Agroforestry Systems **34**: 101–117, 1996.

Incorporating indigenous knowledge of fodder trees into small-scale silvopastoral systems in Jamaica

B.J. MORRISON[2], M.A. GOLD[1] and D.O. LANTAGNE[1]
[1] *Department of Forestry, Michigan State University, E. Lansing, Michigan 48824, USA;*
[2] *Consortium for International Earth Science Information Network (CIESIN), 2250 Pierce Road, University Center, University Center, MI 48710, USA*

Key words: *Brosimum alicastrum* (breadnut), *Guazama ulmifolia* (bacedar), silvopastoral systems

Abstract. A study was conducted to identify and explore indigenous knowledge relating to fodder trees and silvopastoral management systems of small-scale farmers in seasonally dry areas of Jamaica. The objectives of the study were to: 1) explore farmers indigenous knowledge relating to fodder trees and silvopastoral management systems in a subtropical dry climate; 2) examine pastoral land-use systems and technologies in current use; and 3) seek to integrate this information into silvopastoral tree fodder systems. Data were gathered via observation and semistructured interviewing. A snowball sampling strategy was used to purposively select all small-scale farmers who had cattle in the Green Park valley for interview.

Of forty farmers interviewed, 37 males (92.5%) and 3 females (7.5%) were primary caretakers of cattle. Twenty-seven of 40 farmers (68%) raised cattle to generate income. During extended droughts farmers are forced to look for alternatives to desiccated, overgrazed pasture grasses, including: 1) local travel to harvest sugar cane tops and to cut Guinea grass (*Panicum maximum*); 2) purchase of bag feed; and 3) harvest and use of tree fodder. Preferred fodder trees were identified as Bacedar (*Guazama ulmifolia*), Guango (*Albizia saman*), Breadnut (*Brosimum alicastrum*) and Quickstick (*Gliricidia sepium*).

Recommended silvopastoral management systems include fodder hedgerows, three strata forage systems, and living fences. In addition, production of indigenous fodder tree species, introducing improved tree fodder species, and planting improved pasture grasses concurrent with cash trees is suggested.

Introduction

The Jamaican Agricultural Research Program (JARP), in cooperation with the Department of Forestry at Michigan State University, has targeted the Green Park area of Trelawny Parish, Jamaica (Figure 1), as an on-farm research/demonstration site for launching silvopastoral innovations with small-scale farmers. Planting and active management of fodder trees as a source of dry season cattle fodder is one innovation under study. On-farm research was undertaken from 1990–1993 in order to examine the validity and increase the potential success of such an innovation.

This paper has two main objectives: 1) to report on indigenous knowledge specific to fodder trees in Green Park, Jamaica; and 2) drawing upon results of subsequent on-farm field trials and experience from other regions of the

world, to suggest how this information can be integrated into silvopastoral tree fodder systems in seasonally dry areas of Jamaica.

Agroforestry, animals and fodder trees

The importance of ruminants in agroforestry systems is widely acknowledged (Jones, 1988). They provide food, income, traction, transport, fertilizer and fuel (via dung) thereby reducing risks associated with cropping. They may also contribute to social status or satisfy cultural needs (McDowell, 1980). Inadequate nutrition is a major constraint to generating more income from ruminants in these systems as often only maintenance (or subthreshold) levels of energy intake is available for much of the year (Jones, 1988). Providing energy and protein in excess of maintenance is essential to improving animal production. This may be achieved by purchasing expensive bag feed, by using supplements to improve the efficiency of existing feeds, or by increasing quantity and availability of locally produced alternative fodder resources.

Information available regarding actual fodder productivity and yield of trees and shrubs is limited, but beginning to accumulate (Le Houérou, 1980; Skerman et al., 1988; Devendra, 1989). Rusten (1989) found that farmers in one village within the middle hills of Nepal relied on fodder trees for up to 50% of the intake needs of livestock throughout the year. Twenty-eight species (22%) and 4,519 individual trees (33% of the total number of private, on-farm trees surveyed) were used exclusively for animal fodder. In Colombia, Murgueitio (1990) reported promising results from three years of testing an agroforestry model based on utilizing sugar cane and protein-rich, nitrogen-fixing trees and shrubs as an alternative to extensive cattle-grazing systems.

In drought-susceptible regions it is often difficult for cattle farmers to feed their livestock on fodder grasses alone. During droughts, grass production slows or ceases. Although there may be other alternatives available, increasing the tree fodder resource is an inexpensive way (in terms of capital outlay) to help farmers bridge the dry-season fodder gap (Von Carlowitz, 1989).

Indigenous knowledge and rural development

Indigenous knowledge of trees and tree management represents knowledge that has evolved over time, based on local experience, using local resources, adapted to local conditions. Further, this intimate knowledge represents detailed information of all aspects of land use management and is dynamic, undergoing constant change and development in response to changes in the internal and external environment. Finally, this knowledge, typically based on oral tradition, is being lost as populations migrate from rural to urban areas.

At present it is increasingly common to incorporate indigenous agricultural knowledge into the design of agricultural research projects and extension

programs in developing countries (Warren et al., 1995), however until recent years this was seldom done (Schafer, 1989). This oversight contributed to the failure of many development plans. Project planners, administrators, and research scientists, armed with specialized disciplines and information, created and implemented plans that affected farmers without consulting them in more than a cursory fashion (Chambers, 1983). Increasing numbers of development professionals now recognize that non-Western societies have sophisticated resource management strategies and a wide spectrum of knowledge in agriculture, livestock rearing and tree utilization. Project planners now realize that under certain circumstances this knowledge may superior to knowledge introduced by outsiders (Mathias-Mundy et al., 1992).

Small-scale farmers in St. Vincent have demonstrated an abundance of local knowledge and environmental awareness that is skillfully used in managing their farming resources despite governmental intervention (Collymore, 1986). Their decision-making centers around the extent of cultivation, crop types and combinations, fertilizer use, and market outlets. Carloni (1984) reported that farmers in a hillside project in Jamaica were highly adept in traditional mixed farming and could be very articulate about their reasons for allocating their land, labor, and capital.

Brokensha and Riley (1980) claim that a successful agricultural development plan should 'emphasize both local vegetation and local knowledge of plants'. One way to do this is to explore indigenous knowledge of small-scale farmers (Howes, 1980). Rusten and Gold (1991) carried out research on indigenous knowledge of fodder tree resources by small-scale farmers in Nepal. Farmers in their study demonstrated a sophisticated knowledge of fodder trees and tree fodder, leaf fodder nutrition, proper season for harvest, and the effects of tree fodder mixtures on animal health.

Study site

Green Park, Jamaica (latitude 18°27′ N, longitude 77°42′ W) is located six km from the northern coastal town of Falmouth (Figure 1). The study site is situated in a rolling valley, comprising five square km with the elevation ranging between 70 and 232 m above mean sea level.

The climate, heavily influenced by orographic rain, brings northeast winds, periodic rains and cooler temperatures from November to March, with annual precipitation averaging 1140 mm (Regional Research Centre, 1970). Minimum temperatures vary between 18 °C and 22 °C and maximum temperatures vary between 29 °C and 33 °C. The area is prone to drought between January and August, with more than 6 months of the year averaging less than 100 mm rainfall per month. During these drought periods, attempts to grow crops are curtailed and pasture grasses become desiccated.

Nearby dry limestone hillsides contain severely disturbed tropical dry forest

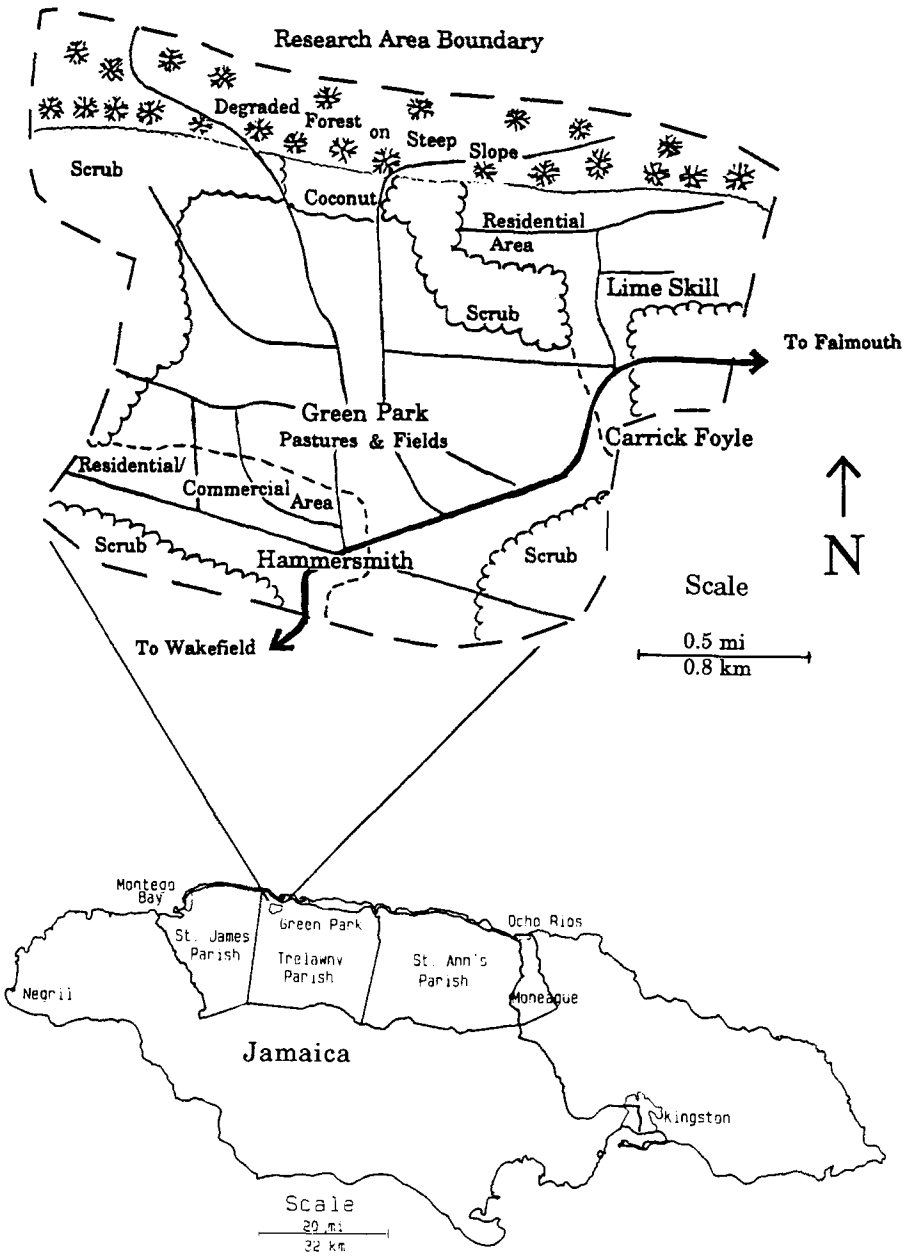

Figure 1. Map of Jamaica and Green Park research site.

vegetation (Kapos, 1986). Disturbance ranges from: 1) hurricanes and strong winds; 2) removal of trees for charcoal production; 3) clearing for expansion of pasture land; and 4) clearing to plant crops. Cleared forest limestone soils are not especially productive for agriculture due to their shallowness and

scarcity of water and nutrients. Green Park soils are generally made up of loam with limestone subsoils suitable for timber production, improved pasture, sugar cane, and vegetables (Kapos, 1986).

Unlike most Jamaicans, most Green Park farmers have not acquired their holdings through ancestral inheritance. Historically, Green Park was a sugar cane estate with facilities and equipment to process cane into sugar. In 1955 the estate was closed and the Kaiser Bauxite Mining Company acquired the estate property and nearby forested hills. The mining company divided up the land into parcels and used them for resettlement purposes. In the 1960s and 1970s, in various areas throughout Jamaica where Kaiser Bauxite wanted to mine, farmers were given the opportunity to acquire a parcel of land and relocate elsewhere. Green Park was set aside as one area for relocation. A few farmers opted to relocate to Green Park from other areas, while others sold their acquired Green Park parcels to nearby inhabitants or to Jamaicans who had been working overseas, returned, and were in search of a place to settle. As such, the general makeup of the Green Park population today is quite varied.

At present, the Green Park valley consists of approximately 90 households. All of the farmers in the study have secure tenure, or have access to some land and tree resources with an average of 11.4 acres (range 1.5–50) available for raising cattle (82.2% of total acreage). None of the farmers belonged to the Jamaican Livestock Association or any other organized group. The cattle farmers who were interviewed were represented as follows: 10% were relocated from nearby parishes, 10% worked overseas and resettled in Green Park, 12.5% grew up in the area, and 67.5% lived outside of the valley and purchased parcels in Green Park from residents who were moving out or from resettled farmers who did not move to Green Park from mining areas.

Materials and methods

Multiple approaches to collecting field data will help overcome the weaknesses of any one strategy (Babbie, 1995; Crane and Angrosino, 1974). Data were gathered via simple observation and semi-structured interviews (Babbie, 1995; Casley and Kumar, 1988; Knoke and Kuklinski, 1982). These methods were used as a means to gather more reliable information, add depth of understanding, and reduce error (Webb et al., 1966).

Boundary specification is an important step in snowball sampling (Wasserman and Faust, 1994). The boundary for this sample was small-scale farmers with cattle in Green Park. Initially, a short list of small-scale farmers' names were collected during an introductory meeting with the farmers; other qualified farmers in the valley were added when they were mentioned during interviews with farmers or during meetings with the facilitator. Also, since results of the research were intended to be used in a project design for small-scale farmers, those valley farmers with over 40 head of cattle (large-scale

farmers) were eliminated. Lack of time prevented additional farmer interviews in other zones, so names of these farmers were eliminated.

From April to June, 1990, the researchers worked closely with one farmer who lived in and knew the community well. This individual served as a logistician, facilitator, translator (patois to English), and as an interpreter at times and was the key reason that almost 90% of the small-scale cattle farmers in Green Park agreed to be interviewed.

A three-page research interview guide was developed to elicit verbal responses. The interview guide was created before the study, and revisions were made during the initial weeks of the study. Interviews were conducted to gather baseline quantitative information and qualitative indigenous knowledge relating to cattle farming in Green Park. These open-ended interviews were guided by a list of questions that focused on main topics and subtopics to be covered (Table 1). A portable cassette recorder was used to record (and later verify) verbal responses during interviews.

Results and discussion

From a list of 45 names, 40 small-scale cattle farmers agreed to be interviewed, 32 Green Park residents and 8 non-residents who had cattle in Green Park (37 males and 3 females). Ages ranged from 37 to 77 years, averaging 60 years. The farmers collectively had almost 400 head of cattle: 11 bulls, 193 cows, and 194 calves. Eight (20%) farmers had automobiles; 5 (12.5%) had pickups or trucks, while the remainder relied on motorbikes, bicycles, donkeys, and walking.

Twenty-seven interviewed farmers (68%) cited income generation as one reason they raise cattle. Farmers referred to their cattle as 'walking banks', gaining higher interest and involving less risk than any other investment within their means, with options for liquidation on short notice. Local demand for beef has been steady over the past few years, so raising cattle remains one of the best alternatives for income generation.

Cattle farmers in the Green Park valley have private pastures where their animals graze on succulent grasses as long as rainfall amounts are sufficient. These grasses include: *Cynodon plechtostachyus* (African Star), *Panicum maximum* (Guinea), *Andropogon pertusus* (Seymour), and *Panicum muticum* (Brachiaria). African Star (introduced in the mid-1970s) and Guinea grasses hold up well under the pressures of drought and grazing. Seymour grass survives lengthy drought periods, but re-emerges more slowly than African Star and Guinea grasses. Brachiaria (also introduced) does not survive well under pressure of grazing and drought. *Pennisetum purpureum* (Napier grass) is not grazed but managed like *Saccharum officinarum* (Sugar Cane) and is cut and carried from non-pasture areas.

When rains taper off, grass production slows or ceases causing a gap in the fodder supply. Even though the majority of farmers have mixed breeds (Jamaican Red Poll × Local or Jamaican Black × Local) that hold up well

Table 1. Semistructured interviews and observational data categories and collection methods used in identification of farmers' indigenous knowledge.

Categories	Interviews	Observation
General Information		
Farmer's age; gender; occupation	X	
Years in Green Park; years raising cattle	X	
Means of transportation	X	
Underemployment in the area		X
Farmers' involvement in projects	X	
Farmers' knowledge about plowing with animals	X	
Animals other than cattle raised by farmers	X	
Impediments to raising other animals	X	
Vegetable crops raised by farmers	X	
Problems with securing labor for farm work		X
Problems with praedial larceny	X	X
Farmers' outlook on government policy & programs		X
Trust within the farming community		X
General Cattle-Related Information		
Time spent doing tasks	X	
Reasons for raising cattle	X	
Impediments to raising cattle	X	X
Interest in continuing raising cattle	X	
Number of cattle; number that died during drought	X	
Acreage available to raise cattle	X	
Service bull information	X	
Methods of cattle and paddock management	X	
Costs involved with cattle/paddock management	X	
Selling Cattle		
Who is involved in selling cattle	X	
Price paid for selling cattle	X	
Age of cattle when selling	X	
Steps involved in a feasible sale		X
Fodder/Tree Fodder Information		
Fodder available with/without adequate precipitation	X	
Methods of and time and cost involved in retrieval	X	
Techniques related to tree fodder management	X	
Knowledge of tree species used for tree fodder	X	
Fodder tree reproduction and seasonality of fruiting	X	
Process involved in planting trees	X	

under drought conditions, they are forced to look for alternatives. Sugar cane tops and local roadside Guinea grass are used extensively until the cane harvest is over and the summer drought strikes hard, generally in June or July. In 1975, a drought occurred for 12 consecutive months, and in 1989, a drought lasted for 6 months.

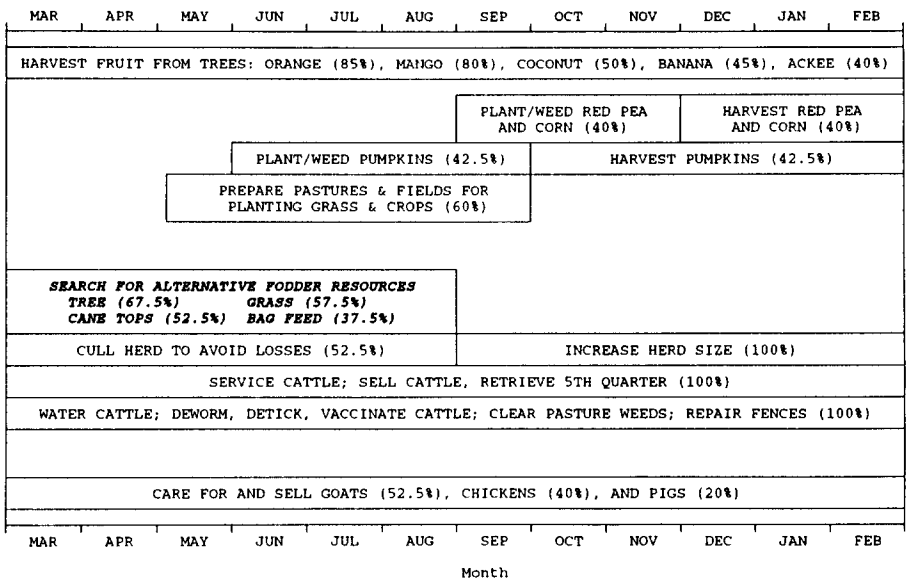

Figure 2. Annual profile of agricultural activities and distribution of labor by Green Park farmers (% of farmers involved).

During extended droughts, farmers have four alternatives to keep their cattle fed. One alternative is to procure sugar cane tops. A second is to travel further inland where rainfall is sufficient for year round growth of Guinea grass. A third is to obtain expensive purchased bag feed. The fourth alternative is to use tree fodder. In actuality, farmers use a combination of all four, but trees are the only local resource available to fill the fodder gap (Figure 2).

Trees, alternative fodder resources

'When cattle cannot find adequate pasture grass to graze', one farmer said, 'they look up, and what do they see? Trees!' Cattle browse on leaves or fruits of certain tree species found growing in the fenceline or free-standing in the occupied pasture or along paths between pastures and water sources. These management systems can be considered passive, as the farmer does not actively pursue, plant, or manage these trees as fodder sources. The extent of active management systems in Green Park to date is exemplified by farmers who take their cattle outside of their pastures to graze on trees along the roadside and in the nearby forests and those who search for tree fodder resources.

Twenty-nine (72.5%) farmers said that they collect tree fodder when needed. Thirty-eight farmers (95%) mentioned at least one fodder tree species that they currently use or that could be used as an alternative to grass. These farmers described a total of 17 tree species that were or could be used for

fodder. Species most often mentioned were *Guazama ulmifolia* (Bacedar), *Albizia saman* (Guango), *Brosimum alicastrum* (Breadnut), and *Gliricidia sepium* (Quickstick) (Table 2).

Based on interview data, *Guazuma ulmifolia* (Bacedar) was the most commonly mentioned local tree fodder source and the only species used in all five locations commonly used by farmers, i.e., pasture, fenceline, forest, around the household and along the roadsides. Both leaves and fruit are fed to cattle (Table 2). It is indigenous to Jamaica and is a medium size tree, growing up to 16 m high (Adams, 1972). The fruit falls from November through April; leaves are obtained by cutting branches with a cutlass, usually in late summer when other fodder resources have diminished due to drought. Most Bacedar trees are found in pastures and along roadsides.

Bacedar trees in Green Park are not numerous. General observation of paddocks reveal an average of 1 to 3 trees per ha, usually found alongside the fenceline. Every observed tree had been lopped. Leafy branches are immediately eaten by animals beneath the tree where the farmer has selectively lopped. Although farmers focus on harvesting Bacedar leaves, the fruit is also eaten by animals.

Albizia saman (Guango) is a fast-growing, multipurpose, nitrogen fixing tree indigenous to Jamaica and found throughout the tropics (NFTA, 1987a), providing fruit and leaves for fodder. Guango is used in multi-layered tropical agroforestry systems, providing shade for cacao, coffee, vanilla and nutmeg (pimento). The pods measure 10–25 cm long and 15–18 mm wide and are available from December to May (Adams, 1972). When drought is severe, the leaves are also used for fodder. Thirty of the thirty-three farmers who mentioned Guango as a fodder species have the tree in their pastures, although it also occurs along the roadside. In nearby forests it can grow to be a large tree (up to 20 m). Guango tolerates a broad range of soil types (NFTA, 1987a).

NFTA (1987a) reported that mature Guango pods have a crude protein content of 12–18% (dry matter). Farmers perceive the pods as one of the best fodder sources in Green Park. A medium size tree (10–15m) might yield 5 kg of pods per week. Two farmers were observed collecting pods.

Farmers like Guango trees in their pastures and along the roadside for four reasons, three of which are documented elsewhere (NFTA, 1987a). First, cattle eat accessible nutritious pods and leaves without input from farmers. Second, cattle are attracted to the shade of Guango trees, offering a cool place to rest in the heat of the day. Third, grass grows better around and under Guango trees than in the open. Fourth, three farmers in Green Park inferred that cattle eating Guango pods drink more water, and in turn eat more grass, than those cattle that do not. They concluded that the cattle that eat Guango pods are healthier and better able to maintain their weight during times when fodder grasses are dry.

Improved grass growth under Guango is thought to be due to soil enrichment from recycled leaf litter (Halliday, 1984; NFTA, 1987a). Cattle dung

Table 2. Green Park farmers' knowledge of fodder tree species, location and part of trees used.

Local Name	Latin Name	No. of Farmers Mentioning Trees	Location					Parts of Tree Used		
			Pasture	Fence-line	Forest	Around House	Roadside	Leaves	Fruit	Both Leaves and Fruit
Bacedar	*Guazama ulmifolia*	36	29	2	5	2	12	10	2	24
Guango	*Samanea saman*	33	30		2		14	1	22	10
Breadnut	*Brosimum alicastrum*	18	6		14			15		3
Quickstick	*Gliricidia sepium*	9		8		1		9		
Logwood	*Haematoxylum campechianum*	6	5		1	1		6		
Bujgum	*Bursera simaruba*	5	3		1			5		
Dogwood	*Piscidia piscipula*	4	3		1	2		4		
Bamboo	*Bambusa vulgaris*	3	2		1			3		
Almond	*Terminalia catappa*	2				2		2		
Figwood	*Ficus* spp.	2	1				1	2		
Mango	*Mangifera indica*	2						2		
Mimosa	*Mimosa* spp.	2	2					2		
Never Die	*Erythrina corallodendrum*	2		2				2		
Trumpet Tree	*Cecropia peltata*	2			1		1	2		
Wild Tamarind	*Leucaena* spp.	2	2							

N = 40.

also adds nutrients to the soil, demonstrating the symbiotic relationship between tree and animal. NFTA also reported that grass dry matter production under *Albizia saman* was not significantly reduced and had a higher protein and lower fiber content than unshaded grass in a control plot.

In spite of its benefits, farmers limit the number of Guango trees in their pastures. Too many trees create a closed canopy, limiting penetration of sunlight, thereby reducing or eliminating grass production. One farmer girdled most of the trees along the fence bordering his paddocks. Given the benefits, a heavy pruning of Guango trees is more beneficial than complete removal.

Green Park farmers reported that *Brosimum alicastrum* (Breadnut) is a prized fodder tree. This species grows slower than Bacedar or Guango, reaching 10–30 m in height, and is indigenous to Jamaica, as well as Cuba, Central America, and northern South America (Adams, 1972; Pardo-Tejeda and Muñoz, 1980). The few remaining Breadnut trees in Green Park are found primarily in the forest on hillsides surrounding the valley, although a few trees are found in or at the pasture margins.

Fifteen farmers (37.5%) mentioned that Breadnut leaves are cut and fed to cattle as fodder. As Breadnut currently exists in the hillside forest, branches are cut and carried to the cattle or lopped for the animals beneath the tree. The yellow fruits are relatively small, measuring 1.5–2.5 cm in diameter (Adams, 1972). Only three farmers use the fruit, although Pardo-Tejeda and Muñoz (1980) reported that on the basis of amino acid content, seeds of Breadnut compare favorably with other animal feeds currently in use.

Breadnut is also highly valued for charcoal production, which is used as a means of income generation for some people in Green Park. Breadnut is on the verge of local extinction in the Green Park valley, due to losses from hurricane Gilbert (in 1988), heavy lopping for fodder, and removal for charcoal production. Charcoal producers have few means of survival and little alternative to cutting Breadnut, regardless of the damaging impact. Although charcoal producers work primarily in the forest, instances of illegal trespass onto private land are causing conflict between farmers and charcoal producers (Eyre, 1987). On-farm experimentation with Breadnut establishment in Green Park indicates that seedling production is feasible. Timing of seed collection and planting are crucial to success. Use of container grown seedlings are recommended over bareroot stock (Morikawa et al., 1994).

Gliricidia sepium (Quickstick) is known and used in Jamaica as an alternative fodder resource. Farmers plant Quickstick as living fence posts. The fast-growing tree reaches heights of 5–6 m, producing 10–12 cm long pods (NFTA, 1987b). Nine farmers mentioned that Quickstick leaves are used for fodder, but only six farmers have planted it, and only two have done so on a scale that would provide them with a resource for more than a day or two of fodder every three or four months. None of the Green Park farmers were aware of the highly nutritious value of Quickstick fodder, but three farmers mentioned that cattle needed to acquire a taste for the leaves before it became a part of their diet.

Interviews did not indicate why or when Quickstick was introduced into the area. In addition to two farmers who had significant numbers of Quickstick, seven other farmers referred to it as a living fence post, adding strength to the fence. Established by cuttings, Quickstick proved vulnerable to the damaging winds of hurricane Gilbert, and tended to blow over. Wind-damaged Quickstick growing in the fenceline made it difficult to repair the barbed wire around farmers' pastures.

Acquisition and provision of fodder to cattle

Twenty-nine (72.5%) farmers collect or use tree fodder (fruits and leaves) when needed. Only three fruits are eaten by cattle: Bacedar, Guango, and Breadnut. Farmers either take their cattle to eat fruit on the ground at the site or they collect fruits and bring them to the animals.

Based upon interviews with the 40 farmers, leaves of all 17 tree species (Table 2) are eaten by cattle. Again the farmers may take their cattle to a nearby area where the leaves are, or if the area is far from the cattle (over 1 km), the farmers transport the fodder leaves back to the paddock or house. Once at the site of the trees, farmers cut the branches, drop them to the cattle grazing beneath, or collect and transport them to the cattle. Some of the older farmers said that they would get help to do this.

Sixteen (55%) of these farmers procure the help of others when collecting fodder, half of them getting aid from family members, half from neighbors or hired workers. Initially, they search for fodder locally, within the valley, but some travel further inland (Figure 1). Time spent cutting and/or collecting all supplemental fodder varies between 0 and 14 person-hours per day, averaging 3.2 person-hours per farmer (Figure 2). Hours reflect totals for all participating, farmers plus family members, helpers, or laborers.

Recommendations

Incorporating fodder trees into silvopastoral systems

There are many ways to bring tree fodder into existing pastoral systems. Optimal management of fodder tree production involves the regulation of several key factors including cutting height and frequency, and tree density (Horne et al., 1985; Morikawa et al., 1995). A few of the more viable practices are drawn from the insights gained in this study, additional on-farm research conducted in subsequent studies under this project, the authors' own experience and other reported research.

Hedgerow systems

A silvopastoral hedgerow system might include growing fodder grass between alleys bordered by rows of fodder trees planted a specified distance apart

(Atta-Krah and Sumberg, 1988; Krecik et al., 1993; Wilson et al., 1986). These trees are trimmed back periodically. Another method of augmenting tree fodder is to introduce woody plants into the pasture system either as hedgerows or living fences. Realistic strategies for fodder tree management in drought prone areas require leaving the trees intact until grass fodder supplies become unavailable. Trees should then be harvested on an intense cutting cycle. Following a period of intense harvest, trees can be left intact or harvested periodically to maintain a shrub-like habit, until the next seasonally induced fodder shortage. This system would permit heavy extraction of tree fodder during periods of greatest need, and the subsequent rest period would allow a restoration of vegetative growth capacity (Morikawa et al., 1995).

Three-strata forage systems

An agrosilvopastoral system innovation currently in use in dryland areas of Bali, Indonesia, has potential for Green Park, other seasonally dry areas of Jamaica and elsewhere. The system has been named the three-strata forage system (TSFS) in which forage, food crop and cattle production complement each other (Lana et al., 1989). TSFS refers to planting and harvesting forages to provide a year round source of fodder and combines many of the suggested practices mentioned into one integrated system (Nitis et al., 1989). The first strata consists of grasses and ground legumes predominately for use during the rainy season. The second strata, shrub legumes, provides a fodder bank to harvest during the middle of the dry season. The third (arboreal) strata consists of fodder trees producing fodder late in the dry season. The overall objective of the TSFS is to increase farmers' incomes via improved land management systems consisting of crops, managed pasture, a woody perennial bank of fodder shrubs, fodder trees and animals.

Living fences

As part of raising cattle on private pastures, farmers have need for fenceposts. Farmers' species preferences for fenceposts are listed in Table 2. Two species, *Erythrina corallodendrum* (Never Die) and *Gliricidia sepium* (Quickstick) are used as living fence posts; both are propagated by cuttings, but Never Die establishes itself more easily than Quickstick (Rupert Brown, pers. comm.).

Never Die is indigenous and has been used traditionally as a demarcation post, usually planted at the point where one farmer's pasture boundary meets another's. As a recently introduced exotic, Quickstick is used more generally along the fenceline, adding strength to the fence. Never Die withstood the high winds of hurricane Gilbert much better than Quickstick.

Summary and conclusions

During extended droughts cattle farmers are forced to look for alternative feed sources that will substitute for the overgrazed and dried out pasture grasses

located on their own farm properties. These alternatives include regional travel to gather sugar cane tops or to cut Guinea grass (*Panicum maximum*), the purchase of imported and expensive bag feed, or the harvest and use of tree fodder. During drought, twenty-nine (72%) of the cattle farmers interviewed collected and used tree fodder. Seventeen tree species were identified that were or could be used for fodder. Preferred fodder trees are Bacedar (*Guazama ulmifolia*), Guango (*Albizia saman*), Breadnut (*Brosimum alicastrum*) and Quickstick (*Gliricidia sepium*).

Understanding the dynamics of existing indigenous silvopastoral farming systems is essential to agroforesters who attempt to successfully co-design workable systems (Gow et al., 1989). In Green Park, Jamaica, these dynamics include: 1) the preference for using breadnut as a fodder species of choice in Jamaica, coupled with the knowledge that breadnut is an exploited, diminishing resource used by charcoal makers in surrounding forests and must be actively cultivated on-farm in the future; 2) the knowledge that farmers rely increasingly on beef cattle for income stability; and 3) the fact that farmers do not stall feed their cattle as this places greater demands on time spent doing regular farming activities.

When local farmers are consulted and given a chance to explore new technologies there have been some stunning successes (Fortmann, 1988). As most of the farmers currently living in Green Park are originally from other, wetter parts of the island, they expressed an interest in learning some of the methods being used successfully by farmers on the drier parts of the island. During the course of the on-farm fodder tree research activities in Green Park, interested cattle farmers were taken on a field trip to the south coast to observe working fodder banks on two small farms in order to learn how (and why) to make and feed molasses-urea blocks to improve fodder digestibility and observe other dry land farming techniques. These field trips were very well received by Green Park's cattle farmers.

Based on the results of this (Morrison, 1991) and subsequent studies in Jamaica (Krecik et al., 1993; Morikawa et al., 1994, 1995), coupled with information from other regions (Devendra, 1989), the most viable options for incorporating or further expanding silvopastoral systems are in fencelines, in fields with crops or grasses, in pastures or, combining these systems along the lines of the TSFS fodder bank system developed in Indonesia. Given identified constraints of land and labor, a realistic strategy for fodder bank management by small scale Jamaican cattle farmers is to maintain fodder trees intact until fodder supply becomes critical. Results from Morikawa et al. (1995) suggest that this strategy would be suitable for these seasonally dry conditions. Increased local production and use of indigenous fodder tree species already valued for fodder production (especially Bacedar and Breadnut), introducing improved varieties of tree fodder species (*Leucaena* hybrids and Quickstick), and planting improved pasture grasses at the same time as cash trees are suggested.

Acknowledgements

Thanks go to Dr. George Wilson and Dr. Lyndon McClaren of the Jamaica Agricultural Research Program for their support in establishing this project and the Jamaica Agricultural Development Foundation for providing the major source of financing for the field research. A special thank you to Mr. Rupert Brown, Green Park farmer, whose advise and hospitality was key to the success of this research. Thanks are also due to Dr. Donald Kass, CATIE, for his review and insightful comments on an earlier version of this manuscript.

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