TAKING ROOT ENRACINE

Social reforestation & Carbon offsets

Technical Specification
Silvopastoral Planting

Registered Plan Vivo Program:
The CommuniTree Carbon Program

(Formally known as the CommuniTree Carbon Program)

Authors: Baker, K., Baumann, D., Michaud, J., van Mossel-Forrester, B.

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1. Executive Summary

The CommuniTree Carbon Program is a community-based reforestation initiative that regroups small-scale farming families in the municipality of San Juan de Limay and Somoto Nicaragua, to develop ecosystem services for the voluntary carbon market. The program is developed by Taking Root, a non-profit organization based in Montreal, Canada, in partnership with the Nicaraguan organization, APRODEIN.

The CommuniTree Carbon Program uses reforestation as a tool to restore ecosystems, improve livelihoods and tackle climate change. Taking into account the causes of deforestation, the program works with smallholder farmers to reforest and maintain under-utilized portions of their land in exchange for payments for ecosystem services.

Reforestation within the program boundary is imperative as the region is situated in a critical watershed that feeds into one of the country's most important estuaries, the Estero Real. This estuary is home to one of the biggest extension of mangroves and migratory birds in the region, and has been recognized by the Ramsar Convention on Wetlands of International Importance. By reforesting this region, the program plays an important role in regulating the hydrological cycle and provides important water and biodiversity benefits both locally and internationally.

In addition to deforestation, the collection of fuelwood, which is used by 99.2% of the municipality's population for cooking, is a large contributor to forest degradation. Moreover, the inhalation of smoke from burning fuelwood within the homes has serious health implications for the women in the families who spend a higher proportion of their time in the kitchen area.

In order to ensure a sustainable solution to these challenges, the CommuniTree Carbon Program works to make forestry a competitive land-use option. This Silvopastoral Planting design consists of planting improved pasture combined with three native tree species. The short rotation nitrogen fixing species are harvested at a young age providing building posts while fertilizing the soil. The longer rotation species are commonly used for sawnwood and are prized on international markets. These trees are sustainably managed to provide carbon sequestration services and a sustainable source of high valued timber.

The ex-ante sale of ecosystem services generated through the program is used to fund the establishment and maintenance of new family-led programs while the sustainable production of forest products provides an on going source of value in the medium and long run.

This Technical Specification was developed through a community-led design process where participating communities and local professionals determined the tree species, planting method, and payment process used, among other things. Each program participant then develops and follows their own personalized farm management plans (*plan vivos*) and is involved in every step of the process, including pre-planting, planting, maintenance and management activities.

In order to be eligible, farmers must own economically under-utilized land within the program boundary that is in need of reforestation. They must also demonstrate that participating in the program will not conflict with their subsistence activities, notably cattle ranching and agriculture.

The average net carbon benefit of this technical specification is 52.3 tonnes of carbon per hectare. This carbon benefit was calculated by estimating the average carbon stock expected under the baseline scenario while subtracting a risk buffer of 15%.

To guarantee the accuracy and success of the program, Taking Root had developed a rigorous monitoring system for its program. Systematically distributed permanent plots have been established on a minimum of 10% of the areas using this technical specification and annual monitoring is conducted to gather

information on species composition, mortality, height, and diameter at breast height. Based on these results, participating producers receive ecosystem service payments upon successfully meeting established management and growth targets. Furthermore, this monitoring, along with research results, is used to modify management on a continual basis to ensure that carbon sequestration objectives are being met. This system of adaptive forest management is achieved by allowing room to account for natural regeneration and early or delayed harvest of the shorter rotation species based on actual stand growth.

2. Introduction

The following document describes the technical specifications for the Silvopastoral Planting under the CommuniTree Carbon Program (CTCP), including: details on the program intervention; the calculation of the baseline; avoiding leakage, assuring the long term sequestration of the carbon (permanence) and additionality; ecosystem benefits; and the monitoring plan.

This Silvopastoral Planting technical specification details the planting methodology concerning silvopastoral plantations on smallholder land within the program boundary, in the municipalities of San Juan de Limay and Somoto, Nicaragua. They are located in the departments of Estelí and Madríz respectively.

The program occurs in a region that has suffered heavy environmental degradation, as the principle forms of livelihood are agriculture and raising cattle. Due to the poorly distributed rainfall, these livelihoods are not highly lucrative and as a consequence the region is quite poor.

To participate in the reforestation activities described in this specification, smallholder farmers must have a clear land title to land that is not being used for agricultural purposes and that is not currently forested. Participant farmers are then engaged in all aspects of the reforestation efforts, and receive regular ecosystem service payments upon successfully meeting monitoring targets.

The ecosystem services provided by the program are sold as Plan Vivo certificates, which represent the long-term sequestration of one tonne of carbon dioxide (CO_2) plus additional livelihood and ecosystem benefits.

The program is coordinated by Taking Root Nicaragua, a Canada-based non-profit organization, in partnership with APRODIEN, a Nicaraguan service provider and partner.

3. Program Intervention

Cattle production is a preferred activity in the rural economy of Nicaragua due to its comparative advantages relative to other forms of agricultural production. It has a low requirement for skill and labour, it is low risk, and products (milk, cheese and meat) can be easily brought to markets.[1] Conventional livestock production is one of the most prevalent land uses in Latin America, and often results in rapid land degradation.[2] In Central America, pastures now cover more than eleven million hectares (about 30% of the total land area), half of which is estimated to be degraded.[3]

Silvopastoral planting represents an alternative production system that integrates trees and improved pasture with livestock. The system takes advantage of the synergy between these components benefiting the environment and smallholder livelihoods. According to Pagiola *et al.*,[4] silvopastoral systems can have various on-site and off-site benefits. On-site benefits include improving pasture productivity as trees extract water and nutrients from the soil that are inaccessible to grasses. Trees also produce products in the form of timber, forage and fruit. Additionally, the presence of trees can enhance livestock productivity in the form of milk and meat. The improved pasture adds nutritional value to the cattle's diet and the additional shade provided by the trees increased grass production in the dry season. This shade also reduces heat stress for the cows compared to open pastures.[1]

Off-site benefits include:

Biodiversity benefits:
Adding trees to the landscape increases structural connectivity of the forest. This increases wildlife habitat and helps propagate native forest plants. Silvopastoral systems can also contain a larger and more complex assemblage of invertebrates.[4]

Carbon sequestration benefits:
Studies in Central America show that silvopastoral planting with different tree species and configurations store relatively large amounts of carbon relative to primary and secondary forests.[5] Silvopastoral systems can fix significant amounts of carbon in the soil and in the live tree biomass. Through this process, research has shown that such practices can accumulate up to 5 tonnes of carbon (18.3 tCO_2) per hectare per year.[5]

Hydrological benefits:
Improved tree cover can reduce surface runoff and soil erosion, increase soil humidity in the dry season, and increase water retention in the wet season, and thus reduce flooding.

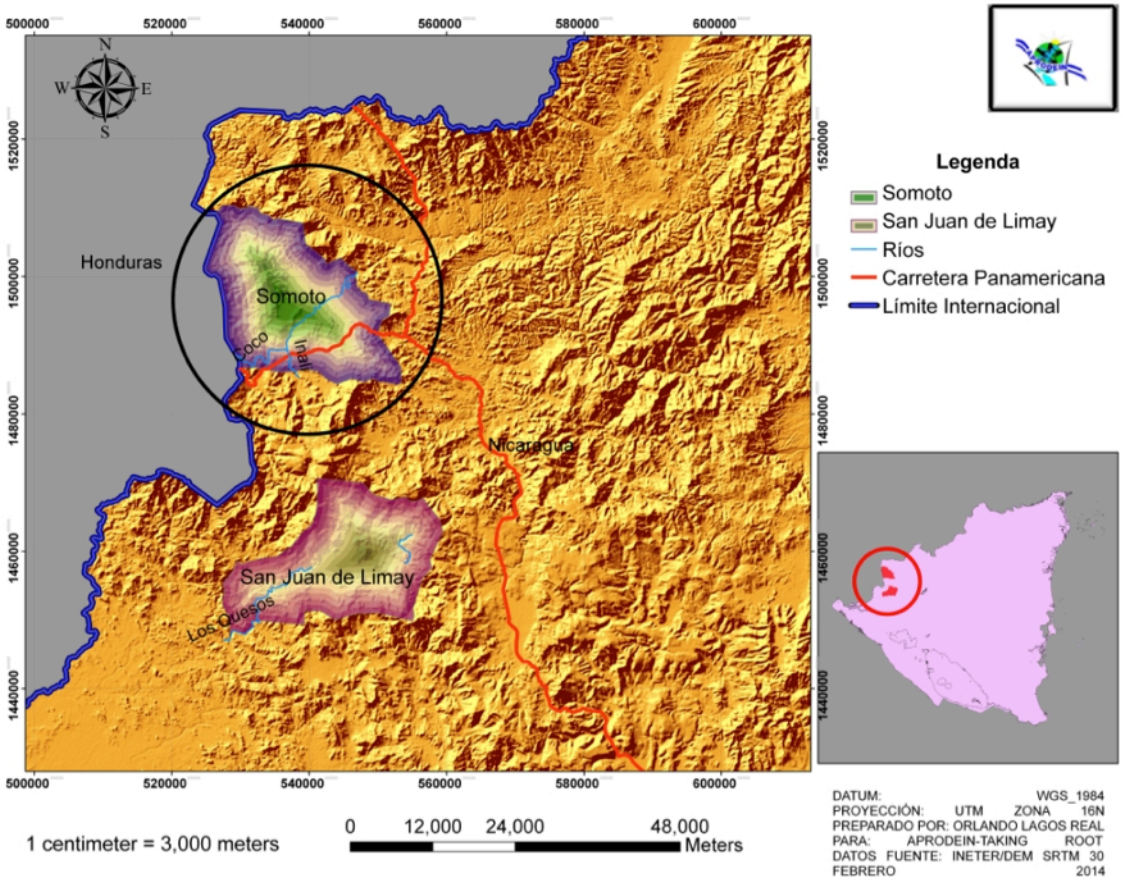
These off-site benefits are positive externalities that benefit society as a whole while the on-site benefits go directly to the producer. Studies in Nicaragua using silvopastoral systems project rates of return to be between of 4% and 14%.[6] However, despite the numerous advantages of silvopastoral systems, adoption rates have been relatively low due to high establishment costs where access to capital is low and the delayed return on investment.[2] These reasons thus justify the need and importance of using carbon finance to help stimulate the adoption of this technical specification.

3.1. Applicability

In order to be eligible to participate in the program, farmers must have underutilized land that falls within the suitable areas of the current program boundary. This boundary corresponds with the boundary of the municipality of San Juan de Limay and the municipality of Somoto, shown in dark green in Figure 1.

Farmers cannot clear forested land to gain eligibility and they must demonstrate a clear land title to their farm.

Figure 1 – Program boundary within municipalities of San Juan de Limay and Somoto



3.2. Elevation Requirements

Due to the choice of tree species, optimal growth for the selected plantation design must take place at elevations below 900 metres above sea level. An elevation map of the program boundary is illustrated in Figure 2a & 2b below.

Figure 2 – Elevation map of San Juan de Limay

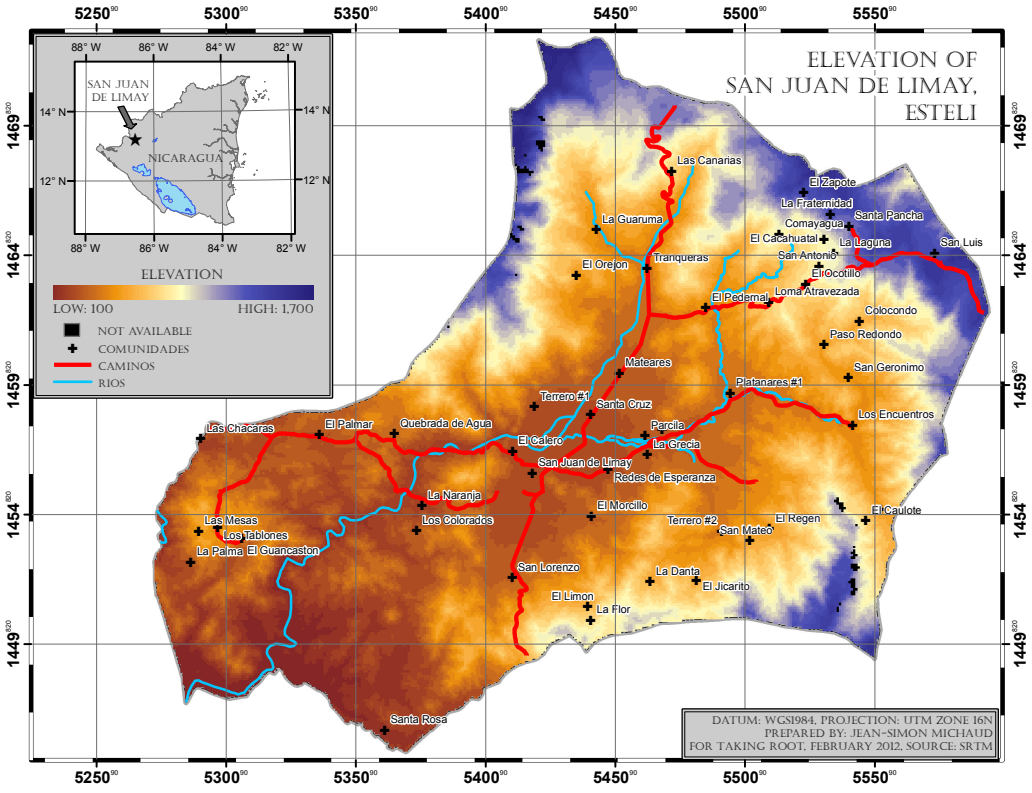
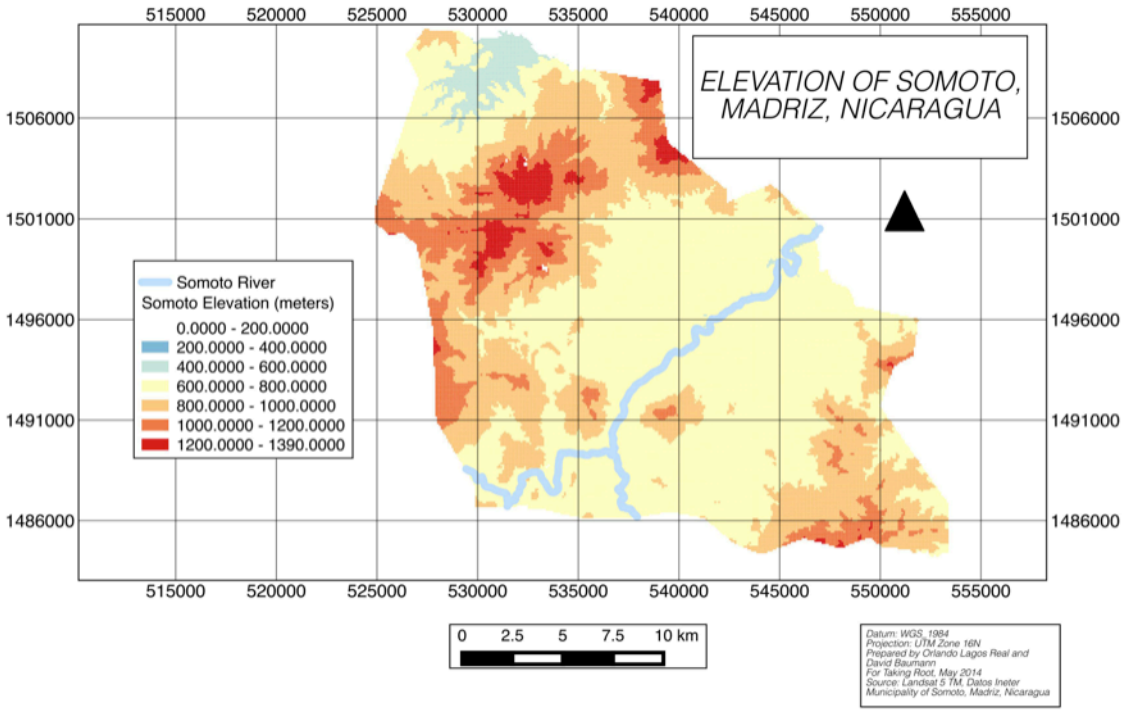


Figure 2b - Elevation map of Somoto



3.3. Land-Use and Land Cover

The land use and land cover of the program area have changed drastically over the past century. Once blanketed in forest with abundant precipitation and wildlife, the program area was transformed during the "Green Revolution" of the 1950s when vast areas of land were cleared for large-scale cotton production. By the end of the 1980s, a drop in world cotton prices left farmers in ruins. The area faced heavy erosion and was contaminated with toxic pesticides, leaving behind what is now a seasonal desert with only small patches of secondary forest at higher elevations. [7]

The steeper summits of taller mountains still contain some old pine forests, and a few scattered remnants of the giant trees that were once typical in the region still remain throughout the valley. The most common mature large trees are *Enterolobium cyclocarpum*, *Ceiba pentandra*, and *Albizia saman*. These are extremely fast growing trees that are not particularly valuable timbers. Although once abundant in the area, Pacific Mahogany (*Swietenia humilis*) and Spiny Cedar (*Bombacopsis quinata*) are close to eliminated from the area.

Presently, the predominant land-use in the area is cattle grazing. However, due to the prolonged 6-month dry season, it requires an estimated 1.4 hectares of pasture to support just one head of cattle. A common land-use strategy in the region is to grow grain for a couple of years then convert the area to pasture. Once the area becomes too degraded to support pasture, it is abandoned for several years before being cleared again for agriculture.

3.4. Climatic Conditions

The region's climate is characterized as warm dry tropical savannahs with a small sub-humid zone in altitude. Its temperatures range between 24-34° C with two distinct seasons, wet and dry. The rainy

season begins in May and ends in October. Annual precipitation within the program boundary is 1,394 mm per year, almost all of which falls within the wet season.

3.5. Social Context

The regions of San Jan de Limay Region and Somoto, as well as the whole of Nicaragua, have undergone drastic political shifts throughout the last century. Clashes between the Sandinista National Liberation Front, the Contras and the Somoza dynasty caused much turmoil for the economy, the people and the land.

International financial institutions, such as the World Bank and the International Monetary Fund, have placed strict measures on the Nicaraguan government while it pays back external debts that were created during this time. As a result, the government has had to cut back on spending, including huge slashes to environmental programs and law enforcement. [7]

3.6. Population

The following socio-economic information is available for the municipality of San Juan de Limay: [10]

Urban inhabitants: 3,668
Rural inhabitants: 9,787
Total inhabitants: 13,455
Population density: 31.5/km^2
Indigenous population: 5,519

The following socio-economic information is available for the municipality of Somoto:

Urban inhabitants: 15,974
Rural inhabitants: 16,406
Total inhabitants: 32,380

Somoto is a "young town", with nearly half of the population in the age groups of 0-4 years (15.5%), 5-9 years (14.2%), and 10-14 years (14.5%) as of 2000.

3.7. Predominant Religions

Catholic and Evangelical Christianity are the primary religions in the program area.

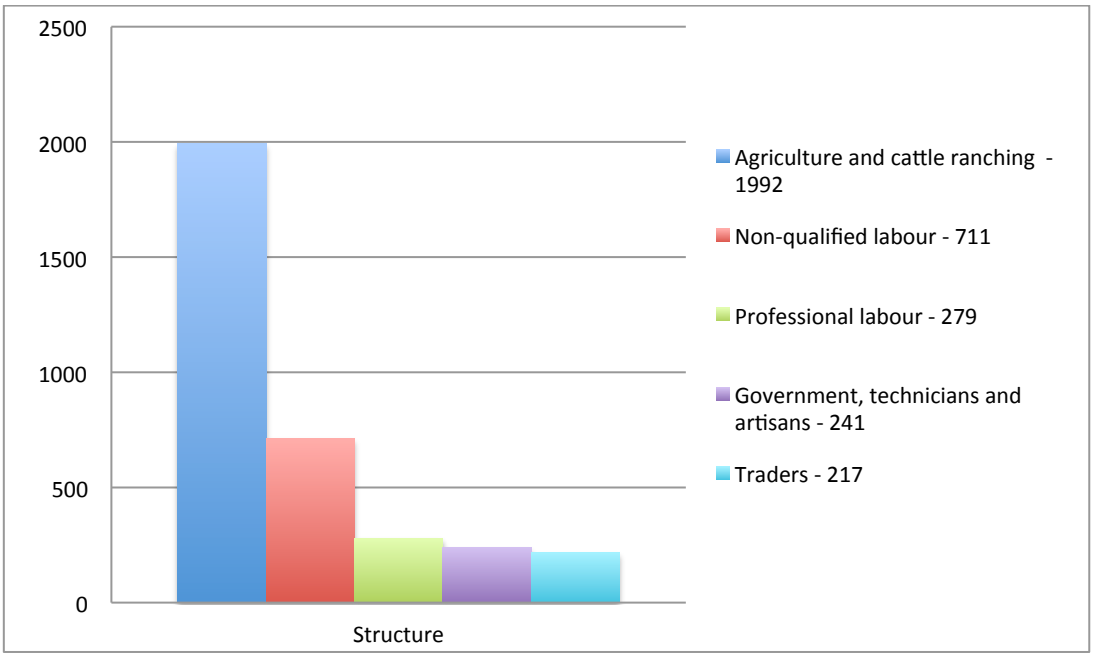
3.8. Local Economy

The local labour force is split up as follows:

- 58% smallholder farmers, earning sustenance directly from the cultivation of beans, corn, sorghum dairy and cattle (program target group)
- 21% non-qualified labours, generally working as contractors on other farms or doing general construction work
- 8% office-based professionals or technicians
- 7% government employees and artisans, predominantly carving soapstone,
- 6% traders, generally buying and selling farmers agricultural surplus

The following Figure 3 exhibits the breakdown and quantity of labour activity in San Juan de Limay.

Figure 3 – Structure of local economy in San Juan de Limay[10]



Agriculture is the most important sector of the economy and encompasses both the production of agricultural goods and, to a minor extent, processing and trading. However, agricultural activities commonly take place without regard to zoning or optimizing the potential of the area. While farmers in the region of San Juan de Limay have relatively large properties with fertile soils, most farming in the region is done purely as a form of subsistence rather than a business and is therefore not very productive. This is largely due to the poorly distributed rainfall, lack of irrigation, and the lack of access to financing.

The principal factors contributing to food insecurity in the region are excessive deforestation and poor management of the available resources. These have also adversely affected people's economic opportunities.

Presently, only a relatively small area is dedicated to agriculture within the municipality of San Juan de Limay. The main crops are sorghum, corn, and beans. The average yields are usually low and are therefore predominantly used for subsistence. In the regions with higher elevations, coffee is cultivated.

3.9. Fuelwood Use

Within the entire municipality, 95.5% of the population uses fuelwood for cooking. Outside of the urban centre and within the program boundary, this percentage increases to 99.2%.[10] The gathering of this fuelwood is a continuous cause of degradation for the surrounding forest, as virtually none of the fuelwood is sustainably produced. Regionally and nationally, forests are becoming increasingly scarce, making it difficult to find accessible sources while demand for the resource increases.

A secondary consequence of burning fuelwood within the household is the negative health effect it has on people's vision and respiratory tracts caused by excessive smoke inhalation. This adversely affects the women in the families as they spend a higher proportion of their time in the kitchen area.

3.10. Community Led Design

As is the standard of all Plan Vivo projectss, the development process of the program intervention was highly influenced by a process of Community Led Design (CLD). CLD gives producers a vital role in shaping

the program according to their needs and allows them to develop a strong sense of ownership. This process is implemented on a continuous basis throughout the program lifetime.

3.11. Community Led Process Determination

The silvopastoral planting system requires multiple steps, from conception, to payment, to cultivation. These steps are continuously revaluated and improved upon to ensure efficient and equitable results for the producers and the participating communities. The following are some of the types of decisions made through the CLD process concerning the program development:*

- The program boundary and the watershed
- The tree species used
- The fencing and labour loan system
- The timing of payments

See the Taking Root's *Plan Vivo project Design Document – CommuniTree Carbon Program* for more information.[12]

* All of the meetings mentioned in this section have been recorded and are available upon request.

4. Description of Activities

Intervention: Reforestation
Title: Silvopastoral Planting

Brief Description

This proposed system involves the planting and intensive management of a multi-purposed, mixed species silvopastoral planting system. The selected species are commonly found within the municipality of Limay and are native to the region. The design consists of the planting of improved pasture combined with the following tree species; *Caesalpinia velutina, Swietenia humilis* and *Bombacopsis quinata* at regular intervals throughout pasturelands. C. *velutina* is a short rotation fast growing leguminous tree predominantly used for posts in rural construction. Whereas B. *quinata* and *S. humilis* are longer rotation species commonly used for sawnwood that are highly valued on local and international markets.

For the first few years of establishment, the use of this technical specification must be done in areas where the cattle are removed for the first three years. Also, the trees selected in this design are not palatable to cattle. As an additional precaution, it is suggested that producers only put smaller cattle in the area in the early years and place wooden stakes around the young trees once the cattle are reintroduced.

After the first year of planting, once the seedlings have established themselves, improved pasture seeds will be sown throughout the pasture to augment the number of cattle the land can support. The planting design consists of trees planted at 5 x 5 x 5 metre spacing with every second tree being *C. velutina* with equal density alternations of B. *quinata* and *S. humilis.* At the beginning of year 10, the *C. velutina* trees will be thinned out leaving behind a young stand of high valued timber trees. In year 25, the remaining two species will be managed on a stand management phase (see Section 4.4 for more details). Since all of these species coppice well, new trees will regenerate as older ones are removed keeping the stand semi-forested at all times.

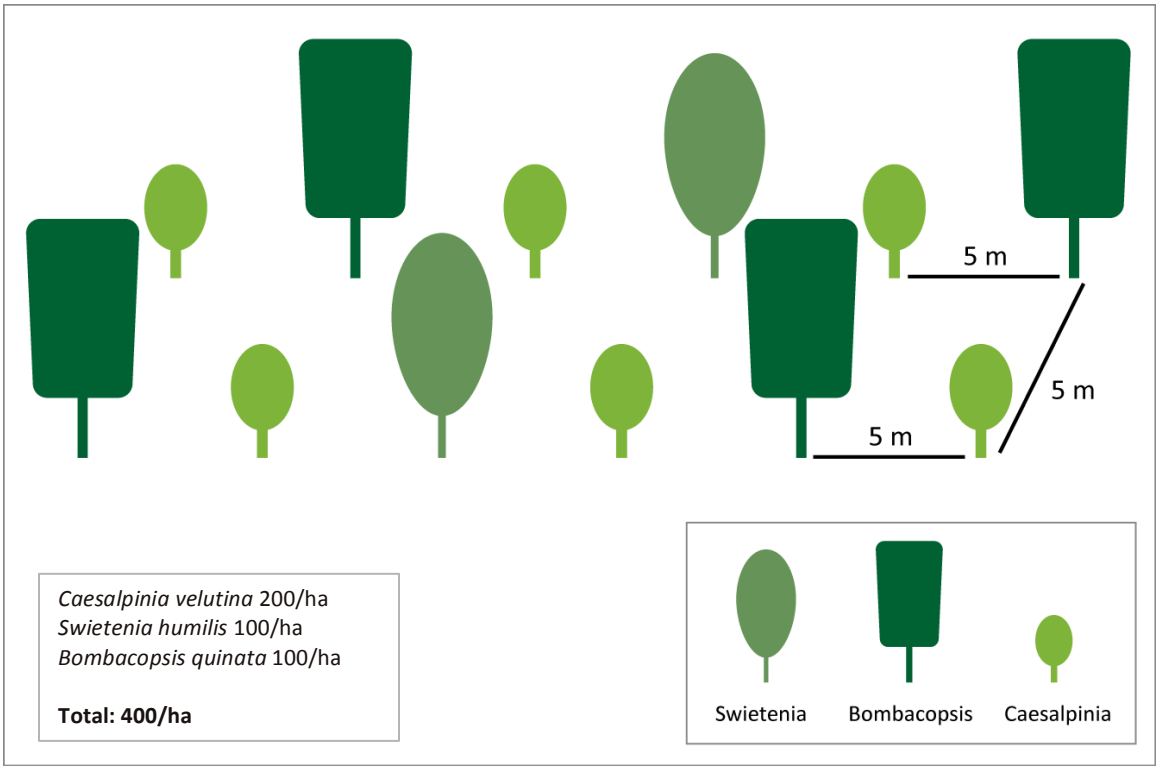
This silvopastoral planting design will sequester carbon dioxide, providing ecosystem services in the short run, production of wood post in the medium run and highly prized sawnwood in the long run. Additionally, the system will provide additional services such as improving the pasture below the trees and adding biomass to the soil.

The payments for the ecosystem services are targeted towards the participating families' short-term needs; the wood post cultivation is targeted towards their medium-term needs while the thinnings and timber harvests are targeted towards their long-term needs. Over the second half of the project, producers will begin receiving revenues from their harvests. This revenue creates incentive for the farmers to continue participating in the project, since the revenue is expected to be large compared to the ecosystem payments of the first part of the project. During the span of the project, producers will receive continual education on the environmental, economic and social benefits of the project.

4.1. Planting Design

One *Caesalpinia velutina* tree is planted between alternating *Bombacopsis quinata* and *Swietenia humilis* trees throughout the pasture. The initial distance between each tree is 5 metres as illustrated in Figure 4.

Figure 4 - Planting Schematics



4.2. Activity plan

The activity plan sets forth the various steps that need to be undertaken for the proper establishment of the technical specification and outlines all parties responsibilities. The plan is designed through a process of consultation between various stakeholders, producer groups and regional experts. Since it is the producers who are responsible for their own project, the activity plan serves as the minimum standard required for the program to be effective and payments are based on the successful implementation of the activity plan. Individual producers have the freedom to exceed the standards set forth by the plan.

Pre-planting activities

Each year, prior to planting, the following activities are carried out.

Seed collection

Seeds are collected locally from trees within the municipality. *Caesalpinia velutina* produces a large amount of seedpods at the end of the rainy season, which remain on the tree throughout the dry season.[13] The seeds are collected between November and January of every year. The number of seeds per kilogramme is between approximately 5000 and 6000.[14]

Bombacopsis quinata produces a fruit that resembles an oblong capsule that varies from 2 to 15 centimetres in height and 2.5 to 5 centimetres in diameter during the dry season. The capsule slowly opens up from the apex when mature, exposing a white cottony substance.[15] This is the stage at which

the fruits are harvested for seed. Each capsule contains an average of 47 seeds and there are between 12000 and 32000 seeds per kilogram.[16]

Swietenia humilis produces a brown elongated oval capsule 8 to 16 centimetres long and up to 10 centimetres wide. The capsules open up around the month of February and within them, the seeds act as a sort of wing allowing for wind dispersion. The fruit is thus harvested just as the capsules start to open up. The number of seeds per kilogramme ranges between 1300 and 2000 and the germination rate of the fresh seeds varies between 60-90%.[17] If sufficient seeds cannot be found locally, purchases are made from outside communities.

Nursery development

Many of the seedlings are grown in communal nurseries, established by the year's participating producers and supervised by the community technicians to ensure the highest quality of seedlings. Some nurseries are established directly on producers' land to simplify transportation.

The earth for the seedlings is a mixture of sand from the riverbed, on-site soil, and manure. Seedling bags are filled with the earth mixture and placed in trenches approximately 10 centimetres deep as shown in Figure 7. None of the seeds from any of the three species require any pre-germination treatment.

Bombacopsis quinata seeds require 8 to 35 days to germinate,[18] and should be kept in the nursery until the seedlings reach 15 to 30 centimetres in height, which takes approximately 40 days.[19] *Caesalpinia velutina* seeds start germinating 3 to 4 days after planting and can be planted in as few as 30 days thereafter.[17] *Swietenia humilis* seeds should be planted at a depth of 3 centimetres and generally germinate within a week. The seedlings can be planted in the field within approximately 2 months time.

Figure 5 - Nursery establishment

Fence building

Prior to the planting season, each area is fenced-in to prevent cattle from grazing on the seedlings. The producers purchase the materials themselves, often using interest-free advanced loan payments.

Clearing

Prior to the planting season, the parcels that will be reforested are cleared of all brush and small bushes. Due to the dispersed nature of these parcels, the barren land between them functions as natural firebreaks.

Planting activities

The following activities are carried out by producers and community members during the planting season.

Planting site demarcation

Long thin rope is used to demark the land according to the planting design. Every five metres a marked tag is tied to indicate the appropriate spacing of each tree. Each end of the rope is tied to a wooden stake that is temporarily inserted into the ground along the barrier that will be planted. A tool is used to make a small mark in the ground underneath each tag, as illustrated in Figure 6.

Clearing

At every demarcation in the ground where a tree will be planted, a two-metre diameter circle in the grass is cleared with a machete until there is exposed soil. This clearing is used to remove competing grasses and shrubs before the seedlings are planted.

Hole digging

At the centre of each clearing, a hole slightly larger than the seedling bag is dug as illustrated in Figure 7.

Tree Planting

The seedling is carefully removed from the nursery bag and planted into the hole. Particular attention must be paid to ensure the correct species are planted according to the planting design. Each seedling must be planted at ground level or slightly deeper so that water accumulates around the seedling. This process is illustrated in Figure 8.

Figure 6 – Site demarcation

Figure 7 – Hole digging

Figure 8 – Tree planting

Inserting wooden stakes (optional)

Around each tree, three large wooden stakes are to be inserted into the ground thus creating a physical barrier around each young seedling to prevent trampling.

Maintenance and Management activities

Clearing

In the first three years, a 2-metre diameter circle is cleared around each tree with a machete to remove competing grasses, shrubs and lianas.[19] This process must take place at least twice per year during the rainy season. Additionally, this process reduces the cattle's desire to graze too close to the young trees.

Pruning

Branches in trees form knots in the wood which, when sawn, can cause holes in the boards and create undesired visual inconsistencies. This diminishes both the integrity of the wood and its value. Consequently, removing the lateral branches of the *Bombacopsis quinata* and *Swietenia humilis* trees is important. Montero and Viquez suggest that pruning schedules are based on tree height as opposed to age and that a cost effective schedule should start when the trees reach between 5 and 6 metres in height.[19] Branches are to be removed from the bottom two metres of the tree. The second pruning should take place when the trees reach between 8 and 9 metres, and the branches at the bottom 4 metres of the tree are removed. A third and final pruning should take place when the trees reach 12 metres and the bottom 7 metres are cleared of lateral branches. All pruning should take place during the dry season and pruning should be done using well-sharpened tools to avoid damaging the tree as much as possible and subsequently avoiding pests and diseases.[19] Pruning is not required for *Caesalpinia velutina* since these trees will only be used for posts and the presence of knots is not important.

Seeding improved pasture

On the third year after the seedlings have been planted when the trees have established themselves, one sack of *Andropogon gayanus* seeds, an improved pasture, is manually seeded per hectare. These varieties of grasses are more productive in terms of biomass, stay greener longer during the dry season, are more nutritious and more shade resistant than traditional pastures.

The above activities, their time requirements, frequency and estimated costs are summarized in Table 1.

Table 1 – Summary of the activity plan

Task	Responsible parties	Time-frame	Resource requirement	Time requirement	Estimated initial cost	Estimated annual cost
Construction of tree nurseries	Community technicians + producer families	January until May	Machete, rope, shovel, wheelbarrow, barbed wire, sifter, bags, manure, sand, earth, water, seeds	1 day	$20 of seedlings	n/a
Establishment of fences	Producer families	February, March	Barbed wire	1 day	$51.03 assuming that only ½ of the area requires additional fencing.	n/a
Clearing land for planting	Producer families	March-April	Machete	2 days	$65.71	n/a
Planting activities	Producer families + guidance from community technicians	After the first big rain (~May 15th) until 45 days later	Shovel, rope, machete, wheelbarrows	4 days	$16 (producer's work contribution)	n/a
Clearing around trees	Producer families	A few times per year for 1st few years	Machete	2.5 days	$8 (producer's work contribution)	Producer's time
Pruning	Producer families	As needed	Saw	1 day	n/a	Producer's time

Planting pasture seeds	Producer families	3rd year after planting	1 bag of seeds	1-2 days	$13 of seeds	n/a

4.3. Thinning and Harvests

Table 2 outlines when species are harvested, the date of harvesting, the purpose of the harvested wood, the processing factor (the proportion of the harvest that is utilized and continues storing carbon), and the volume that is represented through these activities over the initial 25 years of the project.

Table 2 – Thinning and Harvests – Individual Tree Monitoring

Beginning of Year #	Species	Harvested stem volume (m^3 / ha)	Product	Processing factor	Merchantable volume (m^3 / ha)
10	Caesalpinia	8.94	Posts	1.0	8.94
25	Bombacopsis	15	Sawn-wood	0.35	5.25
25	Swietenia	15	Sawn-wood	0.35	5.25

4.4. Thinning and Harvests – Stand Management Phase (Yr 26-50)

After the first 25 years, the stand will have approached its optimal rotation cycle and on-going selective harvesting will commence. As of year 26 of the program, natural regeneration and occasional replanting will be encouraged and the plantation will be used for sustainable forest management. The mature trees will be harvested at a rate comparable to the long-term growth rate of the stand. As a whole, the overall volume and carbon stocks fluctuate around the long-term average. Starting in year 26, 30 cubic metres of wood products per hectare will be selectively cut from the stand every 5 years (see the Appendix 5 for more information).

4.5. Incentives for Participation in the Project

The various expected benefits of this program encourage the participating producers to stay in the program during its 50-year lifetime. They are as follows:

- Ecosystem payments for the first 10 years;
- Merchantable wood products - Taking Root will help to commercialize and create market access;
- Increased pasture quality and higher milk production from existing cattle;
- Increased soil fertility;
- Wood products harvested in the first 25 years;
- Wood products harvested during the stand phase over the next 25 years,

Note: The wood products used in this program are all of high value and should provide a large amount of income, dwarfing the carbon payments of the first 10 years. Also, through the program contract, the participating producers have the legal obligation to stay in the program for 50 years.

4.6. Species Selection

The Silvopastoral Planting design is based on three species of varying growth, use and shape. All species are well adapted to the climactic conditions of the region, and locally valued by the participating producers, technical experts and local markets.

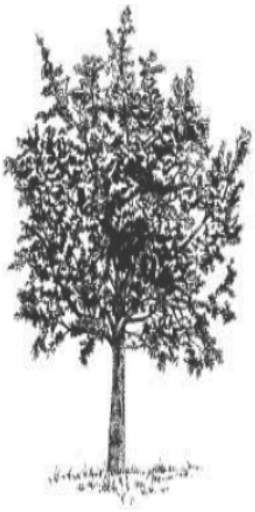
Species selection process

The selection process was conducted in the following order:

1. Producer groups were consulted to determine the favoured native species with which to work
2. Expert groups were also consulted to determine the favoured species to with which to work within the technical specification.
3. The species that overlap with both producer and expert groups were selected.

4.7. Species Description

Name: *Bombacopsis quinata* (recently renamed to *Pachira quinata*)
Native to seasonal dry forests from southern Honduras to central Venezuela, *Bombacopsis quinata* is locally called *pochote*, *cedro macho* or spiny cedar in English. It occurs naturally at elevations from sea level to 900 metres above sea level with mean annual precipitation ranging from 800 to 3000 millimetres. Furthermore, it is located in regions with a well-defined dry season ranging from 2 to 6 months. Spiny cedars have a deep root system with a single taproot that can reach 2.5 metres in depth. The tree can reach heights of up to 40 metres and a DBH of up to 3 metres. The tree produces a straight main bole with a slightly concave shape and is characterized by its stubby thorns along the base of the tree.[17] The tree grows best on slopes < 30% and requires well drained soils that contain a mix of sand and clay with a pH between 5.5 and 7.5.[18] The timber is light with a specific gravity of approximately 0.45 (oven dried weight over green volume) with excellent durability and workability.[17] There is a large contrast in the yellowish grey colour of the sapwood and the pinkish colour of the heartwood, which defines this timber. In the Central American marketplace, spiny cedar harvested from natural forests commands some of the highest prices of all species in the region.[20] Due to the value of the wood, there is increasing experience with the species in plantation settings.



Name: *Caesalpinia velutina*
Caesalpinia velutina is a tree species native to Central America that is commonly used amongst smallholders in agroforestry systems and locally known as *mandagüal*. It is a moderately fast growing tree that is commonly found in arid regions from Mexico to Nicaragua. It has been identified growing in regions with annual precipitation ranging from 450 to 1200 millimetres with a distinct dry seasons lasting up to 8 months. It has also been found growing at elevations ranging from 50 to 950 metres above sea level. The tree grows best in well-drained soils with a pH above 5.5. It was also selected by the Oxford Forestry Institute as a promising species for international field trials across Latin America and Africa due to its growth potential on marginal soils and the high quality of its wood. It establishes well by direct seeding, even in very dry regions. Its initial growth is slow, thus requiring weed suppression when grown in agroforestry systems. *Caesalpinia velutina* grows well on steep slopes and loses all of its leaves during the dry season, which produces an abundant quantity of organic material. In terms of shape, the tree produces a single straight bole that reaches 10 to 12 metres in height and 20 to 30 cm in DBH. It produces a deep taproot and secondary lateral roots. With a specific density of 0.722 g/cm^3, the dense wood is highly durable, making it ideal for fences posts because of its resistance and durability.[21] In San Juan de Limay, Nicaragua, communities often use this tree for living fences with trees planted every 1.5 metres. Furthermore, the wood is commonly used as posts in rural construction, for tool handles and occasionally for carpentry. The wood is also

favoured for fuelwood because it dries rapidly and produces little smoke.[22]

Name: *Swietenia humilis*

Swietenia humilis is a medium-sized deciduous tree with its natural range extending from Mexico's Pacific coast all the way to the north Pacific coast of Costa Rica in what is known as tropical dry forests or tropical seasonal forests. The species has been identified growing in regions with annual precipitation ranging from 800 to 2000 millimetres with a distinct dry seasons ranging from 5 to 7 months. It has also been found growing at elevations ranging from 50 to 1000 metres above sea level. The tree grows best in well-drained acidic soils. *Swietenia humilis* is locally called *Caoba* and *Honduran* or Pacific mahogany in English. There is some discussion on whether or not the species is distinct from *Swietenia macrophylla* (the most commercially important and recognized mahogany) because naturally occurring hybrids have been identified. *S. humilis* wood is highly recognized and valued both locally and internationally due to its aesthetic beauty, durability and workability. The wood of *S. humilis* has a specific gravity of 0.718 g/cm^3.[23] Although predominantly used for timber, the tree has been used for living fences, agroforestry and silvopastoral systems. It is best propagated by seeding, grows at a medium rate and does not perform well in pure stands due to attacks from the shoot borer *Hypsipyla grandella*, which attacks the tree's new shoots causing forking. Trees are particularly susceptible in their first few years of growth and during the rainy season.[17] In San Juan de Limay, this endangered species is actually quite common and grows rigorously, and there has not been any evidence of *Hypsipyla grandella* attacks. Nonetheless, the CommuniTree Carbon Program plants this species at a low density.

5. Baseline

The first phase of determining the baseline consists of establishing the initial carbon stock present within the above ground woody biomass and the below ground woody biomass. Deadwood was excluded from this baseline because its presence is negligible, which was confirmed by an original baseline calculation in a sub-region of the current program boundary. The objective is to obtain an estimate of initial carbon stocks with a precision of plus or minus 15% with a 90% confidence level (two-tailed). To do so, the program boundary was stratified into various vegetation land-covers and sampled to estimate the initial carbon stock. The methodology in the section is based on the Winrock International Sourcebook for Land Use, Land-Use Change and Forestry Projects.[24] The second phase consists of determining the likely trend of the carbon stock over time in the absence of the project.

In 2011, the original baseline calculations for the San Juan de Limay program area were performed. In 2014, the baseline for the new program area in Somoto was calculated.

5.1. Stratification

First, two Landsat 5 TM+ images (2010-12-23, 2011-01-08) of the scene 17-51 were acquired from the United States Geological Survey (USGS) web site.[25] These 30-metre spatial resolution images were selected by considering seasonality of the imagery, minimization of variation in reflectance related to dry or wet season vegetation characteristics, and atmospheric contamination. Atmospheric correction was computed on the two images, which yielded reflectance values corrected from the contamination effect of atmospheric particles that absorb and scatter the radiation from the Earth's surface. Clouds and cloud-shadow presence are also a significant problem when using remote sensing images over humid and tropical latitudes.[26] Therefore, in addition to the reflectance computation, it was necessary to mask clouds and cloud-shadow when encountered.

Second, a fieldwork campaign was conducted to develop a stratification scheme of the different vegetation types and also to train and test the classification products. Patches of uniform vegetation cover of different sites across the study area were identified with handheld GPS units. Based on the initial surveys, the program area was stratified into three broad classes: (i) agriculture-pasture, (ii) bushy vegetation and (iii) forest.

Thirdly, clouds were identified using a decision tree based on the brightness values of the band 1 (blue) and band 6 (thermal). Cloud shadows were identified using a threshold of the band 4 (near infra-red).
A 90-metre buffer was computed on areas masked from clouds and cloud-shadow to ensure that all scenes were free of cloud contamination. Following this procedure, an unsupervised classification was performed on each individual scene (TM+ image), purged from cloud contamination using the ISODATA (Iterative Self Organizing Data Analysis Technique) approach. ISODATA, one of the most used unsupervised classification algorithms,[27] assigns given pixels to a specific cluster based on the multidimensional space attributes and aggregates clusters together based on their spectral similarity.[28]
The classification approach was conducted over a combination of products derived from the Landsat 5 TM+ spectral bands. A Normalized Difference Vegetation Index (NDVI) was calculated from the red and near-infrared bands, which represents an indicator of density of healthy vegetation. This vegetation index is valuable for this program as it normalizes the illumination effects that are substantial in mountainous regions and can yield significant differences in the reflectance values. In addition to the NDVI, the Principal Component Analysis (PCA) technique was used, which is a useful variable reduction technique that is commonly employed with environmental remote sensing imagery.[29] This approach was conducted over all the Landsat 5 TM+ bands, except the band six (thermal band) to exclude the noise and summarise most of the variance. The PCA components containing most of the variance (PCA1, PCA2, and PCA3) were coupled with the NDVI and used as input in the classification algorithm. After performing the classification on each individual image, the two classifications were combined by giving priority to the 2010-12-23

scene, as this scene had lesser cloud contamination and thus provided a more uniform representation of the landscape.

Lastly, the accuracy of the final classification product was evaluated by comparing the vegetation cover type observed from the pilot biomass survey points (further described in Section 5 to the classified vegetation cover types (see Table 3). Agriculture and forest vegetation cover classes were accurately classified, yet the bushy vegetation strata resulted in a lower accuracy (i.e. user's accuracy of 50%). However, most of the erroneous classification for this stratum was due to agriculture (lower carbon stock) being classified as bushy vegetation (higher carbon stock) and not the other way around. Considering that this vegetation cover classification will be used to establish the initial carbon stock present in the various vegetation covers, this type of misclassification makes the classification result more conservative. Once the classification was computed, a systematic sampling approach was used to establish 416 plots across the study area where forest is not present.

Table 3– Confusion matrix of predicted classes of vegetation classification in San Juan de Limay

	Predicted class			
Observed class	**Agriculture**	**Bushy Vegetation**	**Forest**	**Σ**
Agriculture	11	9	3	23
Bushy Vegetation	1	11	6	18
Forest	0	2	11	13
Σ	12	22	20	54
User's accuracy (%)	91.67	50.00	55.00	
Overall accuracy (%)	61.10			

Table 4.1 & 4.2 – Confusion matrix of predicted classes of vegetation classification in Somoto from LANDSAT IMAGES 2010 & 2011

Table 4.1 - 2010 Image

Observed class	**Agriculture & Pasture**	**Bushy Vegetation**	**Forest**	**Σ**
Agriculture & Pasture	443	4	3	450
Bushy Vegetation	157	24	19	200
Forest	27	0	183	210
Σ	627	28	205	860
User's accuracy (%)	70.65	85.71	89.27	
Overall accuracy (%)	75.58			

Table 4.2 2011 Image

Observed class	**Agriculture & Pasture**	**Bushy Vegetation**	**Forest**	**Σ**

Agriculture & Pasture	423	25	1	449
Bushy Vegetation	188	42	21	251
Forest	16	12	394	422
Σ	627	79	416	1122
User's accuracy (%)	67.46	53.16	94.71	
Overall accuracy (%)	76.56			

The land cover classification results for San Juan de Limay and Somoto are illustrated in Figure 10 and Figure 11 respectively.

Figure 10 – Vegetation cover stratification in San Juan de Limay

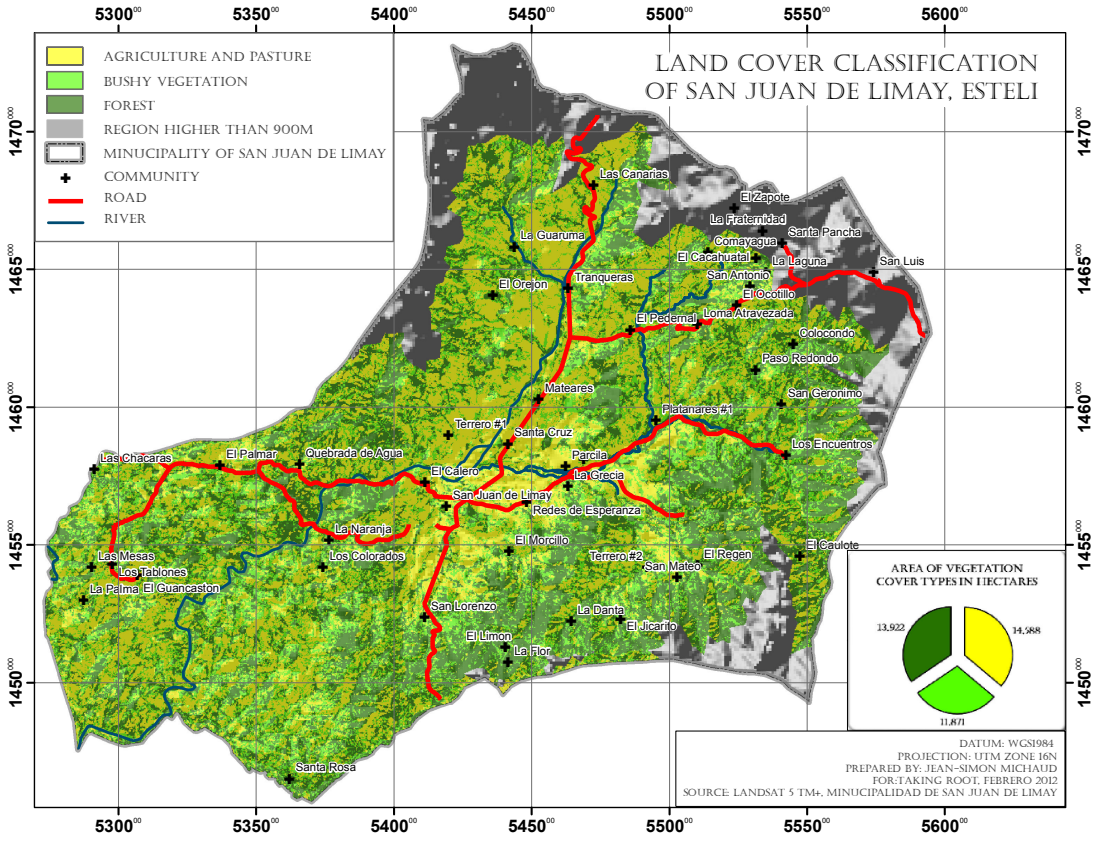
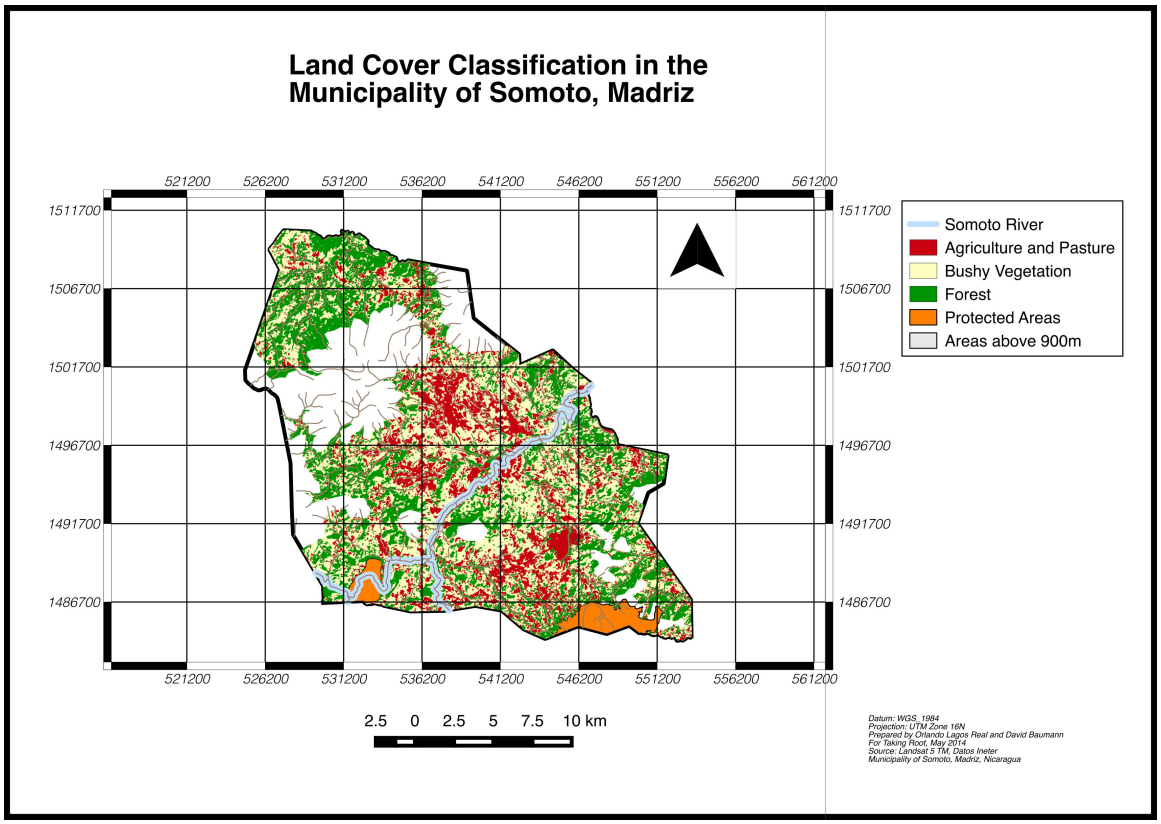


Figure 11 – Vegetation cover stratification below 900 metres in Somoto



5.2. Sampling

Initially, a biomass pilot survey was established (n=52) using a non-stratified random sampling approach. With the data acquired from the pilot survey, the average amount of carbon within the eligible areas for reforestation was determined using the following equation.

$$\bar{y}_{ST} = \sum\left(\bar{y}_h \times \frac{N_h}{N}\right) = \sum\left(\bar{y}_h \times W_h\right) \quad \text{(a)}$$

Where $\bar{y}_{ST}$ = Estimate of the overall mean; $\bar{y}_h$ = Mean carbon value in metric tons of stratum h; N = Population of samples; $\overline{N}$ = Population of samples is stratum h; W_h = Weight assigned to stratum h

The variance was estimated using the following equation:

$$S_{\bar{y}_{ST}} = \sqrt{\sum\left(S_{\bar{y}h} \times \frac{N^2{}_h}{N^2}\right)} = \sqrt{\sum\left(S^2_{\bar{y}_h} \times W_h^2\right)} \quad \text{(b)}$$

Where $S_{\bar{y}_{ST}}$ = Standard Deviation of the mean; $S_{\bar{y}h}$ = Standard deviation of the mean of stratum h

With these results, a Neyman allocation (sometimes known as optimal allocation) was used to determine the minimal sample size required to meet the specified allowable error using sampling without replacement. This allocation procedure was chosen because it takes into account both variation within the different strata and the size of each stratum. The equation for determining the total number of

$$n = \frac{t^2 \times \left(\sum W_h s_{y_h}\right)^2}{AE^2 + \frac{t^2 \times \sum W_h s^2_{y_h}}{N}}$$

samples required and the number within each stratum is as follows:

(c)

and

$$n_h = \frac{W_h s_{y_h}}{\sum W_h s_{y_h}} \times n \quad \text{(d)}$$

Where AE = Allowable sampling error; n = Number of samples required; s_{y_h} = Standard deviation of the sample of stratum h; $s^2{}_{y_h}$ = Variance of the observations of stratum h; t = Student's random variable from *t*-distribution; W_h = Weight assigned to stratum h

However, to construct confidence limits, the appropriate degrees of freedom for the estimate need to be estimated since the required sample size is yet to be determined. As such the effective degrees of freedom was used.

$$EDF = \frac{\left(s^2_{\bar{y}_{ST}}\right)^2}{\sum \frac{\left(W_h^2 \times s^2_{\bar{y}_h}\right)^2}{n_h - 1}} \quad \text{(e)}$$

Where all the variables are the same as in the previous equations.

As a result, it was determined that an additional 340 sample plots were needed in the bushy vegetation classification. As such, an additional 347 additional points were established throughout the stratum using a stratified random sampling approach but with a 60-metre buffer (the length of the largest plot) to ensure that sampling plots would not overlap with a different vegetation cover type. The locations of these sample plots in each municipality are illustrated in Figure 3 and Figure 13.

Figure 3 – Location of biomass samples in San Juan de Limay

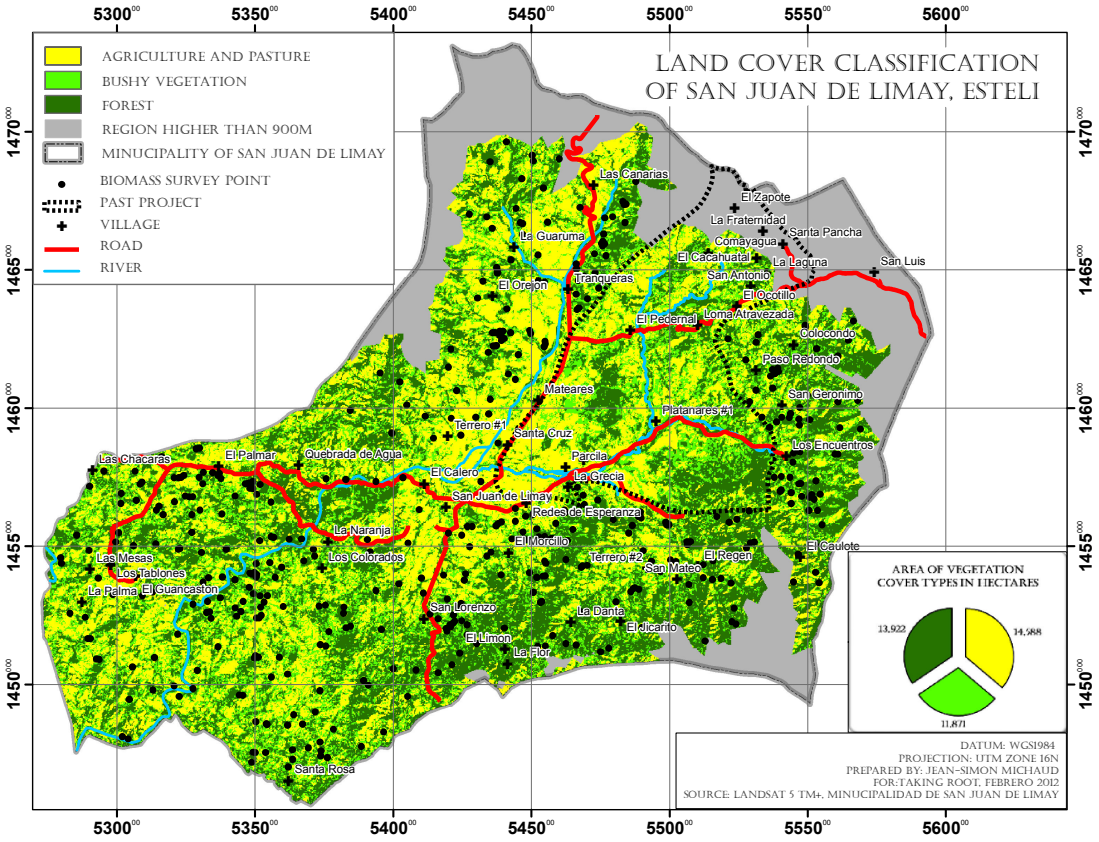
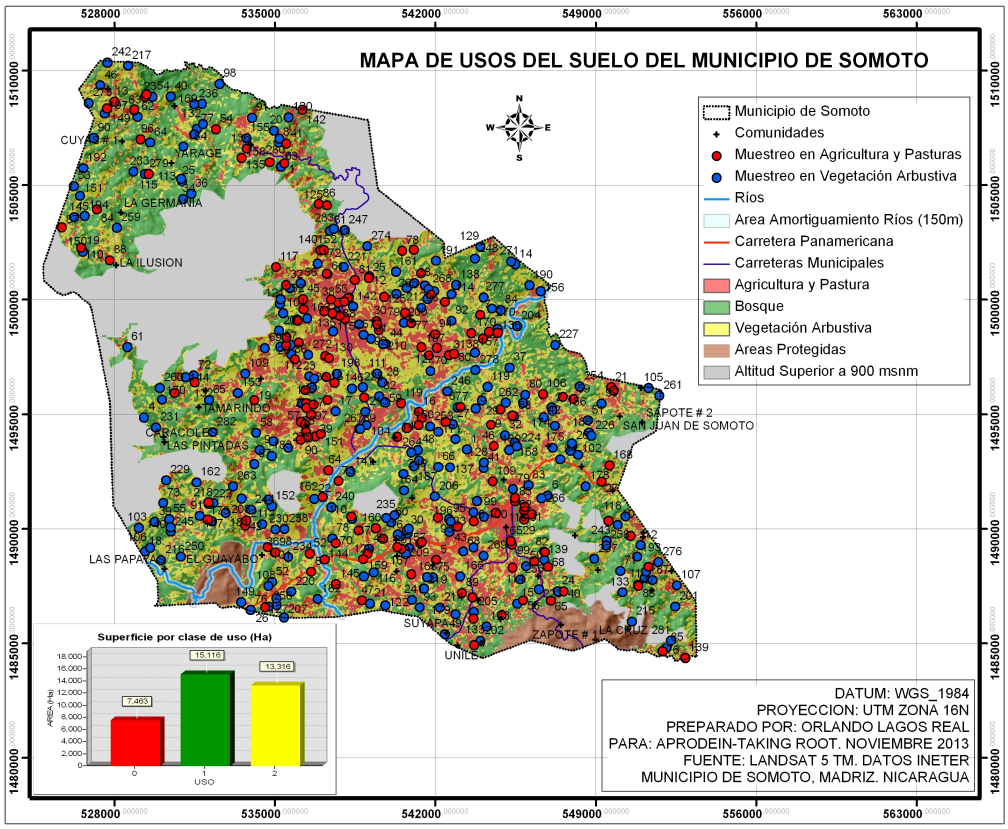


Figure 13 – Location of biomass samples in Somoto.



5.3. Biomass Survey Methodology

A biomass survey was carried out at each sample plot to estimate the quantity of woody biomass within the agriculture and pasture and the bushy vegetation stratum. All trees with a diameter at breast height of >5 centimetres were included in the survey. Nested sub-plots of varying sizes were used within the sample plots to measure trees according to the Table 5 below.

Table 5 – Size of sampling plots, sub-plots and trees measured

Sub-plot	Square	Area	Trees
Small	20 m	0.04 ha	>5 cm DBH
Medium	40 m	0.16 ha	>20 cm DBH
Large	60 m	0.36 ha	>50 cm DBH

Field Measurements

In the field, a standard methodology was used to record the necessary information for the baseline calculation. The GPS coordinates were located using a hand-held GPS receiver and the program boundary map. Once located, the coordinates represented the south west corner of the square nested plot.

The diameter at breast height of each tree was measured and the height of one representative small, medium and large tree were recorded using a clinometre. If this location was not representative of the tree's diameter due to an irregular growth, a second measurement was taken slightly above the growth and the point of measurement was used as opposed to the DBH. All small trees in the small sub-plot were measured, all medium trees were measured in the small and medium sub-plot and all large trees were

measured in the entire plot. If the tree bifurcated below the point of measurement, it was measured as two separate trees. The information with the tree's local name was noted in the data sheet along with the slope of the land at its steepest point.

Estimating the Average Carbon Stock Per Hectare

To calculate the average carbon stock per stratum per hectare, various calculations were made.

1) The slope of the plot was corrected for using the formula:

$$L = L_s \times \cos(S) \quad \text{(f)}$$

Where L = the true horizontal plot radius; Ls = the standard radius measured in the field along the steepest slope; S = the slope in degrees; Cos = the cosine of the angle

By taking the steepest slope, the carbon in each sample is overestimated. This methodology is concurrent with the baseline being calculated as conservatively as possible.

2) The results of each plot were expanded to a per hectare basis using the following expansion factor:

$$EF = \frac{10000}{A} \quad \text{(g)}$$

Where EF= Expansion factor; A= Area of sub-plot in m^2

Using an allometric equation developed for tropical dry forests with annual precipitations > 900 millimetres/year, the above ground biomass (AGB) was calculated as:[30]

Biomass (kg) = exp{-1.996+2.32 x ln(DBH) (h)

3) The expansion factor multiplied by the total calculated biomass of trees on the sample sub-plot gave an estimate of the aggregate of all trees on the hectare of land.

4) Below ground biomass was calculated by multiplying the AGB by 0.56 when AGB < 20 t/ha and by 0.28 when AGB > 20 t/ha. [31]

5) The aggregate of above ground and below ground biomass were summed together to get total biomass (TB), which was converted to Total Carbon (TC) by multiplying the Total Biomass (TB) by the carbon fraction. [32]

TC = 0.49 * TB

5.4. Change of Carbon Stock in Absence of Project

A consultation was held with environmental committee representatives from various communities within the program boundary to discuss likely land-use changes in connection with land resources use.

The first phase involved discussing the environmental history of the area from the participants' perspective over the course of their lives to establish a sense of the time frame of this technical specification. The testimonies of community elders reiterated the devastating impacts of the "Green Revolution" on the local economy and environment. While vegetation was able to recover somewhat from the destruction of the cotton monocrops, elders noted that the forest cover has been in steady decline since the 1990s, which is consistent with published literature on the history of the region.[33]

The second phase of the consultation involved discussing and identifying the various factors that lead to land-use change in terms of intensity and area. Using a pair-wise ranking method, the main threats and their respective intensities were compared to one another to determine their relative importance. The two most important factors identified were the expansion of agricultural land and pastureland.

The third phase involved assessing the communities' expectations regarding the future evolution of each land-use over the program lifetime, relative to the present. It was clear that the communities expected the trend of deforestation and forest degradation to continue. Consultation with an outside expert validated the likeliness of the presented scenario. This confirmation letter can be found in Appendix 6 and the minutes of this consultation are available upon request.

5.5. Baseline Results

Due to environmental and socio-economic conditions in the municipality of San Juan de Limay and Somoto, land-use commonly cycles from agricultural fields, to cattle pasture land, then to fallow fields where bushy vegetation regenerates.

Satellite imagery was used to determine the proportions of the program boundary that was under each different type of vegetation cover at a given point in time. Although the exact location of each vegetation type changes over time, what is relevant is the ratio that the different vegetation covers occupy throughout time. Through the use of this technical specification, the relative proportion of agricultural land is likely to remain constant whereas the relative proportion of pastureland and woody vegetation is likely to diminish due to gains in efficiency brought about by the reforestation program.

At the time of this baseline study, the predominant vegetation cover was bushy vegetation. However, the majority of the program's producers chose to establish this technical specification in open fields, where the baseline would be close to zero. Since woody vegetation will likely be cleared elsewhere as part of the normal land-use cycle, the program chose to take a more conservative approach and integrates the carbon stock present in the other vegetation covers. Due to the land-use and the rapid cycle of land-use change, the two eligible categories of vegetation cover have been considered as one land-use stratum for the baseline. The carbon stock baseline is an area-weighted average of the following two land-use types: (i) agriculture and pasture, and (ii) bushy vegetation. These areas were included in the average scenario because each will be directly or indirectly affected by the program intervention. Despite evidence of a probable decline in carbon stocks over time in the absence of the program within the municipality (a relative increase in low carbon stock vegetation covers), this program recognizes the difficulty in accurately quantifying the decline of the baseline over time. Therefore, the baseline will be conservatively assumed to stay constant, which is consistent with simplified baseline and monitoring methodologies for small-scale A/R CDM program activities. The results of the initial carbon stock are presented in Table 6 and Table 6 below:

Table 6 – Baseline results in San Juan de Limay

	Area (ha)	Above ground woody biomass (tC/ha)	Below ground woody biomass (tC/ha)	Total (tC/ha)
Agriculture and pasture	14,588	0	0	0.00
Bushy vegetation	11,871	5.79	1.67	7.46
Area weighted total	26,459	2.60	0.75	**3.35**

Table 6 – Baseline results in Somoto

	Eligible Area (ha)	Eligible Area (%)	Average Carbon per Class	Total Average Weighted Carbon (tC/ha)
Agriculture and pasture	6,645	54.2	1.17	-

Bushy vegetation	5,624	45.8	5.34	-
Area weighted total	12,269	100	-	3.08

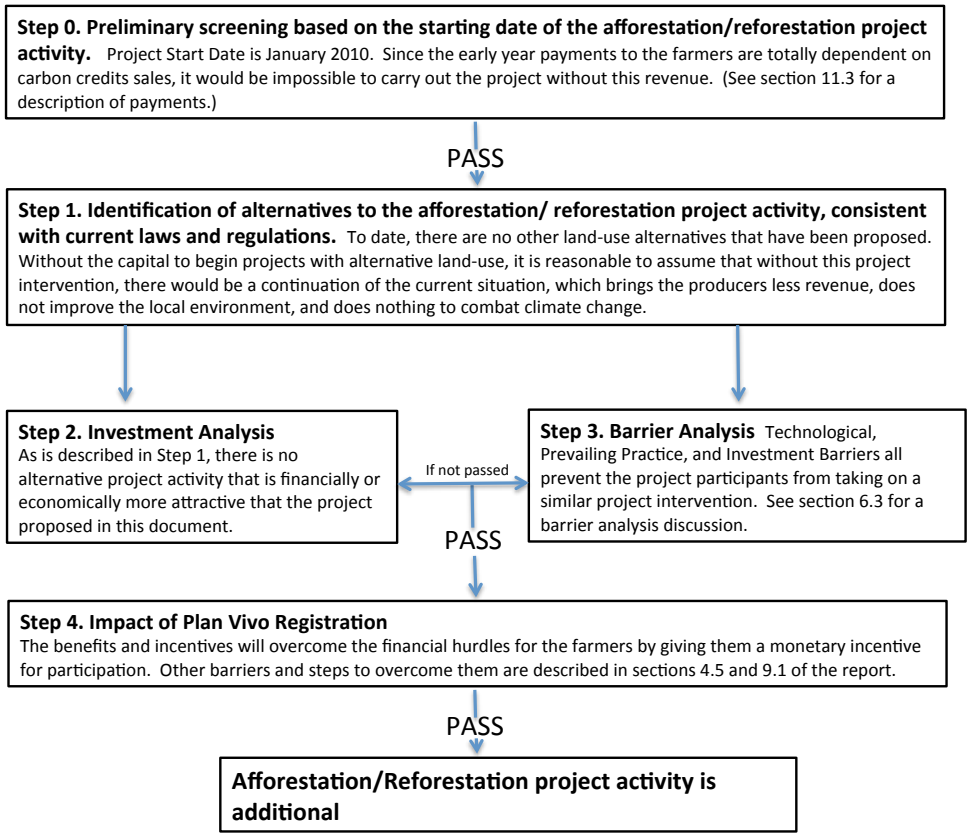
Although the program area in Somoto has a lower baseline, in order to be conservative, Taking Root uses the higher value for the two program areas, 3.35 (tC/ha) from San Juan de Limay to calculate the carbon benefits of this technical specification.

6. Additionality

Taking Root Nicaragua is a non-profit organisation with no ties to any government whether contractual or financial. All of its activities are designed independently and the scale of these reforestation programs is limited by available funding. The primary objective of adopting the Plan Vivo Standard is to increase the marketability of the carbon sequestered. Without this type of finance, this program would not take place.

The following illustration, Figure displays the results from a step-wise tool to test the additionally of prospective program activities.[34] The results of the tool indicate that the program intervention is additional.

Figure 14 – Step Wise Test for Additionality



In Section 6.3 of this document, a barrier analysis is carried out. This is a rapid assessment tool used in community development programs to identify behavioural determinants associated with a particular behaviour so that effective change can be developed.[35] Since the technical specification is designed to be beneficial to the community, a barrier analysis is an important tool to help understand what prevents these activities from taking place in the absence of this program, and therefore ensures additionality.

6.1. Comparison to Normal Practice

To ensure additionality, it is important to understand the land-use processes before the program intervention. In the community of San Juan de Limay and Somoto, traditional means of subsistence farming are normal practice, notably through the expansion of the agricultural frontier. New land is continuously cleared for agriculture as the soil in previous sites loses fertility. Cattle grazing is then

practiced on the degraded land, which prevents natural regeneration. Forested lands in the area are also degraded through the harvest and sale of fuelwood and timber. Through this expansion, natural resources become increasingly scarce.

6.2. Risk of Loss of Ecosystem Services

As a consequence of normal land-use practice, the land surface loses vegetation at a continuous rate. Without this vegetation cover, the soil no longer retains water for long periods of time during the rainy season. The overexploited soil then becomes barren and dry, and no longer cycles humidity. Consequently, wildlife habitat and agricultural productivity declines, and water security worsens. Due to this loss of ecosystem services, these factors lead towards a decline in the quality of life for the residents of the area.

6.3. Barrier Analysis

The predominant barriers to the successful long-term implementation of forest programs are summarized in Table 7 below.

Table 7 – Barrier analysis

Barrier	Why Barrier Exists	Action
Lack of technical expertise	Due to the inaccessibility and unaffordability of education in the region, many people are unable to get formal training in forestry and other necessary fields.	This program utilizes the expertise of experienced foresters and brings such expertise into the community.
Lack of funding	The region is poor and many of the residents do not have adequate sources of income.	The sale of Plan Vivo certificates will enable funding for seeds, nurseries, labour, equipment, and other needs of the program.
Lack of reforestation program examples in this region of Nicaragua. Globally, similar ecosystem services programs are fledgling.	This method of sustainable ecological and economic development is a new field. No program of this type has been attempted in the region.	As the program grows and brings together experts from a wide range of fields, more successful examples to learn from will become available. The science and methodology of this type of sustainable development program will also advance.
Lack of access to appropriate government bodies to legally register forestry plans	Due to other priorities and a small budget, the government of Nicaragua has not developed the mechanisms for registering forestry programs.	All programs will have a forestry plan registered with INAFOR.
Not a part of cultural heritage	No program of this type has ever been developed in the region.	As the program grows within the community, it will slowly gain importance in the community's way of life. The benefits from the program will provide incentives for participation and will become a greater part of the culture of the region.

7. Leakage

The Plan Vivo Standard (2008) defines leakage as "the unintended loss of carbon stocks outside the boundaries of a program resulting directly from the program activity."

There are three broad categories of leakage to be considered:

Activity Shifting

This is the loss of vegetation cover outside the program boundary as a direct result of the program intervention. Example: Clearing new agricultural land elsewhere if the reforested area replaces needed agricultural land.

Market Effect

Although unlikely to have much of an impact from small-scale reforestation programs, market effect leakage occurs when changes in supply and demand cause the loss of forest cover outside the program boundary. i.e. Preventing a large logging activity creates a gap in supply, leading to the felling of trees elsewhere.

Super-Acceptance

This takes place when alternative livelihood activities are so successful that people from the surrounding regions move into the area to take part in the activity. Note that this can have a positive or a negative effect on leakage.

7.1. Assessing the Risk of Leakage

The first step in assessing the risk of leakage involves defining and understanding the processes that lead to deforestation and forest degradation in the area. In San Juan de Limay and Somoto, the harvest of fuelwood and timber, plus the clearance of pastoral and agricultural land, are human activities that fuel the local community. These integral activities also cause deforestation. If a program intervention conflicts with the aforementioned activities, the risk of leakage is considered high.

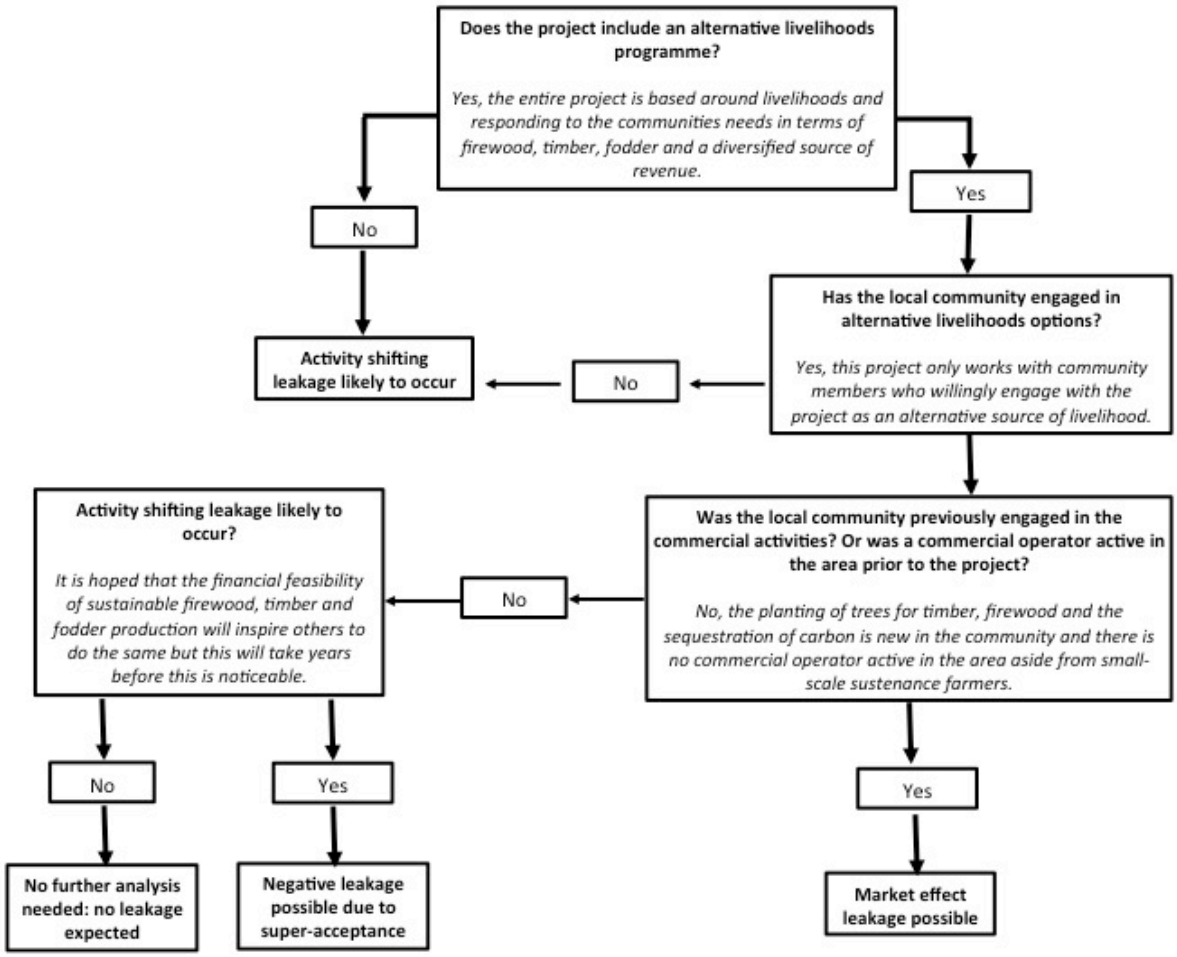
7.2. Minimizing the Risk of Leakage

Since a significant portion of the land within the program boundary is either not being utilized for any economic activities or, if so, very minimally (i.e. for occasional fuelwood collection), leakage is relatively easy to minimize as long as appropriate land-use planning is employed. Every participating producer that uses a technical specification is required to demonstrate through the creation of a plan vivo that they have sufficient additional land to provide for their agricultural and pasture needs and adequate space for reforestation activities.

7.3. Quantification of Leakage

Based on the decision tree, *Assessing the Potential for Leakage* (see Figure 15) from *Sourcebook for Land Use, Land-use Change and Forestry Programs,*[24] the potential for leakage was evaluated. After conducting the analysis, the leakage potential is considered as negligible and therefore not calculated within the carbon benefit.

Figure 15 – Assessing the Potential for Leakage



7.4. Activities to Minimize Risk of Leakage

Although it is suspected that leakage will not affect the program, it is still necessary to be proactive in preventing it currently or into the future. Both positive and negative leakage need to be considered as results of this program. The principal economic activities that could be responsible for leakage are the increase of pasture and agricultural land outside the program boundary.

The following Table 8 outlines these and other factors that could lead to leakage, assesses the associated risk level and outlines appropriate management measures. These risks will be monitored at regular intervals and adjusted if necessary.

Table 8 - Activities to minimize risk of leakage

Leakage Risks	Level of risk (low/medium/high)	Management Measures
Displacement of agricultural activity	Low	Technical support in the development of the plan vivos. Periodic longitudinal land cover analysis through remotely sensed aerial surveying using GIS and Landsat images to monitor land-use changes in and outside of the program area.
Displacement of pastureland	Low	Technical support in the development of the plan vivos. Periodic longitudinal land cover analysis through remotely sensed aerial surveying using GIS and Landsat images in and around program area to monitor land use changes in and outside of the program area. Use of high protein fodder species to provide source of food during dry season and thus reduce the area need for pastureland.
Increased harvesting to meet demand for timber and posts	Low	Establishment of high valued timber species in pasture lands to provide a sustainable source of timber and posts.

8. Permanence

Programs will only succeed if land-use practices are viable over the long-term and provide sustainable economic benefits to communities over and above the carbon payments. The program intervention has a lifespan of 50 years and therefore must incorporate long-term risk management. Considering the lifespan, assuring the permanence of the program through risk management is an essential and intricate task. First, the participation of the producer, and in some cases their successors, throughout the program lifetime is crucial. Second, it is necessary to mitigate external risks unrelated to the producer's participation. A discussion of how to manage these risks follows.

8.1. Activities to Minimize Risk of Non-Permanence

Participation

The most important factors in guaranteeing permanence is ensuring continual participation by the producer. To do so, producers must genuinely want to participate. For this program, participation is voluntary and the yearly payments to the producers are not exceptionally high. Consequently, participants do not only participate for the money but rather for the long-term benefits of the program. Furthermore, there is no aggressive recruitment strategy but rather a series of community consultations. Through these consultations, each plan vivo is designed by the participants and are therefore inline with their needs, resources and capabilities. Additionally, the species used have been selected and are desired by the community, and are chosen to provide multiple benefits to the participants beyond the carbon payments that they receive. As a result, producers participate only if they wish to reforest sections of their farm to gain the benefits of reforestation, and if they lack the means to do so independently.

Establishing a Risk Buffer for Externalities

Even if producers are committed to the program through its lifespan, there are many other risks that can halt the program. In order to prevent such externalities, a risk buffer is calculated. With the buffer in place, the Plan Vivo system can insure the program against such risks.

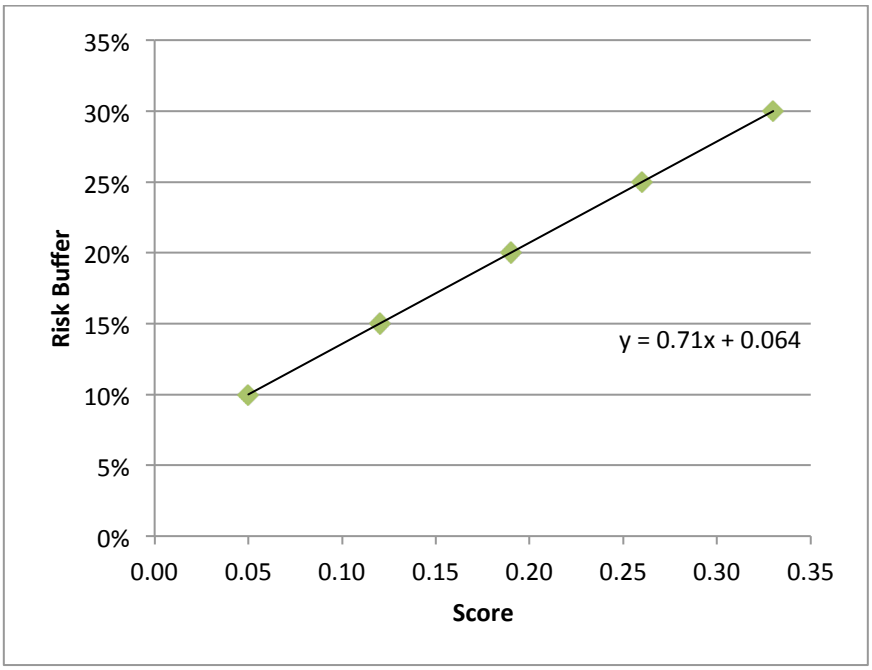
In accordance with the Plan Vivo Standard, this technical specification uses a risk buffer approach that resembles an insurance policy for the buyer of the Plan Vivo certificates. A risk buffer can be defined as a stock of unsold and non-saleable carbon held from each plan vivo, which is generated by deducting a specified percentage from each producer's carbon sequestration potential according to the risk level determined for the program as a whole.[36] If the anticipated carbon sequestered is lower than anticipated, the amount of CO_2 purchased is still sequestered because of the carbon reserve in the unsold risk buffer.

Risk Identification

There are various risks to be considered for a program lasting 50 years. The community itself identified these risks during a series of community meetings. A pair-wise ranking system was created to identify and to measure the risks, the methodology for which was taken from the BR&D document: *Community mapping: Baseline & threat assessment*.[37] Pair-wise ranking can be used to help reach consensus about the relative importance of a list of identified threats of land-use change to land-uses with lower biomass stocks.

The buffer percentage is established using the Managing Risks for Non-Sustainability Tool.[38] This method evaluates each risk and designates values to the program's control over the risk, the risk's estimated timeframe, the probability of the risk after mitigation, and the impact of the risk. The score is then associated with an appropriate risk buffer according the following graph by BioClimate (see Figure 16).

Figure 16 - Risk Buffer and Corresponding Score*



Risk Buffer Results

After performing the analysis, the final risk buffer score was determined to be 13.65%. In order to be conservative and to take into account unidentified risks, the buffer was rounded up to 15%. This further guarantees the stability of the project. Appendix 4 outlines various risk factors to permanence and outlines the mitigation strategy for each.

* In the "Managing risks for non-sustainability" tool, "minimal risk" occurs when all probabilities of risk and all impacts of risk are low (score 0.05). "Higher risk" occurs when all probabilities of risk and all impacts of risk are high (score 0.35). A score of 0.05 is associated with a recommended risk buffer of 10%, and a score of 0.35 is associated with a recommended risk buffer of 60%. A linear relationship between these two points is used to arrive at a recommended risk buffer for each score.

9. Carbon Benefit and Accounting

In order to calculate the benefits of carbon sequestration over the program lifetime, a carbon model for 50 years of tree and stand growth is created. Using a variety of quantitative methodologies and allometric equations derived from relevant journals and datasets, the model estimates the average carbon sequestration over the program period. To do so, the model predicts the growth of the trees in the first 25 years and then of the stand in the last 25. Included in this timeframe is the decay of a selection of the harvested trees. To ensure the program's carbon obligations, a technique called adaptive management guarantees that the actual sequestration of carbon reflects the predicted sequestration in the model.

9.1. Carbon Periods

Crediting Period

The crediting period is for 50 years from each participant's starting year. For example, the program period for the producers that join the program in 2012 will last until the beginning of the planting cycle in 2062 and a producer that joins the program in 2013 will have a program period that ends in 2063. This time period was selected to allow sufficient time for transition from a non-forested landscape to plantation forestry, to sustainable forest management. This demonstrates the program's intent to generate a permanent land-use change and allow for the variability of carbon stocks over the harvest and re-growth period to be averaged out. This crediting period also allows sufficient time to transition towards financially viable sustainable forestry practices.

Project Period

Activities related to the maintenance of the project interventions take place over the entire crediting period. However, the bulk of the work takes place in the first three years when establishing, planting, and clearing the property requires a sufficient labour investment. From years 4 to 8, occasional silvicultural activities are required but to a much smaller extent. For all future years, plantation activities are largely dominated by harvesting.

Payment Period

Ecosystem service payments are made during the first ten years (see Section 11.3for more details). Like most afforestation/reforestation projects, the payment period is shorter than the crediting period as payments are made when carbon finance is needed to incentivise the establishment of a new land-use system. Larger payments are made in the early years to help farmers get through the costly stage of the plantation before the first saleable forest products are generated. Afterwards, the majority of participants will continue with their land-use system and benefit from the selective cutting and sale of wood products. From that point on, the forest itself is the incentive and ensures the perpetual use of sustainable forestry as a more viable land-use option.

Training is given over this period to guarantee that the benefits involved in maintaining the land-use system are understood. Furthermore, when the forest stands approach merchantable sizes, Taking Root intends to play an active role in facilitating the marketing, logistics, and sale of the forest products so that producers receive a fair price, which will keep the incentive system in place.

9.2. Adaptive Carbon Management

The carbon benefit is calculated using the *ex-ante* forecasted average carbon stock of the system over the crediting period minus the baseline and a risk buffer of 15%. Section 4 describes the schedule of activities, including the planned harvest schedules, which have a direct impact on the carbon benefit of this land-use system. This technical specification uses multiple tree species managed for multiple objectives, notably carbon sequestration, ecosystem restoration, and commercial post and roundwood production.

The forecasted carbon benefit is based on the best information available; however results are likely to vary from one stand to another. Therefore, a dynamic approach to forest management is applied in which the effects of treatments, natural regeneration, and decisions are continually monitored and, along with research results, are used to modify management on a continual basis to ensure that carbon sequestration objectives are being met. In order to conservatively account for this variability, a distinction is made between forecasted *ex-ante* stand growth and monitored *ex-post* stand growth.

Forecasted stand growth: The forecasted carbon benefit per hectare only takes into account the carbon benefit of the longer rotation species (*Swietenia humilis and Bombacopsis quinata*). The other species is excluded to actively manage the carbon sequestration of the system based on adaptive management. If the longer rotation species grow at a lower rate than is forecasted in this report, the program can delay or remove fewer of the trees scheduled for shorter rotations (*Caesalpinia velutina*) so that on a stand level the carbon requirements are being met. For example, if one species of timber is not growing to expectation, more *Caesalpinia velutina* can be left uncut to ensure a wider growth until it must be removed to make room for more longer-lived and valuable species, all while guaranteeing the carbon obligations for that year. This also ensures that producers can meet their growth milestones since number of trees are planted is approximately double what is used for the carbon forecasting.

Monitored stand growth: Monitored stand growth accounts for all trees within the stand. If naturally regenerated trees take root, their growth will be encouraged and if they perform better than the plantation trees, they will be given priority. For a full description of the monitoring methodology, see Section 11.

9.3. Carbon Pool Choices

In order to calculate the total carbon benefit, it must be determined what sources of carbon are to be considered. Table 9 describes the choice and justification for the carbon pools included and excluded in the carbon accounting.

Table 9 - Carbon pools included in the calculation of the carbon benefit

Carbon Pool	Factors in calculation	Included (Source Given)	Excluded (Reason for Exclusion)
Above ground biomass	Stem growth	In-house allometric equations for *Swietenia humilis* plus published growth information for more *Caesalpinia* and *Bombacopsis*	
	Biomass Expansion Factor (BEF), which is the ratio of above ground tree biomass in relationship to the tree's stem volume.	IPCC default values	
	Specific density	Published information	
	Carbon fraction	IPCC default values	
Above ground non-woody biomass			Expected to increase as a result of program activities, but difficult and costly to measure with only a small increase in carbon benefit. Thus, conservatively excluded.
Below ground biomass		IPCC default values for shoot to root ratios	
Litter			Expected to increase as a result of program activities, but difficult and costly to measure with only a small increase in carbon benefit.
Soil			Expected to increase as a result of program activities, but difficult and costly to measure.
Timber products (*Swietenia humilis*, and *Bombacopsis*)	Decay rate	IPCC default values	
	Processing loss	Published information	
Caesalpina velutina			Allows to be more conservative in our carbon calculations, and is vital for the realisation of the adaptive carbon management plan.

9.4. Carbon Modelling

Given that ecosystem service payments are based on the growth of the proposed Silvopastoral technical specification, forecasting the mass of carbon sequestered by the proposed system is of great interest. The average carbon stock sequestered over the crediting period is calculated using the following equation:

$$C_{Avg} = \sum \left(C_{ABGB} + C_{AAGB} + C_{AHWP} \right) \quad \text{(i)}$$

Where C_{Avg} = Average mass of carbon sequestered over the crediting period; C_{AAGB} = Average carbon in above ground biomass of tree components; C_{ABGB} = Average carbon in below ground biomass of tree components; C_{AHWP} = Average carbon stored in harvested wood products for all species

Above Ground Biomass of Tree Components (AGB)

The carbon in the AAGB is calculated as follows:

$$C_{AAGB_{avg}} = \frac{\sum_{t=1}^{n} \sum_{p=1}^{2} AGB_{tp} \times D_p \times CF}{n} \quad \text{(j)}$$

Where AGB_{tp} = AGB for species p at time t; D_p = the specific density of the wood of species p; CF is assumed to be constant representing the carbon fraction of dry biomass for tropical forests and is equal to 0.49.[32]

Below is a list of equations used to calculate AGB for the various species employed.

Bombacopsis quinata

Above ground biomass in tonnes was estimated for *Bombacopsis* using the following equation:

$$AGB_{Bombacopsis_t} = V_t \times BEF \times D_{Bombacopsis} \quad \text{(k)}$$

Where BEF is the biomass expansion factor, which was estimated using the following equation[39]

$$BEF = 3.233983 \times DBH^{0.45162} \times ht^{-0.67457} \quad \text{(l)}$$

Where DBH = the diameter of breast height in centimetres; ht = the height of the tree in metres

Published growth equations for *Bombacopsis quinata* from Costa Rican plantations were found however they proved to be overly optimistic based on our experience in the region. As such, the standard Chapman-Richards growth and yield model for both DBH and ht was used but calibrated to local conditions where $Yield_t = b_0*(1-e^{(-b2*t)})^{b3}$. With this functional form, b_1 and b_2 determine the shape of the curve whereas the b_0 coefficient determines the asymptote of the growth curve (the maximum obtainable yield value). As such, as long as realistic and conservative values are used for the asymptote, the yield modelling will always remain constrained to realistic values over a sufficiently long time period. To conservatively calibrate the asymptote, data well below maximum plantation values were used from a recent study on *Bombacopsis quinata*[40] so that DBH was caped at 42 cm and height was caped at 26 m. For the shape of the curve, the model was calibrated to intersect observed datasets from the region. As such, the DBH equation is as follows:

$$DBH_t = 42*(1-e^{(-0.16*t)})^{4.2} \quad \text{(m)}$$

Where t = age in years; and e is a constant representing the base of the natural logarithm.

The height equation is as follows:

$ht_t = 26*(1-e^{(-0.17*t)})^{1.6}$ (n)

Where ht = the height in metres and t = the age in years.

The maximum height (b_1) of 26 metres was taken from this study's dataset.

Stem volume (V_t) was estimated using the following model[41]

$$\ln(v) = -8.0758 + 1.2678 \times \ln(dbh) + 0.9729 \times \ln(ht)$$ (o)

Where *v* represents volume in m^3.

Caesalpinia velutina

C. velutina is the species planted at the highest density is this technical specification but is scheduled to be harvested around year 10 to provide a merchantable source of posts for rural construction. As such, its carbon sequestration is excluded from the carbon modeling. However, the species can grow considerably larger and given the high density of its wood, has the potential to sequester considerable quantities of carbon. Through our system of adaptive management, should stand growth not meet expectations, some of the trees will not be removed to ensure that carbon obligations are met.

Nonetheless, above ground biomass in kg can be estimated for *Caesalpinia velutina* using the following equation:[22]

$$\ln(AGB_{Caesalpinia_t}) = -2.708 + 1.6155 \times \ln(DBH) + 1.1209 \times \ln(ht)$$ (p)

Where AGB = above ground biomass in kilograms, DBH = the diameter at breast height in centimetres and ht = the height in metres.

The stem volume in metres cubed can be estimated using the following equation:[22]

$$\ln(V) = -9.0215 + 1.4263 \times \ln(DBH) + 1.1431 \times \ln(Ht)$$ (q)

Where V = the stem volume in metres cubed, DBH = the diameter at breast height in centimetres = Ht is the height of the tree in metres.

In order to forecast growth and yield, an in house stand level height equation was built using easily obtainable environmental and climatic variables as well as an allometric relationship between height and DBH. The dataset used for building these equations originated from sixty-eight permanent sampling plots (PSP) that were made available to the general public as part of the CATIE technical series[13]. The PSPs originated from Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica and Panama, thus representing a wide range of environmental and climatic growing conditions. Several years later, a newer version of the same dataset with older trees was published in a graduate thesis,[22] which was added to the dataset.

The equation for height is as follows:

Ln(*ht)* = -2.0144 + 0.9862 x ln(*t)* – 0.00179 x *elev* + 0.000187 x *precip* + 0.005728 x *slope* (r)

Where ht = the height in metres; t = the age of the trees in months; elev = the average elevation above sea level in m; precip = the average annual rainfall in mm; and slope = the average slope of the stand.

$$DBH = 2.22982 + 0.74529 \times ht - 0.00032 \times TPH - 0.000555 \times precip$$ (s)

Where TPH = the number of trees per hectare in the stand.

Swietenia humilis

Above ground biomass (AGB) was estimated using the following equation:

$$AGB_t = (BA_t \times ht_t \times FF) \times BEF \times D \quad \text{(t)}$$

Where FF is form factor, which is assumed to be a constant equal to 0.5[*]; BEF is the biomass expansion factor, which is also assumed to be a constant equal to 1.5 times the stem biomass for tropical dry forests [26]; t is time measured in years; and Basal Area (BA) is:

$$BA_t = \left(\frac{DBH_t}{2}\right)^2 \times \pi \quad \text{(u)}$$

Where π = the mathematical constant pi whose value is equal to the ratio of any circle's circumference to its diameter; and FF = form factor, which is assumed to be a constant equal to 0.5

Where BEF = biomass expansion factor, which is also assumed to be a constant for tropical dry forests;[42] and t = time measured in years

Using data from an in-house study, the Chapman-Richards model was fitted and calibrated using height and DBH measurements from different years (for more details on this method, see the growth section for *Bombacopsis quinata*). The maximum DBH was set at 40 centimetres and the maximum height was set at 20 metres (again, well below the species potential). As such, the DBH equation was determined to be as follows:

$$dbh_t = 40*(1-e^{(-0.16*t)})^{4.2} \quad \text{(v)}$$

Where dbh = the diameter at breast height in centimetres; and t = age in years,

The height equation is as follows:

$$ht_t = 20*(1-e^{(-0.17*t)})^{1.6} \quad \text{(w)}$$

Where ht =height in metres; and t = age in years.

The maximum height (b_1) of 20 metres was is the maximum height from the in-house study.

Below Ground Biomass

Average carbon in the below-ground biomass (BGB) is calculated as follows:

$$C_{BGB_{avg}} = \frac{\sum_{t=1}^{n}\sum_{p=1}^{2} AGB_{tp} \times D_p \times CF \times R}{n} \quad \text{(x)}$$

Since species specific BGB equations were unavailable, IPCC default values were used where R is the ratio of below ground biomass to above ground biomass for tropical dry forests equal to 0.56 when AGB_t is less than 20 and equal to 0.28 when AGB_t is greater than 20.[43]

[*] Default form factor suggested in a professional consultation by Henriette Duda, Doctor of Biometrics at PrimaKlima -weltweit- e.V. and also inspired by various publications, notably: Malik, A. (2002). Untersuchungen über waldmess- und waldwachstumskundliche Grundlagen zur Bewirtschaftung der Baumart Diospyros celebica Bakh. (Ebenholz.)

Calculations for Harvested Wood Products (HWP)

Wood products contribute to mitigating climate change through forming a storage pool of wood-based carbon, which can last longer than the lifespan of the tree when used in long-lived products. In this program, some of the carbon in the program trees will provide carbon storage benefits long after they are cut down. The average carbon in the harvested wood products (HWP) is calculated as follows:

$$C_{HWP_{avg}} = \frac{\sum_{p=1}^{2}\sum_{i=1}^{n}(C_{HWP_{tp}} + (C_{HWP_{t-1}p} \times k_p))}{n} \quad \text{(y)}$$

Where k is the decay rate of species p.

$$C_{HWP_{tp}} = HWP_{tp} \times D_p \times CF \quad \text{(z)}$$

and

$$HWP_{pt} = V_{merchantable_{pt}} \times V_{harvested_{pt}} \times PF_p \quad \text{(aa)}$$

where $V_{merchantable}$ is the standing volume per tree of merchantable timber of species p at year t, $V_{harvested}$ is the number of trees harvested from species p at year t and PF is a constant processing factor (the remaining volume after processing) of species p.

For *Caesalpinia velutina*, the following equation for merchantable standing volume was used:[22]

$$\ln(V_{merchantable_{Caesalpinia}})_t = -9.0215 + 1.4263 \times \ln(DBH) + 1.143 \times \ln(Ht) \quad \text{(bb)}$$

For Bombacopsis, merchantable volume was estimated using the following model.[41]

$$\ln(V_{merchantable\ Bombacopsis})_t = -8.0758 + 1.2678 \times \ln(DBH) + 0.9729 \times \ln(ht) \quad \text{(cc)}$$

For Swietenia, the following equation was used for merchantable standing volume

$$V_{merchantable\ Swietenia\ t} = BA_t \times H_t \times FF \quad \text{(dd)}$$

Values for Timber Processing Factors

When the trees are processed, only a minority of the stem is processed into long-lived timber products. For this program, a processing factor of 80% of the stem is used for posts and 35% is used for when larger stems are processed into sawnwood.[44] This factor is taken from a study done in Costa Rica where trees with a DBH of 19 centimetres had a processing factor of 35% and those with a larger DBH had a higher factor. Although trees used for sawnwood in this program all have a DBH much larger than 19 centimetres at harvest, to be conservative, a constant factor or 35% is being used.

Values for Decay Rates of Harvested Wood Products

The rate of decay of harvested wood products is taken into consideration at a constant rate of 2.3% per year,[31] which is consistent with decay rates used in other publications for tropical agroforestry environments.[45] The default value is appropriate because the majority of the sawnwood products use highly valued species with international markets under the trade names Honduran Mahogany and Spiny Cedar. These species are traditionally used for furniture and cabinetry. The programed harvested merchantable volumes of timber for each species is shown in Table 2, which is the wood that is decayed in the form of harvested wood products in the carbon modelling. As with carbon sequestration, the carbon stored in *Caesalpinia velutina* is excluded from the carbon modelling.

9.5. Mortality Considerations

This technical specification requires that all trees that die be replanted in the first few years, when tree mortality is much more likely. However, modelling mortality can be challenging and complex due to the lack of data. Consequently, the carbon modelling is done considering only 90% of the trees planted. If mortality dips below 90%, adaptive management ensures that the carbon obligations are met.

9.6. From Plantation Forestry to Sustainable Forest Management

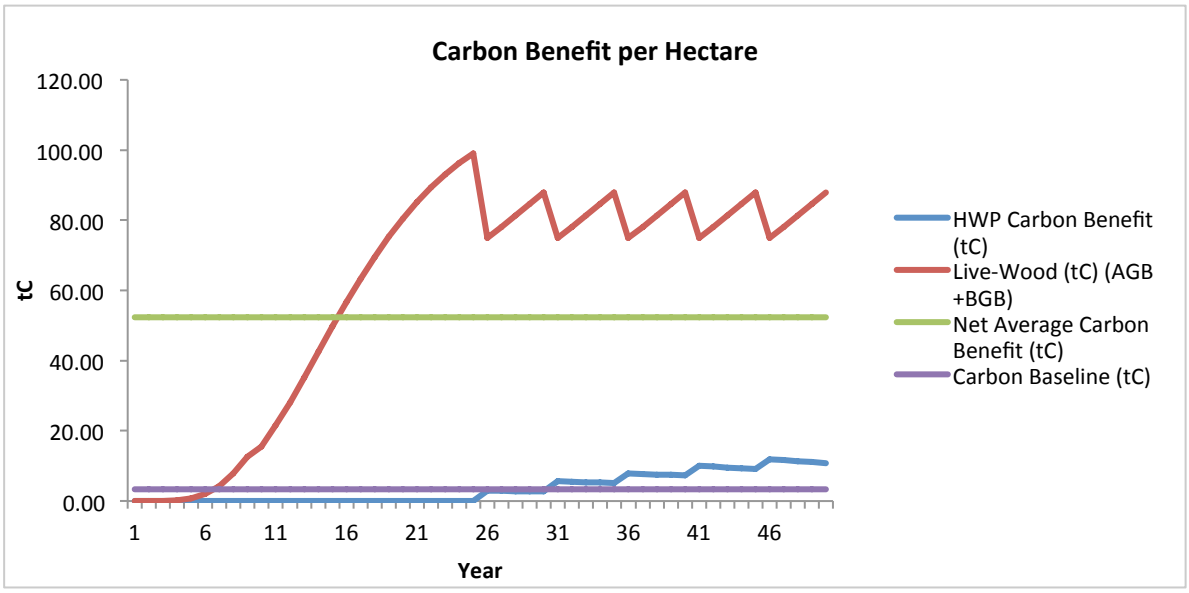
When the plantation approaches maturity near year 25, the management regime will progressively shift towards sustainable forest management. The larger trees will be selectively harvested while natural regeneration will be encouraged and, when needed, new trees will be planted. From this point on, the carbon modelling shifts from a tree level model to a stand level model. A conservative growth rate of 6 cubic metres per hectare* per year is assumed with a harvest regime of 30 cubic metres every 5 years. The average density of the stand is assumed to be the average of the last species left in the stand, which is 0.57 grams per cubic centimetre.

9.7. Carbon Benefit

According to the calculations based on this methodology, the average total carbon per hectare for the timber trees over the program period, after subtracting the baseline, leakage, and the risk buffer, is of 52.3 tC. See the Appendix 2 for specific species growth information and further calculations.

The following Figure 17 and Appendix 3 describe the total calculated carbon benefits:

Figure 17 – Carbon sequestered over time



The net carbon benefit is then converted to CO_2 by multiplying the ratio of the molecular weight of CO_2 (molecular weight: 44) by the molecular weight of carbon (molecular weight 12). Therefore the average total CO_2 sequestration per hectare is 191.9 tCO_2.

* This is based on local professional knowledge and is a common figure for timber stand growth.

10. Ecosystem Impacts

The CommuniTree Carbon Program takes a holistic approach to land-use management in an area that has suffered from intense environmental degradation for several decades. As a result, the community must cope with heavy soil erosion, water shortages and flooding, and a drastic decline in wildlife and tree species. Although carbon sequestration funds the program, its scope integrates watershed management, sustainable resource use and land-use planning. Table 10 provides a summary of the expected impacts:

Table 10 - Summary of expected impacts of program activities on key environmental services

Title of technical specification	Biodiversity impacts	Water availability impacts	Soil conservation impacts	Air quality impacts
Silvopastoral	**Positive impact:** Increase forest cover and thus wildlife habitat through the use of rare native tree species.	**Positive impact:** Entire program designed around increasing water security by prioritizing critical watersheds and thus reducing the probability of flooding in the wet season and increasing water retention in the dry season.	**Positive impact:** Forest cycle and use of nitrogen fixing trees and rapid biomass accumulation that continues nourishing the soil while increased forest cover reduces erosion.	**Positive impact:** Retain humidity and thus reduce particulate matter in the air, particularly in the dry season; Sequester CO_2 and produce oxygen.

10.1. Biodiversity Impacts

Factors that increase biodiversity:

Establishment of silvopastoral systems on underutilized lands with minimal biodiversity. Emphasis is placed on collecting tree seeds from around the community, instead of buying from one supplier, to promote variation within species. A more diverse tree stock will ensure the long term biodiversity preservation and growth as external environmental and human pressures are progressively placed on the ecosystem.

- Increase in forest cover increases wildlife habitat and therefore biodiversity.

10.2. Soil Impacts

Factors that increase soil quality:

- Increase in forest cover
- Use of nitrogen fixing species

10.3. Water Impacts

Factors that increase water benefits:

- Increase in forest cover (increased water retention and decreased evaporation)
- Planting within the vicinity of rivers and streams
- Planting within strategic watersheds

10.4. Air Quality Impacts

Factors that increase air quality benefits:

- Planting trees that sequester carbon and remove particulate matter.

11. Monitoring Plan

Each technical specification includes a monitoring plan, which is used as a basis to assess the progress of each plan vivo. It also sets forth a series of milestones that must be reached in order for payments to be received.

Table 11 describes the variables being monitored as part of the monitoring plan as well as the instruments being used and the justification. Each participating producer's plan vivo is verified at various points of the year by the community technicians for a set of indicators (see Table 12 below for a list of indicators).

Organizational annual reports are the basis by which Taking Root reports the monitoring work and progress. Annual reports will be submitted and reviewed by the Plan Vivo Foundation, and by on-site third party verification every five years. Taking Root management staff reviews the quality of the community technician's assessments before compiling annual reports.

11.1. Annual Monitoring Methodology

Resources needed: Handheld GPS, 7-metre plot cord, M1 data collection sheet, clip board, pen, measuring tape, spray paint, clinometre and DBH tape or calliper for trees with DBH < 5 cm.

Personnel: A community technician is responsible for completing an internal monitoring report for each producer according to this technical specification. Although it is the responsibility of the community technician to head the internal monitoring, it is performed with the participating producer so that all parties have a clear understanding of the process.

Plot selection and characteristics: The sampling procedure uses 7-metre radius PSPs systematically located on each plan vivo. The centre of the first PSP point placement is randomly generated through a GIS upon plan vivo registration. The area of each PSP is 153.9 m^2 or 1.54% of a hectare implying that in order to sample 10% of a hectare, a minimum of 6.5 PSPs need to be established.

For the establishment of these plots, the plot location is identified using a hand held GPS and a high-density, thick wooden stake that is inserted into the ground. Approximately 20 centimetres of it should protrude above ground, be painted with a bright colour and a have a big nail hammered into the top of it. The paint is used to facilitate locating it visually whereas the nail can be used to attach the plot cord. Furthermore, should the stake not be replaced before entirely rotting, a metal detector can be used to detect the nail and pinpoint the plot's exact location for replacement.

Since the plot centres will be visible, it is possible that the trees within that area receive a different treatment, which would bias the results. However, since the stands and plots are relatively small, it will be easy to notice this bias should it take place.

In terms of measurement, when trees surpass breast height, a line demarking 1.3 metres of height (or slightly higher if that height happens to not be representative of the tree's diameter at that point) should be marked on each tree within each plot to ensure that annual measurements are always taken at the same spot. Figure is an illustration of the monitoring sheet that is used.

Summary of Monitoring Methodology

Sampling method: Systematic with random start
Sampling unit: 7 metre radius circular PSPs
Number of samples: Minimum of 10% of technical specification or 6.5 per hectare
Population: All trees of this technical specification on producer's plan vivo
Frequency of sampling: Annual

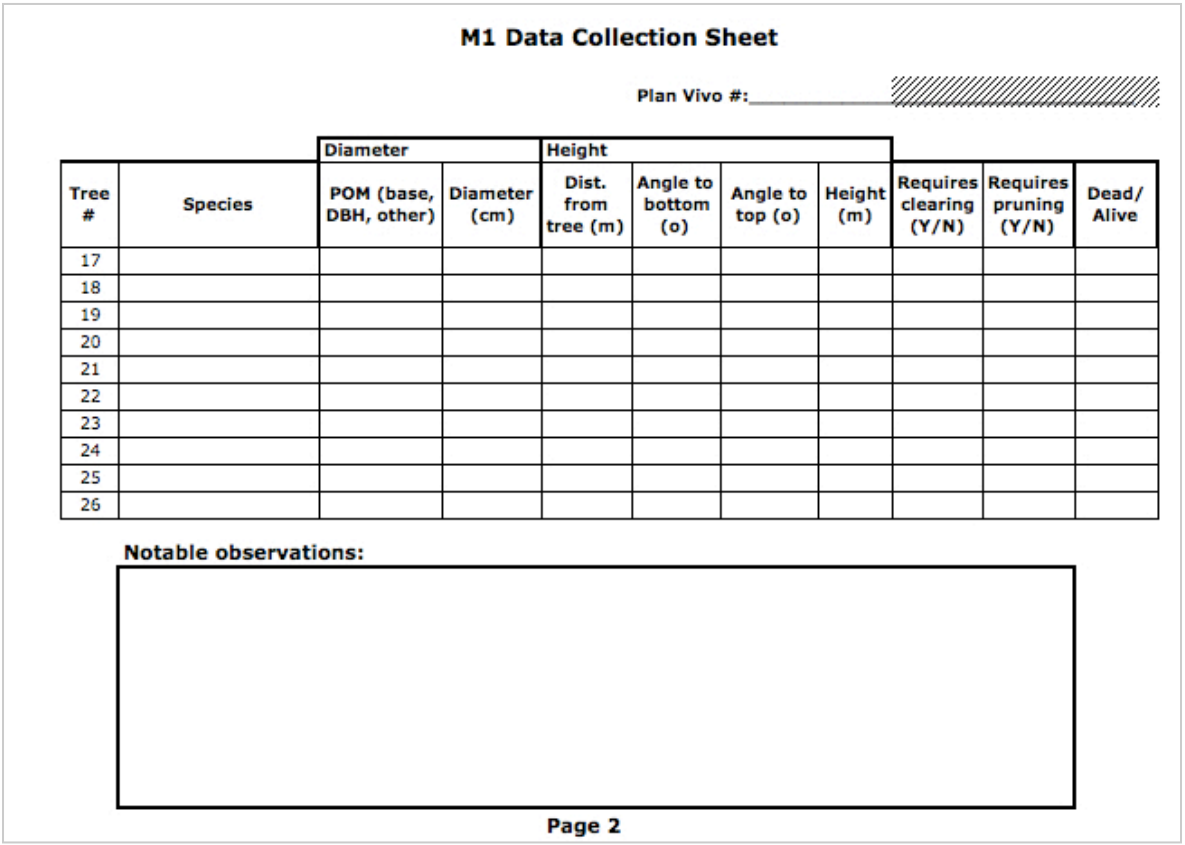
11.2. Specifics of Monitoring Metrics

Table 11 describes the variables being monitored as part of the monitoring plan as well as the instruments being used and the justification. Figure 18 gives an example of the monitoring sheet used by community technicians to record the monitoring criteria.

Table 11 - Details on metrics and their measurement

Variable	Instrument	Justification
Height	Measuring tape or clinometre	Commonly used variable for growth and yield information. When appropriate, a measuring tape is used because it is precise and efficient. When the trees are too tall, a clinometre is used.
Diameter	Caliper or DBH tape	Commonly used variable for growth and yield information. Two caliper measurements are used for seedlings and very thin trees and geometric mean is calculated. Calipers are used because they are easier to use on small diameter trees. However, a DBH tape will be used on trees with a diameter greater than 5 cm because it is faster, accounts for the tree's ecliptic shape, and the same tool can be used on small and large trees.
Point of measurement (POM)	Measuring tape	Used to specify where measurement was taken, which is typically at DBH. However, if the tree is too short, diameter at base is measured. Furthermore, if DBH is not a representative diameter of that region of the tree due to a point of branching or an irregular growth, the diameter just above that point should be used.
# of trees	N/A	Used to estimate stand density, estimate the number of new trees needed from the nursery and is necessary for estimating stand yield.
Species	N/A	Used for growth and yield information, used to know which species are needed from nursery for the following planting season and used to compare between species.
Condition: Dead or Alive	N/A	Used for carbon yield estimations.
Requires Clearing	N/A	Used to verify milestone completion.
Requires pruning	N/A	Used to verify milestone completion.

Figure 18 – Example of the monitoring sheet used by community technicians



M1 Data Collection Sheet

Plan Vivo #:_____

		Diameter		Height						
Tree #	Species	POM (base, DBH, other)	Diameter (cm)	Dist. from tree (m)	Angle to bottom (o)	Angle to top (o)	Height (m)	Requires clearing (Y/N)	Requires pruning (Y/N)	Dead/ Alive
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										

Notable observations:

Page 2

11.3. Basis of Payments

Each year, differing metrics determine the producer payment. Table 9.1 describes the targets that match up to the modelled carbon forecasting. Table 12 describes the producer payment ratio when meeting the threshold versus the target.

Table 12 – Payments Breakdown

Year	Basis of payment	Threshold	Target	Percentage of total payment received per hectare
1	Tree planting Fences placed around properties		Minimum density of 180 trees per hectare* Fence complete	25%
2	Areas cleared Trees replanted	50% of the plots cleared	80% of the plots cleared Minimum density of 180 trees per hectare	20%
3	Areas cleared Survival Rate	75% of the plots cleared	90% of the plots cleared Minimum density of 180 trees per hectare	15%
4	Growth milestone	Basal area no less than 0.01 m^2/ha	Basal area no less than 0.01 m^2/ha	10%
5	No payment			0%
6	Pruning and clearing	75% of trees show evidence of clearing and timber trees are pruned.	90% of trees show evidence of clearing and timber trees are pruned.	10%
7	Growth milestone	Basal area no less than 0.41 m2/ha	Basal area no less than 0.41 m2/ha	10%
8	No payment			0%
9	No payment			0%
10	Pruning and clearing Harvest	75% of trees show evidence of clearing and timber trees are pruned.	90% of trees show evidence of clearing and timber trees are pruned. Harvest of *Caesalpinia velutina*	10%

In the first years of planting, there are three payments given to provide the capital that the producers need to plant. In May, a payment is given for planting or replanting in which the producers receive 50% of their annual payment. The second and third payments, each 25% of the annual payment, and made in July and September respectively, are for cleaning and weeding the area around the plants.

After producers reach close to 100% the technical specifications density target, and after the internal annual monitoring of each plan vivo, payments are issued to the producer according to a predetermined schedule based on the different program targets over the program lifetime. If the targets are reached is determined by a combination of on the ground technician judgement and in office data analysis. If both the technicians and the data suggest that the producer has met his target, full payment is received. If the target has not been met but the threshold is achieved, partial payment is made and corrective actions are implemented. If the threshold is not met, payments are withheld until the following year when the objectives have been reached. In accordance with the carbon accounting model, the majority of the producers will reach 100% planting by first year. If they miss the target, they will replant to 100% capacity by the following year.

* The density requirements reflect the needed number of trees for those species included in the carbon accounting.

Corrective Actions

When producers do not meet their targets, there are various steps to be taken for correction. If they miss the target or threshold, a predetermined amount of pay is withheld from their annual payment until the milestone has been reached (details are in Table 13). Furthermore, corrective actions must be taken to ensure that milestones will be met the following year, which are established on a case-by-case basis. For example, if a producer fails to reach the required planting density, their corrective action would be to replant new trees.

Table 13 – Basis of payments

Performance	Payment
Meets target	100% of payment
Meets threshold	50 % of payment withheld and corrective actions taken
Fails to meet threshold	100% of payment withheld and corrective actions taken.

11.4. Quality Assessment and Quality Control

Various steps are taken to ensure quality control. The operations manager reviews all monitoring data, cleans it, and enters it into the program database. The database calculates if the producer has reached their target for the year. The results of the monitoring are brought to the community technicians in Nicaragua for review. They verify if the monitoring results conform to their field experience. The results of the monitoring from both the database and the community technicians are analysed by Taking Root and published in annual reports. Furthermore, every participating producer is assigned to a specific community technician so that the performance of each technician's group of producers can be compared to each other to identify needs for additional capacity building.

11.5. Monitoring Leakage

In order to ensure that leakage is not affected by the project, periodic longitudinal land cover analyses are performed using Landsat imagery. The target for these surveys is that the change in the proportion of agriculture and pasture inside the program boundary relative to outside the program boundary not be smaller. If there is a detected change, then risk of leakage may be higher than expected and a more detailed review and corrective actions will need to be undertaken.

Appendix 1: Species Growth Modelling and Carbon Accounting (First 25 Years)

Constants used in the carbon accounting section.

Carbon Accounting Constants	Value	Source or *Notes*
Carbon Fraction of Dry Matter	0.49	*Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Ratio of Below-Ground Biomass to above-ground Biomass - Tropical Dry Forest	1.56 1.28	When above ground biomass is smaller than 20 t/ha When above ground biomass is larger than 20 t/ha *Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Biomass Expansion Factor	*1.5*	*Good Practice Guidance for Land Use, Land Use Change and Forestry, IPCC, Editor 2003. p. 151-186. Table 3A.1.10 Default values of biomass Expansion Factors (BEFs)*
Rate of Decay (k)	*0.023*	*Agriculture, Forestry and Other Land Use, in 2006 IPCC Guidelines for National Greenhouse Gas Inventories, IPCC, Editor 2006, Institute for Global Environmental Strategies. p. 1-83*
Rate of Decay for Fence Posts (kp)	0.15	Based on Local Knowledge, Decay rate at 15% per year means that posts need to be replaced once every 6 years.
Form Factor	0.5	Default form factor suggested in a professional consultation by Henriette Duda, Doctor of Biometrics at PrimaKlima -weltweit- e.V. and also inspired by various publications, notably: *Malik, A. (2002). Untersuchungen über waldmess- und waldwachstumskundliche Grundlagen zur Bewirtschaftung der Baumart Diospyros celebica Bakh. (Ebenholz.)*

Wood Densities

Wood Density		Source
Swietenia humilis	0.718	*Maluenda, J., et al., Guia de Especies Forestales de Nicaragua. 1 ed2002, Managua: Editora de Arte, S.A. 304.*
Bombacopsis quinata	0.428	""
Caesalpinia velutina	0.722	""
Average of *Swietenia humilis* and *Bombacopsis quinata*	0.573	The average of the two species is used in the stand management phase since they will be the primary species in the stand.

Site Index Variables

Variable	Value	Source
Annual Precipitation	1394 mm	*Resumen Meteorologico Annual De San Juan De Limay*, M.o.S.J.d. Limay, Editor.
Slope	2 degrees	Based on currently established plantations within the project.
Length of Dry Season	6 months	Ficha Municipal, Municipality of San Juan De Limay. Given to Taking Root by the municipality of San Juan de Limay in 2010.
Elevation	400 m	

Appendix 2: Specific Species Information

Swietenia humilis

Spanish Name: Caoba		**Type: Sawnwood**
Processing factor	0.35	Quirós, R., O. Chinchilla, and M. Gómez, *Rendimiento en aserrio y procesamiento primario de madera proveniente de plantaciones forestales.* Agronomía Costarricense, 2005. **29**: p. 7-15.
DBH Equation	$DBH_t = 40*(1-e^{(-0.16*t)})^{4.2}$	In-house modeling using Chapman-Richards model and in-house allometric equation
Height Equation	$ht_t = 20*(1-e^{(-0.17*t)})^{1.6}$	In-house modeling using Chapman-Richards model and in-house allometric equation

Predicted Growth for *Swietenia Humilis*

Age (years)	Count of Trees per Hectare with Mortality	Tree Height (m)	Tree DBH (cm)	Stem Volume per Hectare (m3)	Basal Area per Hectare (m2)	Above Ground Biomass per Hectare (t)	Below Ground Biomass per Hectare (t)	Total Biomass per Hectare (t)	Carbon per Hectare (tC)
1	90	1.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	90	2.73	0.17	0.00	0.00	0.00	0.00	0.00	0.00
3	90	4.61	0.70	0.01	0.00	0.01	0.00	0.01	0.01
4	90	6.46	1.72	0.07	0.02	0.07	0.04	0.11	0.06
5	90	8.20	3.26	0.31	0.08	0.33	0.19	0.52	0.26
6	90	9.78	5.27	0.96	0.20	1.03	0.58	1.61	0.79
7	90	11.19	7.62	2.29	0.41	2.47	1.38	3.85	1.90
8	90	12.44	10.18	4.56	0.73	4.91	2.75	7.66	3.77
9	90	13.54	12.85	7.90	1.17	8.50	4.76	13.27	6.54
10	90	14.48	15.51	12.32	1.70	13.27	3.71	16.98	8.37
11	90	15.30	18.10	17.72	2.32	19.08	5.34	24.42	12.04
12	90	16.00	20.55	23.90	2.99	25.74	7.21	32.94	16.23
13	90	16.61	22.84	30.61	3.69	32.97	9.23	42.20	20.80
14	90	17.12	24.93	37.61	4.39	40.51	11.34	51.85	25.55
15	90	17.56	26.83	44.67	5.09	48.11	13.47	61.58	30.35
16	90	17.93	28.53	51.59	5.75	55.57	15.56	71.12	35.05
17	90	18.25	30.04	58.23	6.38	62.71	17.56	80.27	39.56
18	90	18.52	31.38	64.47	6.96	69.43	19.44	88.87	43.79
19	90	18.75	32.56	70.24	7.49	75.65	21.18	96.83	47.72
20	90	18.94	33.59	75.52	7.97	81.33	22.77	104.11	51.30
21	90	19.11	34.48	80.29	8.40	86.47	24.21	110.68	54.54
22	90	19.25	35.26	84.55	8.79	91.07	25.50	116.56	57.44
23	90	19.36	35.93	88.35	9.13	95.15	26.64	121.79	60.02
24	90	19.46	36.51	91.69	9.42	98.75	27.65	126.40	62.29
25	90	19.55	37.01	94.63	9.68	101.92	28.54	130.45	64.29

Bombacopsis quinata

Spanish Name: Pochote		Type: Sawnwood
Processing factor	0.35	*Quirós, R., O. Chinchilla, and M. Gómez, Rendimiento en aserrio y procesamiento primario de madera proveniente de plantaciones forestales. Agronomía Costarricense, 2005. 29: p. 7-15.*
DBH:	$DBH_t = 42*(1-e^{(-0.16*t)})^{4.2}$	In-house modeling using Chapman-Richards model,; *Kanninen, M., et al., Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica. Forest Ecology and Management, 2003. 174: p. 345-352.*
Height (m)	$ht_t = 26*(1-e^{(-0.17*t)})^{1.6}$	In-house modeling using Chapman-Richards model,; Kanninen, M., et al., *Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica.* 2003. **174**: p. 345-352
Biomass Expansion Factor	$3.23983*DBH^{45162}*ht^{-.67457}$	*Avendaño, R., Modelos Genéricos de Biomasa Aérea para Especies Forestales en Función de la Arquitectura y la Ocupación del Rodal, 2008, Centro Agronómico Tropical de Investigación y Enseñanza.*
Stem Volume per Tree	ln(v)= -8.0758 + 1.2678 * ln(DBH) + .9729 * ln(height)	*Kanninen, M., et al., Stand growth scenarios for Bombacopsis quinata plantations in Costa Rica. Forest Ecology and Management, 2003. 174: p. 345-352.*
Site Index	8.5565+0.0015*precip+1.5969*monthsdry-0.0839*slope	*Navarro, C., Evaluación del crecimiento y rendimiento de Bombacopsis quinatum (Jacq) Dugand en 14 sitios en Costa Rica. Indices de sitio y algunos aspectos financieros de la especie., 1987, Tesis Mag. Se. Turrialba, CR, Programa Universidad de Costa Rica/CATIE. p. 1-151.*

Bombacopsis quinata is one of the more commonly used native timber plantation species in Central America due to its highly prized wood and fast performance in arid regions.

Predicted Growth for Bombacopsis quinata

Age (years)	Count of Trees per Hectare with Mortality	Tree DBH (cm)	Tree Height (m)	Stem Volume per Hectare (m3)	Basal Area per Hectare (m2)	Above Ground Biomass per Hectare (t)	Below Ground Biomass per Hectare (t)	Total Biomass per Hectare (t)	Carbon per Hectare (tC)
1	90	0.01	1.33	0.00	0.00	0.00	0.00	0.00	0.00
2	90	0.18	3.55	0.01	0.00	0.00	0.00	0.00	0.00
3	90	0.73	5.99	0.11	0.00	0.04	0.02	0.06	0.03
4	90	1.81	8.40	0.47	0.02	0.20	0.11	0.32	0.16
5	90	3.43	10.65	1.33	0.08	0.65	0.37	1.02	0.50
6	90	5.53	12.71	2.90	0.22	1.57	0.88	2.45	1.21
7	90	8.00	14.55	5.28	0.45	3.08	1.72	4.80	2.37
8	90	10.69	16.18	8.47	0.81	5.23	2.93	8.17	4.02
9	90	13.49	17.60	12.34	1.29	8.01	4.48	12.49	6.16
10	90	16.29	18.83	16.74	1.88	11.30	3.16	14.46	7.13
11	90	19.01	19.89	21.47	2.55	14.97	4.19	19.16	9.44
12	90	21.58	20.81	26.35	3.29	18.88	5.29	24.17	11.91
13	90	23.98	21.59	31.22	4.06	22.88	6.41	29.29	14.43
14	90	26.18	22.26	35.94	4.84	26.85	7.52	34.37	16.94
15	90	28.17	22.83	40.43	5.61	30.69	8.59	39.28	19.36
16	90	29.96	23.31	44.61	6.34	34.33	9.61	43.94	21.65
17	90	31.55	23.73	48.45	7.03	37.72	10.56	48.28	23.79
18	90	32.95	24.08	51.94	7.67	40.83	11.43	52.26	25.75
19	90	34.19	24.37	55.07	8.26	43.65	12.22	55.88	27.54
20	90	35.26	24.63	57.86	8.79	46.19	12.93	59.12	29.14
21	90	36.20	24.84	60.32	9.27	48.45	13.57	62.02	30.56
22	90	37.02	25.02	62.49	9.69	50.45	14.13	64.58	31.83
23	90	37.73	25.17	64.39	10.06	52.21	14.62	66.83	32.94
24	90	38.34	25.30	66.04	10.39	53.76	15.05	68.81	33.91
25	90	38.86	25.41	67.47	10.68	55.10	15.43	70.53	34.76

Caesalpinia velutina

Spanish Name: Mandagual		Type: Posts for rural construction
Processing factor	1	Entire biomass assumed to be instantly returned to the atmosphere at time of harvest.
Rate of decay	N/A	
DBH	2.22982+0.74529*ht-0.00032*tph-0900555*precip	In house allometric equations developed using datasets published in CATIE. (1986). *Crecimiento y rendimiento de especies para lena en areas secas y humedas de America Central, 1986: Centro Agronómico Tropical de Investigación y Enseñanza.; and* Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.
Height	ln(ht) = -2.0144 + .9862*ln(t) - 0.00179 * ele + 0.000187*precip + 0.005728* slope	In house allometric equations developed using datasets published in CATIE. *Crecimiento y rendimiento de especies para lena en areas secas y humedas de America Central*, 1986: Centro Agronómico Tropical de Investigación y Enseñanza.
Above Ground Biomass	ln(agb)= -2.708 + 1,6155 * ln(DBH) + 1.1209 * ln(ht)	Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.
Stem Volume	ln(v) = -9.0215 + 1.4263 * ln(DBH) + 1.1431 * ln(ht)	Hurtarte, E.O., *Comportamiento en Plantacion de Mangium (Acacia mangium willd) y Aripin (Caesalpinia velutina (B y R) Standl) en America Central*, 1990, Turrialba (Costa Rica). p. 117.

Predicted Growth for *Caesalpinia velutina*

Age (years)	Count of Trees per Hectare with Mortality	Tree DBH (cm)	Tree Height (m)	Stem Volume per Hectare (m^3)	Basal Area per Hectare (m^2)	Above Ground Biomass per Hectare (t)	Below Ground Biomass per Hectare (t)	Total Biomass per Hectare (t)	Carbon per Hectare (tC)
1	180	2.08	0.99	0.06	0.06	0.04	0.02	0.06	0.03
2	180	2.81	1.97	0.25	0.11	0.14	0.08	0.21	0.10
3	180	3.53	2.93	0.61	0.18	0.31	0.17	0.48	0.24
4	180	4.24	3.89	1.20	0.25	0.57	0.32	0.89	0.44
5	180	4.96	4.85	2.04	0.35	0.94	0.52	1.46	0.72
6	180	5.67	5.81	3.20	0.45	1.42	0.80	2.22	1.09
7	180	6.38	6.76	4.71	0.58	2.04	1.14	3.19	1.57
8	180	7.09	7.71	6.61	0.71	2.81	1.57	4.38	2.16
9	180	7.80	8.66	8.94	0.86	3.73	2.09	5.81	2.87

Appendix 3: Stand Growth Modelling (Years 26-50)

Assumptions	Quantity	Source
Growth rate under forest management (m^3/ha/yr)	6	This is based on local professional knowledge, and is a common figure for timber stand growth.
Density of stand	0.573 (g/cm^3)	Average density of *Swietenia humilis* and Bombacopsis

The following gives the carbon benefit per hectare of the fifty years of the project intervention. It also describes the harvesting in the stand management period.

Predicted carbon sequestered throughout crediting period per hectare

Year	Count of Trees per Hectare without Mortality	Count of Trees per Hectare with Mortality	Above Ground Carbon (tC)	Below Ground Carbon (tC)	Live-Wood (tC) (AGB+BGB)	HWP Carbon Benefit (tC)	Total Carbon Benefit (tC)	Net Average Carbon Benefit (tC)
1	400	360	0.00	0.00	0.00	0.00	0.00	52.3
2	400	360	0.00	0.00	0.00	0.00	0.00	52.3
3	400	360	0.02	0.01	0.04	0.00	0.04	52.3
4	400	360	0.14	0.08	0.21	0.00	0.21	52.3
5	400	360	0.49	0.27	0.76	0.00	0.76	52.3
6	400	360	1.28	0.72	2.00	0.00	2.00	52.3
7	400	360	2.73	1.53	4.27	0.00	4.27	52.3
8	400	360	5.00	2.80	7.80	0.00	7.80	52.3
9	400	360	8.14	4.56	12.69	0.00	12.69	52.3
10	200	180	12.11	3.39	15.50	0.00	15.50	52.3
11	200	180	16.78	4.70	21.48	0.00	21.48	52.3
12	200	180	21.99	6.16	28.14	0.00	28.14	52.3
13	200	180	27.52	7.71	35.23	0.00	35.23	52.3
14	200	180	33.19	9.29	42.49	0.00	42.49	52.3
15	200	180	38.83	10.87	49.71	0.00	49.71	52.3
16	200	180	44.30	12.40	56.70	0.00	56.70	52.3
17	200	180	49.49	13.86	63.35	0.00	63.35	52.3
18	200	180	54.34	15.21	69.55	0.00	69.55	52.3
19	200	180	58.79	16.46	75.25	0.00	75.25	52.3
20	200	180	62.84	17.60	80.44	0.00	80.44	52.3
21	200	180	66.49	18.62	85.11	0.00	85.11	52.3
22	200	180	69.74	19.53	89.27	0.00	89.27	52.3
23	200	180	72.62	20.33	92.95	0.00	92.95	52.3
24	200	180	75.16	21.04	96.20	0.00	96.20	52.3
25	200	180	77.38	21.67	99.04	0.00	99.04	52.3
26	N/A	N/A	58.49	16.38	74.87	2.96	77.84	52.3
27	N/A	N/A	61.03	17.09	78.12	2.90	81.02	52.3
28	N/A	N/A	63.58	17.80	81.38	2.83	84.21	52.3
29	N/A	N/A	66.12	18.51	84.63	2.77	87.39	52.3
30	N/A	N/A	68.66	19.22	87.88	2.70	90.58	52.3
31	N/A	N/A	58.49	16.38	74.87	5.60	80.48	52.3
32	N/A	N/A	61.03	17.09	78.12	5.48	83.60	52.3
33	N/A	N/A	63.58	17.80	81.38	5.35	86.73	52.3
34	N/A	N/A	66.12	18.51	84.63	5.23	89.86	52.3
35	N/A	N/A	68.66	19.22	87.88	5.11	92.99	52.3
36	N/A	N/A	58.49	16.38	74.87	7.95	82.82	52.3
37	N/A	N/A	61.03	17.09	78.12	7.77	85.89	52.3
38	N/A	N/A	63.58	17.80	81.38	7.59	88.97	52.3
39	N/A	N/A	66.12	18.51	84.63	7.42	92.05	52.3
40	N/A	N/A	68.66	19.22	87.88	7.25	95.13	52.3
41	N/A	N/A	58.49	16.38	74.87	10.05	84.92	52.3
42	N/A	N/A	61.03	17.09	78.12	9.81	87.94	52.3

43	N/A	N/A	63.58	17.80	81.38	9.59	90.97	52.3
44	N/A	N/A	66.12	18.51	84.63	9.37	94.00	52.3
45	N/A	N/A	68.66	19.22	87.88	9.15	97.03	52.3
46	N/A	N/A	58.49	16.38	74.87	11.91	86.78	52.3
47	N/A	N/A	61.03	17.09	78.12	11.63	89.76	52.3
48	N/A	N/A	63.58	17.80	81.38	11.37	92.74	52.3
49	N/A	N/A	66.12	18.51	84.63	11.10	95.73	52.3
50	N/A	N/A	68.66	19.22	87.88	10.85	98.73	52.3

Appendix 4: Non-Permanence – Risks and Mitigation Strategies

	Risk type	Program's control over risk	Initial situation	Mitigation measure	Risk estimate time-frame	Probability (After management)	P	Impact (After management)	I	Score
A	Unclear land tenure and potential for disputes									0.1375
A.1	Land tenure	High	Privately owned land but often not registered nationally	Ownership and individual is verified with the municipality	Medium	Medium	0.1	Medium	2	0.2
A.2	Potential for disputes with landless individuals	Medium	Some individuals do not own land	Involve landless individuals in group activities (e.g. Nursery building) and seasonal work on neighbor's land.	Long	Low	0.05	Low	1	0.05
A.3	Disputes caused by conflicting land-use interests	High	A significant potion of land is underutilized but cattle often roam all over the place, which can destroy young trees	All programs are fenced in	Short	Medium	0.1	Medium	2	0.2
A.4	With inheritance to land, new land owner decides to not participate in program	Medium	Privately owned land usually by the patriarch or matriarch of the family	Education to current and future inheritors on medium and long term benefits of program. Continually education on importance of program on environment.	Medium	Low	0.05	Medium	2	0.1
B	Financial failure									**0.175**
B.1	Program financial plan	High	Financial strategy in place with backing and support from the Community Economic Development Corporation + future payments to producers kept in separate guaranteed fund	Development of business plans (reviewed periodically) for economically viable management	Medium	Medium	0.1	High	3	0.3
B.2	Decrease in timber value	Low	Fuel-wood and timber have high relative value	Diversification of chosen species	Long	Low	0.05	Low	1	0.05
C	Technical failure									**0.075**
C.1	Technical capability of program implementer	High	Proven capacity to design and implement activities	Only hire highly qualified staff	Short	Low	0.05	Medium	2	0.1
C.2	Poor choice of	High	Use of species	Evaluation of	Short	Low	0.05	Low	1	0.05

	trees		well adapted to region	species based on experience						
D	Management failure									**0.05**
D.1	Management activities not carried out effectively	High	Organization has experience carrying out program activities	Program managers and staff adequately trained	Short	Low	0.05	Low	1	0.05
D.2	Double-counting due to poor or bad faith record keeping	High	Proper record keeping system in place	Transparent record-keeping procedures written in program design document and quality mapping of program activities and area; up-to-date database maintained with records of all carbon monitored and sold	Short	Low	0.05	Low	1	0.05
D.3	Staff with relevant skills and expertise	High	Staff highly qualified	Careful selection of program staff and training	Short	Low	0.05	Low	1	0.05
E	Rising land opportunity costs that cause reversal of sequestration and/or protection									**0.1**
E.1	Returns to producer and implementer stakeholders	High	Opportunity cost of land very low	Financial analysis of program interventions. In addition of the payments for ecological services, the programs are designed to provide high valued products in the form of fuel wood and timber.	Long	Low	0.05	High	3	0.15
E.2	Introduction of new cash crop in region	Low	Tabaco production, the latest cash cop in region, is banned in municipality	Appropriate land use planning through Plan Vivos	Short	Low	0.05	Low	1	0.05
F	Political instability									**0.075**
F.1	Land reform removes property rights	Low	Government currently in process of legalizing property	N/A	Short	Low	0.05	Low	1	0.05
F.2	Social unrest	Low	Very peaceful community. Economic hardship is generally dealt with by searching for employment in cities of other countries	Continuous process of community consultations	Long	Low	0.05	Medium	2	0.1
G	Social									**0.05**

	instability									
G.1	Disputes caused by conflict of program aims or activities with local communities or organisations	High	Program was built in consultation with other NGOs, community and government consultation	Participatory planning and continued stakeholder consultation over program lifetime	Medium	Low	0.05	Low	1	0.05
G.2	Participants lose interest in program	High	High degree of desired participation by community	Program aims aligned with producers' needs	Short	Low	0.05	Low	1	0.05
H	Devastating fire									**0.1**
H.1	Forest fire	medium	Forest cover in the area is minimal and isolated making it difficult for fires to spread.	Removal of fuel wood from program areas	Long	Low	0.05	High	3	0.15
H.2	Intentional burning of agricultural land	medium	The local government has recently imposed heavy restrictions on the use of fire to clear land.	Ongoing involvement and dialogue with producers	Short	Low	0.05	Low	1	0.05
I	Pests and diseases									**0.05**
I.1	Incidence of tree crop failure from pests or disease	medium	Mahogany is the only chosen species subject to insect attack by the shoot borer, *Hypsipyla grandella.* These attacks are common and effect apical growth but rarely kill the tree when grown in polycultures.	Assessment of tree species, careful selection of tree species, strong diversification	Long	Low	0.05	Low	1	0.05
J	Extreme weather events									**0.25**
J.1	Drought	low	infrequent (<1 in 10 years)	Replanting of trees as required, planting at the very beginning of wet season, selection of drought resistant species	Short	High	0.25	Medium	2	0.5
J.2	Hurricane	low	Hurricanes occasionally hit the region, notably hurricane Mitch in 1998.	Replanting of trees as required	Long	Medium	0.1	Medium	2	0.2
J.3	Floods	low	Infrequent (<1 in 10 years)	Replanting of trees as required in new areas	Short	Low	0.05	Low	1	0.05
K	Geological risk									**0.05**
K.1	Earthquakes	Low			Short	Low	0.05	Low	1	0.05
K.2	Landslides	medium	Land slides haven't caused much damage in the past	Programs don't take place in really steep areas	Short	Low	0.05	Low	1	0.05
	Overall Score									**0.10**

	(average of risk categories)									
	Suggested risk buffer									**13.65%**

Appendix 5: Tree Count and Species Harvesting Schedule

The following table describes the number of expected trees in year 1, not taking into account mortality.

Expected # of Trees in Year 1

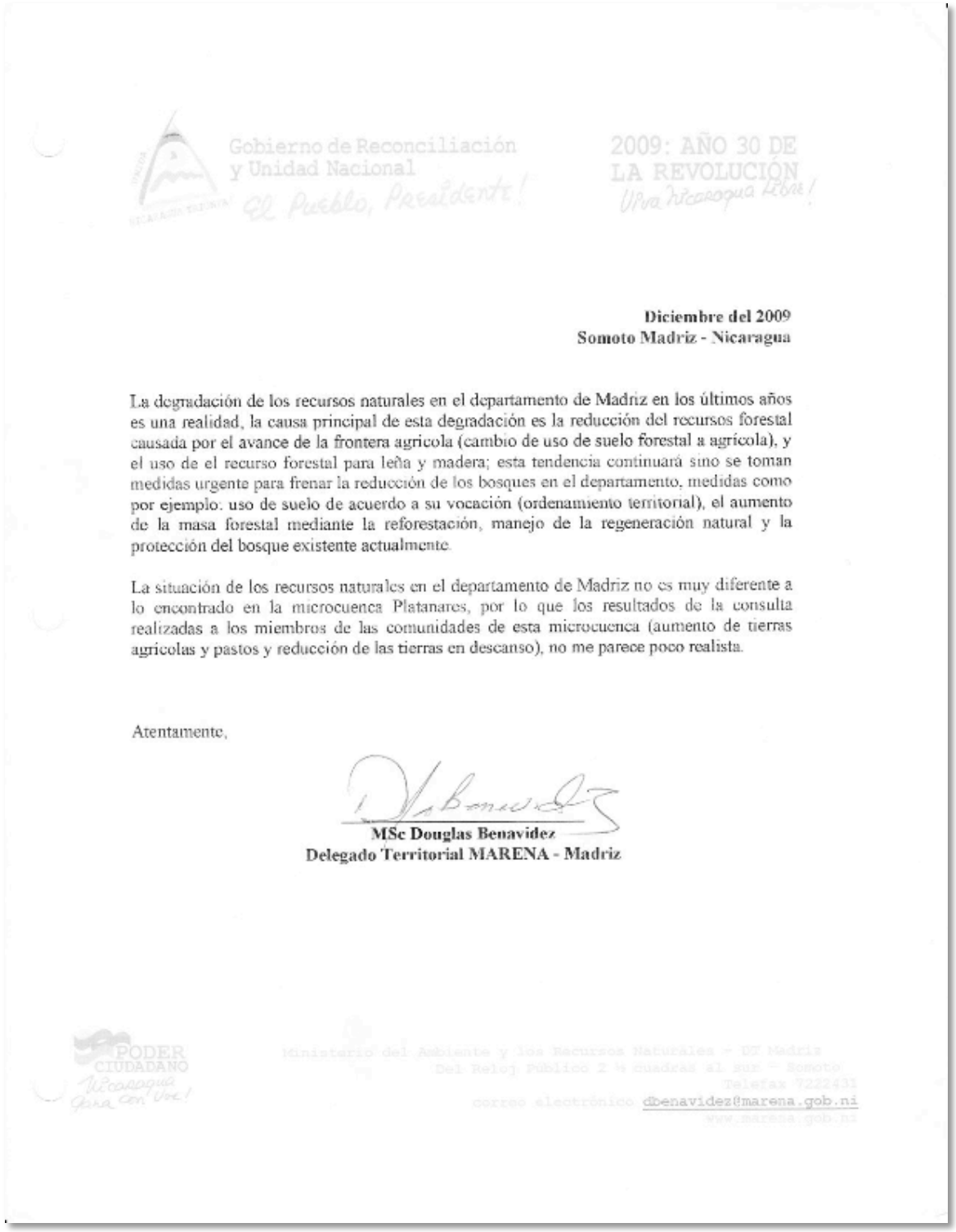
Trees Calculation	Type of Tree
400	Trees per hectare
200	Posts
200	Sawnwood

The following table describes the harvesting of the different species in the program intervention.

Harvesting Schedule

Beginning of Year	Description of Harvest
1	Planting of all species
2	Replanting to take into account mortality of year 1
10	*Caesalpinia velutina* is harvested for posts.
26	*Swietenia humilis* and *Bombacopsis quinata* are selectively harvested and processed.

Appendix 6: Baseline Approval Letter



Gobierno de Reconciliación y Unidad Nacional

El Pueblo, Presidente!

2009: AÑO 30 DE LA REVOLUCIÓN

Viva Nicaragua Libre!

Diciembre del 2009
Somoto Madriz - Nicaragua

La degradación de los recursos naturales en el departamento de Madriz en los últimos años es una realidad, la causa principal de esta degradación es la reducción del recursos forestal causada por el avance de la frontera agricola (cambio de uso de suelo forestal a agrícola), y el uso de el recurso forestal para leña y madera; esta tendencia continuará sino se toman medidas urgente para frenar la reducción de los bosques en el departamento, medidas como por ejemplo: uso de suelo de acuerdo a su vocación (ordenamiento territorial), el aumento de la masa forestal mediante la reforestación, manejo de la regeneración natural y la protección del bosque existente actualmente.

La situación de los recursos naturales en el departamento de Madriz no es muy diferente a lo encontrado en la microcuenca Platanares, por lo que los resultados de la consulta realizadas a los miembros de las comunidades de esta microcuenca (aumento de tierras agricolas y pastos y reducción de las tierras en descanso), no me parece poco realista.

Atentamente,

MSc Douglas Benavidez
Delegado Territorial MARENA - Madriz

PODER CIUDADANO

Nicaragua Gana con Vos!

Ministerio del Ambiente y los Recursos Naturales – DT Madriz
Del Reloj Público 2 ½ cuadras al sur – Somoto
Telefax 7222431
correo electrónico dbenavidez@marena.gob.ni
www.marena.gob.ni

Appendix 7: Technical Validation Report

Available through the Plan Vivo web site at:
http://www.planvivo.org/wp-content/uploads/Limay_Carbon_ProjectProgram_Final_PlanVivoVal-_Report.pdf

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