

Silvo-pastoral systems

in Upper and Lower Barton Creek, Belize



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Silvo-pastoral systems

in Upper and Lower Barton Creek, Belize

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Acronyms

AFS:	agroforestry systems
ASPS:	agrosilvopastoral systems
bd. ft.:	board feet
BLPA:	Belize Livestock Producers Association
MNRE:	Ministry of Natural Resources and the Environment
MAF:	Ministry of Agriculture and Fisheries
FD:	Forest Department
UB:	University of Belize
UBC:	Upper Barton Creek
LBC:	Lower Barton Creek
SAS:	silvo-agricultural system
PSP:	permanent sample plot
SPS:	silvopastoral systems

Introduction

The Mennonite communities of Upper Barton Creek and Lower Barton Creek were settled in Cayo District, Belize, a region of primarily lowland broadleaf forest, with lime-enriched soils (Figure 1). The villagers have traditionally lived off working the land, with little dependence on modern tools and amenities. Both communities were established separately in the late 1960's, and have structured their way of life around religious teachings of non-violence and non-conformity to the world. There is neither mechanized equipment nor electricity, and they live very simple, humble lives, adhering to the strict discipline of their Anabaptist religion. These communities are self-sustained through small-scale farming of crops and livestock, which provides them with food and income from sale at local markets outside of the communities. Their primary production includes potatoes, a variety of vegetables and fruits, timber and fruit seedlings and livestock such as cattle, pigs and sheep.

The material for construction of homes and buildings is taken from their forested lands. Also, some farmers have successfully combined lumber production within silvopastoral systems. In conformity with their religion, farmers have fostered respect for the land and the resources, such as timber, by leaving valuable commercial species within cattle pastures for future use.

The Department of Agriculture estimates that at present only about 10% of farmers in the entire Cayo District employ agroforestry practices on their farms¹. This is however an improvement over the last thirty years, when very little agroforestry was practiced. A few individual farmers may be practicing agroforestry on their own initiative. The knowledge and practice of agroforestry systems in Belize has not been mainstreamed into the work of farmers and technicians. Nonetheless, some farmers have employed the techniques, with limited technical assistance or knowledge, gaining varying degrees of success through trial and error. Such is the case with the Mennonites of Upper and Lower Barton Creek. It is only in recent years that the Department of Agriculture has begun promoting agroforestry, but admittedly, both the advocacy and the technical capacity need to be strengthened in order to provide this extension service to farmers.

¹ Oscar Salazar. Position, Department of Agriculture. Month, 2011. Personal communication.

Some Mennonites in these communities have managed, with different degrees of success, the combination of planting/maintaining timber species of trees within their cattle pastures. To a limited extent, this practice has made available lumber for personal use (home construction) and for sale. It has also nurtured a good agro-environmental practice, which supports soil productivity and integrity, while providing shade for livestock. This is not to say however, that the experience has been without challenges. Nonetheless, there may be lessons that can be passed on to other farmers in other areas of the District and/or the country –lessons which could help to promote, establish and improve timber tree species management in silvopastoral systems.

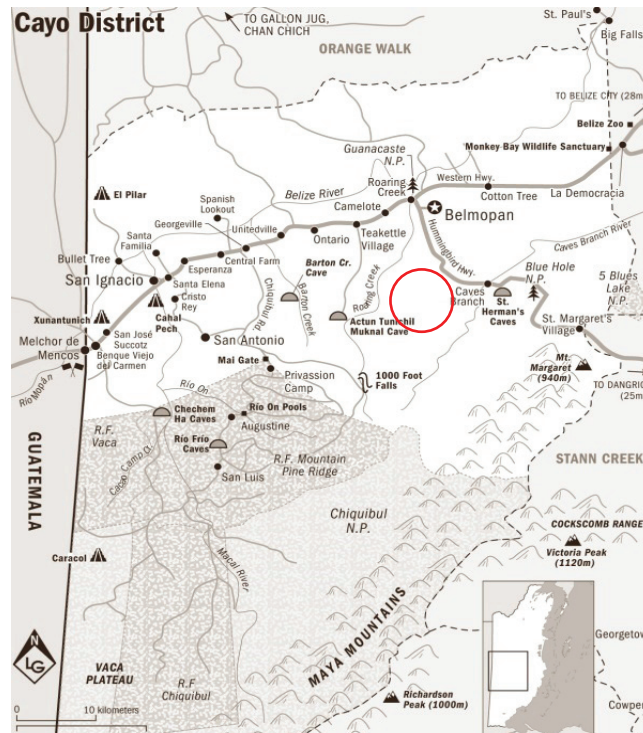


Figure 1. Location of Upper and Lower Barton Creek

The objective of this study is to describe in general terms the traditional agroforestry systems employed in Upper and Lower Barton Creek, with emphasis on silvo-pastoral systems (trees in pastures), and propose recommendations for their improvement.

Upper and Lower Barton Creek

Upper Barton Creek came about in 1969 when five Mennonite families (two from the United States and three from the larger Mennonite community of Spanish Lookout) purchased land and resettled along the Barton Creek. These families decided to move out of their original communities because they saw the mechanization and commercialization increasing; the population was changing its views and conforming to a modern way of life, which was not in accordance with their religious beliefs. Eight hundred acres² of land were purchased at BZ\$25.00 per acre. The newly acquired land contained very hilly terrain therefore much farming was along the steep slopes. About half the property was cleared for agriculture and community development, and the remainder remained forested and was reserved for future expansion. The lumber used to build the infrastructure in the community comes from the same forests that were cleared for agriculture.

Lower Barton Creek was independently established one year later, just south of Upper Barton Creek. About ten families came together from other Mennonite communities in Belize, such as Shipyard (Orange Walk District) and Spanish Lookout, and communities in Mexico. The motive for forming this new population was the same as that of UBC: the settlers were not happy with the direction their former communities were heading. The original extension of the land was 1,500 acres. In the very beginning, approximately 100 acres were cleared for agriculture (cantaloupe, watermelons, tomatoes, corn, peanuts and beans) and in pig farming. The history of LBC is similar to that of their neighbors upstream, although they are completely separate communities. The religion is the same, with some slight differences in practice. The terrain in LBC was less hilly and therefore more favorable for agriculture and cattle development.

Methodology

In order to collect the information for this study, several research methods were utilized, among them: a) literature review on agroforestry systems, b) focus group discussions with members of the communities as well as technicians from the Agriculture and Forest Departments, c) observation from visits to communities, and d) the establishment of an Advisory Committee.

² 1 acre= 4046.85 m² or 0.40 ha.

A review of literature pertaining to agroforestry was carried out to settle important concepts and foster an awareness of its constituents. This literature review also helped in identifying the presence of agroforestry systems in Belize, and particularly in the area of the study. This study also took into consideration the ongoing research being implemented by the Finnfor project (Forests and forest management in Central America), sponsored by CATIE; particularly the set of permanent sample plots in silvopastoral systems being established and monitored in Cayo District.

A questionnaire was developed to gather information on the previous and current situations in the communities. This questionnaire was used as a guide during semi-structured interviews and focus group discussions primarily with members of both communities. A first meeting was held with some of the leaders of the communities (separately) to inform them of the extent of the study and the process that would be undertaken. After they had agreed, several other visits were made to the communities where focus group discussions and individual meetings were held. Photos were also taken during these visits to document some of the observations.

Initially this study was planned to be systematization (documentation and sharing of lessons learned) of the agroforestry experience in the same communities. A consortium was formed to guide the systematization process along. This consortium was comprised of specialists in the fields of agriculture, livestock, forestry, education and social sciences and included membership from the Belize Livestock Producers Association, the University of Belize Central Farm Campus, the Department of Agriculture, the Forest Department, a sociologist and residents in Upper and Lower Barton Creek. However, it was soon evident that, according to the stated objective, systematization was not worth, and consequently the consortium did not meet again. Nonetheless, because of the knowledge and experience of the members in their respective fields, contact was maintained with most of them during the rest of the research process.

Agroforestry concepts

The world population was estimated at 6 billion in 2000 and it is projected to rise to 8 billion by 2025. In 2002, FAO estimated that 29% of the earth's surface is covered by forests (approximately 3.8 billion hectares) (Detlefsen et ál. 2005). Many of these areas are degraded or deforested, resulting in reduced productive capacity of the land and loss of ecosystem services. Agroforestry then, is seen as means to addressing and curtailing some of these threats. According to Detlefsen et ál. (2005), the concept of agroforestry arose as a result of the search for sustainable development that would combine the component of trees on farms or livestock, to improve the living conditions of the population, without destroying or irreversibly degrading natural resources (air, water, soil, flora, fauna).

Several definitions for agroforestry have been developed. Combe and Budowski (1979) stated that “*Agroforestry is a set of techniques of land use involving the combination of forest trees with crops, livestock or both. The combination maybe simultaneous or staggered in time or in space. Its objective is to find the maximum production per unit area, respecting the principle of sustained yield*”.

According to Lundgren y Raintree (1982), agroforestry is the management of the woody perennial component (WP) within a productive system of the farm. Management of the WP tries to fulfilling the needs (food, firewood, timber shade, erosion control, water management, etc.) of the farmer, and bases on the understanding of the interactions between the WP and the other plant components within the production system (Somarriba et ál. 1998).

Somarriba (1990) defined agroforestry as “*a form of multiple cropping that meets three basic conditions: 1) there are at least two plant species that interact biologically, 2) at least one of the plant species is a woody perennial, and 3) at least one of the plant species is managed for forage, annual or perennial crop production*”.

Figure 2 illustrates the relationships that comprise agroforestry systems.

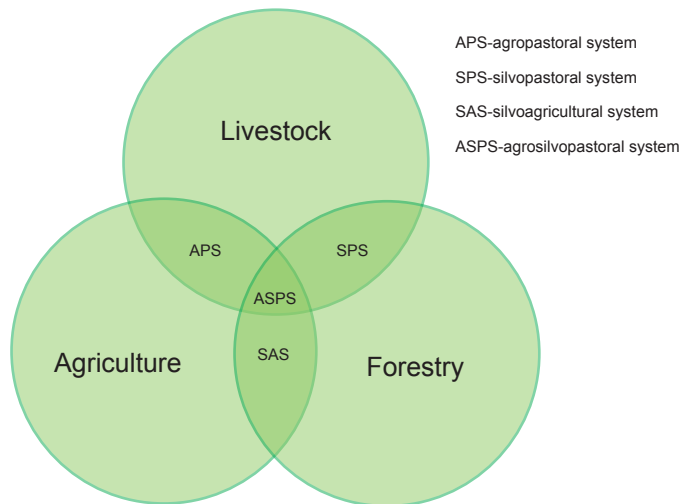


Figure 2. Interactions among agriculture, livestock and forestry
Source: Dellefsen et ál. (2005).

According to Young (1989), agroforestry comprises many types of land use practices (Figure 3). Detlefsen et al (2005) explains a silvopastoral system as a livestock production option where woody perennials (trees or shrubs) interact with the traditional components (forage grasses and animals) under a comprehensive management system. Trees in pastures is a silvopastoral system. *“Trees are usually left in pastures to provide shade, timber or forage for animals. The trees presumably benefit from the manure deposited by the animals under the trees when they congregate to avoid heat. The animals generally eat tree leaves and fallen pods, fruits or litter when grass is scarce. Leguminous trees such as Gliricidia sepium, Enterolobium cyclocarpum and Pithecellobium dulce are well known examples. By eating fruits and pods, animals disperse seeds and may be important in the maintenance of tree populations in pastures”* (Somarriba et ál. 1998).

Rosa Cruz (2010) studied the potential of timber production on 35 farms representative of silvopastoral systems in Cayo District, Belize. An inventory of the saplings, tapers and trees in these farms yielded 1,891 adults trees and 4,265 saplings and tapers (total population of 6,156 individuals). Cedar (*Cedrela odorata*) accounted for 66.5% of the total trade volume of the trees (8.35 m³/ha). A sensitivity analysis of sawn wood prices revealed that small and medium sized farms would receive higher net returns (52 and 45% respectively), than what is currently obtained with only livestock production. The study concludes that scattered trees in pastures are a potential tool for the production of wood on these farms, but the management of natural regeneration should be improved. The presence of cedar in the silvopastoral systems of eight evaluated farms demonstrates a high timber economic potential of the SPS and that timber can be an alternative source of income that can alleviate poverty and reduce the pressures on the forests.

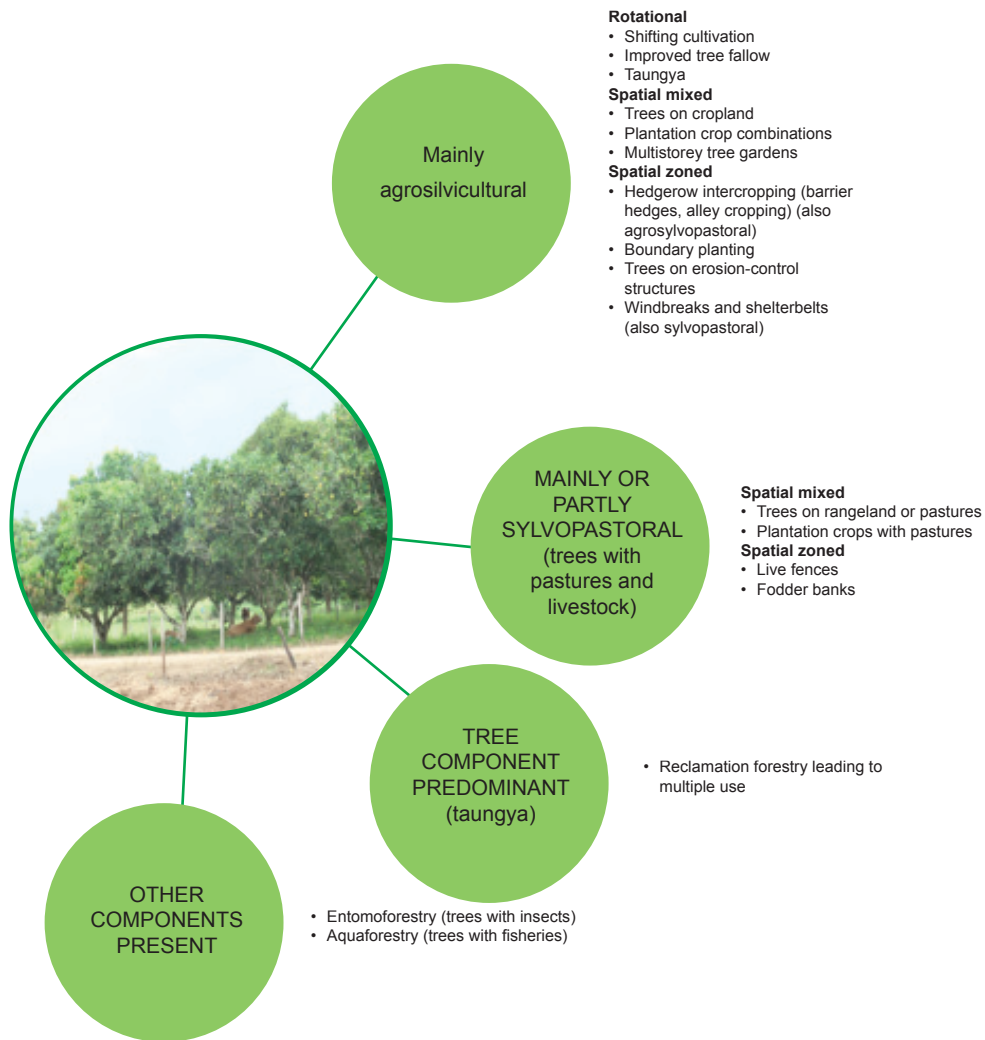


Figure 3. Agroforestry systems
Source: Young (1989)

Silvo-pastoral systems found in the study area

Upper Barton Creek

Today UBC comprises 25 families and approximately 180 people established in two settlements. As the community expanded over the years, they saw the need to acquire more land and, also, some members decided to relocate on Springfield village, a 'sister-community' of UBC. This is located on the Hummingbird Highway about six miles out of Belmopan, Cayo District. Both communities are considered one church, and share not only beliefs but also agricultural practices and livelihoods. The community's land area now stands at roughly 2,000 acres, of which about half has been cleared for pasture. Most of the forested areas left in UBC are found on the rough hills.

Types of AFS

In Upper Barton Creek, three main types of agroforestry systems were observed:

- Scattered trees (timber, shade and fruit) in pastures
- Trees on line
- Live fences

Upper Barton Creek has seen an interest and an increase in the establishment and management of trees within and for the community. Several families have small timber and fruit tree nurseries, the majority of which are for the market outside of the community. However, the seedlings are also used to enrich their farms (in the case of fruit trees) and their pastures (in the case of timber species). They have received no training in the management of these nurseries, and do so only on experience basis. The timber species are generally acquired from the surrounding forests and sometimes from the Ministry of Agriculture nursery in Central Farm.

A few farmers have trees in their pastures, which were established either through natural regeneration, or through enrichment planting. These include cedar (*Cedrela odorata*), mayflower (*Tabebuia rosea*) and some prickly yellow (*Zanthoxylum belizense*). Some of these trees are also used as live fences. Their

management consists primarily of clearing the weeds from around the young seedlings, and protection from cattle trampling by rotating animals in the paddocks and selling the adult animals to maintain a low carrying capacity. Each family has around 14 heads of cattle in 40 acres of pastures subdivided in three paddocks per family farm (approximately 0.35 heads/acre). The principle behind the rotation of animals is beneficial for natural tree regeneration. However, there is too much to be improved in the silvicultural management of trees in order to have good quality timber in this system of scattered trees in pastures.

In the natural forests, very little silvicultural management is practiced. Generally, selective logging occurs, whereby the logger/farmer will go into the forest and select the specific species and quantities of trees required to meet his purposes, be it personal or commercial. There is no enrichment planting in the natural forests; instead, they rely on natural regeneration. In other instances, standing forests are cleared completely for agricultural purposes through slash and burn.

There is one small privately owned mahogany plantation (about half acre) in Upper Barton Creek. Very little silvicultural management is carried out, mainly the clearing of the underbrush. There is no technical expertise in the management of plantations (thinning and pruning) and to date no harvesting has been carried out from this plantation.



Figure 4. Mahogany plantation in Upper Barton Creek

Production and leveraging of resources from AFS

Agriculture and cattle production

The main cash crop of the village is now red potatoes, but they continue to be consistent suppliers of carrots, broccoli, cauliflower, lettuce, cabbage, watermelons and cantaloupes to the local Belizean markets in Cayo District. Statistics from the Ministry of Agriculture and Fisheries (2010) reveal that 26 farmers in Upper Barton Creek planted 19 acres of potatoes in 2010. This produced 166,300 pounds of potatoes from which the community made roughly US\$66,500.

Beef is sold to local meat shops and to a major meat processing company (Running W) in Cayo District. There is a slaughterhouse in the community utilized by all the cattle ranchers. One person is in charge of the slaughterhouse and of marketing and sale of all the beef processed. All funds from sale are deposited into the community account, and records are kept of individual farmers' sales.

Today there are approximately 350 heads of cattle in the community, of which the majority are for beef (300) and about 50 for milking. The cattle are fed with improved grasses (mostly *Brachiaria brizanta* and some *Panicum maximum*) and natural grasses (*Paspalum notatum*, *P. virgatum* and *Cynodon dactylon*); grains such as corn and rice, mixed with molasses and mineral salts, are utilized for horses and milking cows, mainly. There are no protein banks, although farmers have expressed keen interest in applying this technology. Animals are kept healthy: screwworms have been eradicated with the assistance of the national Screwworm Eradication Program of the Ministry of Agriculture, and there are fewer tick infestations, normally kept under control. Antibiotics are used on injured animals and de-worming is regularly conducted. Moisturizing of animals is taken care of with water ponds, especially on hilly pastures.

The pastures comprise mostly improved grasses (*B. brizanta* and *P. maximum*). No fertilization or herbicides are used. Fire is seldom used on pastures, but frequently used when preparing land for crops (slash and burn). The most common management practice is partition and rotation of pastures.

Fruit and timber tree nurseries are geared towards the local markets. Timber seeds are planted during certain times of the year, and are normally done on a demand basis. As is the case with vegetables, each farmer conducts his own sale of seedlings. The community has become known for its availability of timber seedlings.

Production of lumber

The normal practice in these communities is to clear the forest when agricultural development is to occur. The felled trees are normally used for lumber. Permission for the harvesting of timber is obtained by either private forest permits or petty permits from the Forest Department.

Cruz (2009) conducted a study to determine the timber potential in pastures in UBC. Seventeen 1 ha plots were established in ten farms, were an average commercial volume of 1,869 bd. ft. lumber per hectare was found. Bearing in mind that the trees were established through natural regeneration, this clearly demonstrates the viability of maintaining a timber stock within pastures if natural regeneration were to be managed. Figure 5 illustrates the commercial volumes per plot within the ten farms evaluated.

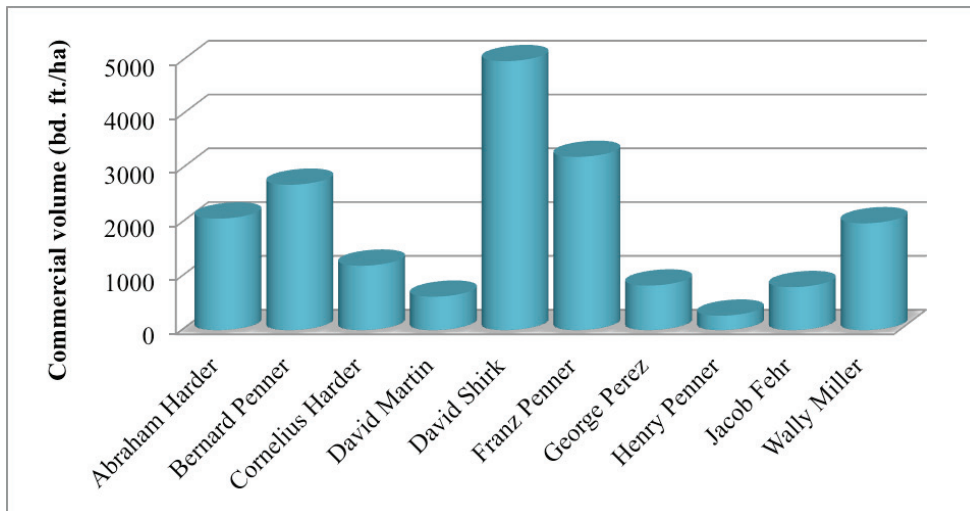


Figure 5: Estimated commercial volume of timber per ha from 17 SPS in Upper Barton Creek
Source: Rosa Cruz (2010)

To convert lumber, there is only one privately owned horse-run sawmill in the community. The owner of the logs is responsible of milling his own logs with his own horses and workers, and a royalty is paid to the mill's owner. At the sawmill site, one person manages the mill itself while another is in charge of running

the horses in a circular pattern. The sawn lumber is then transported to the community gate (entrance), where either the purchaser collects it, or a truck delivers the material to the purchaser. Since it is a private sawmill, all the costs for processing are paid to the sawmill owner. In 2010 the income generated by the sawmill owner was approximately US\$7,000, according to Vidal (2012).

Only 30% of the lumber produced in UBC is destined for the local markets, and the community utilizes the remaining 70%. Vidal (2012) estimated the net income from the sale of lumber in UBC at approximately US\$8,447/ year, which represented a significant alternative income. However, there is variability in the income earned from year to year, resulting from changes in market demand and availability of demanded species. The owner of the lumber is responsible for the commercialization of his material. Most of the lumber sold is softwood (form board), used for construction in the nearby municipalities of Belmopan and San Ignacio. The primary purchasers are hardware supply stores and private lumberyards. Sometimes private contractors would place direct orders from the community. The normal cost for sale at the community gate is US\$297/cu. ft. for hardwoods, and US\$176/cu. ft. for softwoods (Vidal 2012).

The same author mentioned quam wood (*Schizolobium parahyba*), santamaria (*Calophyllum brasiliense*), zapote (*Manilkara zapota*), bullet tree (*Bucida buceras*) and cotton tree (*Ceiba pentandra*) as the main species harvested and processed in UBC. In 2010, approximately 304 m³ (about 128,800 bd. ft.) of timber were processed (Vidal 2012). Nonetheless, over the past four years a consistent decline in volume of timber has been evident. “*This might be due to the shortage of raw materials, considering that there is no management plan or enrichment of the forest after logging, and the fact that there is not a sustainable lumber production system in place*” (Vidal 2012).

Lower Barton Creek

The population of LBC is now about 320 residents, distributed among 50 families. The land of the community now spans some 2,200 acres, and livestock farming remains the major economic activity of the village. Similar to UBC, as the population of LBC grew, some residents sought land elsewhere and eventually the community of Pine Hill in Toledo District was established as a sister community to LBC.

Types of AFS

LBC has not engaged as strongly as UBC in incorporating timber species in pastures, probably because of their availability of arable land for farming and timber for building. Hence, there was not an urgent necessity to plan for future timber sources. The only agroforestry system observed was scattered trees in pastures.

These include shade, timber and fruit trees. Nonetheless, the farmers are moderate with their land and natural resource use practices and some have recently established very small plantations of mahogany and teak.

Production and leveraging of resources from AFS

This community is more cattle-oriented than UBC. Cattle raisers have experimented with different breeds and found that Brahma is a tougher breed, thus they use it for beef production. There are presently about 1,100 heads of cattle in around 1,650 acres; about 100 heads are milking cows and the rest are for beef production. The grassing intensity is estimated at 1 head per 1.5 acres (or 0.67 head/acre).

The same grasses used in UBC are also used in LBC. Pasture management implies some manual control and little burning when replanting with improved varieties. The common practice of partition and rotation of pastures is also used. Producers have expressed interest in experimenting with protein banks for their cattle.

Even though silviculture is not a priority, some residents are concerned for the reducing supply of timber available. The same species of timber as in UBC are harvested here on a needs basis or on eventual request from outside of the community, but this is not a significant contributor to the economy of the village. Harvesting is carried out in the same manner as in Upper Barton Creek, with horse (or oxen) and cart. A couple of farmers have established small plots of mahogany next to other crops. Only two nurseries were found in the community.



Figure 6. Small plot of teak and mahogany adjacent to other farm crops in Lower Barton Creek

There is one community-owned horse run sawmill in the village and the farmers pay to utilize it with their own horses and workmen. This sawmill operates in the same way as that of UBC. Vidal (2012) estimated that the sawmill produced around 151 m³ (roughly 64,000 bd. ft.) of lumber in 2010. The lumber is transported in a similar fashion as in UBC, either to the community gate to be picked up by the buyer, or by hiring a truck to deliver to the buyer.

In Lower Barton Creek the person in charge of the sawmill is also responsible for finding the market for the lumber. The individual logger's tasks end when he delivers the logs to the sawmill and provides horses to run the mill. Once the lumber is sold, the sawmill manager shares the profits among the persons along the production chain: the logger (log owner), the sawmill helpers, and himself.

The lumber produced in this village is mainly for construction purposes; only 20% goes to the market (Vidal 2012), which comprises the same buyers as UBC. The market prices are significantly lower than those UBC receives (Table 1).

LBC remains a very well organized community, with the Chairmen and the Elders as the leaders. The Chairmen are elected for a period of three years, with a period of one to two years before they can be re-elected. The Elders hold the position for life. There is also someone in charge of road works in the village, who coordinates the work of the roads committee. Community labor is now voluntary and there have been minimal problems with cooperation. In the event that a resident does not cooperate, the leaders discuss the situation with him, and the matter is usually resolved promptly. In problematic cases, the elders have the ultimate authority and decision. They are the most revered authority in the community.

Today there is a greater diversity of products coming out of LBC. They have diversified their production and potato has become the main revenue generator, surpassing beef production. In 2010, 65 farmers planted 34 acres of potatoes, which rendered 427,400 pounds. At an average local market price of US\$0.40, potato production alone contributed about US\$170,000 to the community (Ministry of Agriculture and Fisheries 2010).

A tax system on sales has recently been implemented: the producers have to pay to the community a 4% tax on the sale of pigs, and a 2% on other sales. The funds are for improvements that benefit the entire community, and are managed by someone selected by the community.

Land also belongs to the community in the form of a trust, therefore no parcel of land may be sold unless all the trustees approve and sign off on the sale. The land is issued based on need. A young family, for instance, may receive a parcel of 2 acres, and as the family grows so will the allocation of land. In cases where the person cannot immediately pay for the land, the community offers the option of payment over time, with no interest.

Main findings for both communities

Most of the lumber produced in Upper and Lower Barton Creek is for domestic purposes. Even so, the sale on the market generates some income (Table 1), demonstrating that if tree management within the pastures were improved, the income generated from the sale of lumber could increase.

Table 1. Prices received for lumber sale in Upper and Lower Barton Creek, Belize.

Community	Hardwood (US\$/m ³)	Softwood (US\$/m ³)	Volume (m ³)	Volume (bd. ft.)	Net income (US\$)
Upper Barton Creek	297	176	304	128,000	8,447
Lower Barton Creek	137.5	99	151	64,000	2,987

Source: Vidal (2012)

Both communities are deeply centered on their religious beliefs. There is strict adherence to the teachings of the Bible, which guides their daily lives and behavior. Their beliefs foster a strong respect for fellow human and the environment, and result in moderation of their actions in personal interaction and in working the land. This bodes well for the manner land is used, even if additional efforts are not made.

The traditional land use practice of Mennonites is to clear forests for agricultural production. The timber trees felled are for construction in the community or for sale. With growing population, the communities have had to expand to sister villages in other parts of the country.

There is an expressed interest by the Mennonite farmers in improving their land use practices. Some have already planted small forest plantations and are managing trees in their pastures. If farmers were to practice better management of the natural regeneration of timber species in pastures, their incomes would be diversified and increased. This would also allow for an added benefit: the improvement of land use practices within the pasture.

Given that Mennonite communities are quite isolated and unopened to the broader Belizean society, there have been very little project interventions in these communities. Nonetheless, some of the people consulted in both communities expressed great interest in technical assistance for improving their agricultural and forest management practices.

Lessons learned

Social capital is critical to cooperation

One of the most important lessons learned from this exercise is that strong social capital has enabled the communities to maintain order in their actions and behaviors, both in their daily interactions with one another and in the manner in which they utilize the natural resources available. Their very strong religious beliefs maintain this order and serve as their daily guide to living. There is very high respect for elders and chairpersons in the community and non-compliance is dealt with modesty but firmly. Non-compliant residents are eventually removed from the church, although they may physically remain in the communities but will be isolated from the broader community. Participation as a community is also a critical factor to their success. When it was seen that one could pay to avoid working in community activities, the leaders ensured that this was averted by making work voluntary. This created a sense of greater commitment to community by those unwilling to work; all the neighbors are involved so they are also pressured to participate.

The organization and definition/delegation of roles and responsibilities is also very crucial to their success. Roles and responsibilities are clearly defined and strictly adhered to. The community does not believe in extravagance or handouts and do not support “*some getting richer than others*”. In the end, the community is more important than the individual is. When asked what has allowed for the cohesion and success in the community of UBC, Elder David Shirk replied “*work and faith*”.

Willingness to learn and apply new techniques

Both communities have demonstrated a strong willingness to experiment. They have experimented with different breeds of cattle, different types of grasses, fruit and timber trees, and a very wide range of vegetables, all on their own. They have even experimented with farming techniques. One can observe several different farming methodologies employed, from timber species in silvopastoral systems to multicrop one-acre plots. By trial and error, they have found best practices in many cases. Although Mennonites live in

closed communities, they are open to change and learning to improve their farming, land and natural resource use practices, as long as those practices do not impede on their way of life.

Basic silvicultural management

Lumber was in plentiful supply at the establishment of the communities, therefore its availability was not an issue. The settlers soon saw the opportunity for an additional income from the sale of lumber, although admittedly they did not go -and still have not gone- into large-scale commercial production of lumber, as it is against their religious beliefs and practices. With time, experimentation and experience, some of the farmers have learned not to clear all the trees when establishing pastures, and some have benefitted from this practice through harvesting of timber trees left to grow and nurtured in their pastures. Tree management in pastures consists mainly of protecting young trees from cattle trampling by either fencing the tree, or removing the cattle from the area until the trees can withstand disturbance. Avoiding the use of fire is another method used to promote the growth of the timber species. Some of the farmers even chop the overgrowth surrounding valuable tree species.

Improvement of pastures and cattle management

After experimenting with different varieties of cattle, both communities decided to settle with Brahma cattle for beef and Jersey, Holstein and brown Swiss for milking. They have shown very keen interest in learning more about fodder banks, which would help during the dry season, and in improving the cattle stock. Their experiences with diseases and infestations have made them adopting new practices in dealing with their herds. Assistance from the National Screwworm Eradication Program also contributed to control the problem. In the same token, experimentation with different types of grasses has also yielded positive results for these two communities. While it is a contributor to the funds in the communities, there does not seem to be an interest in expanding production, as this would go against their religious beliefs.

Norms and organization for production

Compliance with norms and rules defined by their church is of utmost importance in these communities. This is what holds the community united and what maintains order in every aspect of their daily lives. As it pertains to the production of lumber from trees in pastures, each individual in the chain knows and carries out his/her specific role.

Each farmer with trees in pasture manages them according to best practices acquired through experience. When harvest moment comes, it is an individual decision made on either economic need or for use of the

land where the tree is located. Sometimes it is simply that the tree is at the right age for harvesting. The farmer either would fall the tree himself, or solicit a neighbor's or a family member's help.

This system of organization has existed since the establishment of the communities and before that, in the communities they came from. Religion establishes the social structure in the community, as well as the rules and organization for production. Norms and organization are strictly adhered to and remain unchanged.

Harvesting and transportation of lumber

The farmer decides when to harvest timber based on his own discretion. Obtaining the permits is a relatively easy and quick process, as the harvesting usually does not occur on commercial basis, but as part of the clearing for agricultural or livestock purposes. The permits are obtained from the Forest Department in its nearest offices in Belmopan or San Ignacio.

The lumber produced from trees harvested is utilized primarily for domestic and farm use. Occasionally there are requests from outside, and viable trees from pastures or, otherwise, from the nearby forest are cut to fulfill that order. If the farmer does not have enough trees on his property, he asks a neighbor to complete the order. Either the farmer delivers the lumber on mule or cart, or the buyer drives to the village to collect the material.

Given that lumber production is not on a large scale, this process has proven practical for the Mennonite farmers. The lesson learned here is *"if it isn't broken, don't fix it"*. The communal rules have served well to both communities, and likely, it is going to be the same in the future.

Commercialization and administrative management

Administrative and commercialization processes are similar and even identical in both Upper and Lower Barton Creek as they operate within a similar religious, communal structure. Cattle raising and agriculture is the mainstay of the economy in both villages. Both are involved in the production of agricultural cash crops such as potatoes and vegetable crops and livestock. Only a few producers have managed to implement silvopastoral practice of trees in pastures.

In both communities, each farmer is responsible for planting and tending his own crops and livestock. In special situations, the community contributes with labor and/or financial support. In the case of crops, each

farmer is responsible to market his own product and proceeds go directly to him. There is a steady market for most of the cash crops sold out of the community. Some farmers sell directly to grocery stores or at local produce fairs, while others sell to intermediaries.

The commercialization of meat is also similar in both communities. An individual is appointed by the community to run the slaughterhouse and market the meats for the entire community. This person makes contact with the buyers (restaurants, meat shops or intermediaries), and negotiates the prices for the sale of the products. After the sale, he delivers the payments to the respective livestock farmers whose meat he sold.

Lumber, instead, is marketed differently between the two communities. In LBC the sawmill is communal property and the sawmill manager is responsible for the marketing and sale of timber, on behalf of the farmers/loggers. Once sold, the proceeds are shared between the farmer/logger, the manager, and a portion remains for the maintenance of the sawmill. In UBC, the sawmill is privately owned and each logger/farmer is responsible for milling his own lumber, whether he does it himself or contracts others to do so. The farmer must also take on the tasks of selling and transporting the milled lumber. From the proceeds of his sale he then contributes to the owner for the use of the sawmill.

These rules are strictly adhered to and are not eased to accommodate anyone. If a change is to be made with regards to the process, it will be the decision of the leadership, but only after consultation with the villagers. Once more, the communal structure and norms have functioned to maintain order, compliance and stability within the communities.

Leveraging of resources for the entire community, not the individual

In Lower Barton Creek, a “tax” is charged on the sale of meat, which goes directly into the community funds lodged with a local bank in town. Any member of the community can have access to the funds, and the leadership grants approvals for its use and disbursement after evaluating the situation. For instance, the community may lend seed monies to a new couple to purchase land and establish their crops, on the understanding that they repay the loan within a reasonable and convenient timeframe. The same applies in the case of health problems; when it is the case of a serious illness, repayment may not be necessary. This arrangement has worked well, and non-payment is not an issue. Contributions to the community ‘kitty’ have increased since the introduction of the tax system, but voluntary contributions were not a problem before.

In Upper Barton Creek, there is no tax system as such, but the village members leverage community funds through voluntary contributions. The funds are managed in a quite similar manner, in that anyone has access to the funds and the repayment schedule is lenient. The same as in LBC, there is no repayment for a loan taken when a serious illness. The village leaders make the decisions on use of the funds.

In both cases, the principle of “*all before one*” stands strong, and non-compliance is not really an option. The Bible teachings guide these communities in every aspect of their lives, and determine how the community as a whole should function. This is probably the single most important and influential factor that facilitates the functioning of the productive chain.

Conclusions and recommendations

Small and medium sized farmers in Cayo District could generate up to 45 and 52% more income if there were a system in place to manage the natural regeneration in pastures. This management would involve avoidance of manual chopping, herbicides and fire, as well as establishing protective barriers around young trees to prevent damage by cattle. These and other regeneration management techniques should be demonstrated to farmers and technicians in the respective Ministries to encourage the adoption of such practices.

Recent research has shown that several farmers in Cayo District are managing trees in pastures. In the Mennonite communities, the social cohesion, the land use practices, the organization of roles within the community are all dictated by their strong religious beliefs. Their clearly defined roles and responsibilities, and commitment to carrying out their duties diligently can contribute to greater success along any value chain, including agroforestry practices such as timber in silvopastoral systems.

The Mennonites are not very familiar with the concepts of silvopastoral systems and silviculture, even though they have been practicing some of these techniques on their farms to a limited extent. The lessons learned by trial and error by the Mennonites should be highlighted and used to demonstrate best practices to other Belizean farmers.

There exists strong social organization among Mennonites and they are willing to learn about sustainable management of natural resources. If they joined the production of lumber within silvopastoral systems they could improve their incomes to acquire more land for the expansion of their communities. Likewise, considering that these two villages have a sawmill each; the timber produced in SPS could be included in the value chain.

Timber is a resource required by these communities not only for construction but for income purposes also; so, the diversification of sources of timber should be seriously considered. Currently, the vast majority of the

timber utilized by the communities comes from adjacent natural forests. They should seriously explore the option of managing trees in pastures to maintain a continuous supply in the future. Similarly, given that all Mennonite constructions are timber-made, and that the supply is limited and dwindling from the natural forests around them, these communities will need to reconsider the option of sale of timber at present, even though it is a source of income. Eventually the natural forests will not be able to meet their own demands and they may find themselves having to purchase lumber from other sources.

These communities can take steps to promote the management of trees in pastures and other agroforestry systems on their lands, which requires a technical expertise that they do not currently possess. Institutions such as the Agriculture and Forest Departments can collaborate to increase capacities by providing technical assistance in agroforestry to the farmers. This is also an excellent opportunity for CATIE to offer the capacity building that not only the technicians but also the farmers require.

In the end, a national agroforestry program should be developed with the formal cooperation of the Ministry of Natural Resources and the Environment, the Ministry of Agriculture and Fisheries and other partners. CATIE, through its Finnfor Project, can also collaborate in such an initiative, which would provide innovative incentives for farmers to utilize agroforestry systems in their lands and improve best land use practices.

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