Management and Use of Multi-purpose Tree Species in the Caribbean

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Presented at the Workshop on Management and Use of Multipurpose Tree Species, IUFRO Working Group S1.07.09
Held the 3 - 7 April, 1989, in Antigua, Guatemala

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Summary

The synopsis includes both the management and use of multipurpose tree species (MPTS) in the Caribbean Region.

There are various objectives for establishing forest plantations in the Caribbean, although they are frequently not foreseen. These include provision of both products and services. Among the products sought are sawtimber, fuelwood, edible fruits, forage for livestock, and spices and beverages. Services provided by MPTS are protection of watersheds, maintenance and restoration of soil fertility, windbreaks, living fences, shade for crops, animals and people and support for climbing crops. Species selection is not optimum, due to a lack of knowledge about 1) species/site relationships, 2) the existence of promising species and 3) possible sources of seeds.

Generally, nurseries produce container stock, often in polyethylene bags, but also in other containers such as styroblocks and rootrainers. Sometimes bare root seedlings are produced. MPTS are also established from natural regeneration, direct seeding and vegetative reproduction. Plantations are established in blocks, or more often interplanted with crops.

MPTS in the Caribbean receive little tending after establishment. Many plantations stagnate from overcrowding. Trees interplanted with crops are pruned to give crops room to grow.

Timber is harvested with a broad range of technologies, from pit sawing at the stump to sophisticated light cable systems. Fuelwood is generally cut by hand. Most charcoal is produced with earth mounds, but modern kiln designs have been tried. Fruit processing and marketing offer promise for increasing farm incomes, and MPTS could increase the productivity of Caribbean livestock. Spices and medicines are examples of products from MPTS that can generate substantial income to farmers. Caribbean farmers need to receive a greater return for the products from their MPTS.

Resumen

La sinopsis incluye tanto el manejo como el aprovechamiento de plantaciones forestales con especies de arboles de uso multiple (ALM) en la region del Mar Caribe.

Los objetivos para que se establecen las plantaciones en el Caribe son varios, aunque frecuentamente no son bien previstos, e incluyen el suministro tanto de productos como servicios. Entre los productos buscados suelen ser la madera

para aserrlo, la leña, las frutas comestibles, el forraje para ganado, y especias y bebidas. Los servicios que proveen los AUM suelen ser: la proteccion de cuencas hidrograficas; el mantenimiento y la restoracion de la fertilidad del suelo; los rompevientos; las cercas vivas; la sombra para los cultivos, el ganado y el ser humano; y apoyo para cultivos trepadores. La seleccion de especies no es optima, debido una falta de conocimiento sobre 1) la relacion especie/sitio, 2) la existencia de especies prometadoras, y 3) fuentes posibles de semillas.

Generalmente, los viveros producen plantulas en recipientes, frecuentamente en bolsas de polietileno, pero a veces en otros recipientes como los "styroblocks" y "rootrainers;" a veces se producen plantulas a ralz desnuda. Ademas, se establecen los AUM con la regeneracion natural, la siembra directa y la reproduccion vegetativa. Las plantaciones se establecen en bloques, o mas a menudo intercaldas con los cultivos.

Los AUM en el Caribe reciben poco cuido después del establecimiento. Muchas plantaciones se estancan por falta de raleo. Los arboles que son intercalados con los cultivos se podan para que los cultivos puedan crecer.

La madera se cosecha con una gama amplia de tecnologlas, desde el aserrlo abrazadero al tocon hasta sistemas sofisticados de arrastre por cables. Generalmente se corta la leña a mano. La mayorla del carbon se hace con montlculos de tierra, pero se han probado diseños modernos de hornos. El procesamiento y el mercadeo de las frutas ofrecen promesa para aumentar el ingreso rurale, y los AUM podrlan aumentar la productividad del ganado del Caribe. Las especias y las medicinas son ejemplos de productos de los AUM que pueden generar un ingreso sustancial para los finqueros. Los campesinos caribeños necesitan recibir un ingreso mayor para sus productos de sus AUM.

1. Introduction

Multipurpose tree species (MPTS) have traditionally been a part of small-farm production systems, and play an important role in the rural economies of the Caribbean. They offer products that enrich the nutrition and comfort of rural inhabitants, and that are sold when production exceeds on-farm needs. At the same time they ameliorate the climate, helping to stabilize soil, improve crop production and increase water infiltration. When monocultural, single purpose crop production systems have been imposed on these traditional systems, ecological imbalances have resulted, with far-reaching effects on agricultural productivity, public health and marine ecology. The future of Caribbean island economies depends upon the maintenance of the natural resources base, for both agricultural production and tourism. A renewed focus on MPTS can help to meet the needs for income generation of Caribbean rural inhabitants, at the same time that the natural resource base is conserved.

2. Objectives for MPTS in the Caribbean

Multi-purpose tree species are, by definition, those species which serve for more than one purpose. Some rural development practitioners use a narrow definition of MPTS, restricting the term to those trees that produce more than one product. However, there must be few species that only serve to produce a

single product, and the importance of the services that MPTS provide to small farms is a strong argument against only considering the products derived from MPTS. As pointed out by Burley (1985), the term MPTS can apply to most if not all tree species, because even trees from which no products are harvested are multipurpose, in that they provide multiple services such as shading the ground, intercepting rainfall and breaking wind with their crown, contributing to soil organic matter with shed leaves, branches and roots, and stabilizing soil with their roots.

The purposes for which MPTS serve fall in two main categories: 1) products that are derived from trees, and 2) services that trees provide. MPTS can fall into both categories or can provide only a combination of services. In many cases, trees are planted for only one purpose, such as watershed protection, and then are taken advantage of for additional purposes, such as timber. If it is accepted that virtually all trees are multipurpose, then it can be asked why even use the term, and organize a conference on MPTS? The answer is that, to the non-forester, including farmers without a custom of tree tending, agronomists and politicians, there is little awareness of the multiple purposes of on-farm trees. Education of policy makers and the general public of the multiple purpose potential of trees can help to generate support for programs that promote planting of MPTS.

It must be pointed out that the multiple purposes that a given species can provide are frequently mutually exclusive. A species, such as Leucaena leucocephala, that can be used for fodder and fuelwood, cannot usually be managed so that the same trees provide both. Intensive management for fodder production will consist of frequent coppicing, and the amount of fuelwood produced will be minimal. However, the foliage of trees that are managed to produce fuelwood can be fed to livestock when the fuelwood is harvested. The management given to MPTS will generally favor a particular product or service, and will often be sub-optimal for the other potential goods and services. Care should be taken to not engender mistrust in the audience of a tree planting promotion campaign by claiming unrealistic benefits from MPTS.

2.1 Products

The products provided by MPTS offer a large potential to motivate farmers to include trees in their farming systems. The quality of farm life can be improved by MPTS products consumed by the farm family or livestock, and by income generated by their sale. Processing and marketing of MPTS products is an area in critical need for development and transfer of technology to small farmers.

Timber is one product of MPTS in the Caribbean. Traditionally, timber has been harvested from natural forest (whose trees are also MPTS by the broad definition). Plantations that are primarily for timber production have been established on several islands. Extensive reforestation was financed in Puerto Rico by the U.S. government; results of these efforts are summarized in Marrero (1950). Swietenia macrophylla has adapted well to planting on good soils in Puerto Rico. Hybrid mahogany (S. macrophylla x S. mahogani) does better on drier sites, such as St. Croix (Marrero, 1950). A more recent evaluation of the performance of exotic tree species in Puerto Rico is given by Francis (1987). Trinidad is well known for its teak (Tectona grandis) plantations, which form the basis of a timber industry. Caribbean pine (Pinus caribaea) has been widely

planted around the Caribbean, and blue mahoe (Hibiscus elatus) is planted in Dominica, Jamaica (where it is native), Puerto Rico, St. Lucia and St. Vincent. Generally these plantations are also planted to protect watersheds. Many small farmers are not willing to pay the opportunity cost of tying up scarce capital and land in block plantations of timber trees over the time period between planting and harvest, because both are needed to maintain a flow of crops for on-farm consumption and sale, and/or to produce feed for their livestock. Those species which begin to produce goods shortly after planting will be more acceptable to farmers for block planting. Trees that flower abundantly at an early age are attractive for bee keepers. An example of how MPTS trees can give an early return is found in Haiti. The demand for L. leucocephala seed to plant contour hedgerows (discussed below) is great, and many farmers who had previously planted the species now receive a handsome return selling seed to watershed protection and agroforestry projects there. Trees with palatable leaves can give an early return to farmers with livestock, but tree growth will be reduced more or less proportionally to the amount of fodder harvested. While block plantations can protect watersheds, this benefit is conferred to society as a whole, giving little direct incentive to the individual farmer. The services provided directly to the farm per area planted are much greater when timber trees are interplanted wuth crops or pastures (discussed below). This practice is common in the Caribbean.

Wood is an important energy source in many parts of the Caribbean, used either directly or converted to charcoal. It is estimated that 80% of Haiti's household and industrial energy needs are met by fuelwood and charcoal. Similarly to timber, fuelwood has traditionally been harvested from natural forest. In certain locations, conversion of forest to agriculture has lead to fuelwood scarcity, particularly in areas of limited rainfall. Fuelwood harvesting is often blamed as the cause of extensive deforestation, particularly on the island of Hispaniola; it is more probable that clearing of forest for agriculture is respsonsible for initial deforestation, and that cutting of trees for fuelwood or charcoal by settlers then has a noticeable effect on the remaining trees. In response to fuelwood scarcity, tree plantations are often promoted as a sustainable source of fuelwood. While the rotation period for fuelwood production is less than for timber, small farmers still are unlikely to have sufficient capital or land to invest in sizable fuelwood plantations. In areas of fuelwood scarcity, the wood harvested from pruned branches and thinned trees will provide some early return and make timber plantations more attractive for farmers with available capital and land. MPTS are more attractive for use in fuelwood plantations when the products or services provided are harvestable at an early age, and when this harvesting is consistent with fuelwood optimization management practices. Small farmers frequently plant MPTS in agroforestry associations, and harvest fuelwood and timber, as well as benefit from the services the trees provide. The AID/Haiti Agroforestry Outreach Project has successfully promoted planting of over 25 million MPTS on Haitian farms, as a cash crop for production and sale of charcoal. Ehrlich (1986) summarizes production of L. leucocephala, Cassia siamea, Azadirachta indica, Colubrina arborescens, Eucalyptus camaldulensis and Prosopis juliflora planted in the project. It is worth noting that fuelwood is one of the lowest value forest products, and even in a country of severe fuelwood scarcity such as Haiti, farmers frequently postpone harvest of planted trees to allow them to reach a size permitting their sale as building poles, which gives a much higher return.

MPTS that bear edible fruit have ready acceptance by Caribbean farmers, but have received little attention by Caribbean foresters. Agriculture departments and extensionists are more likely to promote fruit trees, and leave timber and fuelwood trees, and government forest reserves, to the foresters. This division between horticulture and forestry is purely artificial, from the standpoint of the farmer, around whom MPTS promotion programs should be based. The AID/Haiti Agroforestry Outreach Project has found greater farmer acceptance for fuelwood trees when a few fruit trees are included in the package of trees to be planted. The barrier between forestry and agriculture departments must be broken in the Caribbean, and rural development must be pursued with a holistic approach that meets the various needs of farmers. There are many fruit-producing MPTS trees planted in the Caribbean. Some of them are: avocado (Persea americana), mango (Mangifera indica), breadfruit (Artocarpus altilis), jackfruit (A. heterophyllus), coconut (Cocos nucifera), hogplum (Spondias mombin), guava (Psidium guajava), oranges (Citris sinensis), lime (C. limmettoides), soursop (Annona muricata), custard apple (A. reticulata), sweetsop (A. squamosa), ackee (Blighia sapida), tamarind (Tamarindus indica), carambola (Averrhoa carambola), genip (Melicoccus bijagatus) and star apple (Chrysophyllum cainito). On small farms, these trees are usually planted in the yard, or home garden, as well as interplanted with other crops in fields and in living fences.

To a limited extent, MPTS are used in the Caribbean to produce fodder for livestock. The potential and need for further development of this practice is great. Foliage cut from L. leucocephala contour hedgerows (see below) is commonly fed to goats in Haiti, and its use as pig feed is a valuable complement to the swine reintroduction efforts of AID, FAO and other donors there (personal communication, Richard Pellek, AID/Haiti). Plantations of L. leucocephala were established by the Diamond Dairy in St. Vincent to produce fodder that was combined with sugar cane to provide a balanced mix of protein and carbohydrate. However, the practice has been abandoned due to the high cost of harvest, which consisted of cutting branches by machete from head-high standards. The Pine Hill Dairy in Barbados reputedly uses a protein bank of L. leucocephala to supplement sugar cane as fodder for cows. Gliricidia sepium is widely used as a living fence species in the Caribbean (see below), and is consumed by livestock when fences are pruned. In the Dominican Republic, foliage from Calliandra calothyrsus is fed to pigs (Knudson et al., 1988). Cattle on seasonally dry islands, such as Antigua and Bequia, are turned loose to browse in the natural forest during the dry season, termed the "let-go season." Unfortunately, this practice has a negative impact on regeneration of species such as Tabebuia heterophylla used locally for boat construction.

Other products are sporadically harvested from MPTS in the Caribbean. Folk medicines are concocted from many plants, including trees in natural forest and trees found on farms. Several important spice trees are grown on Caribbean farms, such as nutmeg (from Mryistica fragrans), mace (also from M. fragrans), allspice (Pimenta dioica) and annato (Bixa orellana). Grenada is known as the Spice Island because of its nutmeg, mace and cocoa production, while Jamica is the world's leading producer of allspice. Commercial bay oil is produced from P. racemosa leaves in Montserrat and Dominica, the latter being the world's leading producer. Research is being carried out in the United States on the possibility of producing a botanical insecticide from neem (Azadirachta indica) fruits, and oil processed from the seeds has potential for manufacture of flea soap.

2.2 Services

Watershed protection is one of the most important services provided by MPTS in the Caribbean. Land available to small farmers is usually on hillsides, and MPTS are an important resource to farmers for stabilizing agriculture. Destructive agricultural practices have a particularly heavy impact on island ecosystems, because of the relative importance of the marine ecosystem and the high proportion of coastline to land area. MPTS traditionally planted to provide products (discussed above) or services (discussed below) also carry out the additional service of protecting watersheds. The foliage and branches of trees break the impact of rain. Shed leaves and branches protect the soil from the impact of raindrops before they decompose. Along with roots they increase soil organic matter after decomposition, which improves infiltration of rain. Living and undecomposed dead roots hold the soil in place. A promising new technology, contour hedgerows, is being adapted to Haitian farms in the AID/Haiti Agroforestry Outreach and Targetted Watershed projects. Rows of L. leucocephala or C. calothyrsus are direct-seeded at close spacing along the contour. The rows are spaced sufficiently far apart to allow cropping between the trees, but close enough together to minimize sheet erosion. With time, terraces build up between the rows as soil is trapped by the trees and branches that are piled on their uphill side. Dick Pellek (personal communication) estimates that 1,000 km of hedgerows have been planted, and that 500,000 tons of soil have been saved as a consequence (one-half ton per meter of hedgerow).

An important service of MPTS in the Caribbean, and one that has much promise for further development, is restoration or maintenance of soil fertility. Technologies such as contour hedgerows and alley cropping allow agricultural production to be sustained in part because of the input of organic matter to the soil from decomposed leaves, branches and roots. MPTS also serve as a nutrient pump which recycles nutrients from lower soil layers, so that they are available to crop roots. Under these systems the MPTS play a similar role that trees in brush fallow, or swidden, systems play.

Windbreaks are another service provided my MPTS in the Caribbean, although multiple rows of trees planted at right angles to prevailing winds are seldom seen. There is certainly a beneficial effect due to partial wind interception from living fences (discussed below), and trees planted in home gardens provide a service in breaking wind, as well as providing fruit and shade. Windbreaks of galba (Calophyllum calaba, a valuable timber tree) are used in St. Vincent cocoa planatations, and strips of native trees are left between areas cleared to expand banana cultivation in Dominica. Most farmers participating in the AID/Haiti Agroforestry Outreach Project plant some of their project trees around their homes to break the wind.

In the Caribbean, living fences using MPTS are widely used. Commonly used species are G. sepium, Bursera simaruba, Spondias purpurea, Yucca elephantipes, Euphorbia spp. and Hura crepitans. As mentioned above, living fences serve to partially break the wind, as well as provide occasional fodder for animals. It is also common to see animals seek the shade of living fences, when trees are otherwise absent in pastures.

The use of MPTS to provide shade for certain crops is common in the Caribbean. Cocoa and coffee are usually grown under tree shade. G. sepium is widely used

as cocoa shade, as are Samanea saman and the Immortelles (Erythrina spp.). Inga spp. are commonly used as both coffee and cocoa shade. Saman and Ceiba pentandra are commonly seen as shade in pastures. MPTS planted in home gardens and yards are also widely appreciated for the shade they provide, as well as products such as fruits, timber and fodder, and their windbreak function. Terminalia catappa and Delonix regia are MPTS widely used for shade in home gardens, city streets and beaches; MPTS play an important urban forestry role, in providing shade for city and town streets, parks and residences.

MPTS are important in the Caribbean for stabilizing sand in coastal zones. Among the more important native species are Terminalia catappa and Coccoloba uvifera; C. equisetifolia is a valuable exotic species for stabilizing sand. These trees are also appreciated for their shade. Mangroves are important for coastal protection, and serve as habitat for many juvenile fish and crustaceans. They are also an important source of fuelwood and building poles.

MPTS are occasionally used in the Caribbean as living support for climbing crops, such as yams (Dioscorea spp.), passion fruit (Passiflora edulis), black pepper (Piper negrum) and vanilla (Vanilla planifolia). G. sepium is the most widely used species for this purpose.

3. MPTS Management

3.1 Species Selection

Selection of MPTS species is inadequate in the Caribbean, for various reasons. First, potential users lack information about soil and climatic needs of species. Many extensionists lack a sufficient knowledge about soils to determine the type of soil on a farm, and don't have information about what species would be appropriate for a given soil. For many native species, edaphic and climatic needs have not been determined.

Many extensionists are unaware of the many promising MPTS. These species, many of which are exotic, could offer a much higher production of goods and services than traditional species.

Finally, extensionists lack information about where to obtain MPTS seeds. Frequently, they also lack the necessary knowledge about how to process and germinate seeds of native species that already are present in their country.

3.2 Establishment

Regeneration of MPTS in the Caribbean is obtained by planting nursery stock, direct seeding, vegetative reproduction or fostering natural regeneration. Natural regeneration is the traditional method of propagating MPTS, and planting of nursery stock is the most common means employed in recent projects promoting use of MPTS.

Nursery production techniques vary widely in the Caribbean, with container production being more often used than is bare root production. Polyethylene bags are most commonly used container, with a volume ranging from 400 - >3,000 cc, and commonly filled with alluvial soil (Liegel & Venator, 1987). In the AID/Haiti Agroforestry Outreach Project, small plug seedlings are produced in imported plastic book-like containers called Rootrainers (trademark of

Spencer-Lemaire Co., Edmonton, Alberta) with a volume of 177 cc (Dupuis, 1986). These containers are filled with an imported peat/vermiculite medium. Rootrainer designs with different dimensions and volumes have also been used in the project, as have other container types. A local potting mix has been developed, based on composted bagasse, which produced no significant difference in seedling survival, although growth was less for this mix than for the imported mix for L. leucocephala, P. juliflora, Parkinsonia aculeata and A. indica (Dupuis, 1986). Efforts are still underway to improve this local mix, as a means of increasing project sustainability. Styroblocks have also been tried in Haiti, but are not widely used. They are used with success on a production scale in the Dominican Republic (personal communication, Kevin Darrow, Los Arbolitos). Plastic bags have several limitations, as currently used in the Caribbean for nursery production. They are usually filled with heavy soil, resulting in deficient drainage. An excessive volume of medium is used, and although increased volume usually results in increased survival after outplanting, this greatly impedes the transportation of seedlings to the field and limits the number of seedlings a planter can carry. Bag dimensions are also sub-optimal for a given volume of soil; longer, narrower bags would give better results than wide, shallow bags. Furthermore, plastic bags take more labor to fill, and fewer fit into a given space in the nursery, than other container types. However, these deficiencies are manageable, by selecting bags of optimal proportions, developing potting mixes with good nutrient exchange and drainage characteristics, and by devising efficient bag filling procedures, such as the use of mixers, funnels or hoppers.

Bare root seedlings are produced less widely in the Caribbean than are container seedlings. Although it was the primary method used by the USDA Forest Service for producing stock for mahogany plantations in Puerto Rico, the Puerto Rican Department of Natural Resources now produces seedlings in plastic bags. The relative advantages and disadvantages of container and bare root production are discussed in Liegel and Venator (1987). Bare root seedling production could be used more widely in the Caribbean, with positive benefits on the economics of nursery production and tree establishment. A major potential of bare root production is its adaptation by farmers for production of MPTS seedlings for on-farm tree planting.

Although direct seeding is the most common method of establishing agricultural crops in the Caribbean, it is seldom practiced for establishment of MPTS. An exception is the direct seeding of contour hedgerows. The primary species used for contour hedgerows in the AID/Haiti Agroforestry Outreach Project is L. leucocephala. This species adapts well to direct seeding, because it produces abundant seed at an early age (in less than one year). One major reason for the rapid acceptance by Haitian farmers of the contour hedgerow technology is the ease with which they can adopt it, not having to rely on sophisticated nurseries to produce seedlings. Because of its ready acceptance by small farmers, direct seeding should be investigated for other MPTS in the Caribbean and elsewhere. Species that are copious seed producers, and those that produce large seeds, are more likely to be adaptable to establishment by direct seeding. Marrero (1950) reported that Maria (C. calaba), a species with a large seed, could be established easily and cheaply by direct seeding.

Many MPTS regenerate naturally on farms in the Caribbean, from germination of seed from natural seed fall, or from seed discarded or excreted after fruit has been consumed by the farm family, farm animals or wildlife. These seedlings are

either allowed to grow where they germinate, or are transplanted. Jamaican yards frequently have Cedrela odorata trees that are the product of natural regeneration. Allspice also regenerates naturally on Jamaican farms, but is sown from seed or reproduced vegetatively in commercial operations (Nair, 1980). Naturally regenerated secondary forest offers potential for management to improve products they provide. These secondary forests will be more important than planations to produce fuelwood in the Caribbean in the near future. Knudson et al. (1988) report on studies to manage naturally regenerated dry forests in the Dominican Republic for fuelwood. Management of coppice sprouts after fuelwood harvest was also studied.

A significant number of MPTS are regenerated vegetatively in the Caribbean, particulary species used in living fences. Some of the same species that are used as living fences are also used as shade trees for crops or yards, and are also propagated vegetatively for these uses. G. sepium, B. simaruba, S. purpurea, H. crepitans and Erythrina spp. are some of the more widely used MPTS that are propagated vegetatively for living fences.

On Caribbean small farms, most MPTS are interplanted with crops, and receive adequate care during the tending of the crops. Generally, MPTS should be outplanted at the beginning of the rainy season, to allow the maximum amount of time for growth and establishment before the dry season. This period usually coincides with the time when crops are being planted, so MPTS that are interplanted with crops are more likely to receive care than when they are planted in a separate part of the farm. The "parcelero" system employed on the Caribbean National Forest in Puerto Rico (Tropical Forest Experiment Station, 1941) was a version of the taungya system of establishing timber plantations. In this system, farmers that occupied land that had been bought by the Puerto Rico Reconstruction Administration for reforestation purposes were compensated for planting timber trees by being allowed to plant row crops in the first years of the plantations. This method of MPTS establishment, and modifications on private farms in which farmers crop amongst young plantations of their own trees, have promise for meeting farmers' needs to produce food at the same time that MPTS are established.

3.3 Intermediate Operations with MPTS

Tending of established MPTS plantings prior to harvest is an area in need of further technology development and transfer in the Caribbean. These operations imply an additional cost to farmers, that must be offset by benefits if farmers are going to adequately care for MPTS. Many intermediate operations, such as weeding, pruning and thinning plantations, will have a low opportunity cost for the small farmer, because they can be carried out when labor demands for tending traditional crops are slight.

Timber plantations in the Caribbean receive little attention after establishment. Since block plantations are usually established by government agencies or large farmers, rather than small farmers, weeding is generally carried out by contracted labor. The taungya system is a promising technology to defray weeding costs that should be more widely adapted. MPTS that are interplanted with crops benefit from the weeding given the crops. Competition between crops and MPTS certainly exists, but has not been quantified in the Caribbean.

There is inadequate information on optimum thinning schedules for timber species planted in the Caribbean, and many stands have stagnated because of crowding. Guidelines have been developed for liberation of mahogany line plantings in Puerto Rico (Bauer, 1988).

Pruning of timber trees can improve log form. However, no guidelines have been developed for pruning of timber trees in the Caribbean. Trees interplanted with crops are frequently pruned by farmers, to give room for crop development. Tree growth suffers when pruning is excessive, and long branch stubs leave infection courts for introduction of decay organisms.

Plantations account for an insignificant part of fuelwood produced in the Caribbean, and fuelwood plantation management guidelines are scarce. Care during the establishment phase of fuelwood trees planted in the AID/Haiti Agroforestry Outreach Project is provided for by programmed visits of project promoters to farms to monitor survival. During these visits, advice on tree maintenance is given to farmers. Contour hedgerows are pruned back periodically (coppiced) to allow room for crop development, and to provide green manure and/or fodder. Experiments in thinning of native dry forests to enhance fuelwood production in the Dominican Republic are reported in Knudson et al. (1988).

4. Harvest, Processing and Marketing of MPTS

If Caribbean farmers are going to increase their planting and care of MPTS, they need to receive the maximum return for these trees. Participation by farmers in the value added to their tree products through processing and marketing is a requisite to their receiving the maximum benefit from their use of MPTS.

Timber from Caribbean MPTS is harvested using a broad gamut of technology. On the simplest end of the scale, poles for climbing crops are cut by machete, and carried by hand to the field for use. Building poles are cut by hand and carried by animals or trucks to market. Traditional production of timber was by pit sawing, that was carried out at the stump. Small sawyers in Dominica use hand-held chainsaws, with impressive precision, to rip boards out of even large gommier (Dacryodes excelsa) logs. In Jamica, timber trees from home gardens, and cocoa and coffee plantations are felled by axe or chainsaw, skidded by farm tractor to the roadside, and loaded onto trucks for transport to small sawmills. Portable sawmills are being used in St. Vincent and Puerto Rico. Pine plantations in Jamica are harvested using rubber-tired skidders or sophisticated light cable systems, and carried by self-loading truck to a modern sawmill. Little volume and cost information is available for timber harvesting in the Caribbean. The Jamaican Forest Industries Development Company (FIDCO) annual logging report for 1985 reported 36,712 m^3 of pine harvested, at a cost of J$116/$m^3$ (approximately J$ 5 = US$ 1) (Budhlall, 1986). Transport of sawlogs and fenceposts cost J$57/$m^3$. Appropriate technology needs to be transferred to the Caribbean, that will allow small farmers or groups of farmers to receive the maximum possible value from their trees by processing and marketing them.

Fuelwood is most frequently harvested by hand in the Caribbean. Plantations of MPTS for fuelwood production provide a miniscule part of the fuelwood harvested in the Caribbean. Ehrlich et al. (1986) found that the yield from coppiced hedgerows was 68% fodder and 32% fuelwood, and recommended further trials to

determine harvesting cycles to maximize forage and fuelwood productivity. The hedgerows that they sampled had never been coppiced previously. It is likely that yields of both fodder and fuelwood would increase in subsequent rotations. Charcoal is generally produced in simple earth mound kilns. Various aspects of charcoal production using native dry forest trees are discussed in Knudson et al. (1988), including specific gravity and drying characteristics of species, comparisons of kiln designs and production costs.

Fruit harvesting from MPTS in the Caribbean is non-mechanized. Probably the majority of fruit is sold fresh, without special storage facilities such as refrigeration. One of the main constraints to fruit marketing in the Caribbean is the supply and demand cycle; when fruit is in season, the market is saturated and prices plummet. Development of varieties of a given fruit that bear at a different time of year than common varieties could allow farmers to receive much better prices for their fruit.

There is much hope in the Caribbean for development of new markets for fresh fruit in the U.S., Canada and Europe. Efforts are being made to inspect fruit for quarantine clearance in-country prior to shipment, and the USDA Animal and Plant Health Inspection Service (APHIS) maintains quarantine inspectors in several Caribbean countries. In Jamaica, hot water baths for killing fruit fly larvae in mangos are being installed. Grenada, St. Lucia and St. Vincent are in the process of obtaining fruit fly free status with APHIS, which should facilitate export of some fruits to the U.S.

Processing of fruit to prolong its storage life is a method of adding value to fruit by beating the supply/demand problem. While canning is a technologically simple processing method, most Caribbean agroprocessors lack the production capacity to supply markets in the developed countries. Specialty products can command a high price, but are not without problems. Canned ackee has a ready market among Caribbean expatriates in the U.S., Canada and Europe. Unfortunately, the presence of hypoglycine in immature ackee fruit has motivated the U.S. Food and Drug Administration to ban sale of canned ackee. The market for tropical fruit juice concentrates is growing, for both export and local consumption, and equipment for concentrating juice is inexpensive and simple to run. Frequently, the price of fresh fruit needed to make an equivalent amount of fruit juice concentrate is much below the price for concentrate. However, it was discovered in St. Vincent that the the proportional price of concentrate to price of fresh fruit equivalent (1:4) was roughly equivalent to the relative price of bananas sold to Geest, Ltd. compared to the price for fresh bananas in Kingstown (personal communication, Gary Morton, Diamond Dairy). The guaranteed market for bananas with Geest, as well as the technical assistance provided by the Banana Producers Cooperative, provide incentive for Windward Island farmers to continue to produce bananas. Local agroprocessing ventures, especially if producer-owned, could motivate Caribbean farmers to grow fruit-producing MPTS.

Few studies have been made of fodder production from MPTS in the Caribbean. Oakes & Skov (1962) studied productivity, protein content, ensiling qualities and persistance of Albizzia lebbeck, Cajanus cajan, Delonix regia, G. sepium and L. leucocephala in St. Croix. Persistent species were cut an average of four times per year, but growth depended on rainfall. G. sepium was the most productive and had the highest protein content, but did not produce good silage. Along with D. regia it also had a tendency to produce large stumps, that would interfere with mechanical harvesting. Pigeon pea had a low protein

content and died off after a year of repeated cutting. A. lebbeck and L. leucocephala were recommended as protein supplements for the Caribbean. Use of these species to provide fodder for livestock has promise to improve livestock productivity in the Caribbean. Production of silage should be encouraged as an alternative to letting animals loose to graze in natural forest during the dry season.

Harvesting, processing and marketing of secondary products from MPTS offer much potential for development and transfer of new technology in the Caribbean. In Jamaica, pimento trees suffer significant damage during harvest, because branches are broken to obtain the unripe berries. Bay oil cooperatives in Dominica manage a large number of rural distilleries that provide rural employment and allow producers to benefit from the value added to bay leaves with distillation. The extensive repertoire of folk medicines in the Caribbean might include MPTS with potential for development of new treatments for disease by the pharmaceutical industry that would provide a market for on-farm tree products. These many products from MPTS offer an appreciable incentive to small farmers in the Caribbean, if they can adapt appropriate processing technology and capture local, regional and international markets.

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