Exploring Possibilities for Reforestation in Southwestern Nicaragua: The Social and Ecological Dimensions of Living Fence Rows

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Abstract

Deforestation in southwestern Nicaragua as a result of converting rare dry tropical forest to pastures has created fragmented forest habitats and decreased the potential for this area to continue its historical role as a critical biological corridor. The conservation organization Paso Pacifico works to assess the feasibility for reforestation to increase habitat potential and connectivity in the region. Live fence implementation is one potential reforestation method that Paso Pacifico is interested in exploring. Establishing living fence rows would involve a targeted planting of trees along designated boundaries of pastures, producing certain ecological and subsistence benefits of trees without sacrificing grazing land. Living fence rows are already present in southwestern Nicaragua, but they have not been investigated in regards to landowner use and perception or how different taxa respond to them. Our team explored these dimensions for a sample of living fence rows in the region to provide insight necessary for developing a program for promoting living fence rows.

We first produced a literature review to assess the dual value living fences present in both working and natural landscapes. Then, we conducted semi-structured interviews with landowners who own living fence rows to investigate their perceptions and use of these features. We also performed biodiversity assessments of these existing fence rows in order to better understand their conservation potential. Our findings are that landowners generally perceive living fence rows to be a worthwhile long-term investment that are useful for humans, cattle, and the environment. We also found that bees of the locally important tribe Meliponini showed a strong positive reaction to the living fences in our sample. Following from these findings, we have specific recommendations for how further research could continue to explore the social and ecological dimensions of living fence rows in the region and how Paso Pacifico should design a program for promoting live fences in the region.

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1. Introduction

Over the past few decades nearly 80% of Central America's native vegetation has been lost due to a rising demand for pastures and cropland, and the remaining vegetation is becoming increasingly fragmented. Previous studies have estimated that the current amount of protected forestland is insufficient to support the region's natural biodiversity and that this deforestation and fragmentation are important drivers behind the loss of several indigenous species that play crucial roles in healthy ecosystems, such as the jaguar (Dinerstein et al. 1995, Dirzo et al. 2010).

The Paso del Istmo Biological Corridor of southwestern Nicaragua is a 25-km wide isthmus of land between Lake Nicaragua and the Pacific Ocean. This ecologically-significant region historically served as a land bridge for wildlife migrating between North and South America and currently conserves the largest tract of rare tropical dry forest in Nicaragua. However, as is the case with the rest of Central America, the landscape is heavily fragmented, with most of the original forested areas converted to cattle pasture and agriculture. The non-profit organization Paso Pacifico works to assess the efficacy of reforestation and agroforestry in increasing habitat health and connectivity in the region because improving the permeability of this working landscape is essential for conserving biodiversity and maintaining ecosystem services (http://www.pasopacifico.org/where-we-work.html).

During the past two years, Paso Pacifico's restoration efforts largely involved working with local landowners to reforest small areas of their lands close to riparian corridors or existing forest fragments. These reforested parcels were planted with native fruit-producing trees and indigenous timber trees that provide economic benefits to the landowners who chose to participate in the project. To date, around 50 hectares were reforested due to these efforts. However, one recognized drawback of this reforestation practice is that area previously devoted solely to pasture or cultivation must be turned over to producing tree cover. This outcome may not be desirable to landowners who perceive the loss of this area as detrimental to their agricultural or ranching practices.

Paso Pacifico proposes that shifting its efforts towards a program that targets tree planting along property boundaries in the form of living fence rows (Leon and Harvey 2006) would be a more viable option for landowners. Implementation of living fence rows would be different from past reforestation efforts in that the tree planting would occur along current property boundaries and/or internal dividing lines, further delineating them while also creating linear habitat corridors with the potential to connect dispersed forest fragments. Living fence rows have been identified as corridors and alternative habitats for native fauna in other regions of Central

America (Harvey et al. 2005), so their promotion in southwestern Nicaragua could help improve habitat connectivity in this region. Ideally, these fence rows would not only serve as suitable habitat corridors but also help with landowner recruitment into the reforestation program due to the fact that they would involve planting trees only on the peripheries of working pasture or farmland, thus avoiding trade-offs between supporting reforestation and maintaining livelihoods across the agricultural landscape. This strategy could also potentially avoid the risk of the reforested area being logged off or altered in the event of land turnover as the fence rows would be integrated into the physical definition of the landscape.

Landowners in the Paso del Istmo Region to some extent already employ living fence rows on their land but they have never been studied so little is known of their structure, distribution, and composition. Another study surveyed a large sample of living fence rows across Costa Rica and nearby regions of Nicaragua and found them to be quite common, to consist of mostly planted tree species, and to have more tree species richness on the landscape level than in any one particular live fence. This study also found that the living fence rows were managed by farmers to delineate boundaries and obstruct animal movement but also provided other resources such as forage, firewood, and fruit. Finally, this study discovered that the biodiversity potential of living fence rows was determined by their species composition, structural diversity, and arrangement in the landscape (Harvey et al. 2005).

Our team of SNRE Master's students has worked with Paso Pacifico for more than one year addressing the social and ecological dimensions of living fence rows in this region. We focused on how landowners of existing living fences use and perceive these fences and how different taxa respond to them as well. This report will outline our research, findings, and recommendations for future work in exploring the potential for living fence rows to address ecological challenges by improving the agricultural landscape of southwestern Nicaragua in a manner that makes sense for current landowners.

2. Overview

The goal of this research is to explore a sample of existing live fence rows in southwestern Nicaragua to inform the possible promotion of new living fence rows as part of a Paso Pacifico reforestation program. To accomplish this, our team employed multiple methodologies in data collection over the course of two separate research trips to the Paso del Istmo Region from May to July 2015 and from December 2015 to January 2016, and we analyzed this data throughout this time period and the following months. We developed a short interview script and conducted interviews in Spanish with landowners who had existing living fence rows to determine basic information about their lands, their fence rows, and their opinions about the utilization and implementation of living fence rows. These interviews were recorded, transcribed, and analyzed so as to gather information about the fence rows and explore how amenable the social landscape of the region may be to a program that promoted the implementation of living fence rows. We also performed biological assessments of these existing fence rows in order to better understand their structure and their potential conservation value in the pastoral landscape. For this biodiversity study, we characterized the fence rows in terms of their structure and species composition. Further, we performed focused studies on vertebrate and invertebrate diversity within the fence rows, focusing on the response of bees to living fences as an alternative to open pasture.

In performing the data collection in Nicaragua and conducting the subsequent analysis, we were guided by a number of questions that both reflect Paso Pacifico's intentions in evaluating the living fence rows in the region and what we could feasibly address with our methods and given timeframe. The intention was not necessarily to provide concrete answers to these questions but to investigate different dimensions, both social and ecological, of the existing living fence rows in Paso Pacifico's study region. The questions are as follows:

1) What are the structural and compositional characteristics of the living fence rows in our sample?
2) How do the landowners in our sample perceive living fence rows?
3) How do bees respond to the living fence rows in our sample?

These questions are addressed in turn, with an emphasis on each question's particular relevance for exploring the living fence rows in the study region and on how each question is addressed by the results of the various methodological techniques we employed. With a mind to the limitations of our research, we also offer recommendations for future studies that can further elaborate on and be informed by the exploration of these questions.

This report proceeds with a review of living fence rows. In this review we explore how living fence rows present benefits for both working and

natural landscapes. Then we address our different methodological approaches, detailing the methods, results, and limitations of each in turn. Finally, we will cover the discussion of our research questions and conclude with a summary of our findings and recommendations.

3. Living Fence Rows

Live fences are a unique feature in working landscapes because of their dual value both agronomically and ecologically. It could be argued that live fences are not as valuable to local flora and fauna as more traditional reforestation projects because a single line of trees may not provide as many resources or benefit as a forest, but it is important to remember that when considering the context of our sample sites, the livelihoods and survival of landowners take precedence above all else. More conventional conservation methods and approaches may not be as appropriate for implementation because of the sheer amount of space that would be taken up by forest instead of the pre-existing pasture that is often perceived as necessary for raising livestock or planting crops. Living fence rows are an excellent example of practical synergy between working and natural landscapes, supporting native ecosystems and the people living within them.

3.1 What roles do living fence rows play within natural systems?

Ecologically speaking, live fence rows can be very advantageous in terms of resource and habitat availability and ecosystem connectivity. The Paso del Istmo region contains significant challenges regarding wildlife movement due to the highly fragmented nature of the remaining patches of non-deforested area. This deters movement for species that prefer cover, and inhibiting travel from species that require frequent resting or covered sites within their home range or migratory stopover sites for rest and food. Fatigued migrating birds actively search for locations with ample food, suitable shelter, and few competitors or predators. These stopover sites play a crucial role in a bird's survival by serving as places to recharge for a few hours or days before moving onward. In fact, stopover sites are so critical for bird recovery that during migration birds actually spend more time on the ground than in the air (Miller 2015). But the Paso del Istmo biological corridor is of special significance to many animals migrating between North and South America, not just birds.

Increased connectivity between forested segments improves habitat effectiveness for species reliant on large tracts of land to complete their life cycle and encourages genetic diversity through system connectivity. The creation of wildlife corridors can potentially prevent the deterioration of genetic variability and inbreeding depression in forest fragments (Saunders & Hobbs 1991) by providing opportunity for movement between populations.

Live fences also provide habitats and resources for wildlife that would otherwise not be able to survive in the current area due to the lack of diversity for cover and food sources in monoculture field crops and pastures. During data collection, we observed many invertebrate species, especially bees and

other hymenoptera living inside trees in our live fence sample, and using the floral resources in species that were flowering at the time. Invertebrates were the main focus of our study because insect diversity is often overlooked as a critical aspect of biodiversity conservation. They are integral in maintaining balance and stability in population and health for all other taxa. Birds were seen more frequently perched or nesting in the live fences compared to traditional fences composed of dead wooden posts instead of living trees. In one sample site we came across lizard eggs in a decayed hollow of a tree, presumably laid there for the cooler microclimate provided by the tree's shade and cover. Because of frequently experienced high temperatures in the area, shade can be a valuable and sometimes elusive commodity in Nicaraguan pasture. Canopy shadows can provide important refuge for heat sensitive or ectothermic species (Harvey et al. 2005).

On a larger systemic scale, live fences provide multiple ecosystem services that strengthen the integrity and resilience of the working landscape they divide and border as well as the surrounding native ecosystems (Harvey et al. 2014). Floral presence of trees used in living fence rows attracts pollinators that can increase, or at the very least maintain healthy levels of pollination necessary for indigenous plants to thrive and sufficient crop production. Live fences can also provide effective windbreaks to protect these plant and animal communities. In the same vein, these trees can aid in soil stabilization (Harvey et al. 2014) and erosion control in areas affected by strong winds or heavy rains.

3.2 How can living fence rows be utilized within anthropogenic systems?

As shown repeatedly in agroforestry and silvopastoral research, integrating trees into agricultural landscapes of deforested fields with low levels of biodiversity can be significantly beneficial in mitigating some common risks in agricultural operations like drought and supporting overall agricultural function (Harvey et al. 2005). Multiple needs as well as production or ecological goals for individual farms can be addressed depending on the tree species that landowners choose for their fences.

Living fence rows create solid boundary delineations that are useful in both crop organization and the restriction of animal movement. The structure itself lasts longer than traditional fence posts, decreasing the replacement labor regularly required when the traditional fence's structural integrity is threatened by rot. Additionally, the root systems of living trees lend to increased fence stability in the event of a physical impact which could break or damage a dead post. Some tree species regenerate from branches or live stakes, meaning that posts can easily be replaced, and new trees don't necessarily need to be raised from seed. Stake plantings can save years of time between planting and established stability of the fence structure (Zahawi 2005). Prescribed fire is often utilized by Nicaraguan farmers to manage unwanted plants and pests like ticks in their fields. The live wood and green

vegetation of live fences have the advantage of being used as burn breaks to help manage the fire and in the event that a controlled burn starts traveling into an undesired area or jumps intended break lines, trees are significantly less likely to be damaged or destroyed than drier and more flammable dead posts.

Farmers establishing new living fence rows would have the opportunity to choose tree species that can provide additional harvest items such as fruit, oils, saps, or leaves that can be used as food, fuel, medicine, or other commodities that can be an extra income sources for growers. Certain tree species can also act as a renewable source for lumber or firewood. As weather becomes more unpredictable due to climate change and the world's population continues to rise, any assets to augment food security are a valuable investment (Branca 2013). This added level of security does not stop with humans. Live fences can also provide supplementary and fodder or forage for domesticated animals (Harvey et al. 2005) kept within the fences, potentially lessening labor and economic stressors on ranchers. *Madero negro* (*Gliricidia sepium),* a species commonly seen in living fence rows can be especially helpful in this way, as it naturally fixes nitrogen and provides especially nutritious food for livestock in the dry season when grass can be scarce (Beer 1987 cited in Harvey et al. 2005). Diversification of supportive resources that can help mitigate risk of starvation or diet related health issues in years of drought or uncertain weather patterns can help farmers develop long term plans for their property and ultimately protect their financial stability. Through interviews at a large grazing cooperative that hosted two of our sample sites, we learned that an indigenous tree, *jicaro* (*Crescentia alata*) that was used in most of the cooperative's living fence rows has historically served as an auxiliary food source for cattle. This tree species produces large seedpods, rivaling the size of a softball, that have hard, green exteriors and soft, edible interiors that can feed cattle when grasses and other sustenance sources are scarce. The negative aspect of using *jicaro* fruit in this way is that preparation of the fruit is labor intensive. The shells are very difficult to crack and typically need to be opened with machetes or other tools. Though this may seem like an unnecessarily arduous task, it is preferable to losing livestock during hard times. We witnessed troughs full of halved *jicaro* fruit on multiple occasions in a penned area of the cooperative in which we conducted the biodiversity study, the details of which will be found in the next section of this document. This technique has been passed down through generations to the current cooperative managers, and it was clear they have significant interest in continuing the tradition.

The aforementioned windbreaks and shade produced by living fence trees can create microclimatic refuges for domesticated and non-domesticated animals. Cooling and moisture retention can be important for domesticated species that are not traditionally thought of as heat-sensitive. In 2005, a study by Harvey et al. found that Central American dairy cattle in harsh climates

with access to shade are healthier and more productive than those without. Trees dispersed in agricultural regions can also draw in animals that can be helpful in pest control through predation (bats, birds, select insects), limiting the use of harmful pesticides that are commonly used in the area (Wesseling et al. 2001).

One of Paso Pacifico's ongoing goals is community education, and it has found that one of the most effective methods of engaging with the public and disseminating information is through community workshops. The topic of discussion at the workshop our team was fortunate enough to attend focused on composting. This was a novel idea for many of the workshop's participants, and it was clear that this approach to nutrient cycling is not commonly used in the area. Farmers could use leaf litter or other products from live fence trees to augment nutrients in their compost, or simply increase the volume of compost produced. This would be especially valuable in years with lower plant production due to weather and overgrazing.

The reason to separate the roles living fence rows can play in anthropogenic systems and natural systems is, ironically, so that the overlap and opportunity for integration can become more apparent. The survival of humans depends on our ability to adapt to and live within biophysical limits of the ecosystems in which we choose to live and not constantly fight to manipulate them to fit conflicting ideas of how things *should* exist. Systems that effectively address human natural needs can become interdependent and create a healthier, more dynamic, and stable platform for all life. In the instance of the Nicaraguan land redistribution that occurred through the 1980's and 1990's, and the ensuing deforestation and ecosystem fragmentation, all of the living organisms within these systems became more vulnerable to risks such as pests, disease, unpredictable weather, and overall ecosystem degradation because there are fewer factors in play to maintain the stocks, flows, and balances required for mutual support and compensation for disruptions in the larger structure.

As hundreds if not thousands of species are becoming extinct globally every year, assuredly there are many examples of ecosystemic interdependence faltering as aspects of the network are manipulated improperly or damaged. One of the more relevant examples in recent history is the decimation of the western honey bee (*Apis mellifera*) population in North America through Colony Collapse Disorder (CCD), which resulted in billions of dollars in damages and losses in agriculture production because of insufficient pollination and the honey industry (Shepard 2013). The effects of CCD would not be so devastating if it were not for the gross overdependence that large industrialized farming operations have on managed *Apis mellifera,* instead of the thousands of wild bees native to the area which if given adequate resources could provide sufficient pollination to the industry (Winfree et. al 2007). This crisis has certainly shed light on the importance of

studying the diversity of native pollinators within integrated systems and grabbed the attention of a larger audience within the general public as well as the global scientific community. In Nicaragua, where species protection programs and laws are usually less stringent than those in the United States, local conservation organizations like Paso Pacifico and individual efforts are even more important to the preservation of ecosystems.

4. Site Establishment for Interview and Biodiversity Studies

We chose to work in four regions within the Paso del Istmo corridor where cattle pastures are the predominant agricultural land use type. With the help of Paso Pacifico employees, we gained landowner permission to make repeated sampling visits to a total of 14 sites spanning the corridor from Lake Nicaragua to the Pacific Ocean. On the drier Pacific slopes, we established four sites in La Tortuga and five sites in Escamequita. In the wetter lake region, we identified two sites in Aceituno and three sites in La Rejega. Individual sites were at least 400 meters apart (see Figure 1 below).

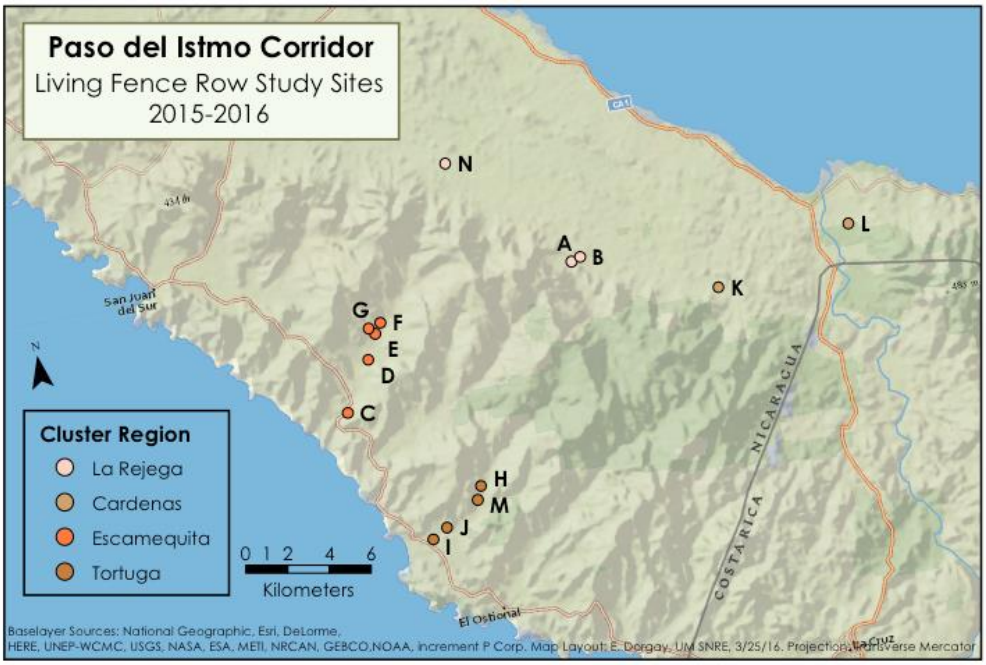


Figure 1. The distribution of the 14 fence rows used in the biodiversity study. Landowners at sites A-D and H-N participated in the interview study.

Living fences are prevalent in the Paso del Istmo region in various forms and stages of growth; they are commonly used to form boundaries along roadsides, forest fragments, and riparian areas. However, due to our interest in the response of bees to living fences as an alternative to open pasture, we opted for farms where living fences were bordered on both sides by pasture. Sites D and N were exceptions; there, the living fences divided pasture from a low-traffic dirt road, which was immediately bordered by pasture on the other side. We did not exclude these sites because we believe the substrate of the roads and their infrequent use would not deter bees from crossing them. Site C was also unique; our study fence was one half of a live fence corridor that formed a shaded cattle run between pastures.

A further criterion used in our site selection was that the canopies of trees forming the living fence had to be fully connected along the length of the fence. This standard helped us filter out the young, newly planted fences in favor of mature ones. Thus, the fences sampled were the most developed ones in the landscape and had the best potential for supporting faunal diversity.

At each site, we identified a dead, wooden fence within 205 meters of our live fence. These dead fences also spanned across open pasture and served as the control treatment for the bee study. Fences, both living and dead, were at least 75 meters long to accommodate the length of the sampling transect used to collect bees.

The interview sample was identified in the process of selecting sites for the biodiversity study. Eight of the interviewees represented at least one of the live fences we selected for the biodiversity study and one interviewee represented live fences that did not match our criteria. The sample is composed of seven men and two women. One of the interviewees is not herself a landowner but was speaking for the owner of the land who was a familial relative and one is the president of a ranching cooperative and was therefore speaking for the eleven members of the cooperative and their families as well. Three of the interviewees live in La Rejega, four live in La Tortuga, and two live in Escamequita. Six of the nine landowners own smaller or modest-sized plots of less than 50 *manzanas*, two own slightly larger plots of around 100 *manzanas* or more, and the cooperative owns over 600 *manzanas* of land. A *manzana* is a Nicaraguan unit of measurement that is roughly equivalent to 1.74 acres (Cardarelli 2012) which will be used in reporting the interview data as it is the measurement that the interviewees use. Four of the landowners were previously affiliated with Paso Pacifico through participation in workshops or programs and therefore their names were already known and no introductions had to be made. The other landowners were located and contacted first by a member of Paso Pacifico who made sure that they were willing to participate in the interview.

5. Interview Study

5.1 Methods

Interview Script

The interview analysis consisted of face-to-face interviews with individual landowners who owned pasture land with living fence rows that for the most part compose the sample of living fence rows used for the biodiversity study. Each interview was conducted in Spanish using a semi-structured interview script (Patton 2002) that asked basic questions about the landowner's property, living fence rows, and perceptions of and uses for the living fence rows (Appendix A, Interview Script). We asked questions about each landowner's land to gather basic information about their ownership status, the current length of their tenure, their anticipated future land use and transfer (passing it on to their children or selling it), and how they employed their land. These questions were intended to ensure that our landowner sample and hence their living fence rows were primarily representing pasture owners and fence rows and to explore whether they were already or were likely to be long-term landowners. The former concern is derived from our desire in doing the biodiversity assessment to have a sample of living fence rows that occur in or alongside pasture land so as to appear to be forested corridors in otherwise working landscapes. The latter concern is predicated on the fact that the tenure status of farmers in Nicaragua is related to the cultivation of trees as a long-term investment. Previous studies show that longer-term landowners are more amenable to longer-term investments in their land (Bandiera 2007) and, vice versa, improvement of the landscape through the planting of trees is indicative of more secure tenure status (Broegaard 2005). Therefore, we wanted to include some measures of tenure status so as to account for why our sample may have invested in features like living fence rows which represent a long-term investment and a semi-permanent landscape feature, adding some depth to later discussions about perceptions of living fence rows. The questions we asked in order to identify how these landowners used their living fence rows were informed by previous research on living fences that highlighted different productive roles of these particular landscape features (Harvey et al. 2005). These questions included sample uses for living fence rows such as for timber, firewood, forage for cattle, and demarcating external or internal boundaries (Appendix A, Interview Script). We also asked basic questions about the living fence rows such as their age, length, and tree composition to determine some basic characteristics and provide some additional context to the data we gathered in our tree survey. Due to limited funding we were unable to secure camera traps for placement along our sample of fence rows, so we also asked a question about what animals the landowners had witnessed using the living

fence rows on their land. Albeit a very subjective measure, it was our only means of getting some sense of how vertebrates may be using living fence rows in these landscapes. Finally, in order to account for each landowner's perception of living fences beyond the usefulness of these features we asked them to compare the advantages and disadvantages of living fence rows to fence rows composed of dead posts and asked whether or not they would consider planting more living fences in the future.

Interview Setting

For seven of the nine interviews, which were conducted on the first research trip from May - July 2015, one of our team members co-led the interview with an employee of Paso Pacifico. Paso Pacifico's employees aided in translation and ensured that the interview space met a desirable level of comfort for the landowner as many of them are also members of the communities in which the interviewees themselves live. Committing to a relaxed and culturally sensitive interview space (Patton 2002) was an important goal of the interview process which operated on the assumption that land use and rights in rural Nicaragua can be a sensitive, highly political topic. In support of this assumption, there is a body of literature on Nicaraguan land policy that highlights the inequalities of access to land titles and agricultural land – drastically separating the land ownership experiences of the socioeconomic elite from those of the rural poor – despite a history of political and social reform aimed at ameliorating these disparities (Broegaard 2005, Broegaard 2009, Everingham 2001, Roche 2006). Due in part to the awareness of this issue and because the research was mainly focused on agroforestry, the Internal Review Board at the University of Michigan determined this research to have an unregulated status. The other two interviews, which were conducted on the second research trip from December 2015 to January 2016, were led solely by an employee of Paso Pacifico.

Interview Process and Analysis

Each interview lasted roughly 15 minutes with the shortest being less than 7 minutes and the longest being almost a half an hour in length. Notes were taken during each interview and eight of the nine interviews were recorded and later transcribed verbatim in Spanish (Bryman and Bell 2003). These interviews were then analyzed qualitatively with a simple coding method to draw out specific information about the characteristics, uses, and perceptions of the sample living fence rows (Patton 2002). The transcripts were organized and analyzed using NVivo software with categorical codes derived from our research questions. These codes were: *Land Use, Tenure Status, Live Fence Characteristics, Animals in Live Fence, Live Fence Use, Advantages of Live Fences,* and *Disadvantages of Live Fences*.

5.2 Results

Land Use

All nine interviewees responded that they devoted their land primarily to pasture for cattle. Some of the landowners shared an approximate head count of their cattle which ranged from two to around 100. However, most landowners also devoted some area to the cultivation of crops – mainly rice, corn, and beans – with one of the interviewees indicating that her cultivation of crops depended on whether or not it was a good *invierno* (winter or wet season). The four landowners who were previously affiliated with Paso Pacifico all had some amount of land that they had devoted to reforestation, with none of these plots exceeding five *manzanas*. It is not clear if this reforested land is related to Paso Pacifico's reforestation efforts as this was not explicitly drawn out in the interviews. Finally, five interviewees had land that they had not developed and had allowed to remain natural forest. The cooperative had around 100 *manzanas* of natural forest, while one interviewee had around five *manzanas*. Accounting for those interviewees who had either natural forests or reforested areas, only one interviewee had neither and only one interviewee had both.

Tenure Status

All of the interviewees owned their land or were speaking for the person or group who owned the land. All interviewees reported having directly owned their land for more than five years, with many reporting time spans much longer than that. The cooperative has owned its land since the era of the Sandinista agrarian reforms in the 1980's (Everingham 2001) and was officially founded in 1982. Three interviewees reported having owned their land for similarly long time periods ranging from 30 to 41 years and had either bought it or inherited it. Another three interviewees who had only owned their land for six, seven, and twelve years respectively reported that the land had been in their families for some time prior to their direct ownership and that they had either bought it or inherited it. The final two interviewees have owned their lands for twelve and fourteen years respectively. One of these interviewees bought his land and the other obtained permission to work his land from the government.

In regards to the future of their land, the five interviewees who explicitly answered the question about whether eventual transfer would ideally involve inheritance or selling the land responded that they desired for their children to inherit their land. Three interviewees did not answer this question directly, instead opting to discuss the future in terms of future land use. One interview did not address this question. The interviewee speaking for the cooperative talked about the future of the cooperative, insisting that the cooperative had no plans to sell off land and that the goal was to increase membership and explore new opportunities for revenue. All of the

interviewees who discussed future land use seemed content with continuing to employ their land primarily for cattle. Two interviewees expressed their desire to expand reforestation efforts on their land, including the cooperative which has plans to reforest the *fuente de agua* (source of water) on the land.

Live Fence Characteristics

Eight of the nine interviewees answered the question that asked them to estimate the length of their living fence rows. Some used kilometers as the unit of measurement and others opted for *varas*. A *vara* is a unit of measurement used throughout Latin America that is roughly equivalent to 84 centimeters in Nicaragua (Cardarelli 2012) which will be used in reporting the interview data whenever the interviewees themselves used it. The cooperative has the longest fence rows by far at 15,000 *varas* (approximately 12.5 km). Three other interviewees have over a kilometer of living fence rows – ranging from one to three – and the remaining four have from 300 to 500 *varas* of living fences. It should be noted that most of these answers were rough estimates that were often arrived at with the aid of a Paso Pacifico employee helping with calculations. Also, these lengths represent a total measurement of all of each respective interviewee's living fence rows which means that they do not directly represent our sample of living fence rows.

Concerning the age of the living fence rows, some interviewees simply gave a rough estimate while others provided some context as to who planted them. Only two interviewees reported that their living fence rows were less than 30 years old. One interviewee reported his living fence rows to be twelve years old and another estimated that the living fence rows were probably older than ten years but they had existed prior to him owning the land so an exact estimate was impossible. The remaining interviewees all estimated the ages of their fence rows to be thirty years or more. One interviewee claimed that she had planted hers and, as she had owned her land for thirty years, they must be around that age. Another interviewee claimed that his living fence rows were more than thirty years old and had been planted by his father as posts of *madero negro* (*Gliricidia sepium*). Yet another interviewee shared that his living fence rows had been planted by a cooperative that used to own his land and were around 35 years old. The cooperative also inherited most of its living fence rows and some of the trees contained within them are roughly 80 years old. All in all, five interviewees reported having inherited the living fence rows on their lands, two interviewees explicitly mentioned planting their live fences, and the other two interviewees possibly could have planted their living fences as they reported having owned their lands for longer than their living fence rows were estimated to have existed but they made no explicit mention of this activity.

Finally, in regards to the tree composition of living fence rows, the eight interviewees who answered this question all identified *madero negro* as being present in their living fences. This tree is often found in living fences

that are planted rather than naturally generated as it can be grown easily from stakes (Harvey et al. 2005). However, most interviewees identified at least one other tree species in their living fence rows besides *madero negro*. The cooperative for instance identified *jicaro* (*Crescentia alata*) as also being prominent in their fence rows due to the ability to use its fruit as feed for cattle in lean times. Other trees identified by interviewees are *jobo* (*Spondias mombin*), *aceituno* (*Simarouba amara*) which is a shade tree and is good for firewood (Burns et al. 1988), *guachipilín* (*Diphysa americana*), *acacia* (*Vachellia cornigera*), and *chiquirin* (*Myrospermum frutescens*).

Animals in Live Fence

When asking the interviewees to identify any animals that they may have seen in their living fence rows we made sure to suggest monkeys as an example given that Paso Pacifico is specifically interested in the potential for monkeys to use living fence rows as an arboreal corridor (Asensio et al. 2009, Estrada et al. 2006). Three interviewees responded that they have never seen either howler monkeys or spider monkeys in their living fence rows, three interviewees responded that they had seen howler monkeys in their living fence rows, and three interviewees reported having seen both spider monkeys and howler monkeys in their living fence rows. Two interviewees even made explicit mention of having witnessed the monkeys traversing the living fence rows like a road. Other animals that were identified as having been seen in living fence rows were squirrels, birds, sloths, and iguanas. Three interviewees also mentioned that bees were present in their living fence rows, with the cooperative claiming that this was because of the fact that bees like the *jicaro* trees in their fence rows.

Live Fence Use

Only six of the interviews asked the interviewees to identify if their living fence rows were employed internally to delineate sub parcels or externally to form property boundaries. All six responded that living fence rows made up some of the boundaries of their pastures and/or their property lines. Two interviewees responded that they also employed living fence rows within pastures to delineate sub parcels. The cooperative insisted that in every area devoted to pastures on their land, living fence rows occupy both the borders and dividing lines between pastures.

When asked if living fence rows served any purpose other than designating boundaries only one interviewee responded that they did not. Four interviewees claimed that they used their living fence rows for wood for building – with one going so far as to indicate during the interview to where he had repaired his house with wood from his living fence row – and four interviewees claimed that they gathered firewood from their living fence rows but only one of these interviewees claimed that they used their fence rows for both. Four interviewees reported that they used the trees in their living fence

rows to produce new fence posts for or replace the fence posts in a fence row composed of dead posts. Finally, one interviewee proposed that he would use his living fence rows as a source of forage for his cattle in the future and the cooperative stated that they used the fruit of the *jicaro* trees in their fence rows to feed their horses and cattle in lean times.

Advantages of Live Fences

When asked to identify the advantages of living fence rows over fences composed of dead posts the interviewees provided an array of answers. Five interviewees responded that a major advantage was the fact that, unlike dead posts that only have a lifespan of five to fifteen years depending on the quality of the wood used for the post, living fence rows represent a long-term investment that does not require continual maintenance. One interviewee put it rather succinctly in stating, "*Cercas de postes por un tiempo. Cercas vivas por todo el tiempo*" ("Fences with posts last for a while. Living fence rows last forever"). Another emphasized the environmental benefit of this longevity as investing in living fence rows meant that one did not have to cut down trees to replace aging fence posts while another highlighted how having a living fence row made it easier to replace fence posts in fence rows composed of dead posts as one could simply do cuttings from the living fence to make new posts. Three interviewees drew out the fact once more that living fence rows provided a readily available source of wood for building and one interviewee who had some land enrolled in a reforestation program informed us that unlike the trees in the reforested area which he was prohibited from using for wood he could use the living fence rows because they were part of his pasture land. Some interviewees also pointed out that living fence rows are beneficial to cattle and other animals, with four interviewees claiming that the trees in living fence rows provided shade for cattle and one interviewee observing that the trees provide a windbreak to protect the cattle from strong winds. One interviewee went on to discuss how most people in the region assume that a pasture should only consist of grass and that this is a mistaken assumption as grass alone cannot provide everything that cattle need. He discussed how forests can provide many essential services to cattle and that living fence rows can also fulfill some of those services. He also stressed the need for more environmental education so that other landowners in the region could realize these benefits of living fence rows. Finally, one interviewee stated that living fence rows helped conserve water on the land.

When asked if they would consider planting more living fence rows in the future, all nine interviewees responded in the affirmative. The cooperative however was not convinced that they needed more living fence rows as they were already quite extensive throughout their pastures and one interviewee did stipulate that he would only plant more living fence rows if they were composed of trees that would provide sufficient shade for cattle and that the cattle would not be tempted to eat.

Disadvantages of Live Fences

Only three interviewees reported the disadvantages of living fences in comparison to dead posts. Two interviewees discussed the fact that in planting new living fence rows one had to be vigilant in ensuring that the cattle did not eat the saplings and one of those same interviewees also emphasized the longer time it required to arrive at an established fence line – due to having to wait for the trees to grow – as a negative aspect of living fence rows. Another interviewee discussed how living fence rows are not as conducive to changing the configurations of pastures to accommodate rotational grazing as dead posts because they cannot be moved and reconfigured.

5.3 Limitations

Challenges

In the course of the fieldwork, the interview study faced a few technical and logistical challenges that made data analysis difficult and hindered our ability to obtain a larger sample size. On the technical side, the recording equipment that we used on the first research trip in the summer of 2015 was discovered to have produced very low quality recordings only after our team had returned from the field. Therefore, the six interviews recorded during that period were difficult to hear during transcription which could have resulted in mistakes and inconsistencies in the transcripts. This unexpected challenge only compounded what was already going to be a difficult task given our team's intermediate Spanish proficiency and inexperience with transcribing in languages other than English. Fortunately, on the second research trip a different recording device was used and this problem was avoided.

Logistically, our lack of dedicated transportation during the first research trip made scheduling and conducting interviews very difficult. Also, the fact that we only conducted interviews with Paso Pacifico employees present made us reliant on them being willing to volunteer their time to participate. Finally, the time-consuming and labor-intensive nature of the biodiversity assessments demanded that they take precedence during our research trips, which further guaranteed that the interviews were only conducted when the opportunity presented itself. Due to these factors, we were not able to interview all of the potential landowners who represented our living fence row samples. This resulted in a sample size of nine interviewees rather than twelve or thirteen had we interviewed every landowner we identified when identifying our sample of living fence rows.

Sample Size

While qualitative interview studies do not require large sample sizes in order to contribute to substantive commentary on the types of research questions we are asking, a sample of nine interviews is still very small (Bauer and Gaskell 2000). Also, the interview sample only represents a little over two-thirds of the living fence rows identified for the biodiversity assessment. However, we do not believe that this compromises the usefulness of the interview data as we did not intend to offer comprehensive answers to our research questions so much as use them to guide our exploration of our sample. Instead, we see those landowners that are missing from our present sample as a potential starting point for further qualitative research that builds on what we have already established in this study.

Lack of Negative Feedback

The lack of negative feedback from reported disadvantages of living fence rows in comparison to dead posts is a potential weakness in the interview study. Our sample of interviewees was comprised of landowners who already owned living fence rows because we assumed that they would be able to speak with some experience about the advantages and disadvantages of living fence rows as a landscape feature. However, while some of these landowners did share with us what they perceived to be the disadvantages of living fence rows, the majority did not. This could be because our sample represented people who are inclined to over report the benefits of living fence rows as they own them and have invested in them. Including landowners who did not own living fence rows would have therefore provided a broader range of viewpoints and perceptions. It could also be due to the fact that the interviews carried an implicit assumption of the ecological and other benefits of living fence rows in comparison to dead posts. In this case, the interviewees perhaps did not feel that it would be acceptable to undermine this assumption and/or that it would reflect poorly on them if they did (Bauer and Gaskell 2000). Finally, it could also simply be that the question asking interviewees to name any disadvantages of living fence rows was not given priority during the interviews. Whatever the case, we do not discount the value of the contributions certain interviewees made in this regard and give these comments full consideration in the ensuing discussions.

6. Biodiversity Study

A primary objective for incorporating fence rows into Paso Pacifico's reforestation efforts is to use trees that have utility to landowners as well as conservation value for local fauna. Previous studies have suggested that living fences have ecological potential for vertebrate species (Coates-Estrada 2016; Estrada et al. 2000; Tuxtlas et al. 2016). However, to our knowledge, none have investigated the response of bees to fence rows. As trees can provide nesting resources for many bee groups and flowers for forage, the addition of living fence rows to pastures could improve the landscape's habitat value for bees. To explore this relationship, we assessed native bee diversity in living fence rows as compared to nearby open pasture at the site of dead post fences (control treatment).

Bee conservation is important and necessary for multiple reasons. In recent years, Paso Pacifico employees have worked with local honey producers to reinvigorate and disseminate knowledge of traditional Nicaraguan meliponicultural practices, with a focus on the domestication of the stingless bee *Melipona beecheii* (Apidae: Meliponini). Local Nicaraguans use honey produced by meliponine bees for medicinal purposes; bees therefore have cultural significance within the region, and their conservation is of interest to many community members.

Meliponines are abundant in the tropics and are important generalist flower visitors that pollinate multiple plant species (Heard 1999). However, they compose just a fraction of the pollinator guild that exists in Central America. The expected composition of bees in our study region is unclear, as bees have been understudied within Nicaragua overall. Currently, only 137 species have been identified for the entire country, whereas 530 species have been documented in neighboring Costa Rica (Ascher and Pickering 2015). Through our systematic sampling design, we intend to elucidate the bee assemblages present in the Paso del Istmo corridor and contribute to a better understanding of bee diversity within the country.

While it is likely that the contribution of native bees to regional food security is negligible (as the crops grown on the largest scale in the region are wind-pollinated grains), native bees may have a large role to play in pollinating kitchen gardens and orchards throughout the Paso del Istmo region (Joyce 2014). Stingless bees alone are known to visit the flowers of 90 crops and have been identified as important pollinators for 9 crops; of these, mango, coconut, chayote, star fruit, and achiote are grown in the study region. However, agricultural land use greatly alters floral and nesting resources, affecting individual behavior, population dynamics, and the community composition of all native bees. In intensified agricultural landscapes where little of the original land cover remains, the provision of

adjacent forage habitat can conserve native pollinators while supporting higher crop yields (Blaauw and Isaacs 2014). In the working and fragmented landscape of the Paso del Istmo corridor, fence row vegetation could provide valuable sources of nectar and pollen as well as nesting resources for key crop-pollinating native bees.

The goal of our research is to examine the role of living fences as drivers of bee abundance and richness across spatial and temporal scales. We assess the characteristics (structure and identity) of living fence trees that best support bee diversity, with the intention of identifying target tree species for new fence row plantings. Making this connection will help maintain pollination services to home gardens, as well as promote habitat resources for native bee populations. Given the ability of fence trees to provide nesting structures for cavity-dwelling bees and temporally varied floral resources, we hypothesize that bee abundance and diversity will be greater in living fences than open pasture (dead control posts).

6.1 Methods

Bee Survey

To test our hypotheses regarding fence rows as drivers of bee abundance and diversity, we sampled bee and vegetation resources along the lengths of each living and control fence. For each fence, we identified one 75 meter sampling transect where we conducted both pan trapping and aerial netting, as each method is subject to a different collection bias (Brosi et al. 2007).

We sampled bees during two distinct seasons. The first sampling event spanned between May and July 2015, which falls at the beginning of the rainy season in Nicaragua. However, in 2015 the region experienced a prolonged drought that extended through our sample period. Therefore, the first season of our biodiversity study will be referred to as the pre-rainy season, and we will refer to the second sampling event in December 2015 and January 2016 as occurring during the post-rainy season. Sites were sampled by pan traps approximately once every two weeks. Netting occurred once during the beginning of the pre-rainy season.

We used blue, yellow, and white pan traps to collect bees. These small, plastic bowls were brightly painted with fluorescent dye and filled with water and a small amount of soap, so that the surface tension of the water was reduced. The pan traps reflected UV light that attracted bees and other insects, which flew into the traps and drowned. To prevent water overflow and the loss of insects during a rain event, we modified our traps by punching holes around the upper rims and gluing a fine mesh fabric along the outside of the trap. This allowed water to flow out of the traps but left the insects

inside. We used 15 traps per fence, each spaced approximately 5 meters apart, and alternated colors so that traps of the same color were not next to each other. Where vegetation was low, pan traps were placed in shallow holes in the ground to prevent them from spilling. When tall grass or shrubs near the fence overshadowed the traps, we raised the traps by taping them to the fence so that they would be visible to insects flying overhead. All insects were collected approximately 24 hours after the traps were set.

Aerial netting took place within a 5x5 meter square along the 75 meter sampling area of each fence. Team members netted for 30 minutes in the morning (between 9am-12pm) and again in the afternoon (between 1pm-4pm) and only when the weather was sunny. To reduce collection bias, bees were netted in the order seen (Brosi et al. 2007).

Specimen Processing and Identification

Bees caught by aerial netting were immediately placed into 70% ethanol for storage. Bees and all other insects captured in pan traps were collected in plastic bags for temporary storage and transport from the field. Bees were then separated from non-bees, and all insects were placed in vials of 70% ethanol within two days of collection.

All bees were cleaned, pinned, and identified in the laboratory to the finest taxonomic level possible. We relied heavily on *Bees of the World*, *The Bee Genera of North and Central America*, Discoverlife.org, and the expertise of J. Gibbs at Michigan State University for identification (Michener 2000; Michener et al. 1994; Ascher and Pickering 2014). All bees were identified at least to genus. We created morphospecies designations where taxonomic keys for certain bee groups were not yet developed.

Live Fence Characterization: Composition, Structure, and Distribution

In order to identify the features of fence rows that best support bee diversity, all of the sites established in the bee study were further analyzed in terms of tree species abundance, composition, and structure. Within the established 75 meter sampling area of each site, we collected data on the tree species present, the number of trees with a stem diameter at breast height (dbh) greater than 10 centimeters, and the number of non-living posts. The maximum canopy radius was recorded for every third tree with dbh > 10 centimeters. Finally, the length of the entire living fence beyond the 75 meter sampling area was measured; endpoints of the fences were identified as areas where the fence either bisected another living fence, became contiguous with forest or reforestation, or the trees or property ended.

Floral Survey

Because bees depend on flowers as sources of nectar and pollen, we measured samples of floral resources within the fences and surrounding pastures every time bees were sampled. Flowers were surveyed either on the day the traps were set or on the day that they were collected. In order to capture the floral resources present in the living fence canopies as well as pasture, all open flowers within a 20-meter buffer of the sampling area were recorded, covering a total of 4600 square meters. Following a modified Daubenmire method (Coulloudon et al. 1996), counts were estimated into 7 binned cover classes (i.e. 1-10 flowers, 11-50 flowers, etc.) for each flower type present. Blossom size was also recorded, and total floral percent cover was calculated. Floral abundance and percent cover were then rescaled from 0-100 and averaged to produce a combined index of "Percent Floral Availability".

Morphospecies were classified in the field, and all plants were later identified at least to genus level. Most bee species are polylectic and feed opportunistically on pollen from diverse plant sources. Even the approximately 20% bees that are oligolectic, specialist pollen feeders may show preference for a closely related group of plants within the same genus (Wilmer 2011). Few species of bee are monolectic and visit only a single species of flower, even in the presence of closely related flowers (Michener 2000). No monolectic bees are known from our sample, therefore, genus–level identification of flowering plants was sufficient for our analysis.

Other Site Environmental Variables

In addition to floral resources, fence elevation was recorded in the field using a handheld GPS unit. Elevation as a variable also encompasses other related aspects of the landscape, such as forest cover and humidity, both of which tend to increase as elevation increases. Fences, both living and control, were searched once per season for bee nests, and nest presence was recorded.

Statistical Analyses

We analyzed whether our sampled bee species richness was close to saturation using EstimateS software version 9.1.0 (Colwell 2013). We also assessed the community similarities of living fence trees based on Bray-Curtis similarity matrices using PRIMER-E. Evidence for spatial autocorrelation of factors between sites was assessed in R (version 3.2.4) with Moran's I using the ape package (R Core Team 2015; Paradis and Strimmer 2004).

We used a generalized linear mixed model (GLMM) to test the explanatory effects of the living fence row treatment, season, percent floral availability, distance to stream, elevation, and presence of bee nests on bee abundance (number of individuals captured) and richness using IBM SPSS

Statistics version 22.0. Because living fences are composed of plants that experience seasonal phenological changes, we also tested in the interaction effect between season and treatment. Given our interest in understanding whether specific living fence characteristics influence bee abundance and richness, we also tested the effects of canopy radius, tree richness, and number of trees on these variables. GLMM variables were fitted upon a negative binomial distribution, with random intercepts and bee numbers offset by the number of traps recovered during each sampling period. We used site cluster as a blocking effect to address the presence of spatial autocorrelation between sites.

6.2 Results

Across both seasons and treatments, we sampled 1655 bees; 68 bees were netted and 1580 were pan trapped (Appendix B, Table 1). Trapping efforts varied between sites and seasons. Sites C-J were sampled with pan traps four times during the first sampling season and twice during the second season. Site A was pan trapped only once, during the first season. Sites K and L were pan trapped twice and only during the first season. Site B was pan trapped three times during the first season and twice during the second season. Sites M and N were trapped twice and only during the second season. We netted at sites A-L once during the first season and were unable to net at sites M or N. Due to the uneven netting efforts across sites, the analyses in this report focus on pan-trapped bees only.

Once incomplete and netted specimens were removed, we analyzed 1550 bees in 43 morphospecies, representing four families, 14 tribes, and 30 genera. The morphospecies accumulation curve for all bees captured approaches but does not reach an asymptote, which is common of studies of insect diversity in the tropics (Figure 2).

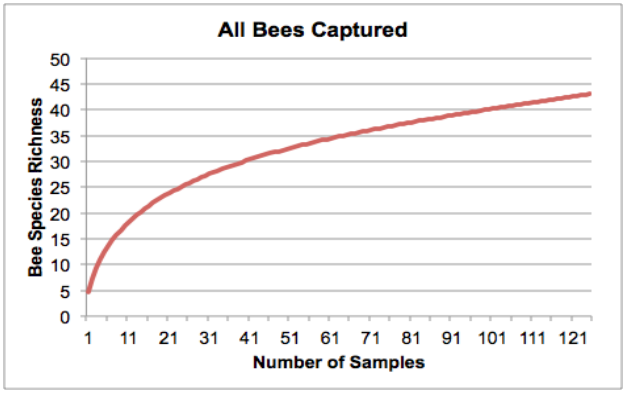


Figure 2. Observed species accumulation curve reaching 43 morphospecies.

Despite greater total bee abundances in the second sampling season than the first, observed richness was lower (though not significantly so). With seasons combined, the living fences captured 27 morphospecies in 62

samples. In comparison, overall richness was higher in the control fences, which produced more than 34 morphospecies after the same sampling effort. However, across both seasons, meliponine richness was greater in living fences than control fences. The only significant difference in richness between fences occurred during the post-rainy season, where richness for all bees captured were higher in the control than living fences (Appendix B. Figures 4-8).

Landscape Predictors of Bee Abundance

For all landscape factors tested, season, elevation, fence treatment, and the presence of a bee nest were most associated with overall bee abundance. Bee abundance significantly decreased per meter increase in elevation, though this change was slight (β=0.010). The season of capture also had a significant effect on bee numbers, as the total abundance of bees increased by a factor of 0.758 post-rain (P=0.007). As compared to living fences, control fences captured more bees per trap, though this difference was not significant (P=0.095). Further, the interaction between season and fence treatment had a compounding effect on bee numbers, with control fences in the pre-rainy season showing the greatest increase in abundance in reference to all other combinations of the two factors (significant at P<0.05). Though not significant at the 0.05 level, the presence of a bee nest also contributed in increased total bee abundance (β=0.311, P=0.206). See Appendix for the fixed effects and fixed coefficients tables.

Two morphospecies in our sample occurred in extreme abundance: Lasioglossum morphospecies 5 and Diadasia morphospecies 1, composing 19% and 40% of the total bee abundance, respectively. Because these morphospecies could have been drivers of the patterns in our data, we also tested all predictive factors with these bees removed (i.e. analysis of non-dominant abundance). Non-dominant species abundances were most associated with treatment, season, and elevation. Similarly to overall bee abundance, non-dominant abundance increased in the control fences compared to living fences; however, for this group of bees, the effect was significant (β= 0.940, P=0.006). When dominant species were excluded from the analysis, bee abundances were greater in the pre-rainy season and decreased per meter increase in elevation, though neither of these effects were significant (P=0.088 and P=0.060, respectively). The interaction effect between season and treatment was not significant. Also in contrast to the analysis for overall bee abundance, the presence of a bee nest did not have an association with non-dominant species abundances (Appendix B, Tables 5-12).

Given the importance of species in the tribe meliponini for local honey production, we also explored the influence of our identified landscape factors on meliponine abundance. The presence of a bee nest had a significant and large multiplicative effect on meliponines captured (β=1.191 compared to no

nest, P=0.007). Meliponines also showed a strong positive response to living fence rows, with season also having an important association with abundances, though neither of these effects was significant (P=0.962 and P=0.064, respectively). The compounding effects between season and treatment indicate that meliponines experience increased numbers in living fences during the pre-rainy season in comparison to control fences under the same seasonal drought conditions (Figure 3. See Appendix B, Tables 5-12 for effects and coefficients tables). Finally, the floral index, which was not associated with changes in total or non-dominant bee abundances, was positively associated with meliponine numbers (β=0.014, P=0.292).

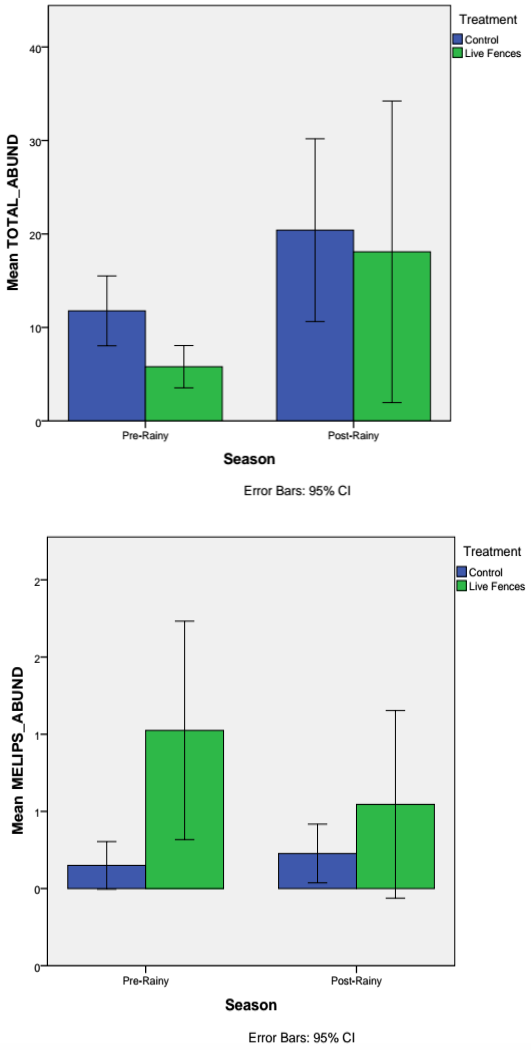


Figure 3. Total abundance and meliponine abundance by treatment in both pre-rainy and post-rainy seasons. All patterns are statistically marginal.

We discovered six bee nests between all of our 28 fence sites; of these, five were located in living fence trees and one was in exposed, bare soil near a control fence. Due to the associations between bee nests and bee abundances, we used a binary logistic regression to test the effect of fence treatment on

nest presence. Though treatment did not have a significant effect on nest presence (Wald χ^2=2.816, P=0.093), the coefficient suggests that nests are increased in living fences compared to control fences (β=1.977). The significance of the treatment is likely low due to our small sample size.

Living Fence Predictors of Meliponine Abundance

Given the positive response of meliponines to living fences rows, we analyzed specific characteristics of our sampled live fences to find whether any of these factors was associated with meliponine abundance in fence rows. Season was also included in the analysis to encapture the phenological differences in the living fences pre and post rain. This analysis of local, fence effects suggests that the factors most associated with meliponine abundance were the presence of a bee nest, season, number of tree species, and mean radius of the tree canopy. Meliponine abundances were significantly increased in fences where nests were present and in living fences during the pre-rainy season (P=0.021 and P=0.030). An increase in the number of fence tree species was associated with a slight but significant decrease in meliponine abundance (P=0.017). Greater meliponine abundance was also associated with smaller canopy radii, though changes in this measure did not significantly impact abundance (P=0.337).See Appendix B, Tables 5-12 for coefficients tables.

6.3 Limitations

Data Collection

The results of our current analysis are based solely on pan-trapped data. This method is subject to bias toward collecting halictid bees and tends to undersample bees in the families Apidae and Mecaghilidae (Brosi 2007). Further, previous studies have shown that pan traps can perform poorly under canopy cover (Brosi 2008). Though we were unable to net consistently across sites, incorporating netting data into future analyses may alter identified trends for certain bee groups.

Study Design

Despite the presence of living fence rows in all stages of growth across the region, our site selection process favored mature fences in the pastoral landscape. Therefore, our data do not reflect the ability of immature fence rows to provide biodiversity support but instead the potential that newly planted fences could eventually provide as they reach their end stage of growth. We also cannot determine from our analysis the length of time between the establishment of a new fence and the point at which its benefits to bees will be observed.

7. What are the structural and compositional characteristics of the living fence rows in our sample?

7.1 Relevance

Understanding the characteristics of the living fence rows in our sample is necessary to establish a contextual framework for the ensuing discussions of landowner perceptions and invertebrate activity. More importantly, our sample represents the existing living fence rows that match the criteria Paso Pacifico would probably want to mirror when promoting new living fence rows as part of their current reforestation program. Comprehending how the samples vary in terms of age, species composition, structure, and spatial distribution is important for gleaning information on how these characteristics affect both the human and natural aspects of the larger system.

7.2 Discussion

Using both the data on our sample of living fence rows gathered from the biodiversity assessment and the information gathered from the landowners in our interview sample, we explored the age, structure, species composition, spatial distribution, and presence of animals in the living fences in our study region.

Live Fence Age

In our conversations with landowners we asked them to report the age of their living fence rows. The youngest age reported was twelve years old and the oldest was possibly more than eighty. In this range, the majority of landowners reported their living fences to be around thirty years old or older. We expected that the living fence rows in our sample would be older as we targeted sites with mature live fences with connected canopies. Some interviewees reported planting the living fences themselves and others claimed that a former agricultural cooperative or a family member had planted live fences on the land before they came to own it. Other than two landowners who planted their living fence rows and therefore gave more exact estimates of twelve and thirty years respectively, all of the other landowners inherited their living fence rows or potentially inherited their living fence rows and were therefore reporting rough estimates. Given that many of these landowners have owned their land for a long time, the fact that they inherited the living fence rows indicates that these features have become more or less fixed in the landscape.

Live Fence Species Composition

A total of 285 trees were identified and described across all sites (sample size = 14 living fences). *Gliricidia sepium*, locally called madero negro, was the most abundant tree, making up 68.42% of the total fence trees. *Guazuma ulmifolia* (guácimo) was the next most common tree, composing 6.32% of the sample. Twenty-two different tree species were observed in the live fences that we visited (Appendix B, Figure 2). The mean number of species per fence was 3.62. The living fence row at site H, the only non-cooperative site sampled in Tortuga, had the highest richness with 8 tree species. Five of the 14 fences contained only two tree species; where this occurred, one of the two species was *Gliricidia sepium* (Table 1).

Table 3. Tree species composition of sampled fences

Region	Site	Tree Species Richness	2 Most Common Species (Percent of Fence Composition)
La Rejega	A	2	*Gliricidia sepium* (81%), *Guazuma ulmifolia* (19%)
La Rejega	B	3	*Gliricidia sepium* (74%), *Guazuma ulmifolia* (21%)
Escamequita	C	2	*Vachellia cornigera* (63%), *Gliricidia sepium* (37%)
Escamequita	D	5	*Gliricidia sepium* (53%), *Vachellia collinsii* (32%)
Escamequita	E	4	*Gliricidia sepium* (83%), *Guazuma ulmifolia* (9%)
Escamequita	F	4	*Gliricidia sepium* (57%), *Dalbergia retusa* (29%)
Escamequita	G	6	*Gliricidia sepium* (64%), *Myrospermum frutescens* (20%)
Tortuga	H	8	*Gliricidia sepium* (54%), *Piscidia grandifolia* (13%)
Tortuga	I	2	*Gliricidia sepium* (64%), *Crescentia alata* (36%)
Tortuga	J	4	*Gliricidia sepium* (60%), *Crescentia alata* (20%)
Cardenas	K	4	*Gliricidia sepium* (78%), Unidentified Spp. 2 (15%)
Aceituno	L	3	*Gliricidia sepium* (67%), *Vachellia collinsii* (53%)
Tortuga	M	2	*Gliricidia sepium* (96%), *Myrospermum frutescens* (4%)
La Rejega	N	2	*Gliricidia sepium* (92%), *Ficus* spp. (8%)

Ordination by nonmetric multidimensional scaling (nMDS) did not elucidate patterns of similarity between sites based on cluster (Appendix B, Figure 4). A Bray-Curtis based ANOSIM confirmed that there were no significant differences in tree species abundances between site clusters (Global R: -0.145, P value: 0.894 with 999 permutations). This is likely a product of management and tree choice explained by the prevalence of *Gliricidia sepium* across all sites.

The prevalence of *Gliricidia sepium* in our analysis is corroborated by the landowners in the interviews as all eight of those who identified the most prominent tree species in their live fences reported *madero negro*. Interestingly, none of the landowners identified *guácimo* despite it being the second most prevalent tree species in our analysis. They did identify other tree species however such as *guachipilín* (*Diphysa americana*), acacia (*Vachellia cornigera*), *chiquirin* (*Myrospermum frutescens*), *jicaro* (*Crescentia alata*), and *aceituno* (*Simarouba amara*).

Live Fence Structure

Although all of the fences that we sampled contained a single row of trees interwoven with dead posts and barbed wire, the structure of the fences varied based on the species present and their density of planting. The mean length of all fences (extending beyond the 75 meter sampling area) was 1005.05 m. The mean tree density, regardless of diameter, was 0.28 trees m^{-1} and ranged from 0.17 trees m^{-1} to 0.49 trees m^{-1}, with the densest fence also being the one with the greatest species richness (site H). When considering trees with a diameter at breast height greater than 10 cm, mean density was 0.26 trees m^{-1} and ranged from 0.17 trees m^{-1} to 0.41 trees m^{-1}. Mean canopy radius varied from 3.92 m to 8.70 m, with smaller canopy radii occurring in fences heavily composed of *Vachellia collinsii* (Table 2).

The amount of pruning and the incorporation of regenerated trees certainly influence the structure and species composition of living fence rows. Though we gathered information on landowner uses of live fences, we did not ask specifically ask them about their management practices (e.g. frequency of pollarding). In addition, we did not inquire into landowner preferences of using planted trees compared to naturally regenerated trees in fences. However, we could infer that the majority of trees that we sampled were intentionally incorporated into fence rows because, by design of our biodiversity study, the fences were linearly arranged across pasture and not opportunistically created on the borders of forest or riparian areas.

Table 4. Structure of sampled fences

			Within 75m Area Sampled for Bees:				
Region	Site	Total Length of Fence (m)	Total Number of Trees	Number of Trees dbh >10cm	Number of Dead Posts	Total Tree Density (m^{-1})	Average Canopy Radius (m)
La Rejega	A	154.81	22	21	13	0.29	5.54
La Rejega	B	216.60	19	19	26	0.25	5.28
Escamequita	C	323.82	19	19	54	0.25	6.75
Escamequita	D	78.26	26	19	18	0.35	3.92
Escamequita	E	162.48	23	23	11	0.31	6.52
Escamequita	F	198.07	15	14	20	0.20	8.70
Escamequita	G	3580.14	25	25	38	0.33	5.62
Tortuga	H	107.45	37	31	23	0.49	5.57
Tortuga	I	735.21	14	11	35	0.19	5.77
Tortuga	J	385.95	15	15	41	0.20	5.86
Cardenas	K	5875.71	27	27	21	0.36	5.33
Aceituno	L	242.05	15	15	64	0.20	4.62
Tortuga	M	Not Measured	25	24	22	0.33	5.25
La Rejega	N	Not Measured	13	13	34	0.17	5.99

In addition to these measures of our sample live fences, we asked the landowners in our interview sample to estimate the total length of all of the living fence rows on their lands. The cooperative (sites I and J) estimated that all of the living fence rows in or around their pastures in total are around 15,000 *varas* or approximately 12.5 kilometers in length, which is by far the

largest estimate in our sample. Three others estimated that their total live fences are three kilometers (site D), two kilometers (site C), and one kilometer (site H) in length respectively. Two more estimated that their total live fences are 500 *varas* or about 400 meters (site M) in length and another two estimated that their total live fences are 300 *varas* or about 250 meters (sites A and N) in length. Given that these estimates represent the total length of all live fences on a landowner's land they expectedly do not match the numbers we collected in our measurements of the lengths of the live fences in our sample of living fence rows. Instead, they merely provide a context for the extensiveness of live fences on any given property and show a roughly even split in our landowner sample between those who have more extensive living fence rows on their land (one km or more) and those who have less extensive living fence rows on their land.

Live Fence Distribution within Farms and the Landscape

The interviews asked landowners to identify where their living fence rows were located on their property and whether they primarily formed boundaries or were used to delineate sub parcels within the property. Six landowners responded and all six claimed that their live fences made up some of the boundaries of their pastures and/or property. Two landowners also highlighted the role that their living fence rows played in dividing up their pastures into smaller parcels.

On the landscape level, all of the fences sampled were part of a larger tree network, either connecting perpendicularly to another living fence on the property or disappearing into forest or reforested areas. Nine of the 14 living fences were directly connected to a forest patch, six were connected to another living fence (with one fence bridging the gap between forest and a greater fence network), extending the connection of trees across the pastoral landscape.

Animals in Live Fences

Paso Pacifico has a specific interest in whether or not arboreal mammals such as howler and spider monkeys use living fence rows because one of the eventual goals of a reforestation program that promoted live fences would be to have these features serves as arboreal corridors for such species (Asensio et al. 2009, Estrada et al. 2006). Unfortunately, our data on how animals such as monkeys use the living fence rows in our study region are limited to the single question we asked of our interview sample in regards to their personal observations of animals in their live fences. This however should not discount the encouraging reports from these landowners. Two-thirds of our sample has observed howler monkeys in their living fence rows and three of those landowners have also seen spider monkeys. Two of these landowners even directly observed the monkeys using the live fences to navigate like one would use *un camino* (a road). The landowners in our

sample also reported seeing a variety of other animals in their living fences such as sloths, iguanas, birds, squirrels, and bees. Though very limited, this measure indicates that within even our very small sample of landowners observations of arboreal mammals like monkeys in living fence rows are not at all uncommon and in fact account for the majority of responses.

7.3 Conclusion

With the survey of our living fence row sample and the data gathered from the interviews we found that our sample of live fences are for the most part thirty to forty years old and are predominantly composed of *Gliricidia sepium* arranged in linear rows through pasture land, but also connected to larger tree networks in the form of forests or other live fences. The relative homogeneity of our living fence row sample is in some ways an effect of our careful site selection process, but is also therefore indicative of the best sample we could identify in our study region of mature live fences with connected canopies that divide pasture land. The abundance of *Gliricidia sepium* can be explained by the fact that it is a very common tree to use in living fence rows due to the ease with which it can grow from a stake (Harvey et al. 2005). Not only does detailing the characteristics of the living fence rows in our sample provide us with a contextual background for the following discussions but it allows us to produce more informed recommendations for Paso Pacifico. This information about species composition, structure, and spatial distribution allows to better predict the effects of various species compositions in living fence rows and to optimize each configuration in accordance with the desires of landowners and the ecological needs of the surrounding natural communities

8. How do the landowners in our sample perceive living fence rows?

8.1 Relevance

In order for Paso Pacifico to determine whether or not a reforestation program involving the implementation of living fence rows would be feasible in the study region, some measure of the local perceptions of living fence rows is necessary to ensure that landowners would be amenable to planting such landscape features. If the landowners view living fence rows favorably and are convinced that they are a worthwhile investment, then it should not be difficult to recruit a number of them into a reforestation program that involves the planting of live fences. It is also important to understand how landowners think living fence rows can contribute to and improve the working landscape of the region by potentially offering benefits to both humans and cattle that dead posts do not. If they do not perceive living fence rows to be useful outside of their role as fence lines, then perhaps they would only be interested in a reforestation program that focused on living fence rows solely as a result of potential programmatic benefits. Considerations such as these explain why this research question is of importance to our study, and why we decided that we would need to conduct interviews in order to address the social dimensions of our sample of living fence rows.

8.2 Discussion

In analyzing the interview data we identified three prevailing trends in how landowners in our sample perceive living fence rows: a perception of living fence rows as useful, a perception of living fence rows as long-term investments, and a perception of living fence rows as environmentally beneficial.

Perception of Living Fence Rows as Useful

Based on our discussions with landowners of living fence rows, these landscape features are employed for a variety of reasons that exceed their use as a means of delineating boundaries, although that use is still a primary function. For instance, most of the interviewees emphasized the fact that living fence rows are a source of firewood and wood for construction, citing this as an advantage that living fences have over dead posts. A number of other studies have also found evidence of landowners in different parts of Latin America using living fence rows to obtain these resources (Harvey et al. 2005, Suarez et al. 2011). However, our findings are interesting in comparison to the findings of a previous study in nearby regions of Nicaragua and Central America that found this practice of harvesting timber or firewood

from living fence rows to be pretty uncommon as landowners preferred harvesting such resources from trees dispersed within pastures (Harvey et al. 2005). While we would hesitate to declare our findings contradictory given our relatively small sample size, this practice seemed to be quite common in our sample with all but two interviewees stating that they harvested either firewood or timber from their living fence rows. One landowner, who was enrolled in a reforestation program, told us that he was not permitted to harvest resources from this reforested area without consultation whereas he was not bound to any such restrictions in his living fence rows. This could help explain our findings as all four of the interviewees who were reforesting some of their land also reported harvesting resources such as wood or firewood from their living fence rows. However, almost just as many interviewees who were not reforesting their land also reported harvesting one of these resources from their living fences. The landowners in our sample also identified the usefulness of living fence rows for producing stake cuttings that can be used to replace posts in a fence composed of dead posts or produce new living fences, another finding supported by other studies (Harvey et al. 2005, Zahawi 2005).

Along with their usefulness for humans, our sample highlighted the usefulness of living fence rows in providing shade for cattle, which they emphasized as an advantage of living fences over fences composed of dead posts. One interviewee even insisted that if he were to consider planting new living fences he would only do so if the fences were composed of tree species that were guaranteed to provide shade for his cattle. In another contrast with the study by Harvey et al. – which found that landowners saw too much shade as a drawback due to its potential to decrease grass productivity and therefore took measures to control the crown size of the trees in their living fence rows – our sample of landowners did not discuss any disadvantages of shade or identify any management activities that would control for shade such as pollarding (Harvey et al. 2005). Additionally, our sample did not put lot of emphasis on the ability of living fences to provide forage for cattle as only two interviewees mentioned this as a potential use for their living fence rows. In contrast, the usefulness of living fence rows in providing forage was something that was widely acknowledged in the Harvey et al. study though few landowners actually managed their living fences for this due to the labor involved (Harvey et al. 2005). Finally, only one of the interviewees mentioned that living fences are useful as windbreaks to protect cattle from strong winds.

What this suggests to us is that our sample of landowners is aware of the variety of uses of living fence rows that benefit both humans and cattle and understand that this usefulness provides an advantage to living fences over dead posts. What is not so clear is whether or not our sample actively manages their living fence rows for any of these uses or how often they take advantage of any of these uses. The Harvey et al. study however did question

landowners on their management of living fence rows and found that over half of their sample was actively involved in managing their living fences as an integral component of farm management. The landowners in their sample pollarded the trees to reduce canopy cover and shade, planted new trees in fence rows to increase density, and pruned the trees in their fences, leaving the scraps from the prunings in the pasture for the cattle to feed on (Harvey et al. 2005). Given that we did not directly ask landowners whether or not they managed their living fence rows, there is a chance that most of our sample does not even though they may still take advantage of the resources the living fences provide. If this is the case, it would explain why our sample did not focus on controlling for shade or draw out more the potential for living fence rows to provide forage for cattle as these are intentional management activities. In addition, the fact that many of the landowners in our sample inherited their living fence rows rather than planted them could influence their status as managers. Indeed, there is a question to pose here about whether or not a landowner who intentionally plants a living fence will be more inclined to actively manage it than a landowner that inherits a living fence as a feature of the landscape.

Perception of Living Fence Rows as Long-Term Investment

The landowners in our sample put a strong emphasis on the fact that living fence rows are a long-term investment. Most considered this to be an advantage that living fences have over dead posts due to the fact that a living fence row, once established, takes less maintenance because the posts do not need to be replaced every five to fifteen years. However, some found the period of time in which it takes a living fence to become established as a disadvantage in comparison to a fence composed of dead posts because one has to be vigilant in taking care of the vulnerable saplings in this period. Also, echoing sentiments that were expressed by some of the landowners in the Harvey et al. study (2005), one landowner mentioned the fact that the permanence of living fences in a landscape can prohibit the ability to reconfigure pastures for rotational grazing whereas dead posts are much easier to rearrange. A valid question to pose here is how much active management plays into whether or not landowners perceive living fence rows to require less maintenance than fences composed of dead posts, especially if they are actively managing them in the same capacity as the sample from the Harvey et al. study (2005). In addition, there is a chance that the landowners in our sample view the long-term investment in landscape features like living fences positively because they are mostly long-term owners who appear to be secure in their tenure status. If this is the case, it would be interesting to explore how landowners who have not owned the land for as long or who are renters of land perceive the relative permanence of living fence rows as a landscape feature. Regardless of the positive or negative connotations of perceiving of living fence rows as a longer-term investment than a fence composed of dead posts, the fact that this perception was related to us so frequently indicates that the landowners in our sample are well aware of the potential trade-offs

resulting from the difference in temporal dimensions between these fence rows options.

Perception of Living Fence Rows as Environmentally Beneficial

Although less common than the previous two perceptions of living fence rows, a few landowners in our sample did wish to emphasize the environmental benefits that living fences have over dead posts. One landowner discussed the benefits of living fence rows as an investment in the future by highlighting how this investment was beneficial to the environment because it does not demand that trees be cut down to furnish new posts. While this statement does not directly comment on the deforestation that has devastated Central American forest habitats it certainly recognizes the importance of conserving trees in the region. Another landowner understood that the trees in living fence rows help conserve water on the land. The final landowner who perceived some environmental benefit to having living fence rows stressed the fact that if there was more environmental education in the region so that landowners realized the benefits of trees and forests they would also realize the benefits that living fence rows can provide in working landscapes devoted mostly to pasture.

8.3 Conclusion

Our conversations with the landowners in our sample revealed that they generally perceive that their living fence rows provide resources to humans and cattle that dead posts do not, they for the most part perceive of living fence rows as a positive and worthwhile long-term investment with some drawbacks, and a few of them perceive of living fence rows as having benefits for the environment. These findings are a positive sign for the idea of promoting living fence rows in a reforestation program as it appears that the landowners we talked with are fairly knowledgeable about the benefits of living fences and would probably be interested in planting new living fence rows; as many of them already indicated in the interviews. However, we recommend that further research will be necessary in order to build on these findings by including a larger and more diverse set of landowners in the region. First of all, more interviews will need to be conducted in general as our sample size of nine is not only not representative of all the landowners we identified with living fence rows that matched our strict criteria but is also not representative of all of the landowners with living fence rows or without living fence rows in the study region. Including landowners without living fence rows in future interview studies may be necessary to determine if there are reasons for why certain landowners choose not to have living fence rows. It would be interesting to know if some of the disadvantages discussed by the landowners in our sample are used to justify not investing in living fence rows and if there are reasons for why these factors hold more sway over certain landowners as this would be important in designing any program for the promotion of living fences. Also, if there is a contingent of landowners who

do not have living fences because they are simply not aware of or knowledgeable about living fence rows this would stress the need for an educational component of any potential program. Furthermore, attempting to include newer landowners or people who rent the land they work would help to tease out the relationship between viewing the long-term investment that living fences represent as positive or negative and the tenure status of a landowner, perhaps illuminating the types of landowners that are most likely to be amenable to investing in living fences.

For future interviews there should be some minor revisions to the interview script in the form of additional questions. One question should directly ask landowners who own living fence rows who planted those features. This would help to determine if there is a difference between landowners who have inherited their living fences and those who have planted them in terms of how they perceive and manage living fence rows. Another more important question would be to directly ask landowners with living fence rows if they actively manage their fence rows and how, allowing a future study to make more informed judgments about whether or not different levels of management activity of living fence rows have an effect on how landowners perceive living fence rows. Adding extra clarity to how perceptions of living fence rows are related to these different factors would only improve any program that Paso Pacifico could create in order to promote these landscape features among landowners in the region.

Our findings in regards to how the landowners in our sample perceive living fence rows are an important first step in exploring the social dimensions of living fence rows in our study region. These findings indicate that more work is needed in order to make truly informed judgments on how the perceptions that we found to be most prevalent in our study are related to factors such as a landowner's tenure status or a landowner's level of investment in terms of planting and managing living fences. There is also the potential that future work with a larger sample of landowners could reveal important perceptions that were not illuminated in our work. The need for more research to build on our initial findings should be regarded as an encouraging sign for Paso Pacifico's intentions as it indicates that there is a real possibility that landowners in the region have positive and informed perceptions of living fence rows and would be interested in a program that allowed them to invest in these landscape features.

9. How do bees respond to the living fence rows in our sample?

9.1 Relevance

The ecological roles of living fences must be explored if Paso Pacifico is to incorporate these features into conservation planning at the landscape scale. To begin the conversation of how fence rows can contribute to biodiversity conservation in the Paso del Istmo corridor, we examined the response of bees to existing fences in the region. Bees are an important taxon that has cultural, economic, and ecological value in southwestern Nicaragua. Our research lends a greater understanding of how living fences function to provide nesting habitat and resources for bees in this fragmented pastoral landscape. If Paso Pacifico chooses to integrate living fences rows into its conservation programming, correlating bee response to fence tree composition, diversity, and structure will help inform its planting decisions.

9.2 Discussion

Overall, our hypothesis that bee diversity and abundance would be greater in living fence rows compared to open pasture was not supported. The data show that bee responses to living fence rows varies by bee identity and across seasons. If consideration were given only to the complete bee assemblage captured by our sampling efforts, the influence of living fence rows on bee abundance and richness appears weak to negligible. However, further analyses reveal more nuanced relationships between living fence rows, open pasture, and native bee groups.

Determinants of Bee Abundance

We did not detect any changes in total bee abundance across fence treatments. When only the non-dominant species were analyzed, the treatment effect became significant, with more bees caught in the control fences. Interestingly, the species that were removed for this analysis belong to the genera Diadasia and Lasioglossum, two clades that are composed of primarily ground nesting bees. Despite this, the open pasture near the control fences did not seem to influence abundances of these bees in the control fences.

The impact of season on bee richness and abundance was variable and compounded the effect of the fence treatment. When considering all bees captured, richness was significantly higher in control fences during the post-rainy season. The control fences in this season are also associated with

significantly greater total bee abundance. However, during the season of extended drought, control fences did not support increased bee numbers.

Meliponines also experience seasonal differences in abundance between fence treatments. Unlike the complete bee assemblage, this group showed a strong positive response to living fence rows in the pre-rainy season that was not experienced in the control fences during the same seasonal conditions. This suggests that living fence trees could play a role as habitat refuges for meliponines during dry periods, even in the event of an extended drought like the one the region experienced leading up to the beginning of our sampling period. In addition, the floral index (combined percent cover and blossom abundance) within 20 meters of the fence sites supported increased meliponine numbers, despite not being associated with abundance for the entire bee community. Though little is known about meliponine foraging ranges, their small body size predicts a smaller flight distance (Roubik 1992). Therefore, it is reasonable that local forage resources such as those provided by living fence trees could be more important for this group than others.

Trees and Meliponines

Our data reveal a few living fence-specific characteristics that support increased meliponine abundance. The presence of a bee nest in a living fence led to a significant increase in meliponine numbers. Our regression results do not allow us to predict the presence of a bee nest based on fence treatment. However, this is likely a product of our small sample size, and the trend is still worth noting. Though only six nests were identified across all fences, five of these nests occurred in living fence rows (amounting to more than one third of our sampled living fences). Of these five nests, four were found in the trunks of *Gliricidia sepium*.

Tree diversity also influenced meliponine numbers; abundance decreases with increasing number of fence tree species. This finding suggests that meliponines prefer fences with lower richness; in our sample, fences with the lowest richness were composed mainly of *G. sepium* and one other tree species that varied by site. The increase of meliponines in *G. sepium*-heavy fences could be explained by either the presence of nests in these fences or the fact that *G. sepium* was one of the few trees in flower during the post-rainy season sampling period.

Finally, canopy structure also influenced meliponine abundance; we caught more meliponines in fences with smaller canopies. This effect of small canopies was not significant and is difficult to interpret. The mean canopy size of the sampled living fences may be a product of the growth habit of trees composing the fence. Alternatively, canopy size could result from management practices. If the latter is the true, it is possible that culling trees will not affect bee abundances in fence rows.

9.3 Conclusion

Our results elucidate some important trends between the living fence rows in our sample and native bees in the Paso del Istmo corridor. Though the response of bees to living fences varied between bee groups, members of the locally important tribe Meliponini showed particularly positive reactions to fence trees that became stronger in the dry season when resources were otherwise scarce. Therefore, living fence rows do have conservation value to native bee species. Importantly, meliponines prefered the fence rows in our sample that were mainly composed of *Gliricidia sepium,* a finding that is amenable to current fence establishment practices. By continuing to plant this select tree species, landowners can positively contribute to bee diversity in the region.

10. Recommendations

We explored the social and ecological dimensions of our live fence sample by focusing on three distinct research questions: 1) What are the structural and compositional characteristics of the living fence rows in our sample? 2) How do the landowners in our sample perceive living fence rows? 3) How do bees respond to the living fence rows in our sample? We found that the fence rows in our sample are composed primarily of mature *Gliricidia sepium* arranged in linear rows through pastures and connected with larger tree networks in the form of forests or other living fence rows. We also found that the landowners in our sample have positive perceptions of how living fences provide a variety of resources and services for humans, cattle, and environment, and are a worthwhile long-term investment. Finally, though bee responses varied by season and identity, bees of the locally important tribe Meliponini showed a strong positive reaction to the living fences in our sample, indicating that fence rows can provide necessary resources for tree-nesting species.

Based on our findings, we recommend Paso Pacifico consider augmenting its existing reforestation program to include a living fence row aspect. We believe that these structures can be beneficial in the same vein as traditional reforestation, albeit in different ways and varying degrees. At this point in time, local cultural norms and understandings of the importance of the cleared pasture and cropland that has fragmented natural systems conflict with recommendations to implement more invasive and land intensive agroforestry or silvopastoral systems. We see living fence rows as unique landscape features that offer a clear opportunity to engage interested landowners with a reforestation program as a step in the right direction toward higher biodiversity and healthier ecosystems.

When crafting this program, it is important to do a thorough analysis of landowner needs and vision for the future. This will guide Paso Pacifico in species selection and optimization processes to be included in proposed plans and possibly cultivation in their nursery for distribution. There are non-site-specific criteria we believe are important for consideration when planning this program; the first being that species that can regenerate from live stakes should be given preference because growth time will be shortened significantly for establishing a stable fence, and repairing the fence in the future will be a less arduous and time consuming task. Even after a stake has taken root and is physically established as a free standing plant, the species' ability to maintain a sturdy structure and root system as it matures is also worthy of consideration. In areas subject to strong winds and heavy precipitation, it is best to select a species of tree that can withstand these stressors from an early age so that landowners may be confident in their

investment. Trees that are native to the area will be better suited to thrive in these natural areas than most non-indigenous species, and will be more beneficial to local organisms that have evolved alongside them, forging interdependent and specialized relationships for millions of years.

Other factors that must be considered when choosing tree species are their invasibility and regeneration tendencies. Trees that regenerate quickly and easily can be an unnecessary burden to landowners who wish to only keep a single line of trees. Toxicity is also an important aspect to consider. Some tree species produce leaves, fruit, etc. that can be harmful to humans or animals and potentially dangerous to keep on the property. In addition, some species, such as *Eucalyptus deglupta* (Daehler 2005) are allelopathic and can inhibit growth of neighboring plants, an obviously undesirable trait for a living fence row placed next to cropland.

Live fences will be most effective and dynamic if they mimic natural structures existing in the surrounding native ecosystems. This is best thought of as a vertical layering system that includes the following layers: 1) tall canopy 2) understory 3) shrub and 4) ground. The canopy trees would hold the barbed wire and be the backbone of the live fence. The understory and shrub sections would consist of more shade tolerant species, and the last segment would be made of grasses and shorter vegetation (Appendix C, Figure 9). Alternatively, the barbed wire could be used as a trellis structure to support vining plants (Appendix C, Figure 10). It is up to landowner discretion to select species that fit their needs or augment the effectiveness of their current system. For example, if the live fence abuts cropland, it would be best to select tree species that would attract desirable insects to the area and encourage pollination of the surrounding plants. If the fence frames grazing land, plants that would produce extra fodder for livestock would likely be the most beneficial. We also suggest temporal planning and phenological analysis for the trees in question, so that resources and benefits may potentially be distributed throughout both the rainy and dry seasons to ameliorate seasonal lulls in economic or ecological productivity.

These layers can also serve as protection buffers for young trees planted with the intention of harvest or increasing the fence's structural integrity. There is a risk of predation and soil compaction from domesticated animals or wildlife that could inhibit growth. In terms of native ecosystems, this structure is beneficial in several ways: the diversity of resources available to indigenous fauna and overall productivity are increased with minimal impact in terms of utilizing horizontal space and encroaching on the working landscape. While there is not much expansion laterally, the amount of biomass is still significantly increased, contributing to shade and cover that larger taxa tend to prefer when traveling through an area, creating a practical corridor for species negatively affected by the previous forest fragmentation. The farming community would still have the opportunity to selectively prune

or thin vegetation within the live fence to increase visibility while still maintaining the integrity of the vegetative cover provided by the fence row. This may an important issue for landowners who are concerned about jaguar presence and livestock predation.

In conclusion, these potential corridors could be an exciting chance to help wildlife thrive while capitalizing on an opportunity to augment the economic potential of their working landscape as well as fortify the ecological integrity of the surrounding area, increasing biodiversity levels and resilience capacity in a highly variable and fragmented region.

Appendix A: Semi-Structured Interviews

Interview Script

English

General Demographics

- What is your name and place of birth?
- How old are you?
- How long have you lived here?
- Do you own property in this area? Manage property?

Property Information and Basic Land Use

- How much land do you own or manage?
- How long have you owned or managed this land?
- How did you come to own or manage this land?
- What do you do on your land?
    - Do you use your land for livestock? How many hectares? How many livestock? (Details about livestock?)
    - Do you use your land for cultivation? What crops and how many manzanas each?
    - Do you use your land for reforestation or forest conservation? How many manzanas?
- What do you plan on doing on your land in the future?
    - Do you have any short or medium term plans to change how you use the land?
    - Would you ever sell your land? Will your children inherit it?

Living Fence Rows

- How many meters/varas, roughly?
- Do you have living fence rows all around your property or only in certain parts?
- Do you have living fence rows delimiting sub parcels within your property?
- How old are the living fence rows? Were they there when you acquired the property, or did you create them?
- What tree species are included in your live fences?
- Have you ever seen any animals using the trees in your live fences? Which animals?
- Do you use the trees in your live fences for purposes other than demarcation of property boundaries? (For example: timber, firewood, to provide fodder for animals, etc.)
- Did your property have other live fence rows in the past that are no longer there? If so, what happened to the old fence rows? Why were they lost or removed?

- Do you think there are advantages to having live fences instead of barbed wire fences with wooden posts? Do you think there are disadvantages to having live fences instead of fence posts?
- Would you like to have more live fences on your property? Why or why not?

Spanish

Información Básica

- ¿Cuál es su nombre y apellido? ¿Dónde se nació?
- ¿Cuántos años tiene?
- ¿Cuántos años tiene Ud. de vivir en esta comunidad?
- ¿Es dueño de una propiedad o finca? ¿Es mandador de una finca?

Información Acerca de la Propiedad

- ¿Cuantas manzanas tiene la finca?
- ¿Cuándo consiguió su finca o cuánto tiempo tiene como mandador?
- ¿Cómo consiguió la finca (comprado, una herencia, por reforma agraria, etc.)?
- ¿Cuáles son las maneras en que se aprovecha de los terrenos?
    - ¿Se ocupa el terreno para ganadería? ¿Cuántas manzanas tiene en potrero? ¿Cuántas cabezas se mantiene en la finca?
    - ¿Se ocupa el terreno para cultivos? ¿Cuáles son los cultivos y cuántas manzanas?
    - ¿Se ocupa el terreno para reforestación o conservación de bosque? ¿Cuántas manzanas?
- ¿Cómo piensa utilizar los terrenos en el futuro?
    - ¿Tiene planes cambiar el uso de suelo dentro de los próximos 5 años?
    - ¿Alguna vez vendería su finca, o piensa regalar los terrenos a sus hijos?

Cercas Vivas

- ¿Cuántas varas de cercas vivas tiene en la finca?
- ¿Dónde se encuentran las cercas vivas? ¿Están ubicadas en todas las zonas de la propiedad o solamente en algunos partes?
- ¿Se ocupan en las linderas de la propiedad? ¿Dentro de la finca para dividir parcelas?
- ¿Cuántos años tienen las cercas vivas? ¿Ya existían a obtener la finca o usted las estableció?
- ¿Cuáles son los tipos de árboles en las cercas vivas?
- ¿Ha observado algunos animales (pájaros, monos, u otros) utilizando los árboles de las
  cercas vivas para alimentarse o trasladarse?
- ¿Cómo se utilizan los árboles de las cercas vivas, por ejemplo, para madera, leña, forraje para ganado, etc.?
- ¿Existían otras cercas vivas en la propiedad que ya no están? ¿Qué las pasó?
- ¿Hay algunas ventajas o desventajas asociadas con el uso de cercas

vivas en vez de postes?
- ¿A usted le gustaría tener más cercas vivas en la finca? ¿Porqué?

Transcripts

Interview 1

M: …Pequeño
I1: Uhuh
M: A cuando no la violenta
I1: Ah, si
M: Yo me huidi aquí pero mi villa (vía?) aquel cerro por agua
I1: Ahhhhhh
M: De le Montiel
I1: Los Montiels
M: Si. Este – {Inaudible} son familia, somos familia pues también ellos son primos míos y me crío con ellos y me hui a – pues mi papa vino aquí. Y me llamo que {Inaudible} para acá pero llego ya tengo familia y no soy soltero y venga entonces (que me?) aquí. Él se {Inaudible}. Entonces, mi dijo que la cuidar que esto era mío. El me dio
I1: ¿Pero eso fue hace cuando entonces?
M: Ya tengo doce años de estar aquí
I1: Doce anos
M: Si
I1: Y
I2: You already asked that [Indicating towards the interview script]
I1: ¿Usted cuantos años tiene?
M: Tengo cuarenta
I1: Cuarenta, okay
I2: We know this [Indicating to next question]
I2: ¿Cuantos manzanas?
M: Cinco
I2: Tiene la finca
M: Cinco
I2: Cinco
I1: ¿Y este – y su papa pues cuando consiguió la finca? Hace cuánto tiempo que
M: Eso si no le pode decir sabe Doroteo porque le
I1: Pero hace mucho tiempo entonces
M: Si
I1: Ya muchos años que ha tenido esta finca en la familia. Y
I2: This is about improving the land or like what you do
I1: I don't quite understand {Reads the question under her breath to herself}
I1: ¿Okay, y cuáles son las maneras en que, pues, para que se ocupa más esta propiedad?

M: Para arroz, maíz – él lo que siembro aquí – arroz y maíz. Nada más
I1: Arroz, maíz para siembra
M: Si
I1: ¿Entonces, no le ocupa para ganado?
0h2m17s
M: {Inaudible} que, ahora {Inaudible} ganado pero la pienso no {Inaudible} porque ahora tengo viene que quiero por estada ahí y no {Inaudible} cerco por – porque no {Inaudible} ganado no tengo pueden. Lo que tengo son dos bestias nada más, nada más. Por eso se puede {Inaudible}
I2: ¿Y para reforestación?
M: ¿Si?
I2: ¿Cuantos manzanas? ¿Un – de reforestación?
M: Un
I1: Gracias. Entonces, tiene dos bestias pero ellos se mantienen
M: Aquí, no la mantengo la. Tengo haya un de trabajo. Ahí las tengo porque la área pues todas a montana que a mire {Inaudible} la área
I3: Mas grande
M: Más grande que quien. Entonces, como {Inaudible} trabajo mi problema
I1: Esta bien. ¿Y pues para la arroz, para la maíz – cuantos manzanas cultivas?
M: Yo no cultivo mucho. No más – dos medio
I1: Dos y medio. ¿Y el de resto se quierda cómo?
M: Se {Inaudible} Se no siembra ahí. Hay {Inaudible}
I1: ¿Entonces, cómo?
M: Y como {Inaudible} trabajo más {Inaudible} al norte
I1: ¿Y tiene algún parte que, que es montana?
M: No solo ese cuadrito {Inaudible} la abeja
I1: Pues, en el futuro si piensa ya sabemos que va reforestar un pedazo
M: Si
I1: ¿Y con el resto de la propiedad? ¿Cómo lo pienso ocuparlo en el futuro?
M: {Inaudible} adelante porque ahorita pienso hacer un {Inaudible} para chagüite porque {Inaudible}. Entonces, yo ahorita pues como {Inaudible} soy solo {Inaudible} tan dos pequeño. Ya {Inaudible} trabajan. Y ellos pueden mi ayudado pero el resto del año para que no me van ayuda porque ellos estudia todo el limpio ya {Inaudible} pero como vengo {Inaudible} sol – trabajo en la mañana y vengo en las tarde ya me quedo hay
I1: Así. ¿Entonces, y siempre va a seguir sembrar arroz y maíz o solo chagüite?
0h5m10s
M: No, que pienso hay una parte siembra puedo un chagüite
I1: Granos básico
M: Si, y puedo el resto de grano básico
I1: Y no tiene – para. ¿Entonces, pensando en los siguientes cinco años siempre piense seguir así? Cultivan
M: Si, yo me lo permite me ahuera que. Trabajamos ir
I1: ¿Y piense que vendría esta propiedad algún día o?
M: Supuestamente, yo no, yo no vendería. Mi a no ofrecía comprando

I1: Así
M: pero no porque digo yo la plata se termine
I1: Así es, así es
M: Como llego a mis hijos {Inaudible} si el día que yo falte {Inaudible}
I1: Así como herencia entonces
M: Si
I1: Gracias. Y – Es obvio que usted si tiene cercas vivas aquí. Y – ¿no sabe puede decir más o menos como cuantas varas o metras de cercas vivas hay? ¿O no sabe?
M: No estoy al tanto lo {Inaudible} solo es rodea pero. Ve, no estoy al tanto cuanto tengo.
[I3 jumps in and says something inaudible and does some quick calculations with M and they come up with a number around 300 varas]
I1: Tres cientos varas. ¿Y pues, esas cercas vivas – son todas las cercas de la propiedad son cercas vivas o algunos son solo postes?
0h7m25s
M: Cercas vivas esta pues todos. A como este tipo hace alrededor
I1: ¿Entonces, en las linderas es donde tiene la cerca viva?
M: Si, {Inaudible}
I1: ¿Y esta cercas viva como a que día – la que vimos ahí – como cuantos años tienen?
M: {Inaudible} tienen más porque tengo, tengo…doce años…trece años estada aquí
I1: ¿Y usted los sembró entonces?
M: No, mi papa sembró madero {Inaudible} el rato porque ellos sembrando {Inaudible}
I1: ¿Y usted no sabe cuándo los sembró más o menos?
M: No
I1: ¿Pero por los menos – desde hace por los menos trece años?
M: Si, tengo estada aquí
{I1 laughs}
I1: Y estaban. Así es, así es.
I1: Y entonces, ya existían pero ya veo que estada ampliando las cerca viva aquí por poner algunos postes que algún día van a ser
M: Ser vivos
I1: Ser vivos. ¿Entonces, pues – para las cercas vivas cuales son los árboles que están usando en las cercas vivas?
M: Aquí es – ahorita pues…este madero y jobo y {Inaudible} porque mi poniendo pero pensaba pone {Inaudible} más postes de {Inaudible} porque se es pegajoso para que {Inaudible} la cerca pueden viva {Inaudible}
[At this point another man rides up on a horse and briefly interrupts the interview]
0h9m50s
I1: Y – ¿Observado algunos animales – aprovechando de los árboles de la cerca viva para alimentarse, para moverse?
M: Que se ocupado para…

I1: Para algo. ¿Este hay animales que entran en las cercas vivas? Que a usted ha visto
M: Si, {Inaudible}. Hay como {Inaudible} abierta la puerta entran animal
I1: ¿Silvestres digo?
M: No, silvestre solo el mono que pasa ahí
I1: ¿Mono congó o mono araña?
M: De los dos
I1: ¿De los dos?
M: Si, y {Inaudible} perezoso que se mira {Inaudible} el otro mono {Inaudible}
I1: ¿Entonces, mono cara blanca aquí hay?
M: Si, hay ahí en la montaña
I1: ¿En la montaña pero aquí no entran? [Indicating live fence]
M: Haber se pasan
I1: ¿Y – pero algunos veces usted ha visto que los monos se transitan por la cerca viva?
M: Si
I1: Okay
M: Pasa las ardillas {Inaudible} [I1 laughs]
I1: ¿Pero entonces perezoso, algunos monos se pueden usar la cerca viva como trasladarse?
M: Si
I1: Y – Y los arboles – pues estos árboles de la cerca viva aquí están, pero se ocupan también para otros propósitos – por ejemplo como leña
M: Si, si, si
I1: Cual es
M: Tan seco puede ser tamal de palos {Inaudible}
I1: Y – ¿pues usted, y lo ocupada para forraje?
M: Para – sí, para forra la casa
I1: Para el ganado digo, cuando tenía…
M: Si, cuando tenía yo le hecho ganado hay. Pero ahora que no tengo ahí.
I1: Si
0h12m10s
M: Estamos no hecho {Inaudible} con la reforestación ya no hecha ganado – este año {Inaudible} anímale aquí lado que {Inaudible} pero para {Inaudible} cerco ya no {Inaudible}. Entonces, ya no pienso {Inaudible}
I1: ¿Usted sabe si, existían algunas cercas vivas aquí en la finca que ya no están?
M: Porque {Inaudible}, la cerca viva hay pasan por allá
I1: ¿Pero entonces siempre este – no hay ningún cerca viva que ya no?
M: Aquí no
I1: Aquí no
M: Aquí no, que esta hora. Esta hora {Inaudible} que divisiones puede que {Inaudible}

I1: ¿Y pues, porque – pues – usted entonces si tiene cercas vivas y usted mira el o piensa que cual es son los beneficios – pues, cuales son los aspectos buenos o las ventajas digo de tener cercas vivas – porque tener cercas vivas?
M: Digo yo {Inaudible}. Es sea que buena tener la cerca viva porque si le ha gana cortar un poste, ya lo corta ahí. No tiene quiere un más largo {Inaudible}. Entonces, ya cupo la le servían palo. Ya lo siembra los postes ahí.
I1: Hay mismo
M: {Inaudible} sale porque {Inaudible} que no tengo nada y voy {Inaudible} puede hacer bueno. Mantener siembra {Inaudible}
I1: Si. Entonces, ellos pueden a reponer los postes viejos algún día.
M: Si.
I1: Y algún otro beneficio o ventaja
M: Como
I1: Que son bonitos o – es lo que opina usted. ¿Y una pregunta es – si – si es bueno tener la cerca viva porque – pues, porque tiene por ejemplo aquí postes? ¿Porque no todas las cercas con cercas vivas?
0h15m00s
M: Porque me (jala puerta vierta ahí) y el ganado se me mete en el noche. Aquí yo podo poner {Inaudible} ahí. Pero, {Inaudible} como es, es calle {Inaudible} de pasa todo el mundo {Inaudible} (me jala puerta vierta) y se me mete ganado más siempre. Por hacer, que voy haciendo {Inaudible} porque ganado ya no me moleste
I1: ¿Pero, como cerca de poste – aquí no tiene?
M: No. Para sacar bueno solo {Inaudible} (tan pequeño)
I1: Si. Pero – pues, hay muchas personas que no tienen cercas vivas. ¿Verdad?
M: Si.
I1: ¿Aquí no más hay – vamos ver una cerca de postes y usted sabe por – porque este no ponen cerca viva? ¿Es más {Inaudible}? ¿Es más difícil?
M: Piense que no tienen interesa tal vez solo compran el poste
I1: ¿Tal vez es más fácil?
M: {Inaudible} pero a me gustaría poner – sembrar palito puede es poste que me van hacer {Inaudible} futuro más adelante.
I1: Así es, entiendo, entiendo.
I2: Es todo.
I1: Creo que esos es todo.
I2: Y para terminar, repite tu nombre completo.
M: Oscar Antonia {Inaudible}
End of Interview
0h16m47s

Interview 3

I1: ¿Para empezar, cuál es tu nombre y apellido?
M: Javier Antonio Obregón.
I1: ¿Obregon? ¿Se dónde nació?
M: ¿A dónde nací?

I2: Si.
M: Aquí en la Comarca de Felipe
I1: ¿Cuántos años tienes?
M: Cuarenta y cinco.
I1: ¿Y en este comunidad, hace años que vive?
M: Aquí, bueno que vivo este {Inaudible murmuring}
I2: ¿Aquí trabájanos?
M: Mire. {Inaudible} este lugar era de un tío mío. Verdad. Aquí vivían mi mama. {Inaudible} explicar {Inaudible} veinte cinco años. Pero como en tío míos {Inaudible} yo hace como siete años (yo le compre) {Inaudible} (de yo comprado ya). Deseo entiendo {Inaudible} ellos para allá. Se vendió. {Inaudible}siete años estada aquí.
I1: ¿Y tu finca – cuantas manzanas?
M: {Inaudible} ochenta y la real ciento noventa. Y se componiendo sienta manzana ahorita (como yo camino este) {Inaudible}
0h2m13s
I1: Y – I don't know how to say this. [Turning to I2] How do you, like, what does he use it for? Is it just for cattle – ganado, o
I2: ¿El uso que tiene ganado?
M: Ganado.
I1: ¿Y cultivación? ¿O no?
I2: ¿Y agricultura no?
M: No.
I2: No, solo ganado
I1: ¿Y reforestación?
I2: ¿De reforestación?
M: No porque tengo muy ganado, no fueron
I2: No
I1: Y
M: {Inaudible}
I1: En el futuro – how do you say like using the land in the future – like does he want to continue to just use it for cattle?
I2: ¿{Inaudible} en el futuro siempre quiere continuar usando ganado, solo en ganado?
M: Si.
I2: Si.
I1: ¿Cuantos cabezas de ganado?
M: Aquí este – cien.
I1: ¿Y las cercas vivas – cuantas varas o no se?
I2: ¿La duración de las cercas vivas que tiene?
I2: ¿Metros?
M: ¿Pero como se llama que le llama vivo – viva?
I2: Cerca viva es donde la parte de cerca tener la fila es palos siembra.
M: Ahh
I2: {Inaudible} palo grande de madero lo me casi
M: Ya, ya, ya, ya

I2: ¿Tiene {Inaudible} cerca viva?
M: Cerca viva –
I2: {Inaudible} (cual es una) cerca viva la que viene en la fila {Inaudible} así.
M: Que yo (alojo)
I2: Que yo (alojo) los acacia y los otros. Y por aquí tan también que parece que se {Inaudible} sembraron unos madero (a lo real cerco).
M: {Inaudible} (viera) como quinientos palitos sembrados (siempre) las vacas de los comen. No ayuda manera {Inaudible} (teca alta)
I2: (Teca alta)
M: Tal vez. ¿Y pagan verdad?
I2: Si. ¿Entonces, más o menos como, como cuanto en cerca viva tiene?
M: En cerca viva – yo miro más o menos – (solo esto que aquí, que mira hay) {Inaudible}
I2: ¿Uno ocho ciento vara?
M: ¿En cerca – que {Inaudible} palo así? {Inaudible}
I2: ¿{Inaudible} hay más?
M: Hay más. Y solo de aquí en la calle {Inaudible}
I2: ¿Si, si {Inaudible} dos kilómetro de cercas vivas?
M: Todos – este – {Inaudible} que sí.
I1: ¿Qué tipos de árboles en las cercas vivas?
0h5m05s
M: ¿Ah, qué tipo de arbole?
I1: Si.
M: {Inaudible} en los que ahí mas es madero.
I2: Madero.
I1: ¿Madero negro?
I2: Y acacia
M: Aha, es correcto
I1: And the animals that use [Indicates towards I2 for help]
I2: ¿Ha visto tipos de animales en las cercas vivas?
I1: Como monos o pájaros
M: Este {Inaudible} lo que miro que caminan ahí {Inaudible} este ardilla, este (garro), {Inaudible} los palitos los iguanas.
I2: ¿Mono no viste? ¿Congo?
M: Este {Inaudible} caminan por aquí sí.
I2: Si, a pues si
M: Si
I1: Okay. ¿Uso los árboles en las cercas vivas para leña o madero o forraje?
I2: ¿Los árboles en las cercas vivas son para leña o madera o forraje de ganado?
M: No. Yo más o menos veinte {Inaudible} para que, para en el cerco – los palos verde
I2: Solo para le tener del cerco
M: ¿De tener el – como le llama {Inaudible}?
I2: El cerco, sí.
M: El cerco. Para tener cerco.

I1: ¿And then – en su opinión, las cercas vivas – tienen ventajas en contraste de cercas de postes solo?
I2: ¿La cerca vivas tiene ventaja a diferencia de los postes? Del cerco de poste – para su opinión
M: Que (si es) mejor le el palo (mojado) cerca viva (quedan) que el poste. (Hombre pues), es mejor digo yo. Si.
I2: He says it's better.
M: Cerca viva mejor.
I1: ¿Por qué?
M: Porque al mismo tiempo le azul son – es bueno sombra. Y este – y no se pude, no (tener) cambian del poste.
I1: ¿Tiene más en el futuro – cercas vivas?
M: Si
I1: I think that is it
M: Quiero sembrar un más {Inaudible} a claro que si – si estado sembrado {Inaudible} (come lo a la) vaca chiquitos. Voy a sembrar a más azteca.
I2: También puede usar este jinote
M: El jinote – el jinote casi. Si. Este jinote pero {Inaudible} casi no me gusta porque este se come el hambre. Se lo – como que se lo pasa mucho y ha este no funcione. Pero también, se puede porque uno los (embaces) del hambre están los palos (seguidos ha) – no pase ganado.
0h8m09s
I2: También puede el pochote
M: Es buena – el pochote. Si se puede pochote sembrar. (Mira este) – {Inaudible} me gusta como que el también {Inaudible} una poquita sombra. El pochote pasan {Inaudible}.
I2: So he is willing to plant trees and live fence but trees that have a shadow.
I1: Yeah, I got that.
I2: For the cattle.
I1: And then the last question is how old is it – the cercas viva
I2: ¿Cuántos años tiene más o menos tienen esa cerca viva?
M: Esa cerca viva tienen – {Inaudible} – ¿del ano ochenta cuantos {Inaudible}?
I2: Veinte - treinta y cinco
M: Por cuando este – la revolución que instala cooperativa - ¿recuerda?
I2: A. Si, si.
M: {Inaudible} cooperativa. Entonces, ya comenzaron (en los) sembrando. Este – todo eso – arboles.
I2: ¿De la ochenta?
M: Si. Triente y cinco años.
I1: Okay. Es todo.
End of Interview
0h9m46s

Interview 4

I1: ¿Para empezar, cuál es tu nombre y apellido?
M: Miguel {Inaudible}
I1: Y - ¿Se dónde nació?
M: {Inaudible}
I1: ¿Cuántos años tiene?
M: {Inaudible} 1951
I1: And how long has he lived here?
I2: ¿Cuantos tiempo tiene viviendo aquí?
M: {Inaudible} 77
I2: ¿1977? Treinta, cuarenta – cuarenta años
I1: Y su finca - ¿Cuántos manzanas tiene?
M: Aquí son 52 manzanas.
I2: 52.
I1: ¿En su finca – su ocupa en la tierra – para cultivar?
I2: ¿Para que usa su finca? Para ganado
M: Para ganado, para reforestación
I1: ¿Cuantos manzanas de reforestación?
M: {Inaudible} cinco manzana in bosque natural.
I2: Cinco manzana.
I1: Y ganado - ¿Cuántos cabezas?
M: Hay como (veinte).
I1: And what does he cultivate?
I2: ¿Que cultiva?
M: Los tradicional.
I2: Maíz, frijoles, y plátano.
I1: Okay.
0h2m05s
M: {Inaudible}
I2: Arroz
M: (Cuando llueve siempre)
I1: And – in the future does he want to continue with the reforestation?
I2: ¿En el futuro, le gustaría continuar con la reforestación?
M: {Inaudible} haciendo todos los anos. (Creo que) es un poquito
I1: Okay. Y las cercas vivas en su finca - ¿Cuántos? How long?
I2: ¿Cuantos más o menos {Inaudible} tienen cercas vivas?
M: Mil – mil quinientos
I2: ¿{Inaudible} o kilómetros?
M: {Inaudible}
I2: ¿Como los tres?
M: Mas o menos tres kilómetros.
I1: ¿Y cuantos años tienen las cercas vivas?
M: Hay una cerca viva que tiene {Inaudible}
I2: Cincuenta. Las más {Inaudible}
M: {Inaudible}
I1: And did he plant them or were they here before?

I2: No.
I1: I couldn't hear, sorry
I2: Eso no, eso no le (planta) {Inaudible}
M: {Inaudible}
I1: Y – the question about animals
I2: Algunos ha visto en la cerca viva monos
I1: ¿Pájaros?
I2: ¿Pájaros?
M: {Inaudible}
I1: Si. ¿Qué tipo de monos?
I2: ¿Qué tipo de mono? congo
M: {Inaudible} mono congo.
I1: Mono congo.
I2: Howler.
I1: ¿No araña? Spider monkey
I2: No, mono araña no.
M: {Inaudible} (no le gusta la cerca) {Inaudible}
I1: And – usa la para leña, para madera
M: Si, {Inaudible}
I1: Y – about the advantages
I2: Las ventajas.
I1: De cercas vivas en contraste de las cercas de postes solo
I2: ¿Que pienso de que – en su opinión, que es mejor la cerca viva o de poste?
M: La cerca viva claro que es mejor. Las cercas vivas tienen postes para todo el tiempo {Inaudible}.
0h5m20s
I1: ¿Más ventajas?
M: Si más ventajas claro.
I2: ¿La otra cosa?
M: Siempre seguimos trabajando para (hace mejorando y) {Inaudible} la cosa mejor porque {Inaudible} que si trabajamos y no le {Inaudible}. Entonces, los trabajo tiene que si (programado) {Inaudible} sembrar (cien) arboles {Inaudible} trabajando mejor y {Inaudible} la cosa sabe mejor. (Por los menos con eso) {Inaudible} cuando (empiezo) {Inaudible} plantar las plantas. (Tiene) {Inaudible} no sabe totalmente lo que en (manejo la tenía). {Inaudible}
I1: ¿Y en el futuro, tiene más cercas vivas?
M: Si, porque {Inaudible}
I1: And then the only other question I forgot to ask is how he got this land – did he buy it or inherit it?
I2: ¿{Inaudible} compro la tierra {Inaudible}?
M: {Inaudible}
I2: He buy it
M: Yo no tengo nada {Inaudible}
I2: {Inaudible} herencia o
M: No {Inaudible}

I1: And does he plan on having his children inherit it or on selling it – what is the plan?
I2: No. La plan es mantener {Inaudible}
M: No. {Inaudible}
I1: Terminamos
End of Interview
0h9m11s

Interview 5

I1: Okay. Comenzamos. ¿Cuál es tu nombre y apellido y donde nació?
M: Erasmo {Inaudible} Tortuga
I1: ¿Cuántos años tienes?
M: 42.
I1: ¿Cuando – consiguió su finca que {Inaudible} su nombre?
M: (Que hace) {Inaudible} diez años.
I2: Como la consiguió – como consiguió la finca. ¿El la compro?
M: Si, compra
I1: ¿Compra? ¿No fue herencia?
M: No, no {Inaudible}
I2: ¿Cuantos manzanas?
M: Once.
I2: Once.
I1: Once manzanas.
I2: Y en su finca – I don't know – how does he use it?
I1: ¿Ah, que hace su finca? ¿En que la trabaja? ¿Cómo la aprovecha?
M: {Inaudible} diferente {Inaudible} reforestación, otra en bosque natural {Inaudible} reforestación puede (que estamos) sembrando en arboles nuevos de lo que no tengo {Inaudible} aquí
I1: Si
M: La que – la compuesta por arboles naturales {Inaudible} y potrero.
I1: Potrero. ¿No tiene cultivos?
M: Y la {Inaudible} para siembra – agricultura.
I1: ¿Qué siembra ahí?
M: Maíz, frijoles, y {Inaudible}
I2: ¿Cuántos manzanas de reforestación?
I1: ¿Cómo cuantos de reforestación nueva – como cuanta {Inaudible} sembró (con la sola)?
M: Si, sí.
I1: Son tres manzanas y media de reforestación.
M: Tres media, tres media.
I2: Okay.
I3: ¿Y cuantos de potrero?
M: En potrero tenemos algo – no lo tenemos {Inaudible} (puede estar más o menos) de uno – seis manzana.
I1: ¿Y el resto en cultivo?
M: {Inaudible} una.

I1: Una manzana para cultivo.
M: Si. Una y media.
I1: ¿Usted pretende mantener esa manera en que está aprovechando la finca como la tiene o en el futuro usted {Inaudible} – como es su finca en el futuro?
M: Bueno si {Inaudible} ver la más distinta
I1: ¿Cómo?
M: Ver la {Inaudible} (en la manera) {Inaudible} los potreros {Inaudible} sola área y siempre lo que mantener reforestación porque el potrero {Inaudible}
I1: Chagüite
0h3m13s
M: Chagüite sí. Porque, también de eso – no beneficiamos {Inaudible}
I1: {Inaudible} mejor {Inaudible}
M: Si, la área de potrero que toda la vida como esta {Inaudible} trabajando {Inaudible} dejaron completamente lo que potrero por maíz {Inaudible}. En potrero {Inaudible} cercas que se mantengan siempre compuesta por cercas vivas que hay en arboles {Inaudible} (en lo que potrero) para que no falte árboles y en lo que este la área de bosque natural {Inaudible} hacer su proprio en cierro ya también para {Inaudible}
I1: Su propia cerca
M: Si, {Inaudible} más seguro.
I1: ¿Dentro los próximos cinco años, planea hacer un cambio en su finca? ¿Cambio drástico o no?
M: Hay vamos. [All laugh] Ya lo comenzamos creo que vamos – no sé. Si, ya comenzamos hay vamos – suave, suave, suave.
I1: ¿Usted piense algún {Inaudible} su finca o una parte de su finca o piensa regalar a sus hijos? ¿Cuál es el plan?
M: Propósito {Inaudible} a mis hijos en el futuro
I1: Herencia.
M: Si. (En el futuro).
I1: ¿Usted considere que tienes cercas vivas en su finca?
M: Si.
I1: ¿Cómo cuantas varas {Inaudible} tanta varas de cercas vivas en toda – en las once manzanas {Inaudible}?
0h5m05s
M: {Inaudible} quinientas {Inaudible}
I1: Varas, quinientas varas. ¿Dónde se encuentran las cercas vivas? ¿Cómo están distribuía en su finca?
M: Están en diferentes lugares {Inaudible} está compuesta {Inaudible} por una dos cientos y la otra {Inaudible} que esta {Inaudible} cientos cincuenta y {Inaudible} (con el otro)
I1: {Inaudible} están como por dos partes
M: Si, si, en diferente lugares
I1: Diferente lugares. ¿Estas se ocupan en linderas de la propiedad?
M: Si.
I1: ¿Todos linderos?

M: No.
I1: ¿Sola una parte?
M: Si. {Inaudible} están puede ahí {Inaudible}
I1: ¿Y usted puso porque están ahí específicamente las cercas? ¿(Lo uso como un propósito)?
M: No.
I1: ¿Cómo fue?
M: Únicamente eso {Inaudible} lo eso cuando yo compre, estaban. Porque {Inaudible} arboles muy buenos {Inaudible}
I1: Y usted las puso ahí porque {Inaudible}
M: En protección únicamente para (antesala) en cerco, menos, menos costo, se {Inaudible} un poste (no más lo tengo) {Inaudible}. Si muchos {Inaudible}
I2: ¿Y cuantos años tienen las cercas vivas?
M: {Inaudible}
I1: Ya estaban {Inaudible}
M: Si.
I1: ¿Por los menos tienen más de diez años?
M: Si, claro
I1: ¿No sabe más o menos?
M: Si.
I1: ¿{Inaudible} arboles de más o menos de cuarenta años?
M: Si. {Inaudible}
I1: Son arboles (más de cuarenta).
M: Si, estaban {Inaudible}
I1: ¿Entonces, como cuantas varas de sembró? ¿De la quinientas, como cuantas de puso y cuantos eran de estaban?
M: {Inaudible}
I1: No (pregunto) {Inaudible}
M: (Era pasa que un aseso trabajo) {Inaudible} sin ningún {Inaudible} por una {Inaudible} lo hacer {Inaudible} poner este postes, este postes porque (en futuro que retoña) o {Inaudible} que no pegue de la {Inaudible} madero negro que un árbol {Inaudible} los (siembra) y pega
I1: ¿Entonces, usted {Inaudible} como cuales son los tipos de árboles que hay en cerca viva? Madero negro
M: Si, madero negro.
I1: ¿Qué más?
M: (Fuera) alguno {Inaudible}, (fuera) alguno aceituno, pero mayor parte es madero, mayor parte es madero negro
0h8m24s
I1: ¿{Inaudible} cuando camina cerca de cerca viva {Inaudible} observado que algunos animales que están en la cerca viva {Inaudible} (volando), pájaro, (o que los monos llegan) {Inaudible}, o algo que usted ha visto insectos, que ha visto {Inaudible}, que animales ha visto?
M: {Inaudible} uno casi lo que mire fue {Inaudible} arboles ahí {Inaudible} (hambre) abejas {Inaudible}
I1: ¿Abejas castillos?

M: Si. Y el parte de eso puedes también {Inaudible} y algunos animales hacen uso como una carretera
I1: Si
I3: ¿Cuáles son los animales?
I1: Cuales son
M: Como mono, la ardilla
I1: {Inaudible}
M: Si, mono y ardilla
I2: ¿Qué monos?
M: Perezoso {Inaudible} llaman.
I1: Perezoso.
M: Si.
I3: ¿(Y los) monos son kongos o mono {Inaudible}?
M: De los dos. El kongo y el mono
I1: {Inaudible} mono (ha visto)
M: Si.
I1: (Esta bien).
M: {Inaudible}
I1: ¿{Inaudible} para que uso la cerca viva {Inaudible} para que la uso?
M: Únicamente (si hay) que {Inaudible} (ando) ahorita {Inaudible}
I2: ¿Para madera?
M: Corta el – si para corta un poste y para {Inaudible}. Si algún árbol de ellos me repara – para sacar un pilar para la casa {Inaudible} (un pilar de madero)
I1: ¿Y usted ha visto {Inaudible} lo ocupa {Inaudible} y ganado – no ocupa la cerca viva para ganado?
M: El madero negro – (la joven lo comen)
I1: ¿Ellas comer?
M: Si, la joven.
I1: ¿Usted los lleva para que comen o no?
M: No
I1: {Inaudible}
M: {Inaudible}
I1: (de ellos buscan)
0h10m50s
I1: ¿{Inaudible} en pasado cercas vivas que ya no están?
M: Si, alguna {Inaudible} equipo destruido
I1: ¿Y quién las puso este?
M: {Inaudible} un tío mío.
I1: ¿Su tío?
M: Si.
I3: ¿Y que paso con esta cerca {Inaudible}?
M: Si, saque el – cuando (llorar la recibir) el vendió otro (espacio) que no a otra persona (así). Tal vez (parecían) comprando madera y {Inaudible} (les negociamos) (en caso pueden) en la parte mía yo no hay {Inaudible}
I1: ¿Esta en su finca no ha vida ante cerca y ya no hay?
M: No hay están

I1: Entonces
M: {Inaudible} mi área {Inaudible}
I1: ¿Ha pensado en el futuro poner cercas vivas {Inaudible} postes muertos?
M: Si, claro
I1: ¿Por qué ha pensado eso?
M: Porque eso, primeramente que hacer poco {Inaudible} en lo que pasita {Inaudible} también no puede {Inaudible} dice que muy bueno tener la cerca viva porque gente que hace potrero y arriba todo. Y gente con la cerca viva dice {Inaudible} tienen futuro el ganado – porque eso arboles {Inaudible} y en este tiempo que (digo al mismo ahorita) que pasan (los fuegos) muchos veces aparecen ahí destruí {Inaudible} (ya algo) ganado. Y (es menos) ayuda para como para proteger la fuerza el viento también {Inaudible} (protege pues al mismo ganado) {Inaudible} el área limpia viaje más con fuerza {Inaudible}
I1: ¿{Inaudible} cuales son las ventajas {Inaudible} las ventajas de las cercas vivas en comparación de postes?
M: (Depende) de puede afectar
I1: ¿{Inaudible} a la (hora) de usarla, de ponerla, de cual (tipos) {Inaudible} como una ventaja, todos tienes ventajas {Inaudible} la cerca viva – desea por ponerla, desea para mantenerla {Inaudible}?
M: {Inaudible} consideran ninguno
I1: ¿Ninguna ventajas?
M: Si, porque
0h13m49s
I3: ¿{Inaudible} ningunas ventajas {Inaudible} (ya que tengo) – si son buenos las cercas vivas porque es que no todo el mundo tienes cercas vivas?
M: {Inaudible} miro muy buena, no sé qué puede {Inaudible} piensa en futuro pero son buenas
I1: ¿{Inaudible} Consideran más fácil (agradaron) poste muerte sembrar {Inaudible} sembrar vivo – porque será?
M: {Inaudible} alguno {Inaudible} decidió de que a veces que árbol {Inaudible} pequeño porque {Inaudible} (usando muy tierra le ponen) en el hambre el árbol {Inaudible} pero un árbol que este (mayor) {Inaudible} afectarlo
I1: {Inaudible}
M: Si, porque
I1: {Inaudible}
M: {Inaudible} por la gente es que un cerco también será aña
porque {Inaudible} centro use dentro el árbol dice algún {Inaudible} que serán cambiar o como que hacer de forma del cerco – porque alguno se pasan por {Inaudible} del árbol {Inaudible} pero yo creo que si qué veces por el poco (control que le árbol) – un árbol. Por los menos lo le siembra que a cerca que vaya – arboles {Inaudible} sembrar (a uso lo lado) y no ponerlo muy {Inaudible} a cerco porque este árbol pronto crezcan y {Inaudible} lo sabe poner
I1: {Inaudible} porque
M: {Inaudible} porque

I1: ¿Cuáles son las ventajas de usar cercas vivas?
M: {Inaudible} el principio era el beneficio de que {Inaudible} lo tengo todo el tiempo (era antesala) un poste para hacer (regularla) de mantenga buena
I1: ¿{Inaudible} cuanto un poste muerto en un cerco de poste muerto (ser) cambio – más o menos – o {Inaudible} (todo cambio)?
M: Alguno hay que esta no les manteniendo
I1: ¿Pero pues el postes muertos como cada cuantos {Inaudible}?
M: (Dependen) en tipo de poste {Inaudible} (bueno) un poste que sea {Inaudible} quince o veinte años de madero que no pegue – poste muy bueno para que duro y si un poste muy delgado {Inaudible} los cinco años.
I1: ¿Y este consideración con la cercas viva no hay que están – se mantiene siempre?
0h16m48s
M: Si.
I1: ¿Que es otra ventaja de cercas vivas?
M: Bueno {Inaudible} de ganado también – que una protección y también que – ahora que no mira hay {Inaudible} son de gran importancia por esto de las aves y los animalitos que buenos
I1: ¿Usted va a tener más cercas vivas en la finca?
M: Claro.
I1: ¿Y por qué?
M: Porque esta beneficio – (alguna entra su potrero) tiene por menos siempre un – tiene arboles siempre (entre la área) {Inaudible} nosotros a menos que – (aunque) {Inaudible} la agricultura (quitar con completo los arboles). (Todos los menos tengan un área) {Inaudible} (tiempo) de la cooperativa {Inaudible} como los tener {Inaudible} bien (bonita arborizado) Aunque siembra ahí agricultura, este – siempre están no arboles ahí solamente le equipo que miro que están dañado y en la cerca, (en lo que es) – cerca viva me gustan porque se mira bonita y a parte de eso que le dar un valor a un propiedad – (le dame valor). Claro que sí, porque {Inaudible} mira y {Inaudible} (si valor en este poste esta) {Inaudible} madera para algún construcción
I1: ¿Ahora, la última pregunta que tengo – ustedes cuando van a necesitar a cortar un árbol {Inaudible} en cerca viva, usted no necesita pedir permiso {Inaudible}?
M: No.
I1: ¿Porque? Porque es en la zona de reforestación si se pide
M: Si
I1: ¿{Inaudible} yo no sabía eso {Inaudible} (cortando), yo sea que no – yo esta en cerca viva no hay límite?
M: No hay {Inaudible} tiene derecho a
I1: Porque está en potrero
M: Si {Inaudible} y lo primero que ellos consultan es que decidió cortar un árbol ya para secar madera, para secar algo – me decía cuidado porque {Inaudible}
I1: ¿Pero la cerca viva?
M: No porque están en la área que {Inaudible} potrero. Si como {Inaudible}

I1: ¿Pero usted {Inaudible} que sea – un árbol que va a cortar, en dentro de un área de reforestar, tiene pedir permiso?
M: Si.
I1: {Inaudible}
M: Si
I1: Y en la cerca viva no
M: No.
I1: {Inaudible} Bueno. Muchas gracias para la información
I2: Gracias
0h20m07s
End of Interview

Interview 6

I1: Este es una entrevista para un estudio de una tesis o un proyecto de maestría que Andrew está haciendo en la Universidad de Michigan para conocer este sobre las cercas vivas en esta zona del país Nicaragua. Entonces, la primera pregunta - ¿Cuál es su nombre y donde nació? Su nombre completo.
M: Si. {Inaudible} (Calderón) {Inaudible}. Nací en Tortuga, municipio de San Juan del Sur.
I1: Del {Inaudible} Tortuga – que gente vino que
M: Todos los asocios de la cooperativa son {Inaudible} de Tortuga
I1: ¿Cuantos miembros son de la cooperativa?
M: Ahorita, {Inaudible} somos once – (entre una mujer) {Inaudible}. Pero no incluya familia – somos como setenta y siete personas
I1: ¿Entonces, directamente son setenta y siete o directamente once?
M: Son once.
I1: ¿Cuántos años tienes?
M: Cincuenta y tres años
I1: ¡No parece! Joven [I2 laughs]
M: (Y estar) – con esta experiencia cooperativa tenemos triente {Inaudible} anos.
I1: ¿Cuál es el nombre de la cooperativa?
M: {Inaudible} Calderón
I1: ¿Cuando fue le ano en que se fundó la cooperativa?
M: Novecientos ochenta y dos.
I1: De mil novecientos ochenta y dos existe
M: Si.
I1: ¿Este – como fue que se formó la cooperativa? ¿Cómo se creó?
M: Se creó por medio de la reforma agraria – {Inaudible} muy beneficiado por la ley de reforma agraria. Entonces, los agrupamos el grupo de compañeros para trabajar.
I2: ¿Cuántos manzanas?
M: Seis cientos setenta siete manzanas.
I1: ¿Seis cientos setenta siete manzanas?
M: Si.

I1: {Inaudible} ¿Y cuantas de esas manzanas son bosques? Más o menos cuantos
M: Directamente ahorita de bosque natural tenemos sienta manzanas que es todo montaña
I1: Y el resto que es
M: El resto que ocupamos para la ganadería.
I1: ¿Es pastero?
M: Es pastero sí.
I1: ¿No tienen cultivos? ¿No siembra?
M: Este – sembramos – muy poco solo {Inaudible} porque {Inaudible} muy mala para
I1: Entonces, ninguna parte tiene una {Inaudible} (estas tierras rivera) {Inaudible}
M: Si.
I1: ¿Y tiene una parte queda con el playa o no?
M: No.
I1: Solo es
M: La carretera {Inaudible} la carretera.
I1: Este – ¿cuándo que se formó, yo comprendo la reforma agraria pero me gustaría saber si una parte de este momento cuando que se formó la cooperativa fue también que se (reloj) de padres alguna parte de la tierra o todos fue totalmente la partición de la reforma agraria?
M: Completamente fue de ley de la reforma agraria porque que se le confisco a Fernando {Inaudible}
I1: Entonces fue {Inaudible}
M: Si.
I: ¿Y anteriormente, la tierra – se utilizaba para ganado antes de ser la cooperativa o para que se utilizaban?
M: Era ganadería.
I1: ¿Todos de ganadería?
M: Si, ganadería.
0h3m50s
I1: ¿En el futuro, no se uno diez años, como ve su – cómo ve la tierra de su cooperativa? ¿Cómo (la ve el) futuro?
M: El futuro nosotros pensamos tener la mejor que {Inaudible}
I1: ¿Y cómo sería mejor?
M: Este – cuando le digo mejor me refiero a (queramos puede) tener – ya más reforestar todo le que son la fuente de agua
I1: ¿Quiera reforestar la fuente de agua?
M: Es el {Inaudible} ahorita por los menos todas que {Inaudible} agua. Reforestarlo para de (que) diez años ya no parecer {Inaudible} toda la vida {Inaudible} pero esta casa ya
I1: ¿Y cuando usted dice reforestaron {Inaudible} cuantas manzanas está hablando?
M: Por decirle algo, de todo {Inaudible} de lo que la área de los {Inaudible} nosotros y como tres manzanas de alguno (ojo de agua)

I1: ¿Entonces, el único cambio usted piensa que piensa como la cooperativa ser es reforestar la (ojo de agua)?
M: Para tener mejor {Inaudible} de agua
I1: Y la zona {Inaudible}
M: Esos se mantiene, sí.
I1: ¿No planean sembrar cultivos?
M: Hasta la vez no.
I1: No planean hacer. ¿Ustedes piensan como cooperativa ampliar su área {Inaudible} ir mas tierra o reducirla o mantenerse igual o en alguno momento {Inaudible} parte de la cooperativa {Inaudible} – como planea la parte del futuro del traspaso la tierra de la cooperativa – como lo
M: El actualidad, no pensamos {Inaudible} sabe que uno {Inaudible} tener cada día más pero de reducirla tener menos – no pensamos. Tener más
I1: Tal vez, se (hay reales)
M: {Inaudible} que vamos (creciendo) como familia ya y tal vez la área es poca – {Inaudible} ingreso y lo {Inaudible} comprarme o compramos y no vendemos tierra. Con otros de le {Inaudible} de los chavarlos – ya soy me experiencia que ya estamos con viviendo porque {Inaudible} que está pensado ya poner lejos de – como miembro
I1: Como miembro – entonces ampliar el número de miembros
M: Si.
I1: ¿Es su plan?
M: {Inaudible} correcto.
I1: ¿Y planean que la cooperativa viva por siempre?
M: {Inaudible} tantos miembros como en tierra
I1: No entienden algún este plan porque {Inaudible} diez años como se ve como cooperativa no se tienen algún plan ecoturístico o porque ustedes {Inaudible}. Pues tal vez, no cuenta que tienen planificado cuanto ampliar o diversificar la forma en que {Inaudible} dinero
0h7m10s
M: La diversificación ahorita les estamos haciendo {Inaudible} turismo y ganadería porque incluso estamos comenzando (ayer) tenemos el primer cuarto equipado
I1: ¿Como un hotel?
M: {Inaudible} (hospedaje a) gente, ya. (Donde) aquí van a {Inaudible} incluso (mismo) estudiante que puedan venir a (levarse su) {Inaudible}
I1: ¿Cuánto el precio por el cuarto?
M: Este entre los cinco y siete {Inaudible}
I1: ¿Cinco o siete dólares de noche?
M: Si, porque si estudiante puedes – hay su consideración
I1: Claro. ¿Y cuantas personas (alcanza) en el cuarto?
M: Ahorita tenemos un cuarto para ocho personas. Pero la idea es (eso es únicamente para comenzarla) porque a donde nosotros pensamos darle trabajo a los hijos familiares inclusa de la misma comunidad porque a {Inaudible} traer turismo {Inaudible} aquí vamos {Inaudible} a caballo. Tenemos centro arqueológico del Conchal donde {Inaudible} bastante persona

I1: {Inaudible}
M: Si. Pero ahorita únicamente estamos {Inaudible} el primero paso en {Inaudible}.
I1: ¿Usted considera que tiene cerca – {Inaudible} que cercas vivas? ¿Usted considera que tiene cercas vivas en la cooperativa?
M: Si.
I1: ¿Cuantos {Inaudible} pues a un cálculo tal vez no ayudo aquí – como cuantas varas de cercas vivas podrán tener – (así un vuele de pájaro)?
M: Ahorita tenemos como un quince mil varas de
I1: ¿Quince mil varas? Este tanto viejas como
M: Si, por dos, por dos
I1: Jovencitas
M: No, este jovencitas claro que menos {Inaudible} estamos hablando de
I1: (De ahí esta ya) {Inaudible} ¿Dónde más o menos encuentran las cercas vivas? ¿Pudiere explicar si en potrero o {Inaudible} el bosque o todos?
M: En toda la área de potrero porque {Inaudible} (adonde se necesita más) por lo que {Inaudible} Entonces, nosotros estamos poblando porque el bosque ya no necesita, ya no necesita más y no que nosotros vamos donde {Inaudible}. Entonces (echamos en lo que las cerca)
I1: ¿Hay está en la parte de potrero?
M: Si.
I1: ¿Usted utilizan las cercas vivas para separar de otra finca, para comenzar un lindero, o para separar entre los potreros? ¿Cómo utilizan {Inaudible} la cerca viva?
M: Este – (básicamente) las cercas vivas las tenemos en toda la finca. Adonde colindamos con (alguien) y en lo que potrero porque (los silve) {Inaudible} para la división {Inaudible} y para división de potrero.
0h10m41s
I1: ¿Cómo cuantos años tendrán las cercas vivas más viejas? {Inaudible} ¿Cuantos años tendrán esos árboles?
M: Este – lo primero incluso (son más pie) porque {Inaudible} experiencia comenzada que (llama)
I1: ¿Entonces, usted heredó eso?
M: Si, heredamos – nosotros únicamente {Inaudible} fue con continuidad. Porque las cercas vivas de inicio aquí fueron todos jícaro.
I1: ¿Entonces tienen como más de treinta años algunas cercas?
M: Así, si (hablando) de lo que (quisimos) nosotros – {Inaudible} (hecho nosotros). Y eso que es {Inaudible}. Todo lo que jícaro. Esos es nosotros {Inaudible} su jícaro pueden {Inaudible} por uno ochenta años.
I1: Ochenta años sí. Es la otra pregunta - ¿Cuál es los tipos de árboles que hay en las cercas vivas? Puedo mencionar jícaro
M: Jícaro. Predomina el jícaro y madero negro.
I1: ¿Mas que todo?
M: Mas que todo sí.
I1: Madero negro.
M: Y algunos que son (caoba) pero menos.

I1: ¿{Inaudible} algunos ustedes o usted propiamente {Inaudible} ha caminando donde están las cercas vivas más viejas o no los jóvenes – usted ha visto que – (observado) se encontraban animales o insectos andando sobre esa cercas vivas?
I2: ¿Cómo pájaros o monos?
I1: ¿Que me puede mencionar que ha visto que hay estaba ahí ellos y que hacen ellos cuando lo encuentra?
M: Hay diferencia porque por decirle algo – si yo voy caminando por una área que está en reforestar y con jícaro {Inaudible} seguro que {Inaudible} ardilla porque alimentación por la ardilla el jícaro. No una ardilla {Inaudible} (cerco de jícaro si no que)
I1: ¿Encuentras muchas ardilla?
M: Muchas ardilla porque incluso ella en la zona de (hice sedimentar) – todas las días en la zona (eso es su comedero)
I1: ¿Y que más encuentra a parte de las ardillas?
M: Y los más por la flor – abeja.
I1: ¿Abejas lo que más?
M: Él lo que más, sí.
I1: Y ardillas. ¿Este – y usted o la cooperativa – que beneficios o como utilizan la cerca para que la usan? ¿Para que la siembran o (la que esta sembrada) para que la usan?
0h13m25s
M: Primeramente la utilizamos para no seguir este deteriorando medioambiente porque si nosotros (por decirle algo) sembramos un poste a los tres, cuatros, cincos años tenemos que, que {Inaudible} poner y decir que tenemos que cortar un árbol. Mientras {Inaudible} con las cercas vivas no necesitamos cortar (mas) arboles.
I1: {Inaudible} (queda ahí) {Inaudible}
M: Este está para siempre ahí. Entonces, que vemos otro benéfico porque ya no tenemos {Inaudible} por poner un poste cortar un árbol.
I1: ¿Y que otro uso le saca a la cerca?
M: Pues. Por lo general, (yo sabe) que todos arboles hecha rama seca de ahí por use de su leña.
I1: Perfecto. Leña – pero me hablo algo al ganado. ¿El ganado que uso {Inaudible}?
M: Por decirle algo {Inaudible} ahorita {Inaudible} esa vaca flaca. Hay existan alimentando con jícaro. {Inaudible} que no tienen necesidades comprarle con (centrado) porque lo tiene. Las vacas alimenta, el caballos alimenta – el cierto. Incluso la misma gallina. La sirve alimentación – el caballo, que caballo pues tiene le experiencia que lo {Inaudible} el solo {Inaudible}. Sirve alimentación por ganado. (Comenzando de la flor).
I1: ¿Anteriormente había cercas vivas en alguna parte de la finca y después ya no había? Pasó eso alguno {Inaudible} por ejemplo, en un potrero había cercas vivas pero después usted decidió eliminarlas porque si pasó es alguna vez
M: No, no, no.

I1: ¿No ha pasado?
M: Incluso más bien con esa {Inaudible} posibilidad de la gente – si en una área les pegan (huevo) y (por équida) son se maltrató árboles y seca {Inaudible} no reponemos. Para es decirle (puedo) que nosotros (llevamos) mantenimiento esas cercas vivas.
I1: ¿Ustedes consideraron me puede decir todos que sabe que tiene ventajas y desventajas? Puede decir porque {Inaudible} por muy bueno que se algo tienes su desventajas y su ventajas verdad. ¿{Inaudible} usted que me dijera la (depéndala) que (usted le ve) a las cercas vivas porque ya sea, porque la (dependa que usted ve) o porque cree que la gente no siembras cercas vivas por todas partes? Porque por algo será que puede son {Inaudible} la siembra tanto porque (debe) tenerla ventajas. ¿Cuál sería?
M: Este – la dependa que considera el productor de {Inaudible} que, en que consiste, que creen que – que la {Inaudible} cierta área de pasto (la sombro), incluso {Inaudible} Si no el – porqué la ganadería (es uno de las que más) (perjudícala) en los bosque porque a talan de viaje quieren que sea solo potrero.
I1: ¿Y usted considera que realmente las cercas vivas disminuí a la continuidad al pasto?
M; No porque lo que la gente cree que la animal solo necesita el sácate y el sácate le falta alguna proteína que tiene el monte.
I1: Es cierto. ¿Usted donde aprendió es?
0h17m14s
M: De aquí este – aquí.
I1: Porque {Inaudible} no saben mucha gente
M: Pero los sabemos {Inaudible} por eso
I1: Tiene buen ganado
M: Nosotros no vamos (así llega). Son experiencia que la {Inaudible} treinta (pico de) años que tenemos está trabajando esto.
I1: Pero me (dije gente que) – mucha gente que tienen postes muertos porque creen que {Inaudible} (paseo para pasto) {Inaudible}. ¿Qué otras {Inaudible} será que la gente por la cual no (están haciendo) cercas vivas o la ventaja que cree que tiene?
M: Aquí la realidad repercute eso que no hay una (educación ambientar). Eso es la (legítima) realidad. Con una buena educación ambientar nosotros buscamos como con vivir con la {Inaudible} el árbol. (Y aquí no, aquí es) la mayoría productor es la {Inaudible}
I1: ¿Consideran que el mantenimiento las cercas vivas poco tedios?
M: Es más fácil. Es lo más fácil.
I1: ¿Porque no le gusta alguno?
[Another man chimes in] – {Inaudible} porque no crea {Inaudible} las cercas vivas por los menos dos o tres años tiene que cuidarle
M: Incluso
[Other man chimes in again] – Cuidarla
I1: {Inaudible} mantenimiento
[Other man] – no quieren.

M: Incluso tiene que {Inaudible} (no estar) pastoreo porque el ganado
I1: {Inaudible}
M: No se {Inaudible} esa madera negra (ahí), como entraba {Inaudible}
I1: Y están chiquitos
M: Si, están pequeño son de {Inaudible} (antes de) pasado. Y {Inaudible} ellos llegar a {Inaudible} que el ganado {Inaudible} (no pueden pastorear) más libre – más libre el ganado - además que en la cerca, pero le viene, si se saca la realización de costo, estar mandando (portería) ese hombre que estarlo mandando a componer porque los tiene que ir, que (no le vaya levantando al hambre) lo tiene que
I1: Directo
M: Que (directo). El que {Inaudible} el que en seleccionar pues, (el buen hijo) pues – y entonces eso ellos {Inaudible} (ver lo ven en común) costo que {Inaudible} (lo que le vas hacer que pido) (más adelante)
I1: ¿Y usted le gustaría tener o la cooperativa gustaría tener más cercas vivas en la finca más de la que tiene?
M: Buenos, sí tenemos más cerco vamos a tener más cercas vivas.
I1: ¿{Inaudible} (ustedes) todos los tienen con cercas vivas?
M: Casi (ya crea) todos sí.
I1: ¿(Puedes hacer que) totalmente casi todo le tiene cercas vivas?
M: No, únicamente lo falta, lo que montaña
I1: Si pero la montaña
M: No hay en su totalidad en las cercas vivas.
[I1 concludes interview by explaining the goals of the study to the interviewees again and thanking them for their time]
End of Interview
0h21m18s

Interview 7

I1: ¿Para empezar, cuál es tu nombre y apellido?
M: Rafael.
I2: Rafael.
I1: ¿Rafael?
M: (Vermueles)
I1: ¿Cuántos años tiene?
M: Sesenta y cinco.
I1: ¿Dónde nació?
M: En un municipio que se llama San José de los Remates. Municipio de Boaco.
I1: ¿En esta comunidad, cuantos años vive?
M: (De) setenta y cuatro
I2: Treinta y – cuarenta y uno
I1: ¿Su finca, cuantos manzanas tiene?
M: Cuarenta.
I1: Cuarenta. Como consiguió la finca, como comprado, herencia
M: Herencia.

I1: Herencia. ¿Cuáles son las maneras en que se aprovecha de los terrenos? Por ejemplo, agricultura o potrero
M: Solamente potrero.
I1: ¿En todas las cuarenta manzanas?
M: Si.
I1: ¿No reforestación?
M: No. Lo que hay (eso) como uno diez manzanas.
0h2m10s
{Inaudible murmurs}
I1: Y en el futuro, well this is worded weird – so like in the future does he plan to keep it that way?
I2: ¿En el futuro piense mantenerlo esa manera?
M: Si.
I1: ¿Y las cercas vivas, cuantos varas de cercas vivas tiene aproximadamente?
M: ¿Un estimado?
I2: Si, un estimado.
M: {Inaudible}
I2: Como kilómetro.
I1: ¿Cuantos años tienen las cercas vivas?
M: Como treinta años.
I1: ¿Cuáles son los tipos de árboles en las cercas vivas?
M: Madero negro.
I1: Otros o
M: (Palo de la real) y chiquirín – gallito.
0h4m25s
I1: ¿Ha observado algunos animales utilizando los arboles de las cercas vivas como monos o pájaros?
I2: No mirado en los palos de la cerca viva animales como tal vez los congós
M: No he mirado en {Inaudible} montana que (cien vistos) mono congó.
I1: ¿Cómo se utilizan los arboles de las cercas vivas por ejemplo para madera o leña o forraje?
M: (A veces) sus cercas vivas los producimos para poner postes.
I1: ¿So – las ventajas de cercas vivas en contraste de un cerca de postes solo – cual es una ventaja de una cerca viva?
M: ¿Cuáles son las ventajas?
I1: Si.
I2: De poner una cerca viva
M: Es para tener seguro ganado, sí.
I1: ¿Otros?
[Another man chimes in] – no tiene que cambiando postes
M: Si. {Inaudible} bien. Esa una ventaja.
I1: ¿Y algunos desventajas?
I2: ¿Desventajas o no?
M: No.
I1: ¿En el futuro, quieres más cercas vivas en su finca?
M: Si.

I1: Si. Okay, terminamos.
End of Interview
0h6m54s

Interview 8

I: ¿Su nombre y apellido?
F: Guillermina Bustos.
I: ¿Dónde nació usted?
F: Nancimi.
I: Nancimi. ¿Eso en Tola?
F: Si.
I: ¿Bueno, cuántos años tiene ahora?
F: Sesenta y dos años.
I: ¿De vivir en esta comunidad – cuantos por tiene?
F: Treinta y siete años.
I: ¿Usted es la dueña aquí?
F: Si.
I: ¿Cuantas manzana tiene eso?
F: Veinte.
I: La compro de qué forma de consiguió
F: Le compre. (Consigue y trabajo muchos) {Inaudible}
I: Si.
F: {Inaudible}
[Small talk]
I: ¿Entonces, la tiene que vino aquí treinta y siete ya {Inaudible} a tener su propiedad?
F: {Inaudible} no porque (yo sabe) {Inaudible}
I: Vino {Inaudible} (acomodarse)
F: {Inaudible} (área trabaje) {Inaudible} (vaya aquí) {Inaudible} treinta años.
I: {Inaudible} que tienes toda la ocupa la finca para ganado o tiene una para sembrar o otra
F: {Inaudible} (tal vez un aquí) pero si {Inaudible} invierno (que sierra a muchacho) {Inaudible}
I: ¿Y de esa manzana, cuantos ocupa más o menos para potrero?
F: Como quince.
I: ¿Cuantos ganado mantiene más o menos?
F: ¿(A sea) aquí?
I: ¿Si, en su terreno que puede mantener?
F: Si este – como {Inaudible}
I: Pero, sin – no es tan {Inaudible} para tener una idea cuantos mantener
F: Si este – (haberse) más o menos ocho
I: ¿Entonces para, cuando hay un buen invierno entonces siembra – cuantos ocupo para sembrar de terreno?
F: Cinco manzanas.
0h5m01s
I: ¿Que le gusta sembrar?

F: Maíz, frijoles, trigo.
I: (Siembra bastante trigo quien Tortuga)
F: Si pero {Inaudible}
I: Si, tuvo mal porque el agua. ¿De eso – de esos terrenitos tiene – ocupa algún, tiene algún lugar para reforestación o como la tiene (huertecito) de bosque o no?
F: Si, solamente a {Inaudible}
I: ¿Cuantos más o menos manzanas?
F: (Hay), como cinco manzanas.
I: ¿En el futuro, piensa cambiar la forma de manejarla tierra o así (pues) piensa estar – seguí continuar así como estar (por ejemplo)? ¿Con ganado, {Inaudible} recibía un bueno invierno sembrar y los bosque – seguir así?
F: {Inaudible} se piensa en {Inaudible} (maíz mas), que dejar, que crezcan los árboles.
I: ¿Algún día se vendería la finca o piensa como heredar a tu hijo?
F: {Inaudible}
I: Ya (estar a partido) (digamos)
F: O sea {Inaudible}, ya saben que son los dueños {Inaudible} (no puedes estar este momento) {Inaudible} (no le dicho) {Inaudible} (ustedes toquen)
I: Si, todavía no está (este ya) destruido. {Inaudible} (Yo saben que)
F: {Inaudible} (y usted tienes saber para a la final verdad)
I: Si, (por alguno necesitado), por alguno {Inaudible}. Nosotros {Inaudible} de la cerca viva- bueno, creo que (sepa) a eso que usted plantan de madero negro, que zona natural digamos (que yo) – palos sirven de postes. ¿Solamente tiene esa cerca o tiene otra? ¿Así esa manera?
F: Así.
I: Ah, para allá. ¿Cuantos más o menos varas que tiene la cerca viva?
F: {Inaudible} para caso cien vara para este lado, dentro {Inaudible} dos cientos y por allá otra cien vara y para este lado cine vara.
I: Una quinientas.
F: Si, más o menos.
I: ¿Todas esa están, no está en solo lugar, (van a están regado)?
F: No, hay van a {Inaudible}
I: Si, si. ¿Esa cerca viva usted {Inaudible} la puso o la encuentro con lo compro?
F: {Inaudible}
I: ¿Usted la puso?
F: Si, si.
0h9m59s
I: ¿Solo tiene madero negro?
F: Si.
I: ¿Usted ha observado alguno – aparte de {Inaudible} para dividir los cercos – ha visto que si los animales ocupan en eso arboles – pájaro o abeja por ejemplo, o otro tipo de anímale?
F: Si, lo puedo {Inaudible} si la flor, (esta comenzado producción) {Inaudible} este bastante, los abejas y los pajaritos – no se {Inaudible}

I: Si, {Inaudible} le chupa la flor – néctar.
F: {Inaudible} (chorcha)
I: Ah, la chorcha. Si también (me entiende).
F: Los garrobo.
I: Si, los garrobo también. Comen {Inaudible}
F: {Inaudible}
I: ¿Mono (si no dijo hay) – {Inaudible} (que hay monos aquí)?
F: Aquí no (se incluyeron) {Inaudible}
I: ¿Y usted usa esa cerca vivas para otro motivos? ¿Por ejemplo, para leña o para sacar madera para postes?
F: Si, {Inaudible} se cortó un palo para poste, para {Inaudible}
I: ¿No lo utiliza para alimenta el ganado – por ejemplo la flor de madero o la hoja?
F: No.
I: Pienso que no todas las cercas que usted planto, siempre hay están {Inaudible} desaparecida alguna por ejemplo que se muerto los arboles
F: No.
I: ¿Todas hay están?
F: Si.
I: ¿Que le gusta mantener poste que en cerco con los postes así muertos o con las cercas vivas?
F: Cercas vivas.
I: Con las cercas vivas. ¿Porque piensa usted que – porque le gustaría?
F: Porque {Inaudible}
I: ¿Entonces, más que todo no le producen problema la cerca viva, más bien lo que producen esos beneficios?
F: Si.
I: ¿Y le gustaría tener plantar más cercas vivas en la propiedad – como sembrar más madero o otro tipo de árbol así para hacer cerca viva?
F: Si, claro.
I: Siempre por lo mismo porque benéfica por
F: Si, si.
I: Gracias por su tiempo.
[Small talk at the end of the interview]
End of Interview
0h16m20s

Interview 9

I: Cual es el dueño, el dueño
F: ¿El nombre el dueño?
I: (No encargado no importa), de su papa
F: Juan Domínguez.
I: ¿Dónde nació el o de aquí nació?
F: No, de La Virgen.
I: ¿Y le edad – cuantos años tiene?
F: Sesenta y siete o setenta (porque igual)

I: ¿Tengo para decir?
F: Si.
I: Okay. ¿Vive aquí cuantos años tiene?
F: Aquí, con nosotros no vivimos en la finca pero (vivíamos) aquí
I: Buenos, (vive) en la finca pues
F: En la finca seis, seis años están en esta finca.
I: Okay. ¿Aquí el, {Inaudible} el mandador de que la finca?
F: Si.
I: ¿Cuantos terreno la finca – cuantas manzanas tiene lo sabe? Un aproximado
F: Yo digo (es) ciento y veinte
I: El dueño que tiene la finca, la compró el o seguro que la compró o que forma
F: El señor {Inaudible} un propio dueño. El señor (que estaba) {Inaudible}
I: ¿Entonces, (ellos) la compraron o no sabe?
F: Era del papa del señor.
I: ¿(De) herencia?
F: Si.
I: Si, tiene – bueno, lo ocupa para ganado verdad, aquí
F: {Inaudible} [Tells a child not to touch something and the child begins to cry]
I: Cuantos terrena tiene – de este piensa usted que tienen de para ganado.
F: Aquí es todo.
I: ¿Todo?
F: {Inaudible}
I: ¿No hay algún lugar que tienen para bosque? ¿Que (no es para ganado)?
F: No.
I: ¿Todo es para ganado?
F: Todo (hallando) – pues tiene lugar que no limpia pero {Inaudible}
I: ¿Más o menos cuantos que el terreno no limpia? ¿No tiene idea?
F: Bastante como
I: Entiendo que hay lugar de (bastante) arbole y no que está {Inaudible} pero ganado se mete. Entonces, digamos que son no es – no son potrero realmente.
F: No.
I: ¿Entonces, yo me refiero esa (a de) más o menos cuantos?
F: Tiene como veinte manzana en eso que no limpia.
I: ¿Más o menos cuantos, buenos, cuantos ganado manejan en esa terrena?
F: En eso – no tiene mucho señor.
I: ¿Más o menos?
F: Como diez le dice señor.
I: ¿Y hay algún área que ocupa para sembrar?
F: Si, pero allí mete el ganado {Inaudible}
I: ¿Cuantos más o menos tiene esa área para sembrar?
F: Como dos manzanas.
I: ¿Que lo que le gusta sembrar?
F: Arroz que (más siembran) {Inaudible} (los digo)
0h5m17s

I: No sabe este sobre la idea del dueño – buenos, (me imagino) que siempre va a tener {Inaudible} para ganado y los potrero (pero) {Inaudible} (piensa) cambiar hacer {Inaudible} para trabajo o
F: No sé.
[Small talk]
I: Mire, buenos – el estudio que {Inaudible} sobre esa cerca donde ahí este – que sembraron eso madero negro más de todo {Inaudible} los sembraron, los pusieron
F: Si, los pusieron {Inaudible}
I: Entonces, eso es todo que tiene o hay en otro lugares que hay
F: ¿Madero?
I: De esa cerca así
F: Yo creo que es {Inaudible} porque puede estar {Inaudible}
[Another woman says something inaudible]
F: Solo ahí.
I: Más o menos – no sabe {Inaudible} como uno cien varas, dos cientos varas, o no se
F: Tiene (más de aquí) porque {Inaudible}
I: Al fondo. Uno tres cientos varas. Voy a poner tres cientos.
[Small talk]
I: ¿Cuantos – cuantos años tiene más o menos esa cerca – que pusieron eso – sembraron por eso o no sabe?
F: Quien sabe {Inaudible}
I: No, no, me refiero los arboles
F: {Inaudible} tienen bastante sus arboles
I: ¿(Tendrá más de diez años)?
F: Más de diez.
I: (Voy a) poner veinte. Y los tipos de árboles solo es madero negro.
F: Madero.
I: ¿Usted ha visto algunas tipos de animales en esa cerca? Animales como mono
F: (No vienen los monos) pero los negros, los congós
I: Los congós.
F: Hay {Inaudible} (se quise viene)
I: Lo ocupa como puente
F: Si, el camino
I: ¿Pájaros?
F: Pájaros, ardillas – todos (están caminando)
0h9m48s
I: Ustedes usan esos árboles para algunas otra cosas, las maderas por ejemplo para poste o
F: Para postes y para leña sí. Entonces, se ocupa para poste y leña.
I: Y para el ganado, no usan para corte la rama para comer el ganado
F: No, no creo que madero comen
[Other woman speaks up] – {Inaudible} (comen cuando estaba chiquito el madero)

F: Buenos, chiquito pero {Inaudible}
[There is an exchange back and forth over when and how cows eat madero between the two women]
I: No, madero es bueno para dos animales porque se lo comen la hoja. Lo que pase {Inaudible} están muy viejo, (cuida porque no es) mucha hoja. Estan como cinco metros de alto que bastante hoja pero {Inaudible} y como ha esta mala invierno también
F: Si, {Inaudible} (le comen)
I: ¿Antes han vivido, existían otras cercas o esas son las únicas cercas vivas? ¿Esos árboles?
F: No.
I: ¿Qué piensa usted que – es mejor, es bueno tener así esas cercas vivas o tener solo postes?
F: No, no, {Inaudible}. No me {Inaudible} (por uno que vaya caminando) (le dan sombra)
I: ¿Que otra beneficios, por ejemplo, que problemas le traen tener cercas vivas o que beneficios le traen – le traen más problemas o beneficios? Para que otra cosas le sirven, a la más de lo que menciona que puede sacar para leña, para sombra, para los animales
F: Los árboles de madero están para hacer casas.
I: ¿Le gustaría tener más cercas de eso tipo?
F: Si.
I: Si, bueno.
[El dueño arrives and I decides to ask him for some clarification]
I: ¿Cuantos más o menos de ese tipo de cerco con madero?
M: Solo ese.
I: ¿Más o menos cuantos de distancia?
M: Tres cientos varas. Creo que (tiene).
I: (Lo me puso) tres cientos varas. Que son buenos pueden tenerlo porque le beneficio
M: {Inaudible} construcción casas, postes – para dos sirven.
I: Si, le sirve usted, le sirve animales. {Inaudible} es que, tal vez, en el futuro no sembrar solo madero, sembrar otros tipos como (aguacuate)
M: {Inaudible}
I: Bueno, es todo.
End of Interview
0h15m44s

Appendix B: Biodiversity Study

Table 1

Identities and abundances of all bee captured (incomplete and therefore unidentifiable specimens excluded). In total, 4 families, 14 tribes, 34 genera, and 43 morphospecies are represented among these 1619 individuals.

Family	Tribe	Genus	Species or Morphospecies	Number Captured
Andrenidae	Calliopsini	*Calliopsis*	1	1
Apidae	Apini	*Apis*	*mellifera*	12
	Centridini	*Centris*	1	1
	Ceratinini	*Ceratina*	1	54
			2	31
	Eucerini	*Melissodes*	1	112
			2	2
		Peponapis	*utahensis*	1
	Emphorini	*Ancyloscelis*	1	24
		Diadasia	1	651
		Melitoma	1	6
	Ericrocidini	*Mesoplia*	*sapphirina*	1
	Euglossini	*Euglossa*	1	2
	Exomalopsini	*Anthophorula*	1	1
		Exomalopsis	1	4
	Meliponini	*Oxytrigona*	1*	2
		Paratetrapedia	1	1
		Partamona	1	1
		Plebeia	*frontalis*	53
		Tetragona	*ziegleri*	20
		Tetragonisca	*angustula*	9
		Trigona	*fulviventris*	12
			fuscipennis	17
			silvestriana	7
	Xylocopini	*Xylocopa*	1	1
			2	2
			3	1
Halictidae	Augochlorini	*Augochlora*	1	1
			2	17
			3	37
		Augochlorella	1	90
		Augochloropsis	1	8
		Caenaugochlora	1	5
			2	10
	Halictini	*Agapostemon*	*nasutus*	1
		Halictus	1	10
		Lasioglossum	1	1
			2	1
			3	31
			4	60
			5	308
Megachilidae	Anthidiini	*Anthidium*	*hallinani*	1
	Megachilini	*Megachile*	1	4
			2	5

*This morphospecies was only captured by netting.

Table 2

Table 2. Live fence tree species found within 75 meter area sampled for bees. All 14 sites included.

Scientific Name	Common Name	Family	Total Number	Percent of All Live Fence Trees	Bee Nests Observed
Azadirachta indica	Neem	Meliaceae	1	0.35%	No
Byrsonima crassifolia	Nancite	Malpighiaceae	1	0.35%	No
Cochlospermum vitifolium	Poro Poro	Cochlospermaceae	1	0.35%	No
Crescentia alata	Jicaro	Bignoniaceae	7	2.46%	No
Dalbergia retusa	Ñámbaro	Fabaceae	4	1.40%	No
Ficus spp.	Chilamate	Moraceae	1	0.35%	No
Gliricidia sepium	Madero Negro	Fabaceae	195	68.42%	Yes
Guazuma ulmifolia	Guácimo	Malvaceae	18	6.32%	No
Mangifera ovata	Mango	Anacardiaceae	1	0.35%	No
Myrospermum frutescens	Chiquirin	Fabaceae	8	2.81%	No
Piscidia grandifolia	Zopilote	Fabaceae	4	1.40%	No
Sapium thelocarpum	Palo de Leche	Euphorbiaceae	1	0.35%	No
Simarouba amara	Aceituno	Simaroubaceae	1	0.35%	No
Stemmadenia obovata	Cachito	Apocynaceae	2	0.70%	No
Tabebuia spp.	Roble/Cortez	Bignoniaceae	3	1.05%	No
Thouinidium decandrum	Melero	Sapindaceae	1	0.35%	Yes
Vachellia collinsii	Cornizuelo	Fabaceae	14	4.91%	No
Vachellia cornigera	Cornizuelo pico de pájaro	Fabaceae	12	4.21%	No
Unidentified spp. 1			2	0.70%	No
Unidentified spp. 2			6	2.11%	No
Unidentified spp. 3			1	0.35%	No
Unidentified spp. 4			1	0.35%	No

Figure 4

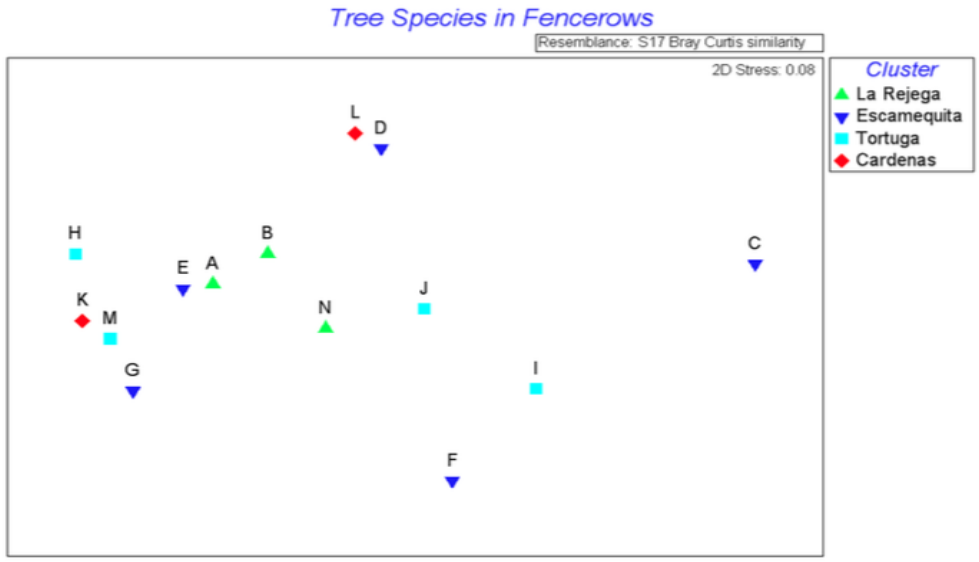


Figure 4
NMDS of Tree Species in Fence Rows

Figure 4. Non-metric multidimensional scaling plot showing an overall lack of differences in fence row tree species abundances across site clusters.

Species Accumulation Curves

All confidence intervals are overlapping at the 0.05 level of significance, except for in Figure 8 below.

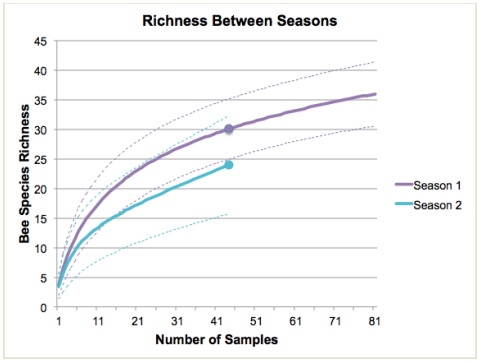


Figure 4. Observed species accumulation curves for each season. Season 2 (after rain) reached 24 morphospecies after 44 samples; Season 1 (before rain) showed a higher richness (approximately 30 morphospecies) at the same sampling effort.

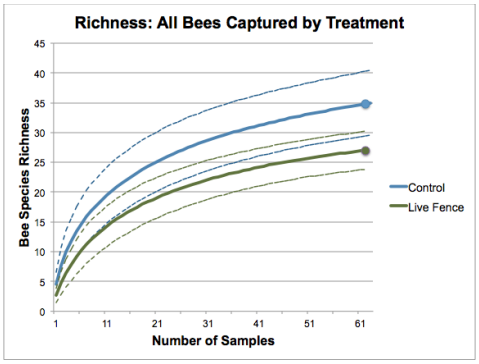


Figure 5. Observed species accumulation curves for all bees in living and control fences (seasons combined). The living fences captured 27 morphospecies at 62 samples. More than 34 morphospecies were obtained across all control fences after the same sampling effort, for a total richness of 35.

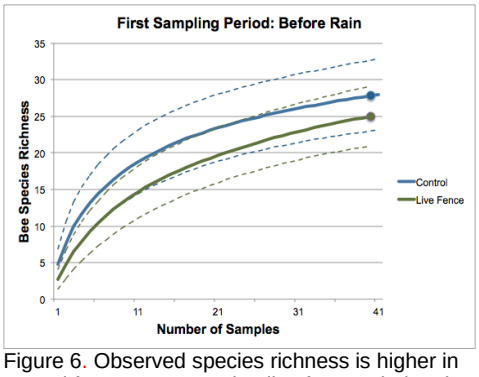


Figure 6. Observed species richness is higher in control fences compared to live fences during the pre-rainy season**.**

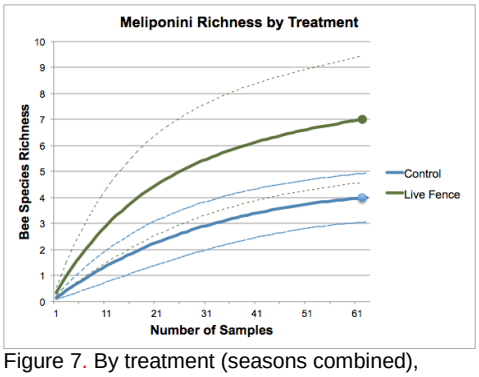


Figure 7. By treatment (seasons combined), Meliponines show greater richness in live fences compared to control fences.

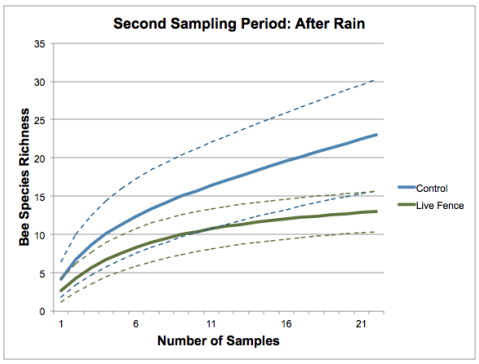


Figure 8. Non-overlapping 95% confidence intervals (15.72 vs. 15.66 species) show significantly greater richness in control fences compared to live fences in the post-rainy season.

Generalized Mixed Model Results: Fixed Effects and Fixed Coefficients Tables

Table 5. Fixed effects table for model predicting total bee abundance in the landscape

Predictor	F	P Value
Corrected Model	5.554	0.000
Treatment	13.941	0.001
Season	6.838	0.011
Elevation	4.615	0.037
Bee Nest	1.649	0.206
Season * Treatment	1.848	0.178

Probability distribution: negative binomial
Link function: log

Table 6. Fixed coefficients table for model predicting total bee abundance in the landscape

Predictor	β Coefficient	Std. Error	t	P Value	95% Confidence Interval	
					Lower	Upper
Intercept	0.363	0.6604	0.550	0.610	-1.427	2.153
Control Treatment	0.523	0.3084	1.696	0.095	-0.093	1.139
Pre-Rainy Season	-0.758	0.2739	-2.766	0.007	-1.303	-0.212
Control Treatment* Pre-Rainy Season	0.513	0.3775	1.359	0.178	-0.239	1.265
Elevation	-0.010	0.0044	-2.148	0.037	-0.018	-0.001
Bee Nest Absent	-0.311	0.2419	-1.284	0.206	-0.798	0.176

Probability distribution: negative binomial
Link function: log

Table 7. Fixed effects table for model predicting non-dominant bee abundance in the landscape

Predictor	F	P Value
Corrected Model	4.644	0.003
Treatment	13.068	0.001
Elevation	3.787	0.060
Season	2.834	0.096
Season * Treatment	0.735	0.394

Probability distribution: negative binomial
Link function: log

Table 8. Fixed coefficients table for model predicting non-dominant bee abundance in the landscape

Predictor	β Coefficient	Std. Error	t	P Value	95% Confidence Interval	
					Lower	Upper
Intercept	-1.396	0.5666	-2.463	0.075	-3.029	0.237
Control Treatment	0.940	0.3343	2.813	0.006	0.273	1.608
Pre-Rainy Season	0.519	0.3010	1.724	0.088	-0.080	1.117
Control Treatment* Pre-Rainy Season	-0.347	0.4050	0.857	0.394	-1.153	0.459
Elevation	-0.009	0.0046	-1.946	0.060	-0.018	0.000

Probability distribution: negative binomial
Link function: log

Table 9. Fixed effects table for model predicting meliponine abundance in the landscape

Predictor	F	P Value
Corrected Model	5.171	0.001
Treatment * Season	2.446	0.123
Treatment	2.213	0.144
Floral Index	1.120	0.292
Season	0.569	0.453

Probability distribution: negative binomial
Link function: log

Table 10. Fixed coefficients table for model predicting meliponine abundance in the landscape

Predictor	β Coefficient	Std, Error	t	P Value	95% Confidence Interval	
					Lower	Upper
Intercept	-3.702	1.3687	-2.704	0.114	-9.589	2.186
Control Treatment	-0.031	0.6622	-0.047	0.962	-1.356	1.294
Pre-Rainy Season	0.965	0.5127	1.882	0.064	-0.058	1.988
Control Treatment* Pre-Rainy Season	-1.281	0.8192	-1.564	0.123	-2.916	0.354
Bee Nest Absent	-1.191	0.4189	-2.843	0.007	-2.038	-0.344
Floral Index	0.014	0.0129	1.058	0.292	-0.012	0.039

Probability distribution: negative binomial
Link function: log

Table 11. Fixed effects table for model predicting meliponine abundance in living fence rows

Predictor	F	P Value
Corrected Model	4.737	0.021
Tree Species Richness	8.978	0.017
Bee Nest	7.806	0.021
Season	5.207	0.030
Mean Canopy Radius	1.034	0.337

Probability distribution: negative binomial
Link function: log

Table 12. Fixed coefficients table for model predicting meliponine abundance in living fence rows

Predictor	β Coefficient	Std. Error	t	P Value	95% Confidence Interval	
					Lower	Upper
Intercept	-0.426	2.4407	-0.174	0.866	-6.148	5.296
Bee Nest Absent	-1.684	0.6028	-2.794	0.021	-3.051	-0.317
Pre-Rainy Season	1.110	0.4864	2.282	0.030	0.118	2.102
Tree Species Richness	-0.440	0.1468	-2.996	0.017	-0.778	-0.101
Mean Canopy Radius	-0.264	0.2592	-1.017	0.337	-0.856	0.328

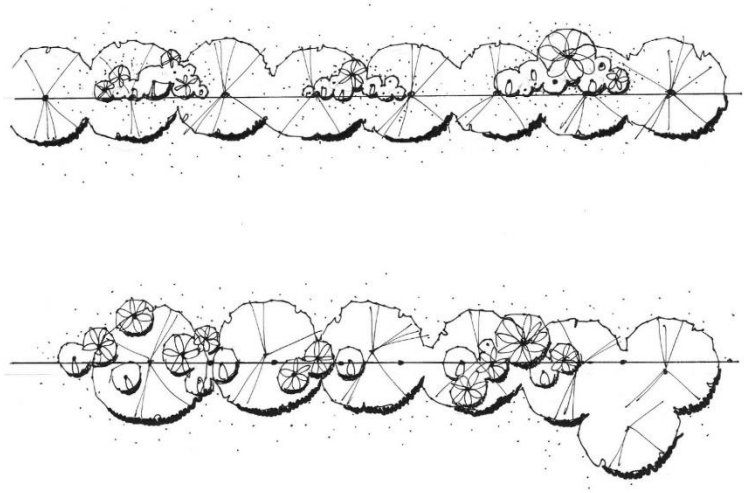
Probability distribution: negative binomial
Link function: log

Appendix C: Recommendations

Figure 9

Figure 10

Figure 11



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