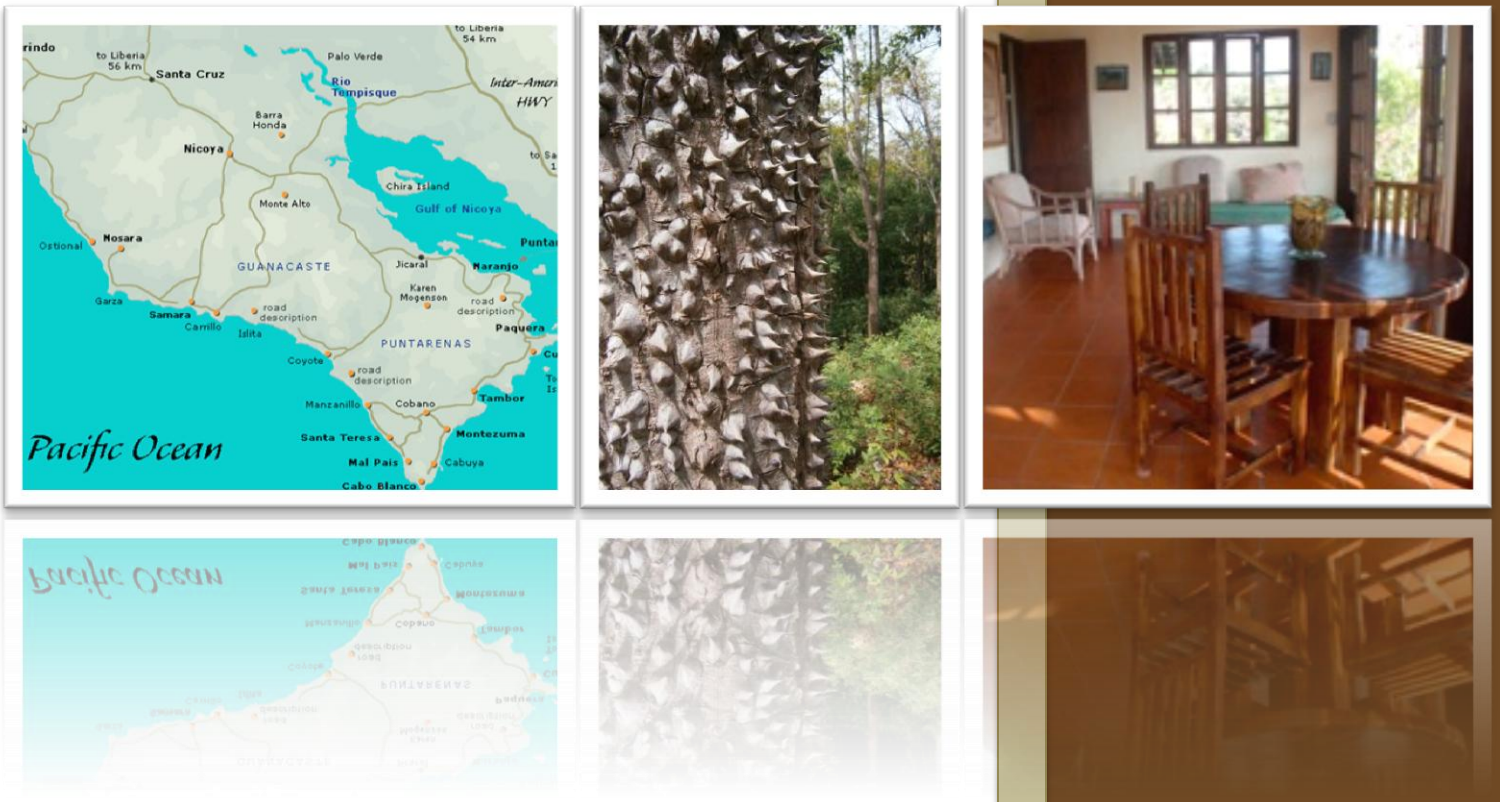
Investigating the Potential of Plantation Pochote as a Lumber Source in Sámara, Costa Rica



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Abstract

In Sámara, Costa Rica, a pochote plantation has 24 year old trees available for harvest. The owners of the plantation, the Sauter family, face the challenge of finding a use for this resource. The quality of plantation-grown pochote is not as well-known as its naturally-grown counterpart, due to its newness and minimal prevalence in the local market. This study's goals were to investigate the potential for plantation pochote as a lumber source by researching the wood's qualities and collecting data about the interest of local woodworkers. To accomplish this, the team completed research through interviews with tree experts and conducted two rounds of interviews and surveys in both Sámara and the nearby canton of Hojancha. Through data analysis, the team found that although it is not considered a luxury wood, plantation pochote wood does have many applications. Due to external market pressures, we estimate future demand for the wood to increase.

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Executive Summary

The Nicoya Peninsula, home to the Guanacaste Province of Costa Rica, is the westernmost area of land in the country. This land has supported several industries in the past century, including lumber and cattle industries. Subsequently, however, these industries have contributed to the overexploitation of resources in the area. For example, the pochote tree, a species native to the mountainous regions of the peninsula, has been overharvested in recent decades and the population of this once prevalent species has been greatly diminished. In response to the decline in the population of naturally growing pochote trees, a number of local landowners created plantations to promote the growth of more of this species. A problem plantation owners have encountered, however, is that there are differences in the qualities of the naturally-grown pochote and the pochote that is grown in plantations. Many woodworkers in the area believe that the different characteristics possessed by the plantation pochote are less desirable and have affected both the popularity and the marketability of the wood in today's lumber market.

The Sauter Plantation, located in Sámara, comprises twenty hectares of land in which six thousand pochote trees are growing. After allowing 24 years of growth for the trees to mature, the Sauter family has an interest in both harvesting and marketing the wood. Consequently, this Interactive Qualifying Project was created by Señor Konrad Sauter in order to investigate the current lumber market in the area and evaluate the best strategies for future uses of the wood from the family's pochote plantation. The research team from Worcester Polytechnic Institute (WPI) designed a project to explore the potential of the plantation pochote wood as a lumber source in the Guanacaste Province of Costa Rica.

First, the team conducted preliminary research to further understand the qualities and characteristics of the pochote tree as a lumber source. On-site field research was then conducted by the team during two trips to the district of Sámara. The first trip included interviews with five local ebanistas (carpenters), two sawmill workers, a pochote salesman, a pochote plantation owner and a forestry engineer from the Centro Agrícola de Hojancha (CACH). During the interviews, the team asked these experts a variety of

questions regarding basic demographic information, their experience working with plantation pochote, their knowledge of the wood's characteristics and features, as well as the potential for products to be made using this type of wood in the future. By speaking with these individuals, the team gathered data about the woodworkers' current perception of the pochote wood (both the plantation and the naturally-grown pochote that was once more prevalent in the market). The responses from these interviews provided data that helped the team reach a deeper understanding of the current lumber market in the region.

After the interviews, a survey was administered to those who had experience with plantation pochote wood. Surveys were given to five of the ebanistas, two sawmill workers, the pochote salesman, and the forestry engineer from CACH. The survey asked questions that addressed topics such as the biggest influence on the individual's opinion of the plantation pochote, their likelihood of utilizing the wood in the future, as well as a numerical ranking of the wood's qualities (workability, appearance, strength, durability, and its demand in the market). The information collected from the survey aided the team in characterizing the overall impression woodworkers had regarding the plantation-grown pochote.

Due to the cost of transportation and a limited supply of lumber, only one ebanista that worked in Sámara could be provided samples of the Sauter's plantation wood. Therefore, based on his responses to the survey questions, the team chose the ebanista who was the most experienced and the most skeptical of the wood, in order to determine if familiarity would change his opinion. During the second visit, a follow-up interview and survey was conducted with this ebanista to once again assess his overall opinion of the plantation pochote as a source of lumber. The survey involved the same questions as the first trip in order to compare the ebanista's responses before and after working with the wood.

The team compiled the data collected through this field research into individual profile tables, which demonstrate the opinions of the experts. Many of the experts had similar attitudes with regard to the value and potential uses of the plantation pochote wood. Although the plantation wood received high rankings in the areas of workability and durability, it has a low market value due to its recent scarcity in the lumber market and subsequent replacement by other woods. Therefore, the experts that the team interviewed

often preferred alternative types of wood because they have more experience working with that lumber than with the plantation pochote lumber. Some of the ebanistas explained that their hesitance to work with plantation pochote is because of the differences in qualities from the naturally grown pochote.

By understanding the current perceptions of the plantation grown pochote in the lumber market of Sámara and the Guanacaste Province, Konrad Sauter and his family will be able to better formulate a strategy for marketing their plantation wood. The WPI research team has compiled a list of recommendations to help increase the future sales of this wood based on the information collected through the interview and survey processes. These recommendations include:

- Collaborating with other pochote plantation owners in order to better regulate the consistency of supply and quality of the wood.
- Combining funds with other plantation owners to purchase the machinery necessary for certain decorative applications specific to plantation pochote wood.
- Increasing marketability of the plantation pochote wood by advertising it as a native species to the Guanacaste Province (as several other popular woods are not native).
- Continuing research into both efficient and inexpensive methods for the treatment of the plantation pochote wood, to prevent damage and promote healthy growth.
- Contacting the two ebanistas in Hojancha to conduct further tests on the plantation pochote wood to better understand its characteristics.

These recommendations will assist in creating more of a demand for the plantation grown pochote in the lumber market of Sámara, as well as other parts of the Guanacaste Province. Collaborating with other plantation owners would be beneficial because it would allow Sr. Sauter to have more control over the future supplies of his wood. For example, if he was able to maintain a steady output of his lumber he could continue to systematically harvest the trees in a manner that is both economically and environmentally beneficial. Emphasizing that the pochote is a native species increases its value to tourists as well as the local people due to the sentimental aspect of having “a little piece of Costa Rica” (Ebanista 4, personal communication, 2012). Through further testing and investigation,

the potential of this wood can be better realized, increasing the possibility that it will be utilized in the future.

Chapter 1: Introduction

Throughout the world, the advancements of civilization have had a significant impact on almost every natural ecosystem. For example, both the growth of the human population and progression of industrialization have led to an increase in uncontrolled extraction of natural resources. This is of great concern because exploitation, or the unsustainable and detrimental use of available materials, has depleted supplies of natural resources.

The tropical dry forests (TDF) of Costa Rica were subject to extreme deforestation and exploitation during the mid-twentieth century, making the TDF the most endangered resource-rich environment in the country (Quesada & Stoner, 2004). One species of the TDF that experienced severe devastation was the native pochote tree, *Bombacopsis quinata*, which was a major source of lumber during this time in the Guanacaste Province of Costa Rica. The pochote was overexploited to such a degree that by the 1980's, the trees were vanishing in areas where they had been prevalent just a few years prior (K. Sauter, personal communication, 2012).

In an effort to keep the species from becoming obsolete, pochote trees are being grown in plantations throughout the Nicoya Peninsula of Costa Rica. In the district of Sámara, Señor Konrad Sauter, the sponsor of this project, with the support of his family, has participated in the movement to bring the pochote back into the lumber market. The Sauter family has cultivated a pochote plantation containing approximately six thousand trees. This was done with the intent of protecting the remaining naturally-growing pochote by harvesting the trees from plantations instead. After 24 years of growth, these trees are ready to be harvested. The current supply of pochote lumber comes mostly from plantations because naturally-growing pochote is no longer prevalent in the area. However, there is minimal demand for trees harvested from plantations due to unfamiliarity with the features of the plantation pochote wood by the people of the Nicoya Peninsula (K. Sauter, personal communication, 2012).

A number of myths are spreading through the Costa Rican woodworking community regarding the qualities of the plantation pochote species. Pochote plantation owners

believe these myths exist because the features of the plantation pochote are different from those of the naturally-growing pochote wood. The naturally-grown pochote was considered a highly-valued luxury wood. However, the potential of plantation pochote wood has not yet been established. Therefore, it is being used for applications less suitable for its qualities, such as wooden crates and pallets (K. Sauter, personal communication, 2012).

The WPI research team worked with Señor Sauter to investigate the possibility of using the Sauter plantation pochote as a source of lumber in Sámara. The goals of this project were to investigate the current lumber market in the Guanacaste Province, to research the current uses of the plantation pochote wood, and to create recommendations to aid in improving the marketability of the wood. The project included a synthesis of preliminary research, which provided a better understanding of the pochote that facilitated in the development of the team's interview and survey questions. On-site fieldwork included an initial round of interviews and surveys that were given to wood experts in Sámara and surrounding areas. These experts included carpenters (ebanistas), a forestry engineer, a lumber salesman, sawmill workers and another plantation owner. By conducting interviews, the team was able to assess the current knowledge of plantation pochote among woodworkers in the Guanacaste Province. The wood experts then completed a survey that summarized and quantified their opinions of the wood's qualities including its workability, aesthetic appeal, strength, durability and market value.

At the end of the first trip, the WPI team identified the ebanista in Sámara with the most experience in the industry and was the most skeptical about the wood's potential. Samples of the Sauters' lumber were then provided to the ebanista so that he could work with the wood firsthand. One week after the ebanista received the samples, the research team re-interviewed him with questions pertaining to his experience with the wood. The team then conducted a follow-up survey, with the same questions as the initial survey, to quantify any changes in his opinion after working with the Sauters' plantation wood.

From this analysis, specific recommendations were developed and provided to Sr. Sauter for methods of improving the quality of the plantation and increasing the wood's marketability. This project is important because it has advanced the investigation of the plantation pochote wood's qualities and its potential in the market. Through this

investigation, the team has synthesized the opinions of experts in the field from Sámara with regard to the wood. The method the team established has laid the groundwork for future researchers to investigate the characteristics of the plantation pochote wood.

Chapter 2: Literature Review

Chapter 2 introduces the geographical region of Sámara and its economy in order to illustrate the environment in which this project was conducted. Sections 2.2 through 2.4 provide relevant background information necessary to conduct successful field research about the pochote tree, such as lumber terminology and characteristics of the pochote wood. Section 2.5 presents case studies of Koa and Alaska birch wood species, whose methods of being brought to the market can be applied to the plantation pochote.

2.1 Regional Background and History of the Economy: Nicoya Peninsula

The Nicoya Peninsula is the western-most landmass of Costa Rica. A map of the Nicoya Peninsula and the major districts that it contains are shown in Figure 2.1- 1. It is met by the Pacific Ocean on the west and the Gulf of Nicoya on the east. The Peninsula spans a distance of nearly 140 kilometers from north to south. It is comprised of two provinces, Guanacaste and Puntarenas, in the north and south respectively (Northern Nicoya Peninsula, 2012). Within the provinces of Costa Rica are cantons, which are regional boundaries comprised of districts in an area (Provinces of Costa Rica, 2011). The site of our project is in the district of Sámara, located in the Nicoya canton of the Guanacaste Province.

Figure 2.1- 1: The Nicoya Peninsula (http://www.nicoyapeninsula.com)

Over the past decade, the ecosystems of the Guanacaste Province have supported the growth of a variety of industries. These industries have been promoted and sustained by the abundance of available natural resources in the province. The cattle and timber industries are two examples of industries whose success were supported by the environment, but due to human exploitation and decreasing market values eventually failed (Calvo-Alvarao et al., 2009).

The cattle industry experienced massive expansion starting in 1950 and reached a peak in the 1970's. During this time, the size of the cattle herded in Costa Rica more than doubled, with nearly 40% of the country's cattle being raised in the Guanacaste Province. Due to a boom in the international cattle market supply in the late 1960's, the value of cattle-based products began to decrease (Calvo-Alvarao et al., 2009). Consequently, the cattle industry in Guanacaste diminished rapidly by the 1980's because it was no longer economically viable to raise and herd cattle (K. Sauter, personal communication, 2012; Calvo-Alvarao et al., 2009).

Many trees were felled by farmers in Guanacaste in order to accommodate for the increasing number of cattle in the region. Unfortunately, several species in the area, like mahogany and the naturally-growing pochote, were exploited for their value in the mid-twentieth century, because they had very desirable features. According to Sr. Sauter, this exploitation of native species, particularly the pochote tree, caused a depletion of its population. In total, this exploitation resulted in the loss of nearly twenty percent of forest coverage in less than thirty years (Calvo-Alvarao et al., 2009). Figure 2.1- 2 provides an example of a landscape that was previously covered in trees.

Figure 2.1- 2: Effects of Farming and Cattle Raising

The government has enacted several laws and founded agencies to protect the environment from further exploitation. The first forestry law, adopted in 1969, created a national parks system and aimed to regulate forest use on public land (Calvo-Alvarao et al., 2009). The Sistema Nacional de Áreas de Conservación (SINAC) in cooperation with Ministerio de Ambiente y Energía (MINAE), manage Costa Rica's forestry, wildlife, and protected areas by creating and implementing methods for the sustainable management of the country's resources and natural environments.

In restoring the environment, much of the natural beauty has returned to Costa Rica (Á. Terrán, personal communication. 2012). This beauty has attracted tourists from all over the world to visit, popularizing the ecotourism industry throughout the country. Ecotourism describes the active observation of the environment by tourists with minimal impact, in order to conserve its natural beauty (The International Ecotourism Society, 2012). The influence of ecotourism on Costa Rica's gross domestic product (GDP) has steadily increased over the past decade. GDP is the national monetary total that represents the value of goods and services produced by a country in a year (Investopedia, 2007). According to the U.S. Department of State's *Country Fact Sheet*, 67% of Costa Rica's GDP is due to "commerce, tourism, and services". The economy of the Guanacaste Province, in particular, is largely dependent upon the revenue created by tourism because its beautiful coastal views make it one of the most visited tourist destinations in Costa Rica. Tourism contributes to the local economy, which is largely dependent upon the revenue tourism creates (Bureau of Western Hemisphere Affairs, 2012).

The potential for increasing the success of industries in Guanacaste is limited by the infrastructure of its roads. The absence of efficient infrastructure impedes the potential of using the Nicoya Peninsula as a center for exportation. It also makes traveling throughout the peninsula more difficult for tourists. The future economy of the Guanacaste Province is dependent upon the improvement of infrastructure in the region and is influenced by the aftereffects of earthquakes and climate conditions that the province experiences (Bureau of Western Hemisphere Affairs, 2010).

The economy of Sámara, a district of the Guanacaste Province, is largely affected by the prosperity of the industries within the province. The progression of the most

economically influential industries in Guanacaste has included cattle ranches, lumber, agriculture, and tourism (Calvo-Alvarao et al., 2009).

2.2 Trees and Lumber

This section explains the terms that were used during the team's field research and that are used throughout this report. These terms include those pertaining to the characterization of trees, the treatment of lumber, and factors associated with potential harm to the wood.

Figure 2.2- 1 shows the anatomy of a tree trunk. The sapwood is the part of the tree that contains sap, which consists of chemicals needed for the tree to survive. As the tree grows, the rings of sapwood closest to the heartwood, the centermost part of the tree, become part of the heartwood (Bamber, 1977). Heartwood is the support structure of the tree. The strength of the heartwood depends on its development, which is influenced by several factors including the chemicals of the sap, the age of the tree, and environmental factors such as soil and climate conditions that the tree has experienced (Nawrot et al., 2008).

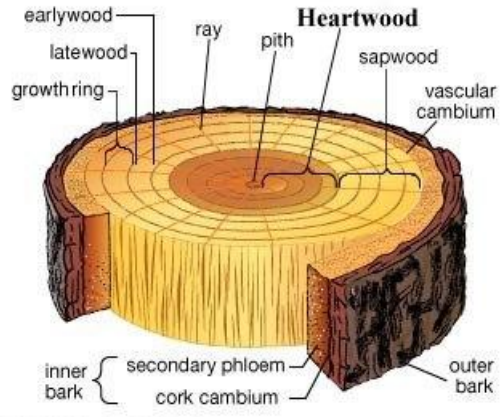

Figure 2.2- 1: Anatomy of a Tree (http://gardeningplus.blogspot.com)

"Hardwood" and "softwood" are two main classifications of wood. These classifications do not refer to the actual strength or hardness of the wood, as there is substantial variance in both of these characteristics amongst species of wood. Hardwood is a classification that refers to deciduous and evergreen broad-leaved trees, whereas as softwoods are coniferous or needle-leaved trees (Parsons Joinery Ltd., 2012). Generally

speaking, hardwoods have a higher density and stronger heartwood than that of softwoods. In order to test for the actual hardness of a wood sample, one can conduct the Janka Hardness Test. This test measures the amount of force needed to drive half of the circumference of a 0.444 inch steel ball into a piece of wood (Green et al., 2006).

Examples of hardwoods are mahogany, teak, walnut, and naturally-growing pochote (Diffen, 2012). Typical uses of hardwoods are for house trimmings and furniture such as doors, tables, molding and flooring. Additionally, because of the resiliency to environmental factors associated with hardwoods, they can be used in the exterior protection of houses (Parsons Joinery Ltd., 2012). Examples of softwoods are pine, spruce, and cedar. Softwoods are usually used for furniture (Diffen, 2012). The value of hardwoods and softwoods depends on factors that include the current market value of the wood, the amount of supply and the quality of the species. Hardwood species are more expensive to purchase because they are stronger than those of softwood due to their densities, making them more suitable for the majority of lumber based applications. This also indicates why hardwood species are generally in higher demand (Parsons Joinery Ltd., 2012).

The main factors that make a species desirable as a lumber source are the ease of access to the species, the quantity of the species ready to be harvested and the intrinsic qualities of the wood. If a species of tree exists in an area that is both easily accessible and harvestable in large quantities, the cost of felling the timber will be minimized, thereby allowing more profit for the seller (Nix, 2012). Qualities of the timber that increase its values are a strong heartwood and the ability to reject fungi. These qualities change depending on the environment in which a tree grows, and therefore not every sample of a species will demonstrate the same qualities. Felled trees are most receptive to fungal damage after their bark is removed (Arbor Day Foundation, 2012). Fungal rot most quickly affects lumber when the lumber has an interior moisture level of at least 25%, and when it is being kept in an environment between 5-40˚C in the presence of oxygen (Timber Research Unit, School of Architecture, The University of Tasmania, 2012). As these conditions are prevalent in most environments in Costa Rica, felled lumber is highly susceptible to damage caused by rot. It is difficult to reverse the damage caused by fungal rot because this process of rotting affects the timber's cell structure (Heywood, 2012). The best method to prevent lumber from being attacked by fungi is to dry it immediately (by

removing the moisture from the tree) and to treat it with protective chemicals (Timber Garden Build, 2012).

When a tree has matured to the point where it can be harvested, it must be processed (dried and cut) and prepared (treated with chemicals) to be used as lumber. The chemicals in, and moisture of the sapwood determine the duration of time needed for a specific species or sample to dry. Additionally, the shape of the sample being dried is a factor that determines the temperature at which it needs to be dried. If the incorrect temperature is used to dry the wood, it will be at risk of degradation, such as warping, twisting, or other undesirable imperfections in the shape of the wood, as depicted in Figure 2.2- 2 (Bousquet, 2000).

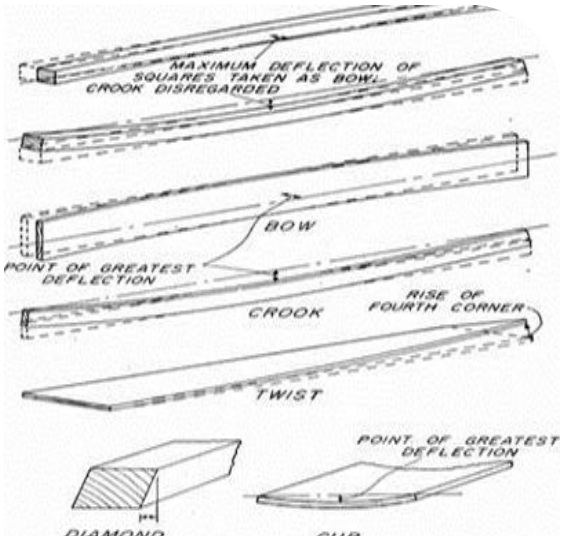

Figure 2.2- 2: Ways Wood Can Warp (https://fp.auburn.edu)

2.3 The Pochote Tree

The pochote tree, *Bombacopsis quinata,* is part of the Bombaceae family of trees. These trees are native to tropical dry forest environments of Pacific Central America. Naturally growing pochote trees have become rare within the Guanacaste region because of overharvesting (E. Sauter, personal communication, 2012). As a result, the Costa Rican government provided incentives, starting in 1996, to repopulate many exploited species. This has caused a rise in the number of plantations growing pochote in an effort to prevent further devastation to the population of the naturally-growing pochote tree (World Resources Institute, 2012). Although the goal of creating the plantations was to preserve

the pochote tree, there are differences in the characteristics that the naturally growing pochote possesses as compared to those of the plantation pochote. These differences are due to the level of maturity of the tree. The older a tree is, the longer it can mature. The naturally-growing pochote trees, which are used for lumber, have typically matured for anywhere from 80 to over 100 years. Plantation pochote trees have only been growing for 20 to 30 years, and therefore have not yet fully matured (Á. Terán, personal communication, 2012; K. Sauter, personal communication, 2012; D. Y. Leuba, personal communication, 2012).

The naturally-grown pochote is characterized by its dark grey, fluted bases, large crown, and distinctive protruding spikes, as depicted in Figure 2.3- 1 (Perez Cordero et al., 2002). They are deciduous trees that grow to an average height of forty meters and a diameter of up to two meters. The diameter of a tree is measured at "breast height", 1.4m from the ground (this is called "diameter at breast height" or DBH). The pochote is a resilient species that is capable of growing in many types of soil, ranging from heavy clays to sandy beaches. It can survive in drought conditions for several years and in flooding conditions for several weeks. When the heartwood is initially harvested it is a pale pink color and easily treated with preservatives. After exposure to air, the color becomes a darker mix of red and brown and is very hard to treat with preservatives. The heartwood is resistant to rot caused by white and brown fungi, however it is susceptible to termite attacks. (Perez Cordero et al., 2004; Hodge et al., 2002; Chudnoff, M., 1984).

Figure 2.3- 1: Pochote Tree in Guanacaste (http://www.fotolia.com/id/23233390)

The value and versatility of the pochote wood led to a high demand for its lumber and subsequent over-exploitation. Foresters unsustainably harvested the naturally-growing pochote because of its long and straight trunk, making the wood an excellent source for door and window frames, cabinets, furniture and molding. The wood was also used to make veneer, plywood, particleboard and paper products (Kane et al., 1993). Currently, pochote wood is being harvested from plantations using a monoculture technique, and natural growing wood is rarely being harvested because of its scarcity.

The use of a monoculture plantation is a popular method for growing concentrated populations of a single species (Figure 2.3- 2). This method allows for harvesting that is uniform, sustainable and easy to manage (Piotto, 2008, 781-786). By using the monoculture method, a single species can survive without competing with different species for nutrients or sunlight. The quantity of trees in a monoculture plantation can be maintained in order to maximize profit. However, it could be more beneficial to grow a mixture of species, called polyculture plantations, instead of only one (The University of Reading, 2012). The polyculture method more closely resembles natural growth in the environment (Fears, 2008). Use of the polyculture method helps the soil by varying the quantity of needed nutrients, however harvesting in a polyculture plantation can be difficult because of different growth rates. Using monoculture rather than polyculture techniques are highly debated and have been for many years (The University of Reading, 2012).

Figure 2.3- 2: Sauter Monoculture Pochote Plantation

The plantation pochote has a similar external appearance to that of the naturally grown pochote. It grows to approximately the same height and has spikes that protrude

from the bark of the tree. However, the plantation pochote is considered a softwood species because it does not have the same molecular structure of heartwood and sapwood as the naturally-grown pochote. The plantation pochote's wood is softer than that of the naturally-grown pochote's and is considered a lightwood because it has a dry density of 0.30g/cm^3 (Roque et al., 2010). Typically, the plantation pochote have been harvested when they are between eighteen and twenty four years old, and as the eighty years or older naturally grown pochote has had more time for growth, the naturally grown pochote is stronger.

The plantation pochote does not have the same taper as that of the naturally-grown pochote. Taper is defined as a ratio of the diameter of a tree's trunk at breast height to the total height of the tree. Trees with a high degree of taper have bad form due to their disproportionality, while trees with a low taper maintain a more stable shape. The plantation pochote has a high degree of taper, which causes irregularities when cutting boards from the logs. Boards from trees with a high taper tend to have more jagged edges because the grain runs diagonal to the length of the boards. The lack of uniformity and asymmetrical growth of the trees is also a challenge when felling the trees, because it is difficult to predict where the tree will fall. Cracks averaging in length between three and seven centimeters were noted to be on nearly half of all pochote boards. In most cases, boards bent to a curve of up to eight millimeters and buckled up to two and a half millimeters. Buckling occurs due to the expansion and contraction of the wood, creating rises in flooring. These differences from the plantation pochote are the result of using a monoculture plantation (Roque et al., 2010).

Although the heartwood from the plantation pochote is softer than that of the naturally-grown, the spikes protecting the tree dull cutting blades more rapidly than trees with softer layers of bark, thereby making it more difficult to fell the trees. During the dry season, logs tend to crack and have dry rot at the base if they are stored in the field or placed in collection areas for long periods of time. The plantation pochote does not have the same protective chemicals in its sap as the old wood and therefore it is more susceptible to insect attack and wet rot, which result in wood discoloration. However, because the plantation pochote is a lighter, less dense wood, it is easier to dry and

therefore easier to treat with preservatives and pesticides to prevent damage caused by insects and rot (K. Sauter, personal communication, 2012).

2.4 Tree Testing

Workability, or the ease with which a product can be manipulated (i.e. how pliable, easy to cut, bend etc.), is one of the most important characteristics of wood that can be determined through testing (Reeb, 1997). A key factor that contributes to the workability of wood is the process of drying, which differs for every species of tree. When trees are cut, they have a high percentage of moisture that increases the potential for problems regarding the structural integrity, warping, of the wood and its receptivity to fungi and insects. Lumber is dried to reduce the weight and shrinkage of the timber, as well as to decrease the potential for mold and insect attack. Drying also improves the strength of the wood and allows the timber to absorb preservatives more easily (Rietz, et al., 1999).

One method for drying lumber is to stack it in layers (Figure 2.4- 1). Planks can be stored in sheds, after being stacked, with spacers put between planks to allow for even air circulation. These sheds can be heated, have fans, or be open, depending on the preference of the artisan and the drying times of the wood. The conditions must be carefully monitored to ensure proper drying so as to avoid rot and other forms of degradation described in section 2.2 (Rogers, 2011).

Figure 2.4- 1: Wood Stacking and Drying (http://www.lumberbylance.com/kiln.php)

Another important property of wood is its resistance to fire. There are many standards defined by the National Fire Protection Agency (NFPA), which recommend

different methods for testing for a species' fire resistance. Single burning item (SBI) tests, ignitability tests, and cone calorimetric tests are examples of techniques used to measure a species' resistance to fire. SBI tests are used to test a product's reaction to fire when exposed to another burning item (Fire Testing Technology Ltd., 2012). These tests are done to see if products are firestop (a term used for a material's ability to inhibit the spread of fire) or fire retardant. Firestop doors, for example, do not let fire pass through and they block the spread of fire throughout various parts of a building. Wood products can be treated to make them more fire retardant (National Fire Protection Agency, 2012; Single Burning Item, 2012).

Another measurable quality of wood is flexure, or the amount a material can be bent, folded, or turned. There are a variety of tests that measure flex, the most common of which is the four point flexure test, as depicted below in Figure 2.4- 2. A beam of wood is placed on top of two pins that apply an upward force on the beam. Two additional pins are then placed to the top of the beam in order to provide a downward force on the beam. A deflectometer is used to measure the deflection in the middle of the sample, the sample location that experiences the most stress. The four point test produces stress along an extended region of the sample. Therefore more accurate results regarding the possibility of defects are provided by exposing a larger amount of the sample (Nordson Dage, 2012). The results are displayed in a stress-strain diagram where the "flexural strength is the maximum stress in the outermost fiber" (Instron, 2012). Flexure is one of the five strength properties commonly measured. Other properties include shear tests parallel to the grain, and tests of compression and tension with and against the grain.

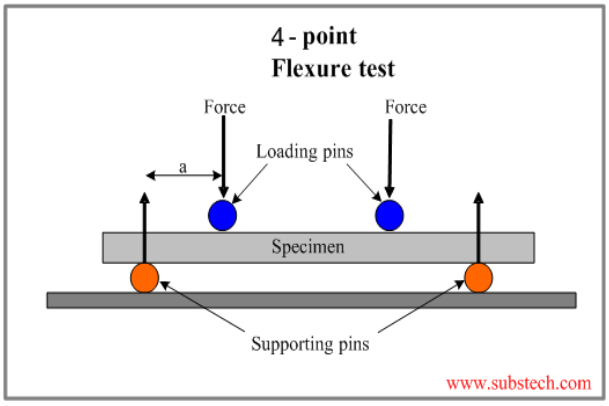

Figure 2.4- 2: 4-Point Flexure Test (http://www.substech.com/)

2.5 Case Studies

As the plantation pochote wood is not highly desired in the wood crafting industry, it is relevant to look at case studies of woods such as the Alaska birch and Hawaiian Koa. These two species of trees have been successfully integrated as lumber sources for niche markets, even though there is little industry-wide demand for their wood. We can use the methods applied by these researchers to develop a successful marketing plan to increase the demand for and exposure of the Alaska birch wood (Donovan et al., 2003). The Koa wood provides an example of marketing the wood of the Koa tree as a heritage wood in the Hawaii ukulele industry (King & Tranquada, 2003).

Alaska Birch Wood

Alaska birch wood serves as an example of generating market exposure and increasing the demand for a species that is neither popularly used nor highly demanded. Alaska birch wood has notable features including knots, bark pockets and inconsistent coloring due to fungi, as shown in Figure 2.5- 1 below. However, these features are seen as imperfections and therefore decrease its grade as a hardwood lumber source in the National Hardwood Lumber Association (NHLA) products (Donovan et al., 2003a). The grade a species of wood receives from the NHLA helps to determine its market value and suitability as a lumber source (American Hardwood Export Council, 2012). Although the birch wood receives a low NHLA grade and is not in high demand in many markets, it serves as a source of lumber in niche markets. Researchers have developed marketing plans by conducting market research with craftsmen and customers of various markets.

Figure 2.5- 1: Alaska Birch Tree (www.yellowplane.com)

The first objective that the researchers had to complete was to identify the characteristics of the birch wood and use these to their advantage (Donovan et al., 2003b). They identified two marketing strategies; "focus" marketing and "product differentiation", which they could use effectively. A focus strategy, a marketing plan that advertises certain features of a product that have the potential to satisfy the needs of a specific customer, was used to market birch wood. "Product differentiation", which is a method of advertising distinguishable qualities of a certain product in comparison with other products that are currently available in the market, is also another viable strategy widely used in the marketing industry (Dickson & Ginter, 1987; Donovan et al., 2003a).

By combining the use of a focus strategy and product differentiation, researchers increased the demand for Alaska birch wood in the niche market of cabinet making and Alaskan craft shops. To prove there was demand for the Alaska birch, researchers presented the results of customer surveys to wood suppliers. Based on certain demographics (middle-aged men) and applications (cabinetry), the imperfections in its wood resulted in an increased desirability because of its aesthetic qualities. Even after presenting these results, potential buyers of Alaska birch were hesitant to work with the wood because of a limited steady supply of the wood. However, researchers solved this problem by creating a cooperative network with suppliers of independent companies who work together to provide a steady supply of Alaska birch to the market. Currently, Alaska birch is being used in the cabinetry and souvenir industries of Alaska and its products are exported throughout the United States (Nicholls, D. L., 2002).

The methods used by researchers to successfully market the Alaska birch as a niche source in the cabinet industry provide a clear example of a process that can be used to increase the demand for a product with seemingly undesirable features (Donovan et al., 2003b). The example of successfully identifying the sources of demand, namely groups to whom marketing the wood is viable, along with assessing the current level of demand for the Alaska birch demonstrates one method of developing a market for a supply of wood held in a similar regard as that of the plantation pochote.

Koa Wood

Koa, *Acacia koa*, is thought to be the most valuable and beautiful native timber of Hawaii. It is a tree that grows to 25m in height and has a DBH of 150cm (Agroforestry Database 4.0, 2009). The trees are much less prevalent than they previously were due to many factors including exploitation for commercial use, land clearing, and destruction by animals, insects, and fires. In the past, this species was used to make canoe hulls, as the Koa tree grew very straight and tall. Despite its beauty, it is not commonly used in many markets. However, one niche market has realized the Koa's potential. The qualities of this wood, such as its natural beauty and ability to resonate sound, have made it a very suitable material for the production of ukuleles. In fact, ukuleles made of Koa wood are some of the most highly prized and valued instruments in the ukulele market. The use of Koa as the lumber source in a niche market is an example of how a species of wood, although not desired in the lumber supply market, could be successfully marketed as a niche product towards specific applications (King & Tranquada, 2003; Whitesell, 2004).

2.6 Summary

Costa Rica is working to sustainably support its economy while balancing obligations to its environment and its people. At one time, the naturally-grown pochote tree was a viable source of timber, but human activity caused its prevalence in the market to diminish. The plantation pochote that is currently being harvested exhibits different properties and characteristics than that of the naturally-grown pochote. In Sámara, as in many areas of Central America, research is being conducted to determine strategies to successfully bring the plantation pochote into a lumber market that was not initially receptive to it. Our research investigates the potential of plantation pochote in the lumber supply market or in other niche markets by employing methods similar to those used with the Alaska birch wood.

Chapter 3: Methodology

To achieve the project's goals, the WPI research team used a three-part approach: first compiling and synthesizing preliminary research, second conducting field research (interviews and surveys), and third performing an in-depth analysis of the wood's qualities by providing samples to an ebanista to work with first-hand. From the preliminary research, the team learned basic information about the plantation pochote wood that aided in the development of the interview and survey questions. It also assisted the team in understanding the participants' responses to the interview and survey questions. The team conducted a two part field research method to gather data pertaining to the perceptions of local woodworkers in Sámara about the plantation pochote wood and its potential in the lumber market (part one of the field research). During this trip to Samara, the team also offered workable samples of the Sauter's harvested pochote wood to the most qualified and skeptical ebanista. A second on-site visit consisted of a follow-up interview and survey (part two of the field research) with the ebanista who worked with the wood samples during a ten day lapse in time between the two visits. The administration of an additional survey enabled the team to quantify any changes in the ebanista's opinion after working with the plantation pochote wood. The team used the information gathered through the conduction of preliminary research and fieldwork to create a set of recommendations for future steps in the overall improvement of the Sauter plantation and the development of a plantation pochote market.

3.1 Objective 1: Preliminary Research and Development of Fieldwork Questions

To develop interview and survey questions that accurately conveyed the information we needed, the team conducted a thorough investigation of previous research. For the preliminary research, the team synthesized and analyzed existing information that had been collected by Elke and Annelise Sauter. This research consisted of published reports and expert opinions about the plantation pochote from various presentations led by engineers from the University of Costa Rica (UCR) and leaders of the lumber industry in Costa Rica. The team also contacted a number of researchers through e-mail correspondence to confirm the results presented in the Sauter's research, in an attempt to

minimize any inherent bias from the data we were provided. Topics of discussion covered in the team's contact with these organizations pertained to the basic characteristics of the pochote wood, its past and present uses, and the wood's current value in the market. By gaining information from experts in the wood industry, the team was more aware of the broad concepts that were to be discussed during field research regarding the wood. The team was also able to better anticipate how the ebanistas might interpret the questions asked. This allowed us to formulate interview and survey questions that could be interpreted correctly. This more informed knowledge base also allowed the team to analyze the results from the field research with a higher accuracy.

The purpose of the interviews was to gauge the current opinions and knowledge of woodworkers in the Guanacaste Province about plantation grown pochote lumber. These interviews involved questions regarding the woodworkers' current understanding and experience with the wood, knowledge about past and present applications of the wood, and any additional information they had about the wood. The final question requested the names of other ebanistas to contact in the area, in order to increase the size of the team's sample for data collection. The interview, found in Appendix A, contains the list of questions which were used to guide the conversation and acted as a pool for topics to be drawn from throughout the interview.

The team did not want to occupy too much of the ebanistas' time, nor lose their interest in participating in the survey, as the team was anticipating the ebanistas to have busy schedules. Therefore, the survey was designed to be completed in minimal time, while still obtaining the information that was of utmost importance to our sponsor. The team made the decision to administer the surveys following the interviews, because the discussion-based interview helped to initiate thought about the plantation pochote wood and provided an opportunity for any necessary clarifications that arose. If the surveys had been administered before the interviews, it is possible that the woodworkers may have provided inaccurate responses due to a misunderstanding of the subject matter (i.e. they could have responded about the naturally growing pochote tree to survey questions, making their response irrelevant to our results). The survey (Appendix B) has four brief questions which were developed with as little ambiguity as possible. The survey questions were administered orally and were designed to facilitate in the comparison of responses

from one interviewee to another. In order to collect quantifiable data, Question 2 on the survey asked the individuals to rank different qualities of the wood on a scale of one to five, where one was the worst and five was the best. The team chose the use of a numeric scaling system so that the responses to each of the qualities of the wood were less subject to our interpretation. Our expectation was that this would result in more accurate responses.

Prior to our first visit to Sámara, Sr. Sauter informed us that his nephew, Álvaro Terán (an agricultural engineer who studied at EARTH University), would be acting as a translator and guide to assist with the research. Woodworkers in the Guanacaste Province spoke with a dialect that made it difficult for the team to understand and to communicate with them independently. Therefore, Álvaro was the primary communicator in that he conducted the conversations with the interviewees and asked the questions in the survey. Following each of the interviews and surveys that were conducted, Álvaro and the team discussed their respective notes, which each person had taken during the interaction. A compiled version of the synthesized responses is presented in Chapter 4.

3.2 Objective 2: Field Research in Sámara

To better assess the knowledge and experience of the woodworkers in the Guanacaste Province, the WPI team conducted a two part field research strategy that was completed through two trips to Sámara. During the first trip, which took place between the dates of November 11th and November 16th, we conducted a set of interviews and surveys with local wood experts in Sámara and the surrounding canton of Hojancha (this is part one of the field research). This first visit gave the team the opportunity to speak with ebanistas (carpenters), saw mill workers, forest engineers, plantation owners, and wood salesmen. A second visit to Sámara, from November 26th to November 27th, consisted of a follow-up interview and survey (part two of the field research). The team initially planned to distribute wood samples to all of the ebanistas that were interviewed, however this plan had to be altered as described below.

Part One of the Field Research

On the first day in Sámara, November 12th, Álvaro took the team to the largest sawmill in the Guanacaste Province and two carpenter shops, where we interviewed and

surveyed one sawmill worker and two ebanistas, respectively. The team first interviewed each individual to gather qualitative opinions, and then asked them to participate in the short survey to quantify their opinions. The following day, the team interviewed and surveyed two more ebanistas, a sawmill worker and a forestry engineer (from CACH, Centro Agrícola Cantonal de Hojancha) in the neighboring canton of Hojancha. Álvaro also conducted phone interviews with one other ebanista, a plantation owner, and a lumber salesman (who had a strong knowledge base of the plantation pochote), as they were located in distant regions that were not easily accessible. By expanding the sample of interviewees to individuals beyond those who directly craft wood, the team was able to gather a broader range of information and opinions.

On the third day, the team visited the Sauter pochote plantation and noticed that only a limited supply of workable (cut, dried, and chemically treated) pochote was available. Thus, we had to alter our original plan of distributing the wood samples to every ebanista we interviewed in order to identify any change in their opinions of the wood. Because a sufficient supply of pochote lumber was not available from the Sauter plantation, the team had to select a single ebanista to work with the wood. We chose Ebanista 2 (for reasons that are explained in the Follow-Up Interview and Survey section below) to use the pochote samples. He was contracted to use the wood to carry out a home improvement project for the Sauter's beach house in Sámara.

The following day, Ebanista 2 came to the Sauter's house to assess the work Sr. Sauter wanted done. Sr. Sauter offered this ebanista monetary compensation for the creation of a short wall, window frames, and molding for a room off of the kitchen. Ebanista 2 accepted the offer and later that night, Álvaro and the team went to the ebanista's residence and waited for the plantation workers to deliver the wood.

Part Two of the Field Research

Because the supply of pochote wood from the plantation was only sufficient to give to one ebanista, the team decided to do a preliminary evaluation of the ebanistas pertaining to their general opinions and numerical responses to the survey questions. To observe whether working with the samples of lumber would have an effect on the attitude of an individual with a strongly negative opinion, the team chose the ebanista with the lowest

opinion of the wood and who was the least likely to use it in the future. Ebanista 2 was chosen to receive samples of the wood because his attitude towards it exemplified the one which we determined would most inhibit the development of demand for plantation pochote wood in the market.

During the second visit to Sámara, ten days after the first, a follow-up interview and survey were administered with Ebanista 2. In that time, Ebanista 2 had created the short wall and window frames using the Sauter's plantation pochote wood (Figure 4.2- 6). The questions posed during the follow-up interview allowed the team to record any changes in his opinion of the pochote wood after working with the samples. The questions also inquired about the overall experience the individual had with the plantation pochote wood and whether after working with it he had an interest in utilizing the wood in future work. These questions can be found in Appendix C.

After the second interview with Ebanista 2, we asked him to respond again to the same survey questions we administered after his first interview. By asking the same questions, in particular the question involving the ranking of plantation pochote's different characteristics, the team was able to numerically assess any changes in opinion between the ebanista's opinion before and after working with the wood.

3.3 Objective 3: Analysis and Synthesis of Results

The final objective was to compare the results from the two parts of the field research (part one- the initial interviews and surveys, part two- the follow-up interview and survey) and analyze any changes quantified by the survey after the ebanista worked with the wood. By using the same survey questions for both parts of the field research, the team hoped to quantify any changes in the ebanista's opinions of the pochote wood. This information is highly valuable because it provides insight for Sr. Sauter on how to formulate a marketing plan for plantation pochote in the future. Moreover, due to the experience and reputation of this particular ebanista, such synthesized findings about the quality of the plantation pochote lumber could be used when trying to sell the wood to other cantons in the Guanacaste Province.

Chapter 4: Results

This chapter presents the results of the research and fieldwork conducted for this project in the district of Sámara in the Guanacaste Province of Costa Rica. Section 4.1 introduces the preliminary research conducted in San José, which aided the team in developing a deeper understanding of the qualities of the plantation pochote wood. Section 4.2 provides the information collected from the interviews and the numeric results obtained from the surveys from each of the individuals. A description of the follow-up survey conducted with Ebanista 2, as well as an analysis of its significance is included in this section. Section 4.2 concludes with information about the Sauter Pochote Plantation which was acquired when the team visited the plantation during their first trip to Sámara. Section 4.3 provides an analysis of the interview and survey interactions.

4.1 Synthesis of Preliminary Research

The WPI team completed preliminary research regarding the plantation pochote wood through contact with various people including members of the Sauter family (Konrad and his daughters Elke and Annelise), and wood experts (defined as people who have had significant experience working with or researching wood). These experts include Francisco Matamoros Hernández (a lumber salesman), Dominique Y. Leuba (CEO of Precious Woods Central America Ltd.) and Carlos Luis Sandí Chinchilla (Professor from EARTH University, Costa Rica). These experts provided information via e-mail about the research they obtained and the work they have done with plantation pochote wood.

Sr. Konrad Sauter is the son of Werner Sauter, the owner of the pochote plantation in Sámara. Sr. Sauter provided the team with information specific to the 24 year old pochote plantation wood, stating that it has qualities that are more similar to the naturally-growing pochote wood than that from other plantations. Sr. Sauter remarked that the plantation pochote wood could be used for door and window frames, cabinet doors or construction applications. He wanted the potential for this to be tested by ebanistas (carpenters) in Sámara and other nearby districts.

Elke and Annelise Sauter, the daughters of Konrad Sauter, spent a few months researching the plantation pochote wood's potential prior to the WPI team's initiation of

this project. Elke provided the team with the research she had gathered. This information was incorporated into the background information in Section 2.3. According to Elke, the main use for the wood is to make wooden pallets used for transportation of goods.

Francisco Matamoros Hernandez is a lumber salesman of species from tropical dry forests. He has been marketing the plantation pochote wood since 2004. Francisco is having difficulty selling the wood due to the plantation pochote's small sized heartwood. According to Sr. Hernandez, the small sized heartwood of plantation pochote (compared with the naturally-growing pochote) has contributed to its minimal demand in the international lumber supply market. Domestically, the lumber is being sold to woodworkers to be used for low value plywood, flooring, molding and furniture products.

Dominique Y. Leuba, the CEO of Precious Woods of Central America, reported that plantation wood is very slow growing, and she suggested that for it to mature fully, 24 year old plantation pochote should grow for another twenty years. According to Sra. Leuba, if harvested before this time, the wood is light in color. After this time, the wood should grow denser and develop heartwood of a deeper red color, thus increasing the value of the plantation pochote wood in the market.

According to Carlos Sandí of EARTH University as well as other contacts with whom the team spoke, the plantation pochote wood is highly susceptible to rot caused by water damage. Sandí has been looking for effective methods to prevent water from damaging the wood. His research suggests that rather than immediately treating the wood with painted-on chemicals, one should submerge the wood in boron salt baths, because these would better protect the wood than applying an external coat of chemicals.

4.2 Field Research in Sámara

The first round of interviews and surveys were conducted in Sámara and in the nearby canton of Hojancha between November 11th and 16th, 2012. This round of interviews was conducted before a select ebanista was chosen to work with the Sauter plantation's pochote wood. Additional interviews with a salesman and a forestry engineer were carried out to obtain viewpoints from people of varying backgrounds about the qualities of the wood. The team interviewed experts from different occupations to obtain a broader range of data. The second round interview and survey were conducted on

November 26th to obtain any differences in the ebanista's opinion after working with plantation pochote wood.

Interviews and Surveys

Six ebanistas, two sawmill workers (SW1 and SW2), a forestry engineer from the Centro Agrícola Cantonal de Hojancha (CACH), a pochote salesman, and a plantation owner were interviewed. These participants were unanimous in their agreement of the following qualities of the plantation pochote wood: it is not a highly valued wood source as compared to the naturally-growing pochote, it has a low market value (500-625 colones/in^3 on average), it is not naturally resistant to water damage, it is a softwood of a white color that can be tinted or painted, and that it can be used in construction and for pallets. The differences in the opinions of the interviewees were mainly with regard to their willingness to use the plantation pochote wood in the future and their skepticism of its potential to produce sellable products. With the exception of Ebanista 5 and the plantation owner, all of these individuals participated in the survey. Ebanista 5 and the plantation owner were contacted via telephone and insisted that they were unable to partake in the survey because they had not personally worked with plantation pochote wood. The interview responses from these two individuals were kept in the results because they aided the team in assessing the overall opinions about plantation pochote wood. Ebanista 6 was interviewed solely by Álvaro using the same interview and survey process as the other participants, as he was unavailable during either of the team's trips.

Interviews with Sawmill Woodworkers and Ebanistas

Sawmill Worker 1 (SW1) was from one of the largest sawmills in the Guanacaste Province of Costa Rica. He has had several years of personal experience milling, the process of cutting trees into lumber, with both the naturally-growing pochote and the plantation pochote. Although he did not favor working with the plantation pochote, he believed that it would eventually become necessary in the future because other types of wood (cedar, guanacaste, and the naturally-grown pochote) are becoming increasingly more difficult to find and some are even illegal to harvest. According to SW1, the plantation pochote is comparable to pine in that it is a malleable softwood with a naturally pale color (Figure 4.2-

1). However, if the wood gets wet, it rots and is destroyed within three months. (Table 4.2-1).

Sawmill Worker 1 (SW1)	
Feature	**Individual's Response**
Workability	Plantation pochote is a pliable softwood species.
Aesthetics	It is a lightly colored wood which is not held in high demand.
Strength	It is a soft wood of no notable strength.
Durability	It is not water resistant and will rot within three months after being exposed to water.
Market Value	600-800 colones/in^3; One of the lowest prices in the market.
Uses	Molding, door and window frames, interior doors, pallets, or laminate.

Table 4.2- 1: Sawmill Worker 1

Figure 4.2- 1: Plantation Pochote Sawmill 1

The second sawmill worker (SW2) was employed by the Centro Agrícola Cantonal de Hojancha (CACH), at a mill in the canton of Hojancha. CACH is a non-profit organization focused on agriculture and piloting projects aimed at enhancing the environment and the economy of the area (Centro Agrícola Cantonal de Hojancha, 2012). SW2 did not have personal experience working with plantation pochote wood, but he knew people who had. Similarly to SW1, SW2 saw a future need to work with plantation pochote, calling it "the plan B" and "future alternative", as the natural populations of other native species were growing smaller due to harvesting. Plantation species are being grown, however the trees take years to fully mature and the need for lumber is always growing. According to SW2, if plantation pochote is treated, it becomes a durable and workable wood that is resistant to water. If treated properly, it is comparable to the wood from the melina tree, a foreign species brought from Asia. (Table 4.2- 2).

Sawmill Worker 2 (SW2)	
Feature	**Individual's Response**
Workability	It is a very smooth and soft wood making it easy to cut.
Aesthetics	It is a white colored wood that can be easily tinted and painted.
Strength	Its strength is comparable to pine, which is not very strong.
Durability	The wood must be treated quickly after being harvested or it will rot from exposure to water.
Market Value	400-500 colones/in^3; comparable to melina.
Uses	Plywood or pallets.

Table 4.2- 2: Sawmill Worker 2

Ebanista 1 works in Sámara, specializing in the production of furniture and often works with pochote and melina wood (Figure 4.2 -2). He believed one advantage of plantation pochote is that it is a lighter wood, so it is very workable. If it is treated properly, plantation pochote wood is comparable in workability to teak. However, plantation pochote wood has to be extremely dry to be workable. According to Ebanista 1, and confirmed by Álvaro, the timber will be of highest quality if the tree is cut under a full moon, which causes moisture to be pulled up the tree trunk. Plantation pochote products sell for less than other woods; a finished pochote door sells for about 80,000 colones as opposed to a cedar door, which he can sell for up to 120,000 colones. An example of an application of the plantation pochote wood is shown in Figure 4.2- 3, which is a seat crafted by Ebanista 1. He showed the product to the team to demonstrate its pale color. (Table 4.2-3).

Figure 4.2- 2: Ebanista 1's Workshop

Figure 4.2- 3: Seat Made from Plantation Pochote

Ebanista 1	
Feature	**Individual's Response**
Workability	It is a smooth wood, easily cut and shaped. It does not separate. After being dried (which can take between 2 and 4 months), it is great to work with.
Aesthetics	It is a lightly colored wood which on its on is not attractively, but it is also easily tinted to look as nice as any other wood.
Strength	After being dried and treated with the correct protective chemicals, it is durable.
Durability	It is not naturally water resistant and will rot within three months after being exposed to water.
Market Value	700-800 colones/in^3; Not the least expensive wood.
Uses	"Used for anything after being treated"; Pallets, stools or dressers.

Table 4.2- 3: Ebanista 1

Ebanista 2 has been in the woodworking business for 26 years and was the mentor for several other woodworkers in the province. He did not like the plantation pochote wood and preferred working with naturally-growing pochote, teak or cedar. According to Ebanista 2, the light weight of the wood is a disadvantage. Also, because the wood does not have heartwood of significant size, he did not consider it to be strong and does not frequently use the wood. He said, "If a house were made of the plantation pochote wood, it would blow away in the wind [due to its softness]". Ebanista 2 worked with the naturally-grown pochote and thought it was a high quality wood that was easily workable. However, he explained that a chemical in the wood causes nails and screws to rust; therefore he would not use it to make furniture. Ebanista 2 was most skeptical of the plantation pochote's potential in any products other than pallets. With his skepticism and experience, the team thought he would be the most qualified candidate to work with samples of the plantation pochote wood from the Sauter plantation (Table 4.2- 4).

Ebanista 2	
Feature	**Individual's Response**
Workability	It is a smooth wood that needs to be set out to dry quickly after being harvested. It dries too quickly (sometimes within one month) making it susceptible to insect damage. It has a narrow and curvy heartwood which makes it difficult to manipulate.
Aesthetics	Without tints it is not an attractive wood.
Strength	It is a very soft wood that cannot support much weight.
Durability	Its softness adds to a lack of resistance with applied tension. Ex: it cannot be used for roofing because strong winds can rip the wood from its nails.
Market Value	400 colones/in^3; Melina is comparable in price but is a better wood.
Uses	Laminate, plywood, crates and pallets.

Table 4.2- 4: Ebanista 2

Ebanista 3 has had a well-rounded career, having worked in the industry for twenty years, with experience in multiple shops throughout Costa Rica. His expertise was in crafting furniture, but he has also built doors and other products using many of the available woods of various values from nearby areas. Because of his diverse training and experience working with many types of woods, Ebanista 3 was very open-minded to working with the plantation pochote wood in the future, as he had already worked with it in the past. For example, Figure 4.2- 4 shows a cabinet that Ebanista 3 constructed from treated and tinted plantation pochote wood. He reported that the treating and tinting period for this piece was a few days longer than for that of products made from melina or teak. He was willing to test samples of the wood for most efficient treatment practices. He realized that a lot of the naturally growing woods were becoming difficult to find and sometimes even illegal to harvest. He noted that the plantation pochote was a quick-drying tree after being felled, but also that it became saturated by humidity if untreated because it is so porous.

Figure 4.2- 4: Furniture by Ebanista 3

In his experience, the plantation pochote wood was expensive to treat and even paint, because the wood absorbed any liquids (particularly a protective treatment called CWF-40) extremely quickly, requiring many coats of treatment. Because of this quality, he wanted to learn how to more efficiently treat the wood so that it would not be saturated by humidity or damaged by rot and would not require three or four coats of tint or treatment. He remarked that although the plantation pochote wood was inexpensive to purchase, and that a piece of furniture made from plantation pochote wood would be of equal monetary value as one of a more expensive and comparable species like melina, it was not currently cost effective to use the plantation pochote because of the amount of time and the monetary investment that treating and preparing the wood requires. Despite these drawbacks, he reported that he creates and sell furniture made of plantation pochote wood (Table 4.2- 5).

Ebanista 3	
Feature	**Individual's Response**
Workability	It is easily treated, tinted or painted with other colors because it is so porous. There is not much sawdust when cutting pieces, which better facilitates the feasibility of the cutting process.
Aesthetics	It has a dull white color but after a few coats of tint or paint it can look more attractive.
Strength	Because the wood is so porous, it is very flexible when steam is applied and can easily take the form of a rounded shape.
Durability	If the wood is treated, it will last the same amount of time under similar conditions as any other semi-hard woods. Treatment methods should be investigated.
Market Value	600-700 colones/in^3;
Uses	Molding, furniture, door and window frames, pallets, plywood, some furniture and anything else that semi-hard woods are used for.

Table 4.2- 5: Ebanista 3

Ebanista 4 has been working in the industry for many years. He was the owner of a larger ebanistería (carpenter shop), with several ebanistas working with him to learn skills of the trade. He has extensive experience working with different woods, and although he has had much experience working with hardwoods such as teak and the naturally-grown pochote, he was open-minded to the idea of using plantation pochote wood for furniture and construction applications. Ebanista 4 commented on the plantation pochote's inability

to fight off insects known as “polillas”, which have effects similar to termites. He remarked that plantation pochote wood is easily treated with protective chemicals because it is so porous. One suggestion Ebanista 4 offered as the best technique for harvesting the timber was to cut the trees in the dry season. When cut during the rainy season, the timber is saturated with water and will shrink when dried (Table 4.2-6). Figure 4.2-5 is a picture of a sample of the plantation pochote wood that he had in his shop. He showed it to us to demonstrate how light the color of the wood is prior to being treated.

Ebanista 4	
Feature	**Individual’s Response**
Workability	The wood can get warped or change shape. The lack of sawdust when being cut is a good characteristic of the wood.
Aesthetics	The wood is not very aesthetically pleasing by itself but can be tinted.
Strength	There are many pores that cause it to warp and make it a light wood. It is easily attacked by an insect called polillas, which are similar to termites, after being felled and has no chemicals to protect itself from them.
Durability	The wood can twist or change form and does not have natural protective chemicals as the old wood did.
Market Value	No response
Uses	Pallets, doors, doorframes, and laminates.

Table 4.2- 6: Ebanista 4

Figure 4.2- 5: Sample of Plantation Pochote Wood from Ebanista 4

Ebanista 5 was contacted via telephone and could not participate in our survey, as he specializes in furniture production and had never worked with the plantation pochote wood. In his opinion, the plantation pochote wood is not suitable for furniture because it is

not strong and does not have aesthetic appeal. According to Ebanista 5, people do not use the plantation pochote wood, for a reason unbeknownst to him, even though it can be used for artisanal door and window frames amongst other uses.

Ebanista 6 was interviewed by Álvaro because he was not available for interviews during either of the team's visits. The ebanista has had much experience working with both the plantation pochote as well as the naturally-grown pochote, and believes that plantation pochote will be widely used in the future. In his opinion the wood is very workable. He did have concerns about the wood's ability to resist breaking when subjected to tension and that its softness prevented screws from fastening into the wood securely. However, its softness does contribute to its flexibility. Although the ebanista has heard myths about the plantation pochote, he had no complaints from his own experiences. Products that he made with plantation pochote included interior furniture, concrete molds, roofing and construction. The ebanista explained the importance of making sure that the products would not get wet and would not stay in the sun, as products exposed to moisture had a decreased lifespan and sunlight reduced the color of the wood. He also said that the process he used to finish his products for the last few years has been to dye the wood, apply varnish and sand the wood. This process of treatment to the wood is repeated until there are three or four layers of varnish on top of the dye. He said that plantation pochote is most comparable to pine (Table 4.2- 7).

Ebanista 6	
Feature	**Individual's Response**
Workability	It is easy to work with because it is soft, but because of this one must be careful working with it because it can break or split more easily.
Aesthetics	The wood is not as nice as others because it is very white but it can be dyed which would increase the aesthetic qualities
Strength	Inability to resist tension.
Durability	It is a soft wood but insects are not as much of a problem for the plantation pochote as opposed to other woods. It rots quickly with water damage
Market Value	700-800 colones/in^3. A middle-ranged price.
Uses	It can be used for any indoor products: furniture, kitchen doors, tables, cabinets but is not recommended for outdoor applications.

Table 4.2- 7: Ebanista 6

The plantation owner declined to participate in the survey, as he had not sold, nor harvested, any of his plantation pochote wood. He took pride in stating that his plantation had been meticulously maintained and that he had grown plantation pochote of higher quality than what was available in the market. When the plantation owner invested in the pochote trees 28 years ago, he based his investment on the high value of the naturally-grown pochote and did not anticipate the difference in qualities between it and the plantation wood. The plantation owner remarked that the only strategy that would enable other pochote plantation owners to make a profit from the timber would be to work together and purchase a machine to cut the pochote wood into ornamental pieces to attach to furniture. Additionally, the wood could be used for door and window frames.

Additional Expert Interviews during Part One of Field Work

The forestry engineer at the Centro Agrícola Cantonal de Hojancha (CACH) believed that there is a stigma associated with plantation pochote that implies it is an unworkable wood and that this stigma can be attributed to its minimal market exposure. According to him, people simply need to be taught proper techniques for treating and working with the wood. As a native deciduous tree in the tropical dry forest, plantation pochote's leaves fall and it stops growing throughout the summer months of December through May. However, foreign species, like teak and melina, are more optimal alternatives for plantations due to

continued growth throughout the summer dry season, when some native species, like pochote, are dormant. The heartwood of the plantation pochote has a twisted grain and large pores, which make it less dense and usually not very strong. In order to make the wood more marketable, the forestry engineer suggested that more research be conducted with respect to the specific properties of the wood and educate the market with these findings. According to the forestry engineer, certification from the Forest Stewardship Council (FSC), which certifies a plantation for sustainable harvesting, would increase the wood's marketability, but not necessarily increase its value. (Table 4.2- 8).

Forestry Engineer at CACH	
Feature	**Individual's Response**
Workability	The heartwood is very curvy which makes it difficult for ebanistas to craft.
Aesthetics	The color is light, making it easy to tint.
Strength	The wood is extremely porous which makes it less dense and therefore less strong.
Durability	If it is treated properly and procedures were investigated thoroughly, it can be made more durable.
Market Value	450-800 colones/in^3; prior to harvesting 60-85 colones/standing-tree.
Uses	Interior support beams, paneling, wall covers, furniture, plywood and pallets.

Table 4.2- 8: Forestry Engineer CACH

The pochote salesman specializes in the buying, harvesting, and selling of trees to sawmills in the Nicoya canton of Costa Rica. He believes the pochote plantation wood is almost as good as the naturally-growing pochote that has a darker red heartwood. However, according to the salesman, the pochote plantation owners in the Guanacaste Province now regret their decision to plant pochote because it grows very slowly. In his opinion, the plantation pochote is a good wood but because it is so slow-growing, it is not a viable resource. He believes it is not wise to promote a market for the pochote because the trees take a long time to grow and it is costly. He also stated that there is not an adequate supply of trees to support this market; therefore the government would have to give stipends to the farmers to promote tree growth and enable them to earn profits off of their investments (Table 4.2- 9).

Pochote Salesman	
Feature	**Individual's Response**
Workability	It is easy to work with.
Aesthetics	No response
Strength	No response
Durability	No response
Market Value	150-200 colones/in^3; prior to harvesting 100 colones/standing-tree.
Uses	Furniture, construction: doorframes, laminate, and plywood.

Table 4.2- 9: Pochote Salesman

Survey Analysis with Sawmill Woodworkers and Ebanistas

The first survey, located in Appendix B, yielded responses from nine of the eleven participants that had been interviewed: two sawmill workers, a forestry engineer, a pochote salesman, and five ebanistas. Participants of various ages and experiences were selected to complete the survey so that a spectrum of opinions could be included in the development of our analysis of the data about the plantation pochote wood. The following tables summarize the results from each question of the survey. In order to answer the survey questions, some of the participants used woods they were familiar with, such as teak or melina, to compare against the features of the plantation pochote wood.

The first question asked was with regard to which factor had the greatest influence on the participant's knowledge of the plantation pochote: "personal experience", "the experience of others who have worked with the wood", "hearsay or public opinion" or "other". Seven out of nine participants had worked with plantation pochote. The other two participants were influenced by the experiences of other woodworkers. The pochote salesman and all of the ebanistas and sawmill workers had personal experience with the plantation pochote wood. The CACH sawmill worker and forestry engineer had not worked with plantation pochote and therefore did not have personal experience with it (Table 4.2-10).

Question 1: Influence on Plantation Pochote Knowledge	
Sawmill #1	Personal Experience
Sawmill #2	Experience of Others
Forestry Engineer	Experience of Others
Pochote Salesman	Personal Experience
Ebanista #1	Personal Experience
Ebanista #2	Personal Experience
Ebanista #3	Personal Experience
Ebanista #4	Personal Experience
Ebanista #6	Personal Experience

Table 4.2- 10: Influence on Knowledge

The second question of our initial survey, found in Appendix B, contains multiple parts and asked participants to rank specific qualities of the plantation pochote on a scale of one to five (one being the worst and five being the best). These qualities included: workability, aesthetic appearance, wood strength, durability and market value. Organizing each quality with a numerical value enabled the team to combine results from different woodworkers to determine the overall thoughts of the woodworking community on the plantation wood, as shown below in (Table 4.2- 11).

Question 2: Ratings for Features of the Wood						
	Workability	**Aesthetics**	**Strength**	**Durability**	**Market Value**	**Average Score**
Sawmill #1	3	1	2	3	2	2.2
Sawmill #2	4	3	2	3	2	2.8
Forestry Eng.	4	4	2	3	1	2.8
Salesman	4	5	4	4	3	4
Ebanista #1	5	2	3	4	2	3.2
Ebanista #2	2	3	1	2	2	2
Ebanista #3	5	2	2	3	2	2.8
Ebanista #4	5	4	2	3	4	3.6
Ebanista #6	3	2	2	2	3	2.4
Average	3.89	2.89	2.22	3.00	2.36	2.87
Standard Deviation	1.05	1.27	0.83	0.71	0.89	0.65

Table 4.2- 11: Responses to Survey Question 2

The first quality that was asked about in the survey was with regard to the workability of the wood. A ranking of one would indicate an opinion that the wood was not very workable and a ranking of five would indicate that it was very workable. Eight out of nine responses gave a ranking of three or higher, which indicated that plantation pochote wood was workable. The average ranking of the workability of the wood was a 3.89 (range=2-5, standard deviation=1.05), which correlates to the majority of the survey participants saying that the wood is soft and workable.

The second quality assessed the aesthetic appearance of the wood. There was a large difference in opinion about the aesthetical appearance of the wood, with an average response of 2.89 (range=1-5, Standard Deviation=1.27). The data obtained had the largest standard deviation and thus the responses to this question indicated that our experts had widely different opinions about this factor. Some of the participants were rating the natural appearance of the untreated wood, whereas other participants were rating how it can be

easily tinted and made to look better. For example, untreated plantation pochote wood is usually a dull white color, therefore it is often stained.

There was less variability in the responses about the strength of the wood; responses had an average score of 2.22 (range=1-4, Standard Deviation=0.83). Most of the participants remarked on how soft the plantation pochote was and how this softness decreased its ability to resist tension. The responses to this question indicated a general perception that pochote wood is not a strong wood as compared to other woods available in the market. Each of the participants reiterated the fact that on its own and untreated, the plantation pochote wood was not durable, as it is not resistant to damage caused by water. However, they remarked that it was easy to treat the wood with protective chemicals, and therefore it was a moderately durable wood, receiving an average rank of 3.00 (range=2-4, SD=0.71).

The estimated market value of the plantation pochote varied widely among responses received in the survey. This is due to the fact that some of the ebanistas worked with the more expensive woods available in the market, such as teak, guanacaste, and cedar woods. For them, the price of plantation pochote lumber is minimal, whereas other ebanistas worked with melina, which is a comparably priced wood. Therefore, these ebanistas said that the plantation pochote was of a higher ranking. On a scale of 1-5, the average market value rating was 2.33 (range=1-4, SD=0.87) showing that the perceived market value was fairly low. The estimated prices reported by the participants fluctuated between 150 and 800 colones per cubic inch (of cut and prepared timber). The average low and high prices of the plantation pochote wood was between 500 colones/in^3 and 625 colones/in^3, respectively (Table 4.2- 12).

Estimated Price Ranges for Timber		
	Price (min)	**Price (max)**
SW1	600	800
SW2	400	500
Forestry Eng.	450	800
Salesman	150	200
Ebanista #1	700	800
Ebanista #2	400	400
Ebanista #3	600	700
Ebanista #4	No Response	No Response
Ebanista #6	700	800
Average	500	625

Table 4.2- 12: Estimated Selling Prices of Plantation Pochote Wood per Cubic Inch

The final question was "How likely are you (the woodworkers) to work with the wood (planation pochote) in the future?" The majority of respondents (67%) answered that they would be very likely to use the wood in the future, but this was dependent on external circumstances, and not because of the inherent qualities of the wood. Most said that the other sources of lumber were becoming increasingly difficult and expensive to obtain, and thus, the plantation pochote may become a more viable option because all of the other species are being overharvested. This demonstrates that more woodworkers are willing to try to work with plantation pochote than those who are not. Many of the workers went on to say that plantation pochote is not their first choice but it is a good alternative wood as other higher quality woods are becoming increasingly difficult to obtain (Table 4.2- 13).

Participant	Likeliness to Use Plantation Pochote in the Future
Sawmill #1	Very Likely
Sawmill #2	Somewhat Likely
Forest Engineer	Very Likely
Pochote Salesman	Not Likely
Ebanista #1	Very Likely
Ebanista #2	Not Likely
Ebanista #3	Very Likely
Ebanista #4	Very Likely
Ebanista #6	Very Likely

Table 4.2- 13: Likeliness to Use Plantation Pochote Wood in the Future

Follow-Up Interview and Survey

Upon returning to Sámara, November 26 through the 28, the team interviewed and surveyed the chosen ebanista in order to determine if working with the wood changed his opinion at all. Ebanista 2 had changed his opinion of plantation pochote wood substantially. He was left with the wood for a week, during which time he prepared it and used it to make an exterior wall and window framework for the Sauter home at Playa Sámara, as shown in Figure 4.2- 6. He was very interested in seeing how the wood would behave outside by testing the strength and durability after some time had elapsed with the wall being exposed to the elements. He predicted that the wood would withstand the elements and maintain the structural integrity of the wall. The ebanista felt that the wood was easy to work with and it behaved as a more "seasoned" or mature wood than he expected. He found that the Sauter's plantation pochote wood had a deeper red color than he had seen of other plantation pochote in the market. He explained that the plantation trees would need a minimum of fifteen to twenty years to be similar to the naturally grown pochote, as the latter is stronger and harder than the former.

Figure 4.2- 6: Exterior Wall and Windows by Ebanista 2
(Picture by Álvaro Terán)

The problem that the ebanista saw with the pochote wood was whether or not supplies of it would be available in the future market. Because the tree in general takes so long to grow and mature, plantation owners are giving up on the pochote because they can receive greater profits growing other species. Those who have invested in pochote plantations have not realized as high of profits as those who have planted teak or melina. As compared to these two species, the pochote tree is less profitable because a smaller number of trees can be cultivated and harvested in a given time period. While he would be open to using the wood in the future, the ebanista does not believe there will be a significant enough supply to work with after this generation of plantation pochote is used. If available in the future, he would use the wood for many different types of uses including furniture, ceilings, closets or for decorative purposes. This is extremely significant, because two weeks prior, he had said that the only use for the wood was for export pallets. He cautioned about using the wood outside, but assured the team that if a sealant was put on the wood the products would last much longer.

When the ebanista was surveyed, he reported very different responses than he did in the initial survey. His average total rank for the plantation pochote from the initial survey was a 2, whereas the average of the other woodworkers who ranked the wood was a 2.93 (standard deviation = 0.667). On the return visit, his ranking increased by 70% from his original score to a total average rank of 3.4 (Table 4.2- 14).

Results from First and Second Survey of Ebanista 2		
Feature	**First Visit Ranking**	**Second Visit Ranking**
Workability	2	4
Aesthetics	3	3
Strength	1	3
Durability	2	4
Market Value	2	3
Average Score	2	3.4

Table 4.2- 14: Results from First and Second Survey of Ebanista 2

Investigation of Sauter Plantation

During their first trip to Sámara, the team noticed several qualities about the plantation and its wood that were previously not known about the Sauter Pochote Plantation (Figure 4.2- 7). Throughout the 20 hectare (50 acre) plantation, six thousand pochote trees had been planted by a Sauter plantation employee 24 years prior to the team's visit.

Figure 4.2- 7: Sauter Plantation Pochote Tree

This same employee cut three trees down five weeks before the team's visit so that samples would be ready for distribution and use. The samples had been left to dry in a method with which the team had not previously researched (Figure 4.2- 8). According to the groundskeeper, the wood was dried using the method of standing the beams upright against a support beam rather than stacking, because stacking would cause damage to the wood. He was unable to say definitively whether this damage was due to the chemicals in

the sap, sunlight or another factor. Additionally, standing the planks upright promoted the natural drainage of water by gravity through the tree.

Figure 4.2- 8: Method of Drying at Sauter Pochote Plantation

The team noticed that the timber of the Sauter pochote plantation had a deeper red color than other samples of plantation pochote wood that the team had seen. Figure 4.2- 9 displays both the Sauter plantation wood, above, compared to the whiter, more common, plantation pochote wood (from an unidentified plantation), shown below. Due to exposure to the sun after being crafted by Ebanista 2, the Sauter plantation pochote appeared lighter in color. However, this coloring was still not as light as wood from other pochote plantations with which other ebanistas had been working. Although the color of the Sauter samples faded, varnish can be used to restore the original red color.

Figure 4.2- 9: Difference in Plantation Pochote Wood

According to Álvaro, there are many factors that determine the features that a tree will exhibit when felled, as described in Chapter 2. Thus, it is not accurate to say that all plantation pochote trees will exhibit the same features. When plantation pochote trees are too close together, their growth form is different, producing trees with thinner trunks and less heartwood. The proper growing practice includes a thinning process to ensure minimal competition for nutrients and ample space for growth. Closely growing plantation pochote trees produce wood that is a whiter color and much lighter wood because they solely contain sapwood. It is the sapwood that is lighter in color and the heartwood that is the deeper red color which signifies a stronger, heavier wood. The variance in techniques used to cultivate the plantation pochote tree accounts for the variance in features of samples that are currently available in the market (Sauter Plantation Employee, personal communication, 2012).

A few of the dried wood planks showed cracking through the middle of the heartwood as shown in Figure 4.2- 10. The plantation workers speculated most of the cracking was due to the impact on the ground the lumber experienced when it was harvested. When other plantation pochote trees were cut down and left to dry as logs for approximately four months and then cut there were significantly less cracks. One problem which arose at the Sauter plantation was the damage caused by fungi and insects on the timber as shown in Figure 4.2- 11. These attacks yielded white and brown spots on the wood. Fungi and insects were not a problem when the pochote received chemical treatment after harvesting.

Figure 4.2- 10: Cracks in Plantation Pochote Timber

Figure 4.2- 11: Damage of Untreated Plantation Pochote Wood

4.3 Analysis

The following analysis discusses the overall success of the interview (Appendix A) and survey (Appendix B) process. At the end of this section, we present a comparative analysis of responses from individuals, based on their experiences with pochote and their professions. This analysis was a necessary step in the synthesis of recommendations for Sr. Sauter and future teams, found in Chapter 5.

In creating the survey questions, the team attempted to minimize the possibility for ambiguity in each question. However, throughout the process, we did realize that ambiguity did exist in the survey. Some of this ambiguity was due to the "one to five" ranking scale that was applied to quantify responses to Question 2 of the survey. Several woodworkers were not familiar with this type of method for responding to questions. Upon evaluation of the results, the team also realized that the meanings of the features included in Question 2 were left up to the interpretation of each participant.

When giving responses to the survey questions, participants did not simply report a number; instead, they supported their responses with justifications as to why they chose the ranking that they did. In order to facilitate their ranking, the woodworkers compared the plantation pochote's characteristics to other woods based on their experiences. For example, Ebanista 1 (the younger and less experienced ebanista) was more accustomed to working with melina, a species of comparable qualities to plantation pochote wood. On the other hand, Ebanista 2 (the older and more experienced ebanista) had 26 years of experience working with teak, guanacaste and cedar, all of which are woods of higher value and quality. Comparatively, the average of the rankings Ebanista 1 gave to the plantation pochote wood was 3.2, which is 60% higher than that of Ebanista 2, who had an average ranking of 2. Differing points of comparison from each participant compromised, but did not invalidate, the rankings of the features in Question 2. A clarification for the values for the extremes (1 and 5) would have contributed to more standardized and accurate responses.

In hindsight, we realize that we should have provided definitions of each of the five qualities prior to the survey, to ensure that the team and the participants were in agreement about what each feature encompassed. The results showed that the participants

seemed to have a common understanding of what the strength and durability characteristics entailed. However, there was some ambiguity with regard to what the "workability" and "aesthetically pleasing" characteristics encompassed. Some of the participants remarked on the ease of tinting the wood as a characteristic that increased the wood's workability, whereas others attributed this to the wood's aesthetic appeal. Clarification for these definitions prior to starting the surveys would have eliminated this ambiguity.

The average overall ranking of the wood's qualities could have been influenced by the various occupations of the participants. For example, the pochote salesman may have given a high overall ranking of 4.0 to the wood because he had a vested interest in the marketability of plantation pochote wood, as his income depends on the demand for and sale of the wood. This may have biased him to think more highly of the wood. On average, the ebanistas gave the wood an overall ranking of 2.8, which is 0.3 points higher than the average overall ranking of the sawmill workers, who gave the lowest overall ranking of the wood at 2.5.

Overall, there was unanimous agreement that the plantation-grown pochote is not of the same quality as the naturally-growing pochote. Although the qualities of these woods are different, agreement in results have facilitated development of a list of recommendations discussed in Chapter 5.

Chapter 5: Recommendations

This chapter contains the recommendations that the team has synthesized after analyzing the results of the interview and survey process. The recommendations are divided into four different areas of focus: recommendations for future sales, recommendations for harvesting, recommendations for treatment methods, and recommendations for future researchers.

5.1 Recommendations for Future Sales

Give the wood additional time to grow (at least 5 years).

As reported by most of the woodworkers the team interviewed and the experts from Precious Woods Holding Ltd., plantation pochote wood takes several decades to fully mature. The Sauter plantation pochote trees that have been growing for 24 years exhibit a darker red color than that of trees from other plantations. However, there are still differences between this plantation-grown and naturally-grown lumber. This is evident by the plantation pochote's light color (as compared to the naturally-grown pochote) and narrow, curved heartwood. We believe that allowing the wood to grow for a longer period of time would increase its maturity and more fully develop the straightness and strength of its heartwood. Furthermore, many of the participants mentioned there will be a need for accessible and sustainable supplies of wood in the future, as the populations of naturally-growing species are dwindling. Therefore, if the Sauter family waits longer, the plantation pochote wood will further mature while the demand for sustainable supplies of wood increases. An increase in demand will also increase the price of the supply. Although it is a longer-term investment, further maturation may yield higher returns in the future and the timber will be of a higher quality.

Collaborate with other plantation owners to provide a consistent supply of plantation-grown pochote wood to stabilize its availability and standardize its selling price.

The ebanistas voiced concern about the accessibility of plantation pochote wood in the future, as it is a very slowly growing tree. If all of the pochote plantation owners collaborated to provide a steady supply of wood to the market, ebanistas might be willing

to utilize the wood more often. If there is not a steady supply of the timber, or if the source of the supply will no longer be available in the future, ebanistas will be less likely to familiarize themselves with working with the wood. The average price of one cubic inch of plantation pochote wood ranged from 500 (low) to 625 (high) colones with standard deviations of 187 and 231 respectively. If the supply of pochote wood is moderated, the average selling prices could be maximized. The variation in current selling prices could be due to variations in the quality of wood from different pochote plantations. If the plantation owners collaborate, they could also develop a method for ranking the quality of individual trees from the various plantations. A ranking system will provide a clear-cut method for distinguishing between samples of plantation pochote wood. It will also prevent lesser quality samples of plantation pochote from decreasing the value of the wood.

Advertise the plantation pochote wood as a sustainably grown and harvested native species.

By directing marketing towards both the Costa Rican and international tourists seeking authentic Costa Rican products, woodworkers and plantation owners could capitalize on the fact that pochote wood is an indigenous species of Central America, and the Nicoya Peninsula in particular. More popular trees, such as teak, that are foreign to the area have been contributing to the sedimentation of rivers and estuaries in the province. Unlike these foreign species, pochote plantations do not cause harm to the environment. This environmental aspect of the use of pochote plantations could increase its marketability as compared to the use of more environmentally detrimental species (Á. Terán, personal communication, 2012). Promoting the use of pochote wood for home decor to foreigners who move to the area could increase its popularity in the market because many people wish to support the local community. However, there is currently competition in this "tourist market" because of furniture producers from the United States, such as Ethan Allen, as reported by an ebanista from Hojancha. One example of a slogan that could be implemented for the use of this wood is "Furnish your home with Costa Rican grown and Costa Rican made products".

Use the wood for ornamental or decorative purposes.

As the participants of our survey did not give high ratings for the strength of the wood, the team recommends the Sauter family to capitalize on the advantages conferred by its softness. The softness contributes to its workability, defined as the ease in which it can be shaped. As suggested by another pochote plantation owner in the area, multiple owners should collectively invest in a fabricating machine that is used to cut decorative patterns out of the wood that can be added to furniture pieces. The softness of the wood also allows the wood to be lighter in weight. This contributes to easier transportation and easier use for decorative purposes, such as ceiling and wall paneling, bedroom doors, and window or doorframes, whereas a heavy timber would need more support to hold the weight of the wood.

Directly market the wood to younger ebanistas.

Younger ebanistas who are new to the industry may be looking for lower-priced woods. Therefore, these ebanistas may be more open-minded to using the plantation pochote wood and it is possible they could find innovative applications for the wood. For example, a niche market could be created which utilizes qualities specific to plantation pochote. If the niche market was successful it would increase both the demand and price of the wood.

Do not invest in an FSC certification.

The team recommends that the Sauter family should not invest in Forest Stewardship Council (FSC) certification. The forestry engineer at Centro Agrícola Cantonal de Hojancha (CACH) reported that it could be expensive to certify a plantation as being sustainable and plantation pochote wood with FSC certifications does not necessarily sell for higher prices. In addition, certain methods for growing the plantation may have to be adapted to qualify for certification. The only case in which it may be beneficial is if the intended market for the final products is tourists visiting the area, because the products might be more marketable if they have FSC certifications.

5.2 Recommendations for Harvesting

Selectively thin smaller trees before conducting a wide-scale thinning.

We suggest that thinning in the near future should take place in two steps. First, in the Sauter plantation, very thin pochote trees are growing next to ones of much thicker diameter. These thinner trees are impeding the future growth of the wider trees by competing for resources. Removing them should be the first step in any future thinning procedure.

Because the trees have such a wide crown, Sr. Sauter plans to thin the trees further according to an 18m x 18m grid pattern. However, future testing regarding the optimal spacing between trees must be conducted. Reducing the density of tree growth in a defined area allows for less competition of resources amongst the growing pochote trees. Therefore, reduction of competition allows the remaining trees to grow larger and healthier, with increased access to water, nutrients and sunlight, thus increasing their market value (Á. Terán, personal communication, 2012).

Investigate turning the monoculture plantation into a polyculture plantation.

When planting new plantations, or maintaining existing ones, the use of polyculture growth should be investigated. Polyculture plantations more closely resemble naturally growing environments and may contribute to the plantation pochote wood becoming more similar to those of the naturally growing trees. Natural forests contain wildlife that decompose and add a variety of nutrients to the soil. They also contain creatures that are natural predators for bugs and other organisms that could harm the pochote. Polyculture growth allows the owner to obtain more than a single source of profit from the land as well (Fears, 2008).

5.3 Recommendations for Treatment Methods

Apply protective chemicals to the wood after it is harvested and cut into planks.

The possibility of timber being attacked by fungi is increased if it is exposed to moisture. These attacks are especially common in areas with high humidity, as is the case in the Guanacaste Province of Costa Rica, where the pochote grows (Timber Research Unit, School of Architecture, The University of Tasmania, 2012). “Polilla” is a word that

translates to mean woodworm in Guanicastican slang (Á. Terán, personal communication, 2012). Polillas were found on some of the samples of the Sauter's pochote wood. These small worms burrowed in the lumber and left holes within the planks of wood. After chemical treatments the wood can become less susceptible to damage caused by insects and mold. Examples of these treatments include applying a chemical known as CWF-40 (as recommended by Ebanista 2), zinc, and boron salt diffusion techniques (Gómez, P., Moya, R., 2008). Ebanista 6 suggested a treatment process that included dying the wood and applying four layers of varnish, sanding it in between each application. These layers of varnish provide the porous wood with protection from moisture. Other methods for preserving plantation pochote wood should be investigated further to find the best methods.

Let the felled timber logs dry for three to four months.

According to a worker at the Sauter Pochote Plantation, allowing the logs from felled trees to dry without being cut into boards may help prevent cracking of the wood. Leaving the bark on the tree after felling the timber also protects the lumber from insect and fungal damage while the wood is drying. When the three trees from the Sauter plantation were cut, some of the planks had large cracks. However, planks that came from logs that had dried before milling did not have cracks.

Allow the treated planks to dry standing against a beam.

When the Sauter plantation pochote samples were laid flat to dry, the color of the wood faded due to exposure to the sun. If the planks are stacked on top of each other, chemicals tend to settle and make the wood "burn", causing structural damage. Therefore, the plantation pochote should be dried by standing the planks up against a beam, as seen in Figure 4.2- 8.

Continue testing and investigating the wood.

Two ebanistas in Hojancha are interested in researching efficient and inexpensive ways to treat and protect the wood from insect and water damage. From our field research we found that treating plantation pochote wood is expensive because it is very porous.

Plantation pochote wood requires multiple coats of chemical treatment because it is almost immediately absorbed into the core of the wood. These multiple treatments increase the cost of working with the wood. If cost efficient methods of treating the wood are found, more ebanistas will be willing to work with the wood. Therefore, decreasing the cost of treating the wood will increase the possible margin for profit when final products are sold.

5.4 Recommendations for Future Researchers

Provide definitions of the features of the wood included in Question 2 of the survey (found in Appendix B).

As described in Chapter 4.3, the significance of each of the defining qualities of the wood (Question 2 of the Survey in Appendix B) was left up to the participant's interpretation. Providing standardized definitions for the features of the wood will prevent ambiguity in the future, allowing the feedback to be less subjective to the participant's own interpretation of the feature's definition.

Repeat the methodology with more samples of plantation pochote wood.

Repeating our fieldwork with more wood samples will allow for more follow-up surveys to be conducted. This will also result in more conclusive data regarding changes in opinion. Providing samples to multiple ebanistas will increase market exposure of the Sauter plantation pochote wood, thus raising awareness of the qualities it possesses.

Investigate the selling price of plantation pochote products as compared to similar products made with other, possibly more valuable, species of wood.

If products made from plantation pochote wood sell for a similar price to melina, a more expensive but comparable wood, using plantation pochote wood would be more profitable. If cost efficient treatment methods are developed, profits as well as marketability of plantation pochote wood will increase even more.

Chapter 6: Conclusion

In the Guanacaste Province of Costa Rica, human manipulation of land over the past century has greatly diminished the natural supply of timber. As the population of naturally-growing native trees began to dwindle, plantations of both native and foreign species were created in the area. Although native species, like pochote, are available for purchase from plantations, many ebanistas are choosing to work with alternative foreign species, such as melina and teak. The plantation-grown pochote trees have much different properties than the naturally-growing trees and are valued less than the investors originally anticipated when they first planted the tree. The native plantation pochote tree must compete in the market with foreign species, which some consider superior.

The synthesis of preliminary research, which was conducted and incorporated in Chapter 2, increased the team's understanding of relevant concepts and terminology associated with defining characteristics of wood. This information enabled the team to ask more appropriate questions to the woodworkers and gather additional data for the Sauter family. Through personal communication with various experts in the field, the team also learned about the problems facing other plantation owners and ebanistas concerning the plantation pochote.

In order to investigate any changes in attitude about the plantation pochote wood after working with the timber, the team developed a two-part field research method that is detailed in Section 2 of Chapter 3. This method was contingent upon the quantity of samples available from the Sauter pochote plantation and processing costs. The first part of the team's strategy was to interview and survey local woodworkers about their opinion of plantation pochote wood as compared to other woods currently available in the market. This part of the strategy investigated the attitudes of experts in the area regarding the characteristics of the plantation pochote wood. The second segment of the strategy was to offer samples of the plantation pochote lumber to the most skeptical ebanistas and then conduct a follow-up interview and survey after each ebanista had worked with the wood. The team was not able to conduct multiple follow-up interviews and surveys due to a limited supply of available samples from the Sauter plantation. In fact, only one ebanista

could be given the samples. This ebanista was chosen based on his level of experience and skepticism towards the potential of plantation pochote wood.

The responses from the two rounds of interviews and surveys yielded a wide spectrum of results regarding the specific qualities of the wood. However, there was unanimous agreement of the following characteristics of the plantation pochote's wood: its market value, water resistance, color, and several uses. These characteristics are discussed in detail in Chapter 4. Although the results from the follow-up interview and survey cannot be considered conclusive, it can be said that the method the team used in order to expose the potential of the Sauter plantation pochote wood merits further implementation. After working with the plantation pochote wood, the selected ebanista's survey showed that his opinion of the wood increased by 70% (from an initial score of 2, to 3.4, after). The information synthesized from the two visits to Sámara is important to consider when developing a marketing strategy for the plantation pochote wood.

A synthesis of the data obtained from the interviews and surveys guided the team to create recommendations for Sr. Sauter so that he could create a successful marketing plan for the plantation pochote wood. These recommendations have been organized into four categories: recommendations for future sales, harvesting, treatment techniques, and future research. Examples of recommendations from each of these categories include: letting the wood mature for five to ten more years, practicing selective thinning, applying protective chemicals to the wood after being cut into planks, employing the two ebanistas from Hojancha to research cost efficient treatment techniques, and conducting more follow-up surveys to obtain more definitive information on the potential changes in opinion about plantation pochote wood. Both increases in the quantitative survey rankings of plantation pochote wood after exposure to it, and an increase in the overall market demand for plantation pochote wood would suggest that the wood does have potential to be a source for the lumber supply in the Guanacaste Province. Although the information gathered was not conclusively due to circumstances outside of the team's control, we do believe that our two-step method could be re-employed in the future to obtain more definitive data.

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Appendices

Disclaimer to all Participants in Interviews and Surveys

Your confidentiality will be maintained. Any personal information that is obtained about you will not be affiliated with the responses you have towards the questions.

Descargo de Responsabilidad en Entrevistas e Encuestas

Su confidencialidad se mantendrá. Cualquier información personal que se obtiene de usted no estará afiliada con las respuestas que usted tiene hacia las preguntas.

Appendix A-1: First Round Interview Questions (English)

1. What is your profession?
2. Who are your primary buyers?
3. What are your most frequently used materials?
4. Have you worked with the pochote before?
5. Have you worked with the plantation pochote?
    - What have you built with the plantation pochote?
    - Would you use it again?
    - Do you know anyone who has worked with it?
6. What do you know about the following features:
    a. Is it insect resistant?
    - How do you dry the wood?
    - Does the wood warp when dried?
    - How dry does the wood have to be to work with it?
7. What are some characteristics of the plantation pochote?
8. What are products or potential products that can be made using pochote wood?
9. Do you know of any other ebanistas or people in the area who could assist us with this interview and survey?

Apéndice A-2 Preguntas de la Primera Sesión de Entrevistas (Español)

1. ¿Cuál es su profesión?
2. ¿Quiénes son sus principales compradores o clientes?
3. ¿Cuáles son sus materiales utilizados con más frecuencia?
4. ¿Tiene experiencia previa trabajando con el pochote?
5. ¿Tiene experiencia previa con el pochote de la plantación?
    - ¿Cuales son sus productos principales? ¿Lo usaría Ud. otra vez?
    - ¿Conoce a algunas artesanas en este área que debemos hablar con sobre este?
6. ¿Que son las características del material?
    - ¿Es el pochote resistente a los insectos?
    - ¿Qué método se utiliza para secar la madera?
    - ¿Existen efectos de secado, por ejemplo, ¿cambia la forma?
    - ¿Es necesario que la madera sea seca para trabajar con el pochote?
7. ¿Cuáles son las características de la madera de pochote de una plantación?
8. ¿Cuáles son los productos o los productos posibles de la madera de pochote?
9. ¿Conoce usted a otras ebanistas o personas en el área que nos podrían ayudar con esta entrevista y evaluación?

Appendix B-1: Survey Questions (English)

1. **Which of the following has most influenced your knowledge of the plantation pochote?**
    - Personal experience
    - Experience of others who have worked with the wood
    - Hearsay (general public opinion)
    - Other
2. **Please rank the following qualities with respect to the plantation pochote on a scale of 1 being the worst to 5being the best:**
    - Workability 1 2 3 4 5 no response
    - Aesthetically pleasing 1 2 3 4 5 no response
    - Wood strength 1 2 3 4 5 no response
    - Durability 1 2 3 4 5 no response
    - Market demand 1 2 3 4 5 no response

3. **How likely are you to use this wood in the future?**
    - I will not likely use this wood in the future
    - I am not very likely to use the wood in the future
    - I am somewhat likely to use this wood in the future
    - I will very likely use this wood in the future

4. **How does the pochote wood compare to other types of wood?**

Apéndice B-2: Las Preguntas de La Evaluación (Español)

1. **¿Cuál de los siguientes ha influido en su conocimiento del pochote plantación?**
   - La experiencia personal
   - La experiencia de otros que han trabajado con la madera
   - Rumores (opinión pública general)
   - Otros

2. **Por favor, clasifica en una escala de 1 a 5, siendo 1 lo peor y 5 lo mejor del pochote:**

• Trabajabilidad	1	2	3	4	5	no comentario
• Apariencia estética	1	2	3	4	5	no comentario
• Madera fuerza	1	2	3	4	5	no comentario
• Durabilidad	1	2	3	4	5	no comentario
• El valor del mercado	1	2	3	4	5	no comentario

3. **¿Qué posibilidades hay de que usar esta madera en el futuro?**
   - No es probable que utilice esta madera en el futuro
   - No soy muy propensos a utilizar la madera en el futuro
   - Soy un poco proclives a utilizar esta madera en el futuro
   - Es muy probable que utilice esta madera en el futuro

4. **¿Puede comparar la madera del pochote a los otros tipos de los árboles?**

Appendix C-1: Follow-Up Interview Questions (English)

1. After working with samples of plantation pochote, how have your thoughts changed regarding the wood?

2. What is your overall opinion of plantation pochote?

3. How was your experience working with the wood?

4. How does the Sauter plantation pochote differ from other sources of plantation pochote?

5. How does the plantation pochote wood compare to the naturally grown pochote wood?

6. Would you consider working with this wood in the future?

7. What are the best uses for the plantation pochote wood?

Apéndice C-2: Las Preguntas de la Entrevista Siguiente (Español)

1. Después de trabajar con esta muestra de pochote, ¿Cómo han cambiado sus pensamientos sobre de la madera?

2. ¿Cuál es su opinión general de pochote plantación?

3. ¿Cómo fue su experiencia general cuando trabajó con esta madera?

4. ¿Qué son las diferencias entre la madera del pochote plantación de la familia Sauter y de otras fuentes del pochote plantación?

5. ¿Cómo es la madera del pochote plantación en comparación con la madera de pochote del monte?

6. ¿Usaría esta madera en el futuro?

7. ¿Cuáles son los mejores usos para la madera de pochote plantación?