given period of analysis are essentially zero. The second reason for focusing on the central west region of the reserve is that this area, unlike the eastern region, has been under greater pressure for deforestation and land-use change. As a result, the concession policy is more likely to have an impact here, where the increased protection of forest areas under concession management would act as a deterrent to people looking to clear land for ranching or farming.

Figure 7 shows the reserve broken down into regions. The far west region of the reserve contains no community forest concessions and the majority of the area is part of the core zone, which is under different management strategies and thus is not included in

[20] In Rio Chanchich (Suchitecos) out of 135,140 observations of 30x30 meter pixels of forest, only 3 pixels were deforested during the period 1997 to 2000, or approximately 0.002 percent.

the analysis. The buffer zone, which runs along the southern border of the reserve, is not included in the analysis either for similar reasons.[21]

Figure 7: Map of East and Central West Regions of the Maya Biosphere Reserve



Source: Land-use data from CEMEC. Notes: Dots represent population settlements in within the Maya Biosphere Reserve, and black lines are roads. Grey areas indicate deforestation or forest disturbance occurring during the period 1986-2009. The "Other" regions include the western half of the reserve, comprised mostly of national parks, and a section in the east, just north of the buffer zone that is part of the multiple-use zone.

Grey areas on the map in Figure 7 represent deforestation that has taken place during the period 1986-2009. In the central west region, deforestation has branched off from the road that goes north to Carmelita. In contrast, the road through Uaxactún in the eastern half of the reserve has experienced very little deforestation. This is likely due to the fact that access to this road is restricted since it goes through Tikal National Park and

[21] The buffer zone was designed to act as a buffer for the main forested areas of the reserve and is under different management and settlement policies than the multiple-use zone. The core zone includes multiple national parks and biotopes with varying levels of protection, which complicates any straight comparison of the protected areas in the reserve with the concessions and non-concession areas.

in order to travel north through the park people have to first pass through a security gate and obtain a permit from the park office. It should also be noted that in the central west region Paxban and La Gloria are industrial timber concessions and are not included as part of the control group since they are privately owned and operated.

Table 13: Concessions in the Treatment and Control Groups

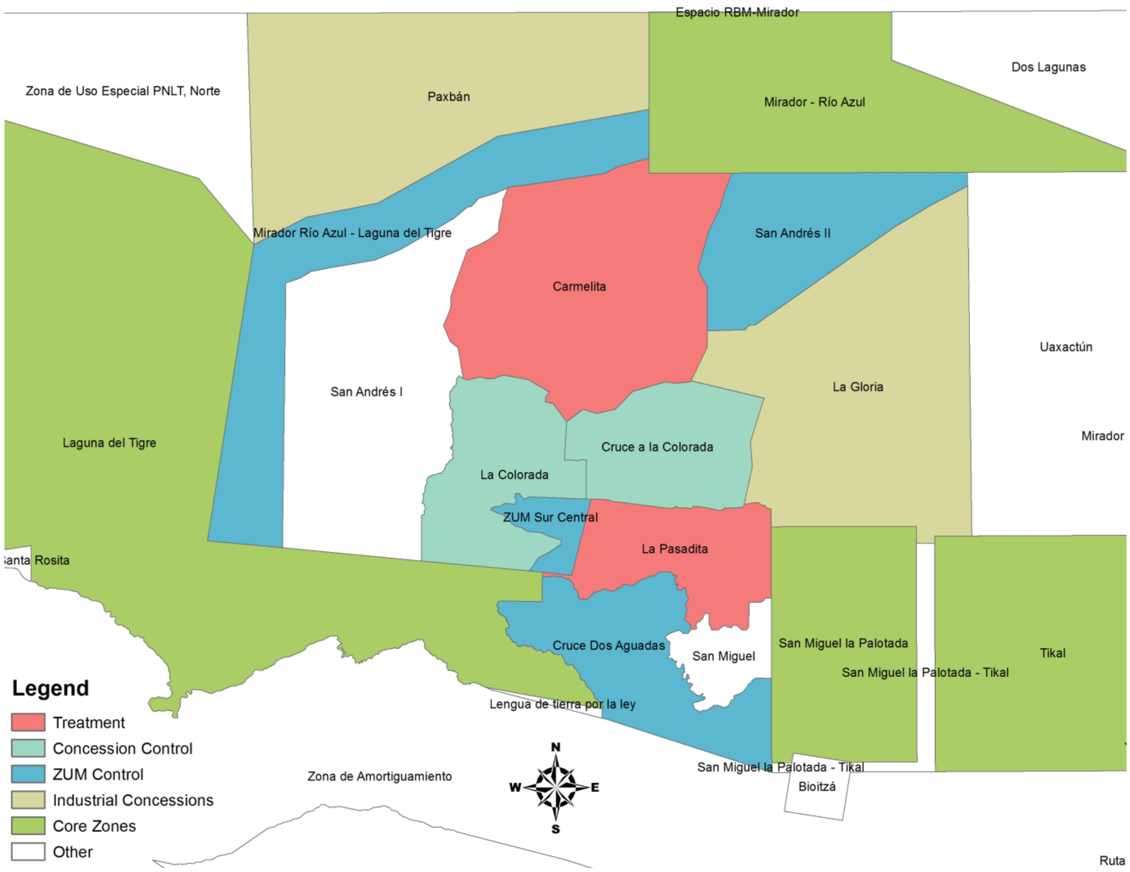
Region	Concession	Year Formed	Status
Western	San Miguel	1994	Pilot
	Carmelita	1997	Treatment
	La Pasadita	1997	Treatment
	San Andres (AFISAP)	2000	None
	La Colorada	2001	Control
	Cruce a la Colorada	2001	Control
Eastern	Suchitecos (Río Chanchich)	1998	None
	Laborantes (Chosquitán)	2000	None
	Arbol Verde (Las Ventanas)	2001	None
	El Esfuerzo (Yaloch)	2002	None
	CUSTOSEL (La Unión)	2002	None

Focusing on the central part of the reserve, two concessions in this region formed in 1997 (Carmelita and La Pasadita) which serve as the treatment group and two concession formed in 2001, which make up the concession control group (Cruce a la Colorado and La Colorado).[22] I also compare deforestation rates in the treatment group

[22] Analysis was also conducted with the non-resident concession of San Andres included in the control group. However, the balance between the treatment and control groups after matching was slightly better when San Andres was not included (see Appendix Table A1). Therefore, in the final results San Andres is not included since it was formed a year earlier than the other controls (2000 verses 2001) which shortens the post-treatment analysis period. Also, San Andres is a non-resident concession, and has many

with an alternative control group made up of observations from nearby forests in the central west region that are part of the multiple-use zone (ZUM) but not under concession management (see Figure 8). This second control group would be considered a more standard comparison group to the community forest concessions.

Figure 8: Map of Treatment and Control Areas in the Central West Region



Note: The "Other" regions include the Buffer zone to the south, concessions not included in the treatment or control group, and regions in the ZUM that are not in the central west region.

substantive differences from the other resident concessions. The difference-in-difference results did not change with the inclusion of San Andres either (see Appendix Table A2).

3.3 Description of Data

The primary data set used for this analysis covers over 2 million hectares of land in the Maya Biosphere Reserve. The land-use data were compiled by the Center of Monitoring and Evaluation (CEMEC) within CONAP for the period from 1986 to 2009. The data are derived from satellite imagery obtained by CEMEC, which classified the images into various land uses at 30 meter resolution. The unit of observation for this analysis is a 30 by 30 meter pixel of land coded as "forest" if it remained forested from 1986 until 2009. If at some point it was determined that the area of land experienced forest disturbance based on satellite images from various years, that pixel is given a code based on the year of disturbance (see Sader et al. 1998 for more details). One limitation of the data is that it only indicates the period when deforestation occurred and does not account for potential reforestation in later periods. The outcome variable of interest is binary, equal to "1" if the pixel of land was deforested during a given time period, "0" otherwise.

Environmental covariates used to match observations in the treatment and control groups include elevation, slope, aspect, and soil acidity level (pH). The slope and elevation measures come from digital elevation models (DEM) created by the Ministry of Agriculture, Livestock, and Food in Guatemala and are analyzed using ArcGIS. Data on roads and population centers in the reserve were obtained from the National Institute of Statistics in Guatemala. Other spatial covariates used in the analysis include distances to the nearest road, pixel of land cleared prior to 1986, archeological site, major town, and village. Major towns are defined as having a population over 10,000 people.[23] Villages are smaller and include all villages in the reserve established prior to its formation in 1990.

The analysis is based on two cross-sections of data, one for the pre-policy period and one for the post-policy period. The pre-policy period is 1990 to 1997, after the reserve was formed but before the concessions were established. The post-policy period is 1997 to 2001, when concessions in the treatment group were actively managing the forest area, but before the control group concessions were created. Each cross-section is comprised of a random sample of 50,000 observations from the central west region of the reserve.

3.4 Methods: Matched Difference-in-Differences

This analysis uses a matched difference-in-differences approach to estimate the impact of the community forest concession policy on deforestation in the Maya Biosphere Reserve. Observations in the treatment group are first matched with a group of control observations from forest concession areas before they became active, reducing the selection bias problem since the control group is comprised of areas that are ultimately also selected for treatment. An alternative control group made up of observations from adjacent forest areas is also matched with the treatment group. Post-matching, difference-in-differences regression analysis is conducted comparing deforestation in the treatment

[23] There are four towns in the Petén that meet this requirement, Flores, San Benito, Melchor de Mencos, and Poptun. However Poptun is located farther away from the the MBR area than the others so no parcel of land included in the analysis is closer to this town than compared to the other major towns.

group with deforestation in the two matched control groups before and after the concession policy was implemented.

3.4.1 The Selection Bias Problem

The most challenging part of conducting an evaluation of policy effectiveness is constructing a valid counterfactual group for comparison when using non-experimental data. If observations in the treatment and control groups are not randomly selected, then the results of any analysis may be subject to selection bias, which happens if the estimated policy effect is confounded with other factors that impact the measured outcome and are correlated with the selection of observations into the treatment group. For example, if areas of forest were selected for community concessions because they are less suitable for agriculture (either due to location, soil quality, or other unobserved factors), which is a primary source of deforestation in the region, then the concession areas would likely have lower deforestation rates regardless of the policy. Not taking this into account would lead to overestimating the effectiveness of the concessions in any policy assessment.

To determine the effectiveness of the concession policy, I estimate a treatment effect, which compares the outcome variable of interest (deforestation in this case) across treatment and control groups. If $Y_i (D_i)$ is the outcome of interest and D_i is an indicator variable equal to "1" if observation i is in a concession area and "0" otherwise, then the treatment effect can be written as (Caliendo and Kopeinig 2005):

$$T_i = Y_i (1) - Y_i (0). \tag{1}$$

This paper focuses on estimating the average treatment effect on the treated (ATT) or $E[T|D=1]$, which in this case is the difference in deforestation rates in forest areas under concession management compared to what it would have been in the same area without the concession policy. The ATT can be written as:

$$T_{ATT} = E[Y(1)|D=1] - E[Y(0)|D=1]. \quad (2)$$

We observe $E[Y(1)|D=1]$, which is deforestation in areas under concession management, however, what would have happened in the concession areas had there not been a policy change, is not observable. This is called the counterfactual, $E[(Y(0)|D=1]$. Since we do not actually observe the counterfactual outcome, to estimate the ATT, we use the outcome of a control group of forest observations not under concession management, $E[Y(0)|D=0]$. Adding and subtracting this term to the right side of equation (2) we get:

$$T_{ATT} = (E[Y(1)|D=1] - E[Y(0) \mid D=0]) - (E[Y(0)|D=1] - E[Y(0)|D=0]) \ . \quad (3)$$

Selection bias occurs if the last term in equation (3) does not equal zero:

$$E[Y(0)|D=1] - E[Y(0)|D=0] \neq 0 \ , \quad (4)$$

or in other words, there is an unobserved difference between the treatment and control group that affects the outcome variable of interest. Matching methods attempt to control for selection bias by matching observations in the treatment group with similar, control group observations based on a selection of covariates. One of the main assumptions however, is that all of the factors that affect selection into the treatment group are controlled for in the matching process, also known as selection on observables or conditional independence. If this is not the case and there remain unobserved differences between the treatment and control groups such that equation (4) is true, then any estimation of the policy effect will be bias.

To address the selection bias problem, I exploit the staggered timing of the concession formation so that the treatment group is made of early concessions areas, and the control group is made up of forests areas in concessions that formed four years later. By selecting the control group observations from future concession areas, traditional selection bias problems are greatly reduced since both areas of forest are ultimately selected for treatment based on, arguably, the same set of observable and unobservable characteristics, which decreases the probability that there are unobservable factors affecting selection in the treatment group *and* deforestation that differ between the two groups.

The other condition that needs to hold in order for matching to product unbiased results is the stable unit treatment value assumption (SUTVA) which requires that the treatment of one observation does not affect the outcomes of observations in the control group. This assumption is challenging given the spatial aspect of this analysis and the potential for leakage due to increased forest management in the concession areas. To test if this condition holds true I test for leakage in surround buffer areas outside the concession boundaries to see if the policy resulted in increased deforestation in areas adjacent to the concessions compared to forests farther away.

3.4.2 Matching Methods

The first part of the analysis involves matching the treatment and control groups. Observations in the treatment group are matched to observations in the control group based on environmental and spatial characteristics including: elevation, slope, soil quality, and distances to roads, villages, and previously cleared areas. The goal of matching is to make the treatment and control groups as similar as possible with the same distributions for the covariates upon which selection is based. Assessing the quality of matches is commonly referred to as checking the *balance* between the treatment and control groups post-matching. The main advantage for this analysis is that it controls for unobservables by using a control group that is also ultimately selected for treatment. In this case, matching also helps to further reduce bias if there were any differences in the selection criteria between concessions formed earlier and those formed later.

Matching is based on nearest neighbor propensity score matching with Mahalanobis distance metrics, where the propensity score is used first to narrow down the range of possible matches in the control group, then the treatment observations are matched to the control observations with the smallest distance metric given a vector of covariates.[24] The propensity scores are the latent values from a logit regression that estimates the probability of being selected into the treatment group (early-formed concessions) based on the set of covariates discussed above. Balance is assessed by measuring the difference in means between the treatment and control groups for each

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[24] Mahalanobis distance metric is measured as $D(i,j) = (u-v)^T C^{-1} (u-v)$, where i and j are treatment and control observations respectively, and u and v are vectors of covariates for the treatment and control observation. C is the sample covariance matrix (Guo and Fraser 2010).

covariate, and the median difference in the quantile-quantile (QQ) plots of the treatment and control group, where zero indicates that the empirical distributions are the same for each covariate (Ho et al. 2007).

Matching was conducted with and without replacement. When matching with replacement, each control observation is placed back in the pool of potential matches after being matched with a treatment observation, so ultimately, one control could be matched up to multiple treatment observations. In matching without replacement, after a match is made, the control observation is removed from the pool of potential matches. There are tradeoffs associated with each type of matching. Matching with replacement retains all of the treatment group observations in the analysis, so the sample more closely resembles the original the treatment group. However, this significantly limits the number of control observations in the final matched sample and the balance between the treatment and control groups is reduced (the samples are less similar). When matching without replacement, the balance between the treatment and control group is better, however more observations from the treatment group are dropped due to lack of good matches in the control group. Ultimately, matching without replacement is used for this analysis since the balance for this sample is better (see Appendix B Table 28 for comparison), however, as a robustness check, regression analysis is also conducted with the samples matched with replacement.

Table 13 shows the difference in means between the treatment and control groups comparing the raw (unmatched) dataset with the matched samples for the two control groups, one made up of observations from later-formed concessions and one using observations from the non-concession areas of the multiple-use zone (ZUM). The difference in means and the median eQQ value is smaller for almost every covariate in both the matched *Concession Control* sample and the *ZUM Control* sample compared to the unmatched sample. Nearest neighbor propensity score matching is used as the primary matching method so that post-matching regression analysis can be performed (Guo and Fraser 2010, p.149).

Table 13: Balance Comparison for Matched Datasets using Concessions and Non-concession ZUM as the Control Group

	Unmatched		**Concession Control**		**ZUM Control**	
Variable	**Mean Diff**	**eQQ Med**	**Mean Diff**	**eQQ Med**	**Mean Diff**	**eQQ Med**
Dist to road	3.59	3.30	0.34	0.41	0.07	1.85
Dist to city	9.36	13.51	0.55	6.89	3.80	3.80
Dist to village	0.62	0.28	0.14	0.35	0.28	0.58
Dist to cleared parcel	4.65	4.65	0.38	0.32	0.77	0.05
Dist to archeo site	-5.69	6.09	-1.28	1.29	-1.72	2.32
Aspect	-18.4	17.6	-4.64	4.33	-6.20	4.90
Ph	-0.19	0.35	-0.10	0.00	-0.04	0.00
Elevation	28.9	36.3	-1.84	22.0	7.30	4.75
Slope	-1.11	1.12	-0.36	0.12	-1.19	0.83
Observations	99385		28690		16406	

Note: Balance results are based on nearest neighbor matching with Mahalanobis distance metric matching with calipers set to 0.25, without replacement. Matching was conducted in R using "MatchIt".

3.4.3 Difference-in-Differences Estimation

After matching the data, I conduct difference-in-differences (DID) regression analysis with two cross-sections of matched data to estimate the average treatment effect on the treated (ATT), or the difference in deforestation in forest areas under community concession management compared to the deforestation that would have taken place had there been no concession policy. Following Ho et al. (2007), matching prior to conducting regression analyses allows for more robust estimates of the treatment effect since the data is less dependent on model specification.

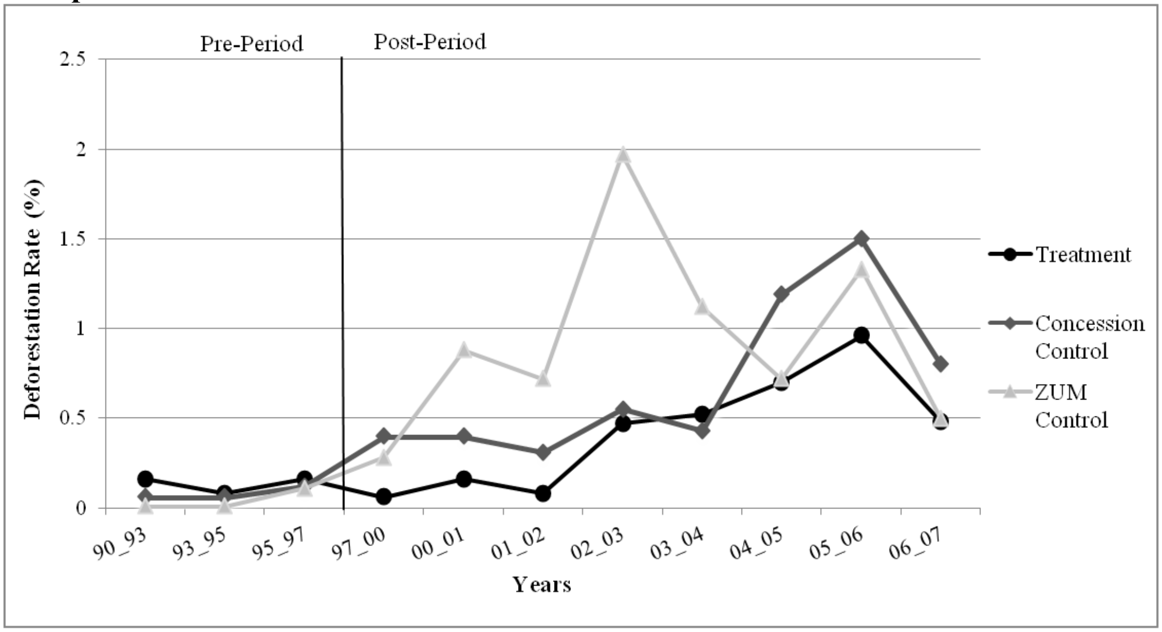
The DID estimator compares differences in the outcome variable between the treatment and control groups before and after the policy was implemented. The regression equation can be written as:

$$y_{it} = \beta_0 + \beta_1 \, TREAT_{it} + \beta_2 \, POST_{it} + \beta_3 \, TREAT_{it} * POST_{it} + \beta_4 \, X_{it} + \varepsilon_{it} \quad ,$$

where *i* indexes the observed pixel of forest area and *t* indexes the period, "0" before the concessions, or "1" after the concessions were established. The coefficient of interest is β_3, the DID estimate, which can be interpreted as the impact of the concession policy on deforestation in the observed sample. An advantage of using DID is that unobservable, time invariant factors that might affect the outcome of interest and selection into the treatment are controlled for. The main assumption for this method is the parallel trends assumption, which in this case requires that the trends in deforestation for treatment and control group areas would have been similar if the policy had never been implemented (Wooldridge 2002). Figure 9 shows the trends in deforestation for the matched treatment and control areas from 1990 to 2007.

From 1990 to 1997 (the pre-concession period), the deforestation rates for the matched treatment and control groups had similarly low rates of deforestation. After 1997, when the treatment concessions started actively managing their forest areas, the deforestation rates have a general upward trend for all groups, however, rates are higher in both control groups through 2007.

Figure 9: Comparison of Deforestation Rates between the Treatment and Control Groups



Note: For some periods rates are not available for each year, in which case the average rate for the period is used for each year, hence the horizontal lines for some years. This is done for the periods: 90-93, 93-95, 95-97, and 97-00.

In order to justify the difference-in-differences approach, the establishment of the later formed concessions should be similar to that of the earlier formed concessions on all accounts. The question then is: what were the factors that determined the order of concession formation, and why did some concessions form before others? After the initial pilot concession was established in 1994, community interest in forming more concessions was high, but the actual processes for legalizing subsequent concessions were slow and lacked clarity (Monterroso & Barry 2012). Thus, the next three concessions were not formed until three to four years later. The communities living within the reserve boundaries were given priority in forming concession groups (Radachowsky et al. 2012, Nittler & Tschinkel 2005), however, many of these resident communities were not initially interested in forming concessions since they came from primarily agricultural backgrounds. Eventually, promotion in the communities by NGOs (CATIE and The Nature Conservancy in particular) garnered more interest among the community members and encouraged them to apply for concession status. Overall, there were no substantive differences to note between the early and later formed concessions and the timing of the staggered formation was mostly due to the lengthy process associated with a community gaining concession status. Furthermore, the initial lack of interest and reluctance to form concession groups among the communities in the west central region provides additional assurance that these groups were unlikely to change their behaviors in anticipation of gaining access to the forest concessions, which is another potential concern with using future treatment areas as a control group.

For the DID analysis, I use a linear probability model (with robust standard errors) since the dependent variable is binary, equal to "1" if the parcel of land was deforested in the period of analysis. I also run a probit model and estimate marginal effects as a further robustness check. The DID model includes dummy variables for *POST* and *TREAT* and the interaction of *TREAT*POST,* where the coefficient is the estimated effect of the concession policy. DID analysis is conducted for both sets of control groups, one only using later-formed concession observations, and the other using non-concession areas of the ZUM. By comparing deforestation rates between the two control groups, I am able to estimate the degree of selection bias by differencing the DID coefficient for the two control groups.

3.5 Results

The results from the difference-in-differences analysis indicate that the concessions reduced deforestation in the treatment group by approximately 0.9 percent compared to the concession-based control group (see Table 14). The DID estimate is slightly larger when using non-concession areas as the control group, at 1.5 percent. These results suggest that despite matching, some degree of selection bias remains when comparing deforestation rates in concession areas to forests never considered for the policy. The results from the probit estimation are similar, where the concession policy reduced deforestation in the concession control group by 0.8 percent compared to 1.6 percent in the non-concession control group. Furthermore, not controlling for differences between observations in the treatment and control concession groups leads to underestimating the effectiveness of the policy, where the DID estimate for the unmatched sample is near zero and not significant.

Other factors that have a statistically significant effect on reducing deforestation include greater distances to major cities, roads, and previously cleared parcels of land (see Table 14). These results are intuitive since areas that are more remote and farther away from human settlements are typically under less pressure of deforestation and land-use change. Additionally, higher elevations and steeper slopes also reduce deforestation, since these areas are often harder to clear and less suitable for agriculture. As a robustness check, regression analysis is also conducted with samples that are matched with replacement (see Section 3.4.2) so the matched sample of treated concession observations more closely resembles the true treatment area since fewer observations are dropped. The DID coefficients for these models are also negative and significant (see Appendix B Table 29).

Table 14: Results of Difference-in-differences Analysis and Probit Marginal Effects

Variable	Unmatched		Concessions		Non-Concession	
	Coef.	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Linear Probability Model						
Post	-0.005***	0.001	-0.002	0.001	0.008***	0.002
Treat	0.004***	0.001	0.010***	0.002	0.015***	0.002
DID	0.0001	0.001	-0.009***	0.002	-0.015***	0.003
Dist to road	-0.002***	0.0002	-0.0003	0.001	-0.004***	0.001
Dist to major city	-0.0001**	0.0000	-0.0006***	0.0001	-0.0004***	0.0002
Dist to village	-0.001**	0.000	0.001	0.001	-0.001	0.001
Dist to clearing	-0.005***	0.0003	-0.011***	0.002	-0.003**	0.001
Dist to archeo site	0.0003***	0.0001	-0.0007***	0.0002	-0.0002	0.0001
Elevation (meters)	-0.0001***	0.0000	-0.00003*	0.00002	-0.0002***	0.00003
Slope (degrees)	-0.0003***	0.0001	-0.001***	0.0002	-0.001***	0.0002
Ph	0.003***	0.0002	0.002***	0.0004	0.005***	0.001
Constant	0.018***	0.004	0.068***	0.011	0.062***	0.015
Probit Marginal Effects						
DID	-0.004***	0.001	-0.008***	0.002	-0.016***	0.003
Observations	99385		28690		16406	
R-squared	0.0139		0.0184		0.0195	
Log likelihood	-3148.93		-1050.06		-505.23	

Note: Matching was conducted in R and regression analysis was done in Stata.
***Indicates statistical significance at the 99% level, ** 95% level, * 90% level.

In terms of avoided deforestation, based on the area of the two treatment concessions, the concession policy resulted in approximately 634 ha of avoided forest loss using the later-formed concessions as the control group. Compared to the non-concession areas in the alternative control group, the amount of avoided deforestation is about 1057 ha. If we attribute this difference in deforestation to selection bias, then the treatment effect is overestimated by approximately 0.6 percent or 423 ha of avoided deforestation in this analysis, implying that the concession areas would have experienced less deforestation than non-concession areas of the reserve even without the policy. The policy overall, though, still appears to contribute to additional reductions in deforestation compared to what would have been the case under business as usual.

3.5.1 Leakage Analysis

In order to confirm the results that the concession policy had a positive effect on reducing forest disturbance, the possible presence of leakage or spillover needs to be considered. Leakage could be positive or negative, though the main concern is negative leakage which occurs if increased forest management in the concession areas leads to more deforestation outside the concession boundaries. In this case, deforestation in aggregate may not be reduced if reductions in deforestation in the concessions are countered by increases in other areas. Positive leakage occurs if the creation of the community forest concessions discourages people from deforesting nearby the concessions, leading to positive spillover effects of reduced deforestation beyond the boundaries of the concessions.

To estimate leakage due to the implementation of the concession policy, I use a buffer method (Andam et al. 2008) to compare deforestation in buffer areas surrounding the outside boundaries of the concessions, which serves as the treatment group, with areas further away from the concessions (control group). Observations inside the buffer areas are matched with observations in the surrounding control area, which is restricted to the central west region of the multiple-use zone and excludes all concession areas. Two buffer distances are tested, a 2 km radius surrounding the concession boundaries and a 5 km radius. Leakage is estimated based on a regression coefficient for a “buffer” dummy variable, indicating if an observation is in the designated buffer area during the period 1997 to 2001 (after the treatment concessions became active). I also estimate marginal effects using a probit model as a robustness check to the buffer coefficient.

Table 15: Leakage Estimates based on Buffer areas around the Treatment Concessions

	2 km Buffer		5 km Buffer	
Variable	**Regression Coef.**	**Probit M. E. Coef.**	**Regression Coef.**	**Probit M.E. Coef.**
Buffer	0.0005	-0.0047***	0.0019**	-0.0009
	(0.0008)	(0.0008)	(0.0010)	(0.0010)
Dist to road	-0.0055***	-0.0062***	-0.0058***	-0.0032***
	(0.0004)	(0.0005)	(0.0005)	(0.0007)
Dist to major city	-0.0002***	-0.0002***	0.0000	0.0001*
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Dist to village	0.0007	0.0039***	0.0010	0.0011
	(0.0005)	(0.0009)	(0.0006)	(0.0010)
Dist to archeo site	0.000004	0.0010***	-0.0003***	-0.0001
	(0.00004)	(0.0002)	(0.0001)	(0.0001)
Dist to cleared parcel	0.0003***	-0.0005	-0.0001	-0.0042***
	(0.0001)	(0.0004)	(0.0001)	(0.0011)
Elevation (meters)	-0.0001***	-0.0001***	-0.0001***	-0.0001***
	(0.00001)	(0.0000)	(0.00002)	(0.00001)
Slope (degrees)	-0.0003***	-0.0001*	-0.0006***	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Ph	0.006***	0.006***	0.006***	0.007***
	(0.0005)	(0.001)	(0.001)	(0.001)
Constant	0.030***		0.026***	
	(0.004)		(0.005)	
Observations	43374	43374	30836	30836
R-squared	0.019		0.02	
Log-likelihood		-1122.2		-945.1

Note: Standard errors in parentheses. Matching is conducted in R based nearest neighbor matching with Mahalanobis distance metrics (caliper = 0.25) without replacement using the "MatchIt" Program (Ho et al 2009) and regression analysis is conducted in Stata. ***Indicates statistical significance at the 99% level, ** 95% level, * 90% level.

The results indicate that leakage is not an issue, further supporting that the DID results are valid. In the 2 km buffer area, the leakage coefficient is near zero and not significant in the regression model and negative and significant in the probit model (see Table 15) indicating that areas in the 2 km buffer are less likely to be deforested, or in the case of no significance, there is no difference in probability of deforestation between forested areas near the concession boundaries and those farther away. In the 5 km buffer area, the results are inconclusive, where the leakage coefficient in the regression model is small, but positive and significant, but negative and insignificant in the probit model.

Overall, the results indicate that increased forest protection by the concession communities is not leading to leakage on a local scale. However, this analysis does not account for other types of leakage that may result due to the concession policy on a larger, regional scale. For example, if the creation of the community forest concessions led to ranchers buying land and clearing forests in areas farther away from the concessions, then in aggregate, the total amount of deforestation is not reduced. On the other hand, if the concession policy makes it more difficult to acquire land for farming and ranching, and thus deters people from clearing land and deforesting, then the policy would have additional, positive spillover effects. Such estimates of the types of leakage described above are beyond the scope of this paper and are topics for future analysis.

3.6 Discussion

This paper examines the effectiveness of the community forest concession policy in Guatemala's Maya Biosphere Reserve, and the degree of selection bias associated with estimating the policy treatment effect after matching. The staggered timing in the formation of the concessions provides a unique opportunity to compare deforestation rates in a treatment group of community forest concessions with a control group that was also selected for treatment in a later period. The result is that selection bias is minimized since both the treatment and control groups were ultimately selected on the same set of observable and unobservable factors. Previous studies assessing the effectiveness of various forest management strategies on reduced deforestation use matching methods to control for selection bias and to ensure that comparable areas of forest are being used in the analysis. One limitation of this approach is the assumption of matching on observables, which requires that all of the factors that affect selection into the treatment group be accounted for in the matching process. This opens up room for error given that the main covariates used in the matching process are typically environmental and spatial variables, such as elevation and slope, and distances to roads and villages, while the actual decisions regarding which forest areas are to be included under the policy are often made by the local government. Any unobservable factors that affect selection into the treatment group and the probability of deforestation that are not accounted for in the analysis will lead to bias in the estimation of the treatment effect.

The results in this paper suggest that there is a degree of selection bias associated with the community forest concessions, where the estimated treatment effect of the policy is 0.6 percent lower for the control group made up of future concession areas, compared to results using the control group of non-concession areas in the multiple-use zone. Even with the presence of potential selection bias, the concessions still appeared be an effective method for slowing deforestation. In the period of analysis, 1997 to 2001, approximately 634 ha of forest in the two treatment concession areas were saved that would have otherwise been deforested without the policy.

One limitation of this study is the restricted time frame for the post-period of analysis due to the timeline of the concessions forming. During the period of 1997 to 2002, 11 concessions formed. Given my focus on the west region of the reserve, where the majority of deforestation and land-use change has taken place, this only allows for a post-period of four years, between the establishments of the first two concessions in 1997 to 2001, when the two control concessions formed. Fortmann et al. (2014) estimate the treatment effect for the community concessions covering an extended period from 2000 to 2009 and find that, on average, the concessions reduced deforestation by 5.4 percent compared to matched forest areas in the multiple-use zone.[25] The smaller treatment effect estimated in this paper is likely due in part to the shorten time frame of the analysis.

The results of this paper offer a few policy implications. One, selection bias, though minor, may be an issue when trying to determine how effective various forest management strategies are at reducing deforestation. As climate change negotiations and Reducing Emissions from Deforestation and Degradation (REDD) programs gain momentum on an international scale, being able to accurately estimate the effectiveness of different approaches to forest conservation and management will be important when deciding which strategies to focus on and where to direct resources. Second, given the presence of selection bias in the treatment estimates even after applying matching strategies that are intended to minimize such problems, it would be beneficial for future community forestry programs to set up projects on an experimental basis at least initially,

[25] Fortmann et al. (2014) separated the concessions into three subgroups based on community and spatial characteristics, 5.4 percent is the average treatment for the three groups, which ranges from 3.3 percent in the non-resident concessions in the east to 7.8 percent in the resident, recently inhabited concessions in the central west region.

so true measures of project effectiveness can be assessed, along with setting standards to enable comparisons across programs to determine what the most effective and efficient strategies are for reducing deforestation (Bowler et al. 2009; Ferraro and Pattanayak 2006). Other factors, however, should also be taken into consideration, such as livelihood benefits associated with community forestry programs and cost savings by local governments that would otherwise be responsible for managing and protecting the forest area (Somanathan et al. 2009).

Chapter 4: Assessing Preferences over Community Forest Concession Attributes and Forest Conservation using Choice Experiments

4.1 Introduction

Worldwide, approximately 80 percent of forests are under state management (FAO 2010), with an estimated 188 million hectares in timber concessions (Molnar et al. 2011). The majority of these concessions are industrial, although, a shift is happening from forests managed primarily by private logging companies to a community-based approach, particularly in developing countries (Bray et al. 2003; Agrawal et al. 2008; Molnar et al. 2011). Community-managed concessions, where local residents form groups and enter into voluntary contracts with the state to gain property rights over a tract of forest, provide a way for governments to enforce sustainable management policies while providing a means of income for local populations. Additionally, this model has the potential for being implemented in other regions of the world due to the large amount of forests currently under concession management. Given that many of these same forest areas are under pressures for development or land conversion, the success of this approach will largely depend on matching the benefits of membership with the contracts. It is critical to build a better understanding about the preferences local residents and potential community members have for the management of concessions to help policymakers design contracts that are more resilient to external pressures.

A number of studies have used stated preference methods to examine preferences for environmental amenities (a few examples of this literature are: Farber and Griner 2000; Hearne and Zenia 2002; Lehtonen et al. 2003), or estimate their willingness-to-pay for a certain service or environmental improvement, such as water and sanitation services in developing country contexts (see Carson 1998). Choice experiments are one approach that has been used increasingly, where individuals are presented with a set of alternatives such that they must make implicit tradeoffs across different attributes characterizing each alternative. For example, survey respondents may be asked which recreational fishing site they would prefer going to provided different travels times, catch rates, and park fees for each site. This method has been employed in environmental economics to elicit preferences over parks and recreational amenities (Adamowicz et al. 1994; Adamowicz et al. 1998), tropical forest preservation (Rolfe et al. 2000), willingness to participate in cooperative management agreements (Stevens et al. 1999), and agri-environmental schemes (Ruto and Garrod 2009).

Choice experiments and conjoint analysis methods have also been used in developing countries, but they have mostly been related to health (Hanson et al. 2005; Mangham and Hanson 2008) or agriculture (Tano et al. 2003; Tesfaye and Brouwer 2012), where such methods have become common for testing preferences for agricultural contracts (Ruto and Garrod 2009; Duke et al. 2012; Tesfaye and Brouwer 2012). The application of choice experiments to community forest management, however, is less common. Gelo and Koch (2012) use choice experiments to examine preferences for community forest plantations in Ethiopia. Their attributes include type of tree species, protection status, harvest quota, location of plantation, and costs to households. The researchers find that households have heterogeneous preferences across groups of farmers and that area enclosures (protected areas restricted from grazing) had the highest marginal willingness-to-pay value among all of the attributes. The researchers hypothesize that this is due in part to study site variations, but also because of the positive perceptions of area enclosures among farmers in Ethiopia and the off-site benefits (such as soil erosion) associated with them. Arfin et al. (2009) use conjoint analysis to examine community forest contracts between governments and local farmer groups in Indonesia. Their findings indicate that farmers care more about the duration of the contract, with longer contracts preferred, and are less concerned with requirements on tree species or density.

This paper examines the preferences of individuals in and around a set of community forest concessions in Guatemala's Maya Biosphere Reserve. The community concessions were created as part of the overall management strategy for the Maya Biosphere Reserve. Rather than turn over the forest to private logging companies, a portion of the land was dedicated to community concessions, where local community groups formed associations and applied for property rights to a forest area after developing sustainable management plans for harvesting timber (Nittler and Tschinkel 2005). The 12 community concessions all formed under the same legal framework, but vary in terms of association rules, activities, and membership location. These differences provide an excellent basis for selecting the attributes in the choice experiment. The four attributes considered in this analysis are membership fee, land allocation, concession activities (ecotourism or non-timber forest product [NTFP] collection), and the distribution of benefits (cash dividends verses in-kind).

In addition to differences amongst the concessions in the types of benefits they receive, some concessions are residential concessions, where members live in small villages within the concession boundaries, while in other concessions there are no villages and members live in nearby cities. The nearby villages contain a large number of both members and non-members. Both of these groups have a stake in the success of concessions, and given that one goal of the concessions is to preserve the abundant archeological and biological resources in the area, it is important to assess the preferences held by members and non-members alike. To do this, we undertook a household survey of 494 concession members and neighboring non-members in 2012. The survey used a choice experiment to assess which characteristics of the community forest concessions in Guatemala are preferred.

The results from the choice experiment indicate that members and non-members have varying preferences over the different concession attributes and that the location of the community also influences which attributes of the concessions are preferred. Members who live inside the reserve are more likely to join a concession if land is allocated to members and they engage in the collection of non-timber forest products (NTFP). Members living outside of the reserve, on the other hand, prefer ecotourism over the collection of NTFPs and are less likely to join a concession that provides land to members for personal use. Surprisingly, both members and non-members prefer in-kind benefits, such as scholarships or community enhancements, over cash dividends paid out to members directly. Other results for non-members indicate that they are more likely to join a concession if land is allocated to members, but older individuals and male household heads were more likely to select the status quo alternative.

As climate change moves up the international policy agenda, the trend toward decentralization and solutions that promote community engagement are likely to continue, particularly in the UN-REDD Programme (Reducing Emissions from Deforestation and Degradation), which aims to promote collaborative approaches for sustainable forest management and local community development. Community forest concessions are one way to meet these dual goals; however, there remains a need for a better understanding of how different project mechanisms and designs influence desired environmental and socioeconomic outcomes (Bowler et al. 2010). This is one of the first papers to conduct a choice experiment with survey respondents that have actually participated in community forestry and therefore, have firsthand knowledge of the different attributes of the concessions. The results of this paper offer insight into the design of the community forest concessions and which features of the concessions increase the likelihood of participation, thereby providing direction for the development of future concessions on both a local and international scale.

The remainder of this paper is organized as follows: Section 2 provides details on the background of the community forest concessions and the Maya Biosphere Reserve. Section 3 describes the choice experiment in detail, including descriptions of the attributes and their levels. Section 4 reviews the data collection process for the household survey. Section 5 explains the theoretical and empirical methods. Section 6 presents the results from the conditional and random parameters logits, and Section 7 concludes with a discussion of the results and associated policy implications.

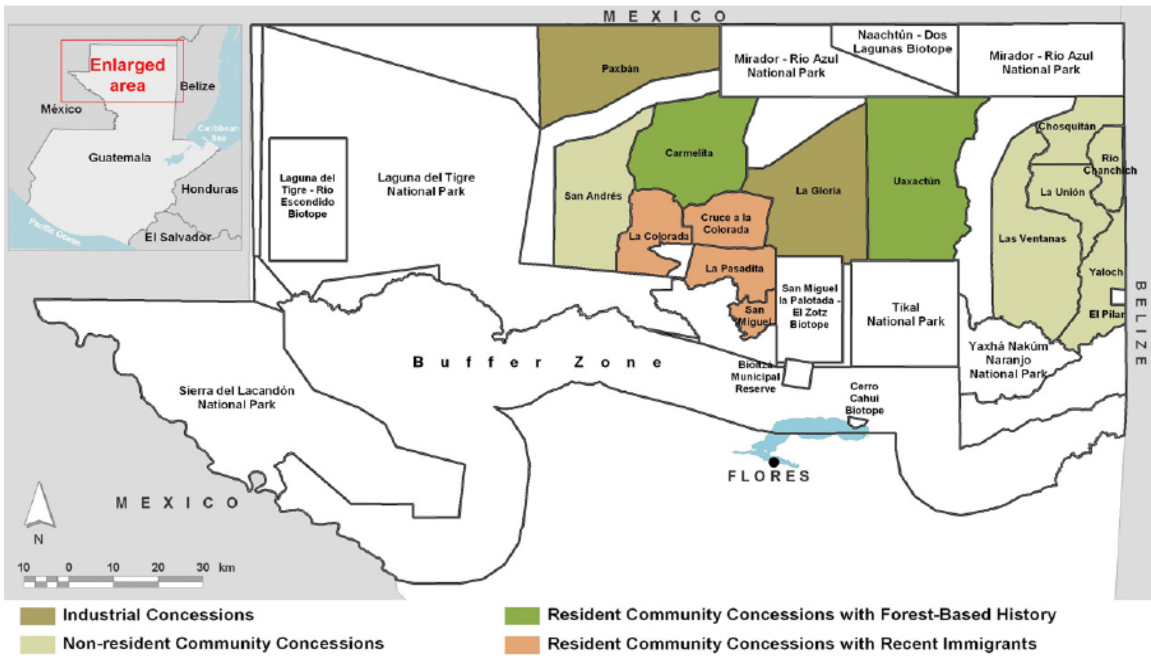
4.2 Background on Community Forest Concessions

The Maya Biosphere Reserve, in the northern department of the Petén in Guatemala, is home to the community forest concessions. Due to increasing pressures on land and other resources, the reserve was established in 1990, under the management of the National Council of Protected Areas (*Consejo Nacional de Areas Protegidas* [CONAP]), with the aim of slowing deforestation. The protection of cultural and historical sites such as Tikal National Park, which is an ancient Maya city and UNESCO World Heritage site is a priority as well (Nittler and Tschinkel 2005; Gómez and Méndez 2007). Part of the initial management strategy for the reserve included the formation of community forest concessions, where CONAP granted property rights to a forest area to local communities if they qualified for concession status. In order to gain access to a forest concession, the community groups had to attain legal recognition as an association, conduct an environmental impact assessment of the proposed forest area, and create a sustainable management plan for harvesting timber. Once their concessions were approved, the community groups were granted property rights to a forest concession dedicated to the sustainable harvest of timber and NTFPs for a renewable period of 25 years provided they became Forest Stewardship Certified within the first three years.[26]

[26] The Forest Stewardship Council is "an independent, non-governmental, not for profit organization established to promote the responsible management of the world's forests" (for more information see: us.fsc.org).

The concessions remained valid as long as the management plan was followed. Between the years 1997 and 2002, eleven community forest concessions were established.

Figure 10: Map of Concessions in Maya Biosphere Reserve



Source: Radachowsky et al. 2012

The community concessions all formed under the same legal framework; however, individual groups have a number of differences with regards to association bylaws and the background and location of their members. Some concession members live inside the reserve, within their concession borders, in communities that were established prior to the reserve's formation in 1990. These are referred to as *resident* concessions. The resident concessions can be further distinguished based on how long communities have been established in the reserve. Members of *long-inhabited* concessions typically have a background in forestry and have been living in the Petén their whole life. In contrast, the *recently-inhabited* concessions are largely comprised of people who were born outside of the Petén and moved to the region in search of land for agriculture. Alternatively, other members live outside of the reserve, typically in larger towns and villages. These are considered *non-resident* concessions (see Figure 10).

Table 16: Community Forest Concession Summary Statistics

Concession Group	Concession Name	Year Formed	Number of Members	Concession Area (ha)
Resident Long-inhabited	Carmelita	1997	122	53,797
	Uaxactún	2000	244	83,558
Resident Recently-inhabited	San Miguel	1994	30	7,039
	La Pasadita	1997	110	18,817
	La Colorada	2001	39	27,067
	Cruce a la Colorada	2001	65	20,469
Non-Resident	Suchitecos (Río Chanchich)	1998	27	4,607
	Laborantes (Chosquitán)	2000	78	19,390
	San Andrés (AFISAP)	2000	174	51,940
	Arbol Verde (Las Ventanas)	2001	364	64,973
	El Esfuerzo (Yaloch)	2002	39	25,386
	CUSTOSEL (La Unión)	2002	96	21,176

Source: Gómez and Méndez (2007)

With respect to association rules, some groups are allowed to distribute cash dividends to the members and others are only allowed to provide in-kind benefits such as life insurance or medical care. The rules surrounding profit distribution are based on the legal status of the association (e.g. non-profit verses for profit groups). Additionally, some concessions distributed land to their members for personal use and are engaged in various activities outside of timber extraction (e.g. ecotourism or NTFP collection). The proposed attributes and levels selected for the choice experiment focus on these differences found among the community concessions groups and are described in detail in the following section.

4.3 Choice Experiment

Preferences for different characteristics of community concessions are assessed with a choice experiment (Adamowizc et al. 1998; Louviere et al. 2000) where individuals were shown two different concessions with varying attribute levels and asked which concession they would prefer to join. The attributes were determined based on actual differences among the concessions groups and through consultations with local professionals who have experience working with the community concessions.

4.3.1 Choice Experiment Design

Choice experiments are being used increasingly in developing countries; however, considerations need to be made recognizing that participants often lack survey experience and many may not be familiar with hypothetical situations (Whittington 1998; Mangham et al. 2009). For these reasons, the choice experiment for this analysis was designed to focus on four critical attributes: membership fee, area of land allocated to members, distribution of benefits, and concession activities (Table 17). While these attributes are important to the concessions in the Maya Biosphere Reserve we also suspect that they are important to a broader set of concessions internationally. Not all concession members had to pay a membership fee, but among the members who did pay, the one-time fee ranges from as little as $1.50 USD to more than $6,000 USD. For the choice experiment, we elected to break the fee up into monthly payments over 5 years, with the aggregate fee (ignoring interest) ranging from $1,500 to $6,000 USD. By paying the membership fee and joining the concession, the participants gain access to jobs from working in the concession and annual dividends or other in-kind benefits.

Table 17: Concession Attributes and Levels in the Choice Experiment

Attribute	Description	Levels
Membership Fee	Monthly payment for 5 years	200Q, 400Q, 600Q, 800Q*
Land	Land allocated to members for personal use	0, 10, 20 manzanas*
Benefits Distribution	Distribution of concession profits earned from the sale of timber and NTFPs	Dividends (cash), In-kind (scholarships, medicine, improvements to health clinic)
Activities Allowed	Activities in addition to harvesting timber that are allowed in the concessions	Eco-tourism, NTFP collection

*Q is for Quetzales, the Guatemalan currency. Approximately Q7.80 = $1.00 USD. Manzanas are a local measurement unit for land. 1 manzana equals approximately 1.73 acres.

Profits from a concession can be distributed as cash dividends only if the concession has been set up as a for-profit association. If not, members can only receive in-kind benefits. Dividend payouts are based on concession profits and the number of concession members, which ranges from 27 people to over 350. Survey participants are told that they can expect the next dividend payment to be Q10,000 or approximately $1280 USD.[27] Non-profit associations are not allowed to distribute monetary benefits directly from the concession profits. Benefits in this case are referred to as *in-kind*, where concession profits may be used for community enhancement such as improvements to the local health clinic or educational scholarships, or personal benefits such as life insurance

[27] Based on the survey results, actual dividend amounts ranged from Q500 to Q49,000 with a mean of about Q5,000.

or access to loans. Another difference among the concessions is the allocation of land. Land is allocated only to members who live within concession boundaries. Based on survey data, the parcels assigned to concession members range from 0.5 ha to over 100 ha, with the majority of people receiving 25 ha or less.[28] Members of non-resident concessions were not eligible to receive concession land.

The final attribute is based on variations in concession activities. In addition to harvesting timber, concession members also may engage in the collection of non-timber forest products (NTFP), primarily *xate*, and a few communities have expressed interest in ecotourism. While only one community was actively involved in ecotourism, Carmelita (based on annual reports and financial statements of the concessions), the reserve is home to many ancient Mayan sites and ecotourism can potentially play an important role in future economic development of the region.

Given the four attributes and their associated levels, there are 48 possible combinations of concessions types. The final choice scenarios are based on an orthogonal, fractional factorial design with minimal overlap (Louivere et al. 2000; Hoyos 2010), such that the attributes are uncorrelated across choice scenarios, and the individual has to make tradeoffs across all attributes. For example, no two hypothetical concessions, A and B, will ever have the same attribute levels for an alternative in a given choice scenario. The fractional factorial design allows for the estimation of main effects for the parameter estimates, but does not require the inclusion of all possible combinations of attributes and levels in the survey (Hoyos 2010).

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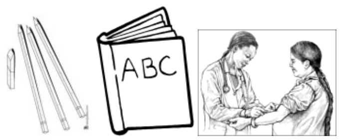
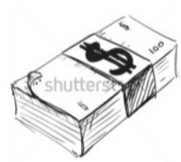
[28]Among the survey respondents who were allocated land from the concessions, over 70 percent reported that they received 25 ha or less.

Figure 11: Sample Choice Scenario

Concession A	Concession B	Neither
10 manzanas* 	**20 manzanas*** 	
In-kind Benefits  **Life insurance, scholarships, medicine and equipment for the health center**	**Individual Dividends**  **Payment of Approximately Q10.000**	**I do not want to join either concession**
Ecotourism 	**Non-timber Forest Products** 	
Payments of Q600/month for 5 years	**Payments of Q200/month for 5 years**	

Note: *Manzana* is a local unit of land measurement. 1 *manzana* equals approximately 1.73 acres or 0.7 hectares

The choice experiment was conducted at the end of the survey. Each person was presented with four different choice scenarios. If the survey participant was not a concession member, he or she was first provided with an overview of the concessions including a map of the location of the different concessions and information about how they operate. The enumerators gave detailed descriptions of each attribute and their varying levels to all survey participants and provided an opportunity for the participant to ask questions at the end of the explanation. All participants completed a practice choice scenario question to ensure that they understood the task.

4.3.2 Status Quo Option

In the survey, all participants were given a status quo option, indicating that if given the opportunity they would either remain in their existing concession, or not join at all. For the analysis, we gave survey participants who were currently members of a concession the attributes of their existing concession for the status quo option. The amounts for the membership fee and land allocation are based on the individual values reported by the members. Another option for incorporating the current situation of the concession members in the status quo would be to use the average values for membership fee and land allocation for each concession that were reported in the survey by the members. I run an alternative model with the average values for the status quo. The results are similar to the model with self-reported values (see Appendix C Table 30). Therefore, the main model is based on self-reported values for the status quo option since these are the values the individual members likely had in mind when deciding which concession they would prefer joining compared to their current situation.

The inclusion of ecotourism and NTFP activities is based on annual reports for each concession group. If the concession reported revenues or expenses involving NTFPs (primarily *xate*) or ecotourism, then the status quo option for members of that concession included those activities (see Table 18). For non-members, the status quo option was set at zero for all attributes.

Table 18: Community Forest Concession Attributes for Status Quo Option

Concession	Allocate Land	Benefit Distribution	Ecotourism or NTFP	Membership Fee
Carmelita	Yes	Both	Both	Yes
Uaxactún	Yes	Both	NTFP	Yes
San Miguel	Yes	None	None	No
Cruce la Colorada	Yes	In-kind	None	No
La Pasadita	Yes	In-kind	None	No
Custosel	No	Both	None	Yes
Arbol Verde	No	Both	None	Yes
Laborantes	No	Both	NTFP	Yes
El Esfuerzo	No	Both	NTFP	Yes
San Andres	No	In-kind	None	No
Suchitecos	No	Both	None	Yes

Note: La Colorada is the 12th concession, however at the time of the survey, the members had been removed for the concession area and thus were not available for interviews.

4.4 Data Collection and Survey Methods

The data for this analysis come from a survey conducted during the fall of 2012 of 494 households, some of which belong to community forest concession and some of which are non-members. The members of the concession groups are spread out across the Petén in 22 different villages and towns. The sampling strategy was based on obtaining member lists for each of the twelve community concession groups.[29] Membership within the concessions ranged from as few as 28 members to more than 300. For each concession, 20 to 25 percent of the members from the list were randomly selected to be interviewed.

[29] Of the 12 concessions, one (La Colorada) was cancelled prior to the survey and all the members were removed from the Maya Biosphere Reserve. As a result, we were not able to interview members from this concession group.

Table 19: Summary Statistics of Members and Non-members

	Members		Non-members		Total Sample		
Variable	**Mean**	**Std Dev**	**Mean**	**Std Dev**	**Mean**	**Std. Dev.**	**Obs**
Head Male	0.88	0.33	0.83	0.38	0.86	0.35	494
Head Age***	49.6	15.1	44.0	14.0	47.2	14.9	490
Head Educ.	4.32	3.26	4.32	3.31	4.32	3.28	493
Spouse Educ.	4.05	3.14	4.34	3.17	4.17	3.15	387
HH Size	5.38	2.59	5.15	2.25	5.28	2.45	494
Household Income (USD)	6,020	17,206	5,155	8,091	5,651	14,050	494
Born in Petén	0.54	0.50	0.47	0.50	0.51	0.50	488
Concession Member	0.57	0.50	--	--	0.57	0.50	494
Membership Fee (Q)	1797	7338	--	--	1797	7338	125
Dividend Amount (Q)	5079	8100	--	--	5079	8100	95
Concession land (ha)	9.87	12.2	--	--	9.87	12.2	46
Prefer In-kind	0.47	0.50	0.54	0.50	0.50	0.50	402

Notes: The total number of concession member households surveyed is 283 and non-member households is 211. *** indicates the two groups are significantly different at the 99% level. Guatemalan currency is the Quetzal. $1.00 USD is approximately Q7.80.

Identifying a non-member sample population was more challenging since obtaining community lists for the whole village or town was not feasible in most cases. For example, members from three of the concession groups live in Melchor de Mencos, which is a town with a population of more than 10,000 people. To obtain the non-member sample, we interviewed the closest neighbor of each member that was randomly selected for an interview. This sampling strategy is based on the assumption that neighboring households have similar incomes, educations, and job opportunities. The data indicate that the two groups are similar across almost all variables, supporting the sampling strategy (Table 19). The only statistically significant difference is in the age of household head, where the average age is 50 for members and 44 for non-members.

Prior to conducting the interviews, the research team met with board members from each concession to explain the purpose of the survey and to ensure cooperation. To alleviate suspicion in the villages, a member of the concession group or a person from the local community introduced the research team to each household that randomly selected for an interview. The interviews were administered by four student enumerators from the University of San Carlos a local university over the course of two months.[30] Prior to commencing data collection, the enumerators underwent four days of training, which included conducting pilot tests of the survey in one of the larger concession communities with members who were not in the sample. The survey instrument included a number of questions collecting basic demographic information, as well as sections on perceptions of trust and risk, attitudes toward forest conservation and extraction, and a detailed section on community concession membership. As noted above, the final section of the interview was the choice experiment.

4.5 Theoretical Model and Estimation Methods

Choice experiments involve providing individuals a set of alternatives and having them make choices based on attributes such as price, quality, or quantity. As one alternative is selected over others, respondents make tradeoffs, thus revealing their preferences over the different attributes. Including price in the choice sets also allows for the implicit valuation of other attributes (Farber and Griner 2000). Based on the theories

[30] This research would not have been possible without the help of Bayron Milian, a Professor at the University of San Carlos, and my four student enumerators: Luz Diamela Cano Méndez, Eddy Nicolas Chan Tesvan, Ruth Elizabeth Domingo, and Gerber Isben Guerra de Luca Torres

of utility maximization and rational choice, this approach is consistent with random utility models (McFadden 1974; Ben-Akiva and Lerman 1985).

4.5.1 *Random Utility Framework*

Choice experiments are based on the assumption that individuals make choices to maximize their utility. In this case, the survey participants select the community forest concession with the attributes that will provide them the greatest benefit. The underlying framework is the random utility model, where the utility of the decision maker, i, for alternative j is modeled as:

$$U_{ij} = V_{ij}(X_{ij}, Z_i) + e_{ij} \quad , \qquad (1)$$

where U_{ij} is the utility of the decision maker and V_{ij} is the systematic component of utility. V_{ij} is in turn a function of observable attributes of both the alternatives, X_{ij}, and the decision maker, Z_i. The error component, e_{ij} is random. The right-hand side of equation (1) can be expressed linearly:

$$V_{ij}(X_{ij}, Z_i) + e_{ij} = \alpha + \beta X_{ij} + \gamma Z_i + e_{ij} \quad , \qquad (2)$$

where α is an alternative specific constant, β is a vector of coefficients representing preferences over alternative attributes, and γ is a vector of coefficients representing preferences related to individual specific characteristics (Hole et al. 2009; Gelo and Koch 2012).

4.5.2 Empirical Estimation Methods

Traditionally, conditional logit (or multinomial logit) models (McFadden 1974) have been used in the analysis of choice experiment data. Given the linear formulation, the probability that the decision maker will choose alternative *j* is:

$$P_{ij} = \Pr(U_{ij} > U_{ik})\ \forall\, j \neq k = \Pr(\alpha + \beta X_{ij} + \gamma Z_i + e_{ij} > \alpha + \beta X_{ik} + \gamma Z_i + e_{ik})\ \forall\, j \neq k\ .$$

The conditional logit model follows, which is based on the assumptions of IID (independently and identically distributed) and a type 1 extreme value error distribution. The probability that individual *i* will choose alternative *j* is:

$$P_{ij} = \frac{\exp(\alpha + \beta X_{ij} + \gamma Z_i)}{\sum_{k=1}^{K} \exp(\alpha + \beta X_{ik} + \gamma Z_i)} \qquad ,$$

There are limitations associated with the conditional logit model in that it does not allow for heterogeneity in preferences and it is restricted by the IIA (independence of irrelevant alternatives) assumption due to the requirement that the error terms are IID.

Mixed logit models, such as a random parameters logit, provide a more flexible approach, in which the parameters for the alternatives are allowed to vary among the individual decision makers. Probabilities for the random parameters logit are estimated such that:

$$P_{ij} = \int \frac{\exp(\alpha + \beta_i X_{ij} + \gamma Z_i)}{\sum_{k=1}^{K} \exp(\alpha + \beta_i X_{ik} + \gamma Z_i)}\, f(\beta|\theta) d\beta \qquad ,$$

The regression model follows:

$$U_{ij} = \alpha + \beta X_{ij} + f(\beta) X_{ij} + \gamma Z_i + e_{ij} \qquad ,$$

where f(β) is the density function, estimating the mean and standard deviation for the set of β coefficients. This allows the survey participants to have heterogeneous preferences for the different attributes in the choice scenarios.[31]

In the final model, three of the attributes are specified to have random parameter values, land allocation, concession activities, and the distribution of profits. The parameters are normally distributed with no correlation across coefficients. The parameter for the fee variable is held constant since in previous models, when fee was included as a random variable with a normal distribution the fee coefficient was not significant, indicating that there is no preference heterogeneity in the sample for the membership fee (see Appendix C Table 30). Additionally, the model with a random fee parameter was no better fit than the model with a fixed fee parameter based on likelihood ratio tests.[32] A second model with the fee parameter restricted to being negative with a lognormal distribution was also tested for the member sample. A negative coefficient for fee is expected and indicates that as the membership prices increases, people are less likely to join a concession group. The results from the loglikelihood ratio test indicate that this model is no better fit than the main model with a fixed fee parameter. [33] Coefficients for this model are similar to the main model (See Appendix C Table 30).

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[31] A generalized multinomial logit model (G-MNL) was also considered to test for potential scale heterogeneity, which would occur if survey participants had different variances in utility across choice scenarios (Fiebig et al 2009). These models, however, failed to converge.
[32] For fee modeled as a random parameter with a normal distribution, the log-likelihood test statistic is calculated as $-2*(\text{loglikelihood}_{fixed}) - 2*(\text{loglikelihood}_{random})$ or -2*(-878.48)+2*(-876.80) = -3.36, which is less than the Chi squared critical value at the 0.01 significance level for 8 degrees of freedom (20.1), thus I fail to reject the null hypothesis that the model with fee modeled as a random parameter is a better fit.
[33] For fee modeled with a lognormal distribution, the likelihood ratio test statistic is -2*(-878.48)+2*(-877.38) = 1.16 when compared to the fixed fee model, thus failing to reject the null hypothesis the lognormal fee model is a better fit.

While the sign for the fee coefficient is expected to be negative, the signs for the coefficients of the other concession attributes are less predictable and vary based on individual preferences. For example, some concession members may prefer opportunities to engage in ecotourism, while other may have backgrounds in NTFP collection. Prior to the survey I assumed that more land allocated to concession members would be more desirable, and thus result in a positive coefficient, however, interviews with concession members revealed mixed preferences for land allocation, discussed more below.

Finally, the main model includes an alternative-specific constant for the status quo (SQ) option, which captures unobserved factors that affect utility and preferences over the different alternatives. In this case, the alternative specific constant also reveals preferences for the status quo option among the survey participants. Socio-demographic characteristics are entered into the model through interactions with the status quo, including age, education, income, gender (male=1) of the household head, and a dummy indicating if the household head was born in the Petén, which serves as a proxy for forest experience, since less than 30 percent of the members of recently inhabited concessions were born in the Petén. Interactions with the individual specific characteristics help to further explain preference heterogeneity by identifying socio-demographic factors that influence the likelihood of the respondents having preferences for the status quo option (Duke et al. 2012). Concession attributes are also interacted with a *resident* dummy variable, indicating if the survey respondent lives in one of the resident concessions inside the reserve. These communities tend to be farther away from major towns and market centers and the members are more likely to have an agricultural background,[34] which may result in further heterogeneity in preferences for these members compared to people living closer to larger towns and cities outside of the reserve.

The final sample of participants is separated into two subgroups, members and non-members, based on the assumption that members have different preferences due to the experience they have had in a community forest concession. When comparing separate member and non-member samples to a pooled sample of all survey participants, the loglikelihood ratio test indicates that the separate samples are a better fit for the data (see Appendix C Table 31).[35]

4.6 Results

The results for the random parameters logit (RPL) model indicate that individuals have heterogeneous preferences for the attributes associated with the community forest concessions (see Table 20). The RPL provides a better fit for the data compared to the conditional logit model based on a loglikelihood ratio test ($2\Delta LL = 433.16 > 20.1 = \chi^2_{8,0.01}$). The results of the random parameters logit model suggest that there is significant preference heterogeneity among members and non-members alike (Table 20). The parameters on fee and land can be interpreted directly such that a negative coefficient for fees indicates a preference for lower fees, and a positive coefficient on land indicates a preference for more land. The parameter on in-kind is interpreted as a preference for in-

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[34] Among survey respondents, 66 percent of people in the resident concession communities identified their primary occupation as farming.
[35] Likelihood ratio test statistic for pooled and separated samples = -2[-1516.48 – (-623.07 - 876.80)] = 33.22 > 20.1 (χ^2, 0.01 significance with 8 degrees of freedom) (Ou and Yabe 2010).

kind payments if positive and a preference for cash-dividends if negative. Similarly, a positive parameter on NTFP indicates a preference for harvesting non-timber forest products over conducting ecotourism. The parameter values themselves are utility measures and do not have a straightforward interpretation (Green and Hensher 2003).

Based on the results in Table 20, focusing on the member sample, the coefficient for membership fee is negative and significant, as expected, indicating that higher membership fees reduce the likelihood of people joining a concession. Interestingly, the coefficient for *Land* is negative (albeit insignificant), although there is substantial heterogeneity. We control for some of this heterogeneity by including an interaction term for resident members. The interaction term of *Resident x Land* is positive signifying that resident members have positive preferences for land. This is perhaps not surprising given that many of the residential concessions are located further from larger villages, and the costs of purchasing food are higher.

Amongst members, there is a preference for ecotourism (the NTFP parameter is negative), although the interaction of *Resident x NTFP* is positive indicating that those members living in concessions prefer NTFP collection. Within the member sample, there is no strong preference for in-kind versus cash payments, and the preferences do not appear to differ among resident versus non-resident members.

Among the members, socio-demographic variables did not seem to have a large effect on predicting the likelihood of a member joining a concession. The only significant interaction was for *SQ x Petén*, indicating that members born in the Petén were less likely to select the status quo option, which makes sense given that they are more likely come from long-established communities and have backgrounds in forestry and NTFP collection. The results from the RPL model also show heterogeneity in the

Table 20: Results for The CL and RPL For Member and Non-member Samples

	Conditional Logit		Random Parameters Logit			
	Members	Non-Mem	Members		Non-Mem	
Variable	Coef.	Coef.	Coef.	SD	Coef.	SD
Fee	-0.0004***	-0.0001	-0.0004*		-0.00006	
	(0.0001)	(0.0002)	(0.0002)		(0.0003)	
Land (ha)	-0.008	0.01**	-0.01	0.03**	0.02*	0.04***
	(0.005)	(0.006)	(0.01)	(0.01)	(0.01)	(0.01)
In-kind	0.19*	0.30***	0.15	0.15	0.34***	0.23
	(0.11)	(0.10)	(0.13)	(0.48)	(0.12)	(0.43)
NTFP	-0.28***	0.01	-0.23**	-0.47***	0.002	0.41*
	(0.09)	(0.10)	(0.11)	(0.18)	(0.12)	(0.25)
Status Quo	0.63	-2.95***	-0.11	6.78***	-12.63*	7.42***
	(0.99)	(0.97)	(6.59)	(1.06)	(7.60)	(1.50)
SQ x Head Age	0.01**	0.06***	0.07		0.23***	
	(0.005)	(0.007)	(0.04)		(0.07)	
SQ x Head Edu	0.02	0.009	0.14		0.20	
	(0.03)	(0.03)	(0.21)		(0.28)	
SQ x Born Petén	-0.56***	0.30	-2.28*		0.77	
	(0.17)	(0.22)	(1.30)		(1.57)	
SQ x Head Male	-0.61**	1.32***	-3.07		5.91***	
	(0.29)	(0.22)	(2.03)		(2.02)	
SQ x Log Income	-0.13*	-0.18**	-0.47		-1.08	
	(0.08)	(0.09)	(0.53)		(0.76)	
Resident x NTFP	0.56***	0.08	0.58***		0.12	
	(0.13)	(0.16)	(0.16)		(0.19)	
Resident x In-kind	-0.38**	-0.26	-0.14		-0.24	
	(0.15)	(0.16)	(0.20)		(0.19)	
Resident x Land	0.02***	0.002	0.04***		0.005	
	(0.008)	(0.01)	(0.01)		(0.01)	
Log likelihood	-1093.38	-774.16	-876.80		-623.07	
LR Chi 2			433.5		302.18	
Wald Chi 2	147.83	129.48				
Observations	3230	2376	3234		2376	

Note: Standard Errors in parentheses. Random parameters logit fitted using Maximum Simulated Likelihood (Train 2003) in Stata. Statistically significant at the 99% level***, 95% level**, 90% level*.

parameter estimates for land, NTFP, and the status quo, which have significant standard deviations from the mean parameter estimate based on a normal distribution, indicating that preferences for these attributes vary among individuals.

Non-members are more likely to join a concession if land is allocated. They also have preferences for in-kind benefits over dividend payments, but there is no significant difference between NTFP compared to ecotourism. Regarding the socio-demographic interactions, older survey participants and male heads of households are less likely to join a concession and more likely to select the status quo. None of the interactions with the *Resident* dummy are significant, which may be due to lack of familiarity with the concession attributes among non-member populations. The negative and significant coefficient on status quo for the non-member sample indicates that there is not status quo bias, and non-members were in fact, more likely to elect to join a concession than choose the status quo option. Non-members may also be more prone to joining a concession compared to members since the status quo alternative does not include any concession group, whereas the status quo option for members includes their current membership status. Finally, given the RPL results, non-members have heterogeneous preferences over land, NTFP activities, and the status quo, which all have significant standard deviations from the mean coefficient values (see Table 20).

After participants finished the four choice scenarios, they were asked to rank the concession attributes based on which had the most influence in their decision to the least influence. The results show that membership fee was the least important attribute, with 60 percent of the survey participants ranking it fourth and only 7 percent ranking it as the most important attribute (see Table 21). The allocation of land was the highest ranked attribute in terms of importance, with 35 percent of the people ranking it first. The distribution of benefits and concession activities closely follow with 66 and 67 percent of the participants ranking these attributes as first or second, respectively. These rankings provide insights regarding what attributes are most valued by the local residents, which may inform the development of future community concessions. In order to maximize program uptake and community engagement, the concessions should be promoted such that the most desired attributes are highlighted while taking into consideration heterogeneity in preferences based on the location of the communities and their previous forest experience.

Table 21: Ranking of Attribute Importance by Survey Respondents

	Ranking (1 = Most Important)				
Attribute	**1**	**2**	**3**	**4**	**Total**
Land (%)	144 (35)	92 (22)	99 (24)	74 (18)	409
Benefits (5)	127 (31)	147 (36)	109 (26)	30 (7)	413
Activity (%)	120 (29)	153 (37)	89 (22)	47 (11)	409
Fee (%)	26 (7)	22 (6)	110 (28)	240 (60)	398

Source: Household Survey by author conducted fall 2012

4.7 Discussion and Conclusion

This paper uses a choice experiment to assess preferences over four different attributes of the community forest concessions in Guatemala's Maya Biosphere Reserve. The data come from a household survey of concession members and non-members, in which they were asked which concession they would prefer joining if given the opportunity - Concession A, Concession B, or neither - based on differences regarding the membership fee, amount of land allocated to the members, concession activities (ecotourism or NTFP), and distribution of benefits (cash dividends or in-kind).

The findings indicate that the survey participants have heterogeneous preferences over the different concession attributes. In general, members prefer the opportunity for ecotourism over the collection of NTFPs. However, members who live inside the reserve prefer that the concession is involved in the collection of NTFPs. This is probably due to the fact that resident members who were born in the Petén are more likely to have a background in forestry and many of the people from these communities are familiar with harvesting NTFPs, such as *chicle* and *xate* (Gómez and Méndez 2007). Members that live in communities outside the reserve are more likely to have a greater exposure to tourism and thus may have preferences for expanding concession activities to include ecotourism.

With regards to the allocation of land, members who live inside the reserve are more likely to join a concession if land is distributed to the members. This result reflects actual variations in the concessions, in which resident members were allocated land for personal use but members of non-resident concessions were not allocated any land. The fact that non-resident members have a negative preference for land is surprising since one might assume that more land would be desirable. This outcome may be a result of non-resident members having greater tendencies toward forest conservation. During the survey, some members of the non-resident concessions expressed opposition to the idea of allocating concession lands to members. The non-resident concessions are more remote, with historically low deforestation rates, thus some of their members may associate providing land to members with land clearing and deforestation in their concession areas. The resident concession members, on the other hand, currently live and farm within the reserve and many of these members come from agricultural backgrounds.

The results for the non-member sample indicate that males and older populations are more likely to choose the status quo option. Non-members also prefer in-kind distribution of benefits over cash dividends, which was a somewhat surprising result from the survey data discussed further below.

The findings in this paper have policy implications for the development of future community forest concessions. First, members and non-members have heterogeneous preferences across the concession attributes. This is not surprising given the wide range of backgrounds among individuals living in and around the Maya Biosphere Reserve. It suggests the importance of allowing self-selection in group formation. Second, members' backgrounds seem to influence their preferences and attitudes concerning land distribution. In communities comprised of people with primarily farming backgrounds, providing land for people to engage in agriculture (for example, previously cleared or degraded land) may make community forestry more appealing to these communities. However, this may not be the case with non-agricultural communities who have other opportunities for employment.

Finally, the results indicating that non-members prefer in-kind benefits to cash dividends were an unexpected finding. In fact, approximately 50 percent of the entire sample population preferred in-kind benefits to dividends. When prompted in the survey regarding why they have this preference, many people responded that it in-kind benefits are better for their family and the community in the sense that they benefit more people and have a longer term effect than receiving money which can be spent quickly. Others reported that it is better to have access to medicine and scholarships than cash. This was the case across both resident and non-resident concession communities.[36] This finding may have policy implications for the development of future concessions and other community forest projects where community members receive benefits for providing environmental services such as Payments for Ecosystem Services (PES) programs. Rather than making direct payments to program participants, the community as a whole could be compensated with improvements to infrastructure, local schools, or health clinics. This may lead to issues with free riding, where some people may not actively participate since they cannot be prevented from receiving community-wide benefits. Social norms, however, could also put pressure on people to comply with the contracts for the benefit of the whole community (Ostrom 2000).

The success of community forest concessions will largely depend on the incentives and benefits associated with membership. Therefore, understanding preferences for forest conservation and which concession attributes are most valued by local residents will provide important information that could contribute to future forest concession policies and increase the likelihood of creating successful community forest concessions that both protect the forests and provide livelihoods for their members.

[36] Among the 402 survey respondents who answered the question, which type of benefits would they prefer, in-kind or cash dividends, 201 said they prefer in-kind. Among the 158 respondents from resident concession communities, 75 (47 percent) of them preferred in-kind over dividends.

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Appendix A: Chapter 2

Table 22: Logit Results from Estimating Propensity Scores for Matching

Variable	Non-Resident		Long-inhabited		Recently Inhabited	
	Odds Ratio	Z-score	Odds Ratio	Z-score	Odds Ratio	Z-score
Dist to nearest road	1.41	61.8	0.83	-33.1	2.13	58.6
Dist to road sq.	1.00	-8.9	0.99	-36.9	0.97	-43.9
Dist to nearest major city	0.91	-54.5	4.74	156.2	2.34	65.3
Distance to city sq.	1.00	-50.6	0.99	-149.0	1.00	-24.4
Elevation	1.00	0.4	1.03	106.9	1.02	68.8
Slope (degrees)	1.05	25.5	1.04	9.4	1.06	24.5
Dist to nearest cleared parcel	2.08	115.0	1.62	51.2	0.40	-44.4
Cleared dist sq	0.97	-122.3	0.97	-65.4	0.93	-37.3
Dist to nearest village	1.35	79.6	0.62	-88.9	0.33	-74.0
Nearest village sq	1.00	-49.2	1.00	33.3	1.04	34.7
Dist to nearest archeo site	0.97	-26.7	1.16	79.1	0.47	-131.4
pH	2.32	99.6	0.63	-51.3	0.95	-2.0
Aspect	1.00	5.1	1.00	-10.9	1.00	2.1
West (location dummy)	424.5	144.6	0.25	-45.0	--	--
Constant	2.19E-06	-165.8	2.59E-23	-156.9	8.24E-07	-44.0
Observations	293248		294208		232984	
Pseudo R2	0.5828		0.7794		0.8384	
Loglikelihood	-78344.1		-41589.9		-25643	

Note. - Logit results from Stata Version 12. All results are significant at the 99% level except for Elevation for the non-resident concessions and pH and Aspect for the resident non-indigenous, those are significant at the 90% level. The dependent variable is membership in one of the three concession groups.

Table 23: Comparison of Balance for Non-Resident Concessions

Variable	Unmatched Data Mean Diff	Unmatched Data eQQ Med*	NN Mah Matched* Mean Diff	NN Mah Matched* eQQ Med*	NN w/o Replace Mean Diff	NN w/o Replace eQQ Med*	Bias-Corrected Mean Diff	Bias-Corrected eQQ Med*	Kernel Mean Diff
Dist to nearest road	6.91	6.79	1.91	1.72	3.51	5.33	3.92	5.75	-1.83
Dist to nearest major city	-23.18	24.13	-1.14	7.16	1.51	6.14	-3.20	3.92	-7.12
Dist to nearest village	6.61	6.49	1.16	2.69	3.21	5.86	0.22	2.89	-2.68
Nearest village sq	303.5	218.3	47.5	63.7	170.7	210.1	-13.82	88.19	-102.01
Dist to nearest cleared parcel	1.88	2.10	-0.64	1.29	-1.64	1.31	-0.20	0.49	-0.69
Cleared dist sq	18.30	21.33	-20.06	26.68	-30.18	23.95	1.54	9.11	-7.57
Dist to nearest archeo site	-0.75	5.33	-1.99	1.89	6.35	2.35	4.54	3.33	1.21
Aspect	12.40	8.43	0.21	6.81	6.66	2.73	-1.11	3.37	-4.48
Ph	0.34	0.36	0.14	0.13	-0.33	0.05	0.01	0.00	0.01
Elevation	29.34	48.50	13.35	11.00	-8.06	21.00	10.17	8.00	2.17
Slope sq.	0.54	0.87	-0.27	0.00	-2.21	0.58	0.09	0.00	0.09
Observations	49180		16642		24323		22056		22637

Note. - Kernel results are for the pre-policy matched sample, eQQ median distance statistics are not available, so comparison is based on difference in means for each covariate. Matching done in R using MatchIt. NN refers to Nearest Neighbor, and "Mah" is for Mahalanobis matching. *Indicates balance for matched sample used in DID analysis.

Table 24: Comparison of Balance for Resident, Long-inhabited Concessions

Variable	Unmatched Data		NN Mah Matched*		NN w/o Replace		Bias-Corrected		Kernel
	Mean Diff	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**
Dist to nearest road	-5.69	6.82	0.04	0.79	-0.64	3.51	-1.18	1.53	-2.71
Dist to nearest major city	-3.26	23.10	3.19	17.13	0.94	24.58	11.12	16.94	-5.82
Dist to nearest village	-5.60	6.70	-1.32	0.88	1.53	0.89	-0.08	0.83	-0.92
Nearest village sq	-233.3	261.5	-48.45	30.56	50.06	30.65	-2.40	16.50	-18.90
Dist to nearest clearing	-1.77	1.31	-0.15	0.69	-1.00	1.15	-0.53	0.68	-1.20
Cleared dist sq	-46.08	13.54	-5.96	4.68	-21.38	16.55	-8.95	3.62	-12.57
Dist to nearest archeo site	-5.78	3.14	-0.21	3.83	2.35	5.54	-0.37	0.81	-1.18
Aspect	-2.75	7.13	-3.00	1.00	0.96	5.31	0.63	9.19	-8.56
Ph	0.55	0.50	-0.05	0.05	-0.01	0.05	-0.01	0.00	-0.01
Elevation	61.87	68.50	1.59	41.00	-10.14	27.25	-4.43	8.50	-12.93
Slope	0.40	0.52	-0.12	0.00	-0.83	0.40	0.22	0.58	-0.36
Observations	49291		17480		25355		21672		24972

Note. - Kernel results are for the pre-policy matched sample, eQQ median distance statistics are not available, so comparison is based on difference in means for each covariate. Matching done in R using MatchIt. NN refers to Nearest Neighbor, and "Mah" is for Mahalanobis matching. *Indicates balance for matched sample used in DID analysis.

Table 25: Comparison of Balance for Resident, Recently Inhabited Concessions

Variable	Unmatched Data		NN Mah*		NN w/o Replace		Bias-Corrected		Kernel
	Mean Diff	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**	**eQQ Med***	**Mean Diff**
Dist to nearest road	-8.94	8.23	0.96	1.53	-6.24	0.61	0.03	0.05	-0.02
Dist to nearest major city	-14.94	21.87	6.34	7.45	-2.16	6.00	-0.03	0.74	-0.77
Dist to nearest village	-9.66	10.14	0.45	0.70	-2.75	0.86	7.89	8.17	-0.28
Nearest village sq	-240.4	201.1	11.58	5.21	-32.46	7.41	-0.40	0.87	-1.27
Dist to nearest cleared parcel	-8.69	10.74	0.93	0.28	-0.31	0.12	-0.54	6.39	-6.93
Cleared dist sq	-152.6	134.8	7.47	0.56	-3.09	0.22	0.38	0.10	0.29
Dist to nearest Archeo site	3.72	5.60	-2.97	2.84	-2.23	2.10	3.58	0.17	3.41
Aspect	20.32	14.86	-4.65	4.66	-44.82	8.36	-1.52	2.23	-3.75
Ph	0.32	0.00	-0.14	0.00	0.00	0.00	-0.44	5.60	-6.04
Elevation	0.51	0.36	16.24	14.50	-0.03	0.00	-0.02	0.00	-0.02
Slope	29.66	34.75	-2.22	2.37	57.77	33.50	17.56	41.00	-23.44
Observations	98704		13558		42479		21476		36460

Note. - Kernel results are used from for pre-policy matched sample, eQQ median distance statistics are not available, so comparison is based on difference in means for each covariate. Matching done in R using MatchIt. NN refers to Nearest Neighbor, and Mah is for Mahalanobis matching.
*Indicates balance for matched sample with the same methods used for a larger sample in DID analysis.

Table 26: Leakage Estimates for "Buffer" Coefficient for Concession Groups

	2 Km Buffer		5 km Buffer		10 Km Buffer	
Model	Unmatched	Matched	Unmatched	Matched	Unmatched	Matched
Resident Indigenous						
Basic	-0.832***	-0.294***	-0.946***	-0.216***	-0.106***	-0.143***
	(0.001)	(0.001)	(0.001)	(0.001)	0.0013	0.0015
Extended	-0.411	-0.372***	-0.265***	-0.028***	0.0008	-0.010***
	(0.007)	(0.001)	0.0007	(0.001)	0.0013	0.0016
Kernel	--	-0.014***	--	-0.013***	--	-0.002
	--	(0.001)	--	(0.001)	--	(0.003)
Observations	96041	47246	95480	42136	94648	26932
Pseudo R2	0.181	0.1474	0.1757	0.119	0.167	0.0896
Non-Resident						
Basic	-0.473***	0.0005	-0.040***	-0.018***	0.0290***	0.0029
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)
Extended	0.0115***	0.006***	0.0146***	-0.0014	0.015***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Kernel	--	0.005*	--	-0.012**	--	0.010**
	--	(0.003)	--	(0.005)	--	(0.004)
Observations	95007	38176	94723	29674	94602	24568
Pseudo R2	0.168	0.239	0.164	0.236	0.164	0.242

Note. - Standard errors in parentheses. Standard errors for the Kernel matching results do not take into account that propensity scores are estimated (i.e. not bootstrapped). Reported observation numbers are for the Basic and Extended regressions. The number of observations for the Kernel estimates is similar to the unmatched number of observations minus obs off the support.

* p<.10. ** p<.05. *** p<.01.

Appendix B: Chapter 3

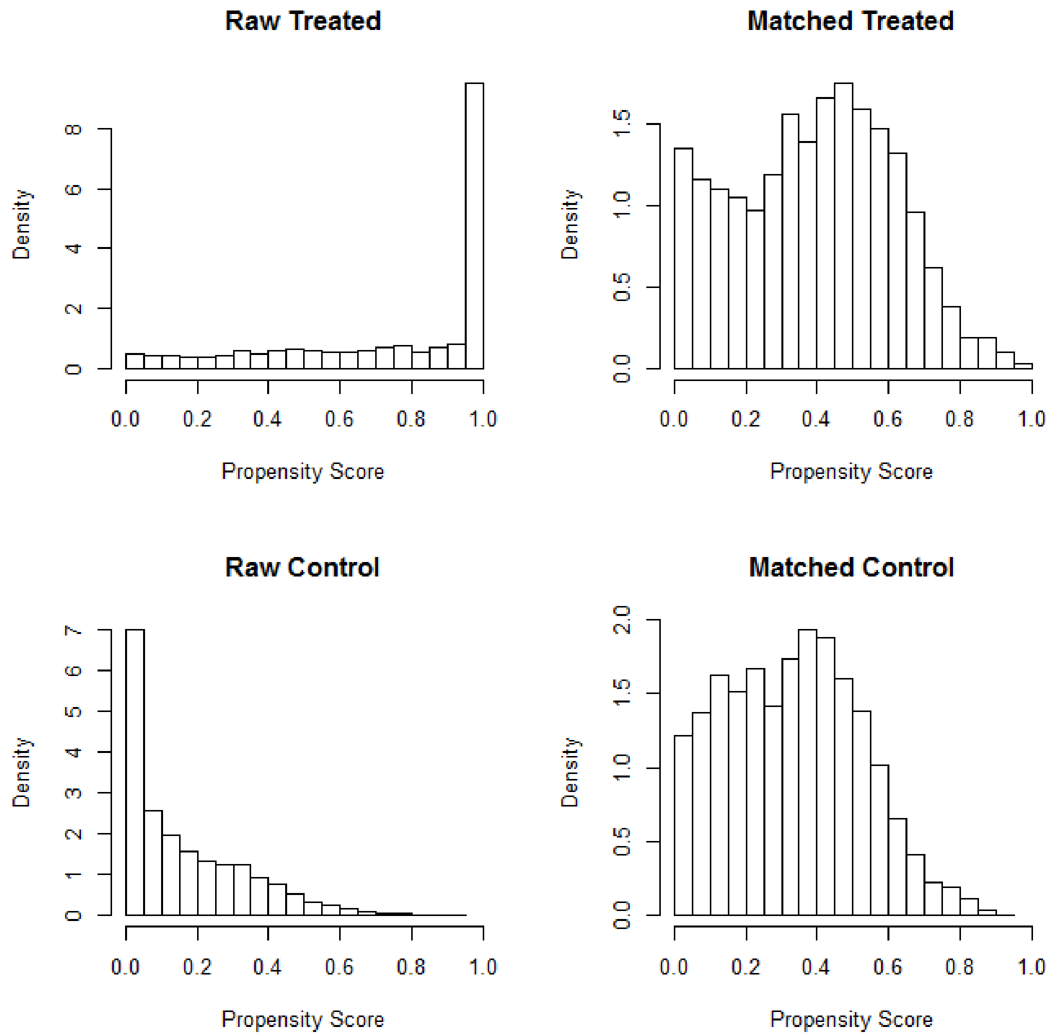
Table 27: Comparison of Balance for Alternative Datasets and Matching Methods

	Unmatched		Without San Andres w/ Replace		With San Andres w/o replace		Non-Concession w/replace	
Variable	Mean Diff	eQQ Med	Mean Diff	eQQ Med	Mean Diff	eQQ Med	Mean Diff	eQQ Med
Dist to road	3.59	3.30	3.31	6.02	1.55	1.74	2.15	3.42
Dist to city	9.36	13.51	9.26	11.34	1.31	7.99	11.98	23.61
Dist to village	0.62	0.28	1.42	2.04	0.64	0.55	1.78	1.02
Dist to clearing	4.65	4.65	3.04	5.37	1.06	0.24	2.08	1.60
Dist to archeo site	-5.69	6.09	-1.98	6.94	-1.56	1.28	-5.73	1.60
Aspect	-18.4	17.6	6.90	15.26	-4.41	4.40	28.48	9.13
Ph	-0.19	0.35	-0.03	0.00	-0.01	0.00	-0.09	0.00
Elevation	28.9	36.3	31.48	12.00	-3.11	22.00	4.58	7.00
Slope	-1.11	1.12	-12.49	1.23	-0.05	0.00	-2.60	2.43
Observations	99385		43035		31494		41181	

Table 28: Difference-in-Difference Results with Alternative Datasets and Matching Methods

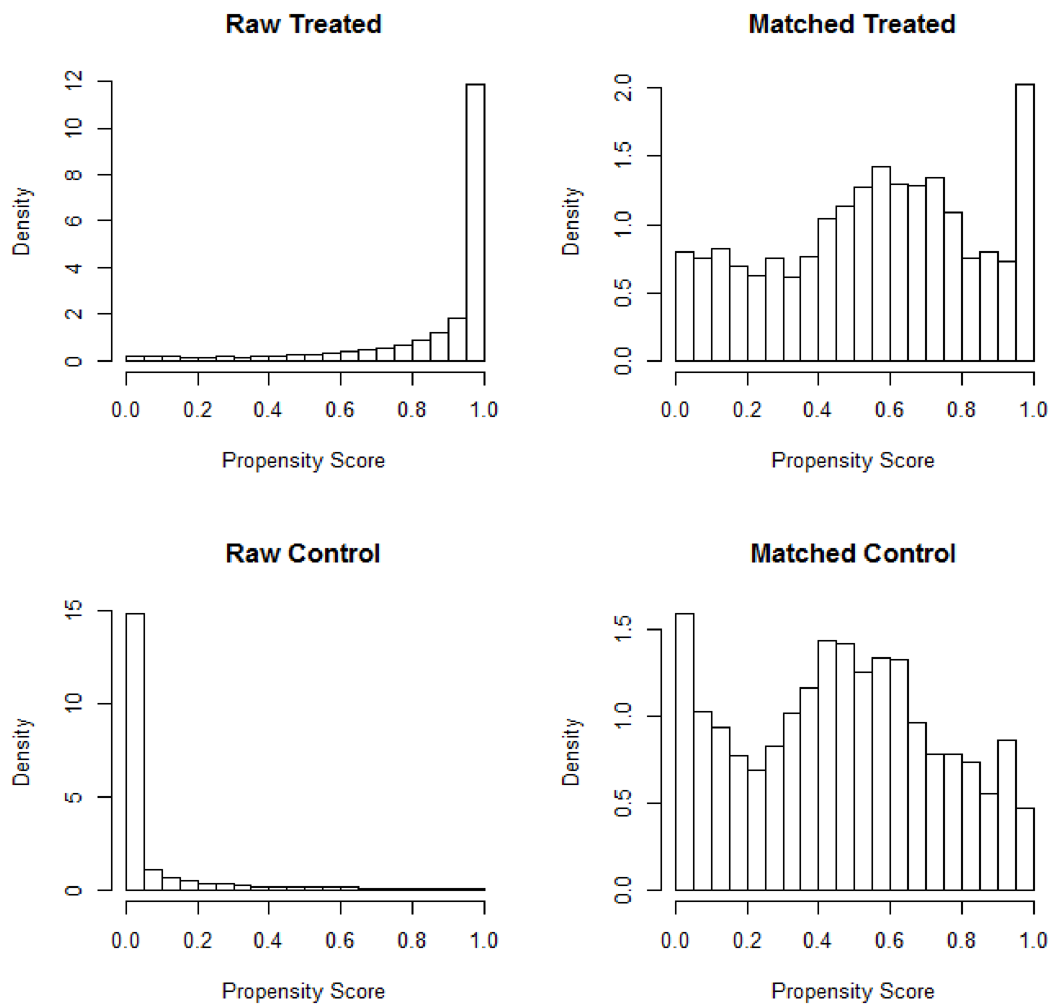
	Regression		**Probit M.E.**				
Sample	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Obs.**	**R-Sq.**	**LL**
W/o San Andres w/replace	-0.008***	0.003	-0.008***	0.002	43035	0.019	-850.4
W/ San Andres no replace	-0.009***	0.002	-0.011***	0.002	31494	0.018	-1018.3
W/ San Andres w/replace	-0.004	0.003	-0.007***	0.002	42441	0.018	-711.9
Non-con Control w/replace	-0.007**	0.004	--	--	41181	0.022	--

Figure 12: Historgrams of Common Support for Concession Sample



Note: Sample of treatment and control concessions without San Andres. Results based on nearest neighbor matching with Mahalnobis distance metric (caliper=0.25) Matching conducted in R using "MatchIt" (Ho et al. 2007).

Figure 13: Historgrams of Common Support for Non-concession ZUM Sample



Note: Sample of treatment concessions and control group of non-concession observations in Multiple-use Zone. Results based on nearest neighbor matching with Mahalnobis distance metric (caliper=0.25) Matching conducted in R using "MatchIt" (Ho et al. 2007).

Appendix C: Chapter 4

Table 29: Results for Members with Status Quo Average Values for Concessions

	Conditional Logit	Random Parameters Logit	
Variable	**Coef.**	**Coef.**	**SD**
Fee	-0.0001***	-0.0004*	
	(0.00003)	(0.0002)	
Land (ha)	-0.001	-0.01	-0.03**
	(0.003)	(0.01)	(0.01)
In-kind	0.34***	0.17	0.19
	(0.11)	(0.13)	(0.36)
NTFP	-0.28***	-0.23**	-0.45**
	(0.09)	(0.10)	(0.18)
Status Quo	0.52	0.86	7.01***
	(0.99)	(6.90)	(1.09)
SQ x Head Age	0.01	0.06	
	(0.01)	(0.05)	
SQ x Head Edu	0.02	0.16	
	(0.03)	(0.23)	
SQ x Born Petén	-0.73***	-3.01**	
	(0.17)	(1.37)	
SQ x Head Gender	-0.49*	-2.96	
	(0.29)	(2.1099)	
SQ x Log Income	-0.09	-0.46	
	(0.07)	(0.57)	
Resident x NTFP	0.58***	0.57***	
	(0.13)	(0.16)	
Resident x In-kind	-0.47***	-0.15	
	(0.14)	(0.20)	
Resident x Land	0.015**	0.03***	
	(0.006)	(0.01)	
Log likelihood	-1098.08	-877.73	
LR Chi 2	--	440.72	
Wald Chi 2	146.59	--	
Observations	3234	3234	

Note: Standard errors in parentheses.

Table 30: RPL Results with Fee included as Random Parameter

	Member Sample Normal Fee		Non-member Sample Normal Fee		Member Sample Lognormal Fee	
Variable	**Coef**	**SE**	**Coef**	**SE**	**Coef**	**SE**
Mean						
Fee [a]	-0.0004*	0.0002	0.0001	0.0003	-0.00095	0.027
Land (ha)	-0.006	0.007	0.02*	0.01	-0.01	0.01
In-kind	0.15	0.13	0.36***	0.13	0.15	0.13
NTFP	-0.23**	0.10	0.003	0.12	-0.23**	0.11
Status Quo	0.54	6.74	-12.19*	7.30	0.85	7.33
SQ x Head Age	0.06	0.05	0.22***	0.07	0.06	0.04
SQ x Head Edu	0.13	0.22	0.15	0.30	0.13	0.23
SQ x Born Petén	-2.61**	1.35	0.71	1.75	-2.36*	1.28
SQ x Head Male	-2.87	2.06	5.92***	2.21	-3.13	2.00
SQ x Log Income	-0.51	0.55	-1.09	0.73	-0.50	0.61
Resident x NTFP	0.58***	0.16	0.13	0.20	0.59***	0.17
Resident x In-kind	-0.14	0.20	-0.26	0.20	-0.14	0.20
Resident x Land	0.03**	0.01	0.004	0.02	0.04***	0.01
SD						
Fee	-0.000006	0.002	0.001	0.001	77.2	765.3
Land (ha)	-0.03***	0.01	0.04***	0.02	-0.08**	0.83
In-kind	-0.11	0.51	-0.29	0.34	0.48	0.18
NTFP	-0.46***	0.18	0.44*	0.26	6.59***	1.09
Status Quo	6.95***	1.12	-7.49***	1.67	4.24***	1.68
Log likelihood		-878.48		-622.77		-877.38
LR Chi 2		439.56		302.8		432.33
Observations		3230		2376		3230

Note: All random parameters for both member and non-member models have a normal distribution except for the fee variable for the member sample, which was restricted to negative and has a lognormal distribution. [a] The reported coefficient values for the lognormal model are converted from the natural log of the price coefficient, which had a mean value of -13.66 (SE: 4.34) and the standard deviation is 0.03 (SE: 0.01) The converted mean is given by $\exp(b_p+s^2_p/2)$ and the standard deviation by $\exp(b_p+s^2_p/2) \times \sqrt{(\exp(s_p^2)-1)}$ (see Hole 2007). The same model was run for the non-member sample, but it would not converge.

Table 31: Pooled Sample of Members and Non-Members Compared to Split Sample

	Member Sample		Non-member Sample		Pooled Sample	
Variable	**Coef**	**SD**	**Coef**	**SD**	**Coef**	**SD**
Mean						
Fee	-0.0004*	0.0002	-0.00006	0.0003	-0.0002	0.0002
Land (ha)	-0.01	0.01	0.02*	0.01	0.003	0.005
In-kind	0.15	0.13	0.34***	0.12	0.25***	0.09
NTFP	-0.23**	0.11	0.00	0.12	-0.13*	0.08
Status Quo	-0.11	6.59	-12.63*	7.60	-8.55	5.27
SQ x Head Age	0.07	0.04	0.23***	0.07	0.13***	0.04
SQ x Head Edu	0.14	0.21	0.20	0.28	0.14	0.18
SQ x Born Petén	-2.28*	1.30	0.77	1.57	-1.10	1.00
SQ x Head Male	-3.07	2.03	5.91***	2.02	2.27*	1.30
SQ x Log Income	-0.47	0.53	-1.08	0.76	-0.59	0.46
Resident x NTFP	0.58***	0.16	0.12	0.19	0.40***	0.12
Resident x In-kind	-0.14	0.20	-0.24	0.19	-0.20	0.13
Resident x Land	0.04***	0.01	0.01	0.01	0.02**	0.01
SD						
Land (ha)	0.03**	0.01	0.04***	0.01	0.03***	0.01
In-kind	0.15	0.48	0.23	0.43	-0.13	0.42
NTFP	-0.47***	0.18	0.41*	0.25	0.45***	0.14
Status Quo	6.78***	1.06	7.42***	1.50	7.38***	0.93
Log likelihood		-876.80		-623.07		-1516.48
LR Chi 2		433.5		302.18		786.95
Observations		3230		2376		5606

Table 32: Logistic Marginal Effects Results for Status Quo

	Members		Non-Members	
Variable	**Coef**	**Z-stat**	**Coef**	**Z-stat**
Resident (dummy)	-0.006	-0.42	0.010	0.51
Head Age	0.001	1.06	0.002***	3.62
Head Male	-0.025	-0.92	0.068***	3.63
Head Edu	0.000	0.16	0.0002	0.05
Farmer (dummy)	-0.010	-0.66	0.010	0.47
Household Size	0.002	0.71	-0.004	-0.87
Income	-9.47E-08	-0.92	2.72E-08	0.24
Born Petén	-0.028*	-1.66	0.017	0.94
Choice Attributes				
Land	0.0005	1.54		
Member Fee	-0.0004**	-2.04		
Ecotourism	-0.021	-0.43		
NTFP	-0.044	-1.48		
In-kind	-0.030**	-1.97		
Dividend	9.00E-07	0.71		
Observations		3302		2436
Log Likelihood		-591.95		-564.48