PN-AAR-715 37960

THE POTENTIAL OF CHARCOAL PLANTATIONS FOR HAITI

BY

RONALD SMITH

Prepared for the United States Agency for International Development

Port-au-Prince, Haiti

November 4, 1980

ACKNOWLEDGEMENTS

I would like to thank John Becker and Glenn Smucker for their invaluable assistance in organizing and refining the material used in this report.

TABLE OF CONTENTS

	Page
SUMMARY	i - iii
INTRODUCTION	
SPECIES SELECTION	1
Neem	2
Leucaena leucocephala	4
Cassia Siamea	5
Eucalyptus camaldulensis	5
Casuarina equisatifolia and cristata	6
NURSERY ORGANIZATION	6
NURSERY TECHNIQUES	7
Direct seeding	7
Bare-Root Planting	8
Plastic Sacks	8
Mini-Containers	9
Chart: Capital Investment for Speedlings Versus Rootrainers	12
Chart: Nursery Costs For Speedlings vs. Rootrainers	12
TECHNICAL ASPECTS OF PLANTING IN THE FIELD	14
Spacing	
Firewood and Poles	
FIVE EXPERIMENTAL CHARCOAL BURNS	17
Burn I. -- Casuarina cristata	18
Burn II. -- Cassia siamea	19

SUMMARY

Haiti is suffering extensive environmental damage that is directly related to the consumption of wood resources in the form of firewood and charcoal. The price of these commodities is steadily rising as supplies decrease, and transportation lengthens. This study explores the potential of tree farming on a private enterprise basis for the express purpose of producing charcoal. It focuses on an income analysis of the present land use patterns for both plantations and subsistence farming, and compares them to the projected income for charcoal on the same given land space.

The study includes technical considerations such as species selection, nursery techniques, spacing, conversion factors from wood to charcoal, appropriate planting sites and their productive potential, and comparisons of tree mono-cropping versus the inter-cropping of trees with other agricultural crops.

Some general conclusions that can be drawn from the study are as follows:

(1) Even with conservatively calculated growth increments, charcoal plantations seem to be able to compete with most subsistence agricultural enterprises on a dollar and cents per year basis. The first cutting usually pays for the extra cost of planting and still yields a margin of per year profits somewhat higher than that which would be obtained from subsistence crops. Because of the reduced time lapse between the first and second

cutting, and because of the absence of planting costs on the second cycle, the second cutting profit margins are considerably higher than the first, and show a clear income advantage over subsistence agriculture on the same land site.

(2) It would appear that large-scale plantation style charcoal production competes successfully with most of the present large-scale plantation crops grown in Haiti, but with no significant profit margins per carreau over the small producer. It is conceivable that a land owner with a large land space could accept a lower margin of profit per carreau. On sugarcane land, this would quickly eliminate the small profit advantage of charcoal over cane, but on sisal land, the income differences are greater, thus greater price drops could be tolerated.

(3) Experiences here in Haiti and in other countries indicate that the inter-cropping of trees with traditional agricultural practices offers one of the best possibilities of success when working with the subsistence farmer. There is often a mutually beneficial relationship that develops between the two cropping systems. On the one hand, the trees are weeded and protected from the animals during the early stages of development, while on the other hand, the tree offers increased moisture retention, and (in the case of the leguminous varieties) additional nitrogen for the food crop.

(4) Charcoal production is a labor intensive process. The biggest expenditures are not in planting the forests, but rather in cutting the wood, and converting it to charcoal.

(5) At least on some sites, new nursery techniques can greatly improve the cost-benefit ratio for tree planting. While the traditional plastic sack costs $53.00 per thousand at the Farm Gate, and consumed 20 man-days per thousand to plant, the mini-containers cost $15.00 per thousand at the Farm Gate, and take only six man-days to plant. The survival rate of the mini-container is as yet untested on dryer sites, so we should move cautiously in introducing this system to these areas.

(6) There are a number of fast-growing tropical trees suitable for charcoal production, that adapt themselves well to a variety of environments. In choosing species, premium value was placed on growth rate, wood density, and ability to coppice (resprout from the stump when cut) consistently and vigorously. The five species selected (Leucaena leucocephala, Cassia siamea, Casuarina cristata and cauisetifolia, Azadirachta indica, and Eucalyptus camaldulensis) all had these qualities. Test charcoal burns of all but the Azadirachta indica indicate that these species make a high quality charcoal that would be commercially viable on the present market.

(7) While there is an increase in total volume of wood produced as tree spacing becomes closer, there is a point at which crowding begins, and the growth increment drops off. Trees should be spaced with a clear idea of the desired tree diameter in order to get maximum volume without reduced growth rates. The idea of close spacings for early firewood production does not seem to be viable option, since it costs more to grow the trees than the returns will yield in this form. It does appear that there is a good pole market that could be filled either with a plantation exclusively for poles, or with careful planning, as an early thinning in a charcoal plantation.

The deforestation of the countryside in Haiti is a long-standing and well documented problem. It is well known that 80% of the wood volume harvested in Haiti is for combustibles. It is well known that large land surfaces are being stripped of their cover, and that now whole areas of Haiti are exhibiting vegetative life forms that should be typical of a much dryer environment. This all is toward Haiti's desertification) brings with it pseudo-drought (drought caused by lack of water retention, rather than by lack of rain), severe erosion problems, a marked decrease in agricultural productivity, and an increasing scarcity of wood and wood products. The question is, what should be done about it? When I first came to Haiti more than a decade ago, the assumption of many was that Haiti was still a "developing nation". As such it was perceived as being on the verge of leaving behind such [illegible] forms of energy consumption as wood and charcoal. This mindset meant that the few efforts that were made in reforestation did not center around [illegible] that were directed toward the increased production of [illegible]. Today it is clear that the environmental crisis in Haiti is [illegible] directed to what has been termed "the poor man's energy crisis" wood and charcoal. Wood will be the only source of cooking fuel for most of the population of Haiti for sometime to come, and if a [illegible] level for the rational production and consumption of wood, it will mean increasing scarcity, and increasing environmental degradation for the whole country.

The purpose of this study will be to explore the feasibility of developing a private enterprise approach to the problem of wood production for fuel. It will explore the advantages and disadvantages of both large plantation scale production, and small decentralized owner-operated type [illegible] with a view toward developing an analysis of the comparative advantages and disadvantages of each system.

The [illegible] of the study will be that only a profit motive will induce either large or small scale producers to invest in the production of charcoal. If this endeavor does not have the potential of competing with the prevailing [illegible] in any given area, it will ultimately fail. We will therefore [illegible] only a discussion of nursery costs and technical [illegible] but also a discussion of the earning potential of present land use systems in comparison to charcoal production.

[illegible]

The first technical consideration in developing a program of intensive charcoal production is the species selection. The following is a list of the desirable characteristics of a charcoal producing tree:

(a) Ability to survive under adverse conditions including shallow soil, extended periods of drought, or even saline conditions.

(b) Do not have thorns....There are many spiny type trees that do well under adverse conditions, and make good charcoal, but they have the disadvantage of much higher handling costs and potential injuries due to their thorny nature.

(c) Grows well within the desired altitude range: many trees that do well at sea level in the tropics will do poorly, or even fail completely if they are planted in the mountains, and vice-versa. The altitude range of any given species must be matched to the planting site.

(d) Rapid growth: Since the volume per acre of wood produced will ultimately determine the profitability of a charcoal enterprise, careful attention should be given to growth rates. Many slower growing woods produce a high quality charcoal, but the volume per acre would be insufficient to warrant planting these species.

(e) Wood density: Since there is a direct relationship between wood density and the quality of the charcoal produced, careful attention should be paid to wood density. Many fast growing species that are suitable for pulp or paper production are not suitable for charcoal.

(f) Ability to coppice: Coppicing, the ability of the tree to resprout when cut, is an absolute necessity for a charcoal species. It would be uneconomical to plant a new forest after each harvest. The speed and vigorousness of coppicing is also a consideration in determining a tree's production potential.

(g) Resistance to animals: If trees are to be planted in sites where there is open grazing, species should be selected that are resistant to animal damage. Many species are bitter and/or toxic, and will be pretty much ignored by animals.

The five species that I have selected as potential candidates for charcoal production exhibit at least some of all of the above characteristics. Naturally, the species will have to be matched to the planting site, depending upon the variables that make any given characteristic desirable, or unnecessary. Following is a short summary of the five species, focusing on their relative strengths and weaknesses relating to the above criteria:

1. <u>Neem (Azadirachta indica)</u>

Neem, commonly known as African Mahogany, is a tropical lowland tree (maximum altitude 2000 feet) that survives almost desert conditions (temperatures up to 120 degrees F. and rainfall as low as 400 mm., with a six to eight month dry season). This tree does better than most species on rocky or shallow soil, but it does not like poorly drained soils. It has been planted successfully by the bare-root system, but plastic sacks are recommended where the annual rainfall is less than 600 mm. Experiments in India have indicated that direct seeding is more successful than prior nursery preparation, but the high perishibility of the seed hampers the

widespread use of this system, since a large supply of fresh seed would have to be available at the time of planting.

The India experience also indicates that Neem can be quite successfully interplanted with other crops; this procedure was carried out in a dry region of Bombay (annual rainfall slightly under 20 inches), and was considered to be the most successful system in the area. Tenants of government land were given a lease in which they sowed field crops the first year, and field crops with neem seeds in the second year. It was noted that the practice of sowing Neem seed on a high mound has a beneficial effect on the initial growth rate. The plantations in Bombay reached a height of three feet in sixteen months from the time of sowing. As this growth indicates, the initial growth of the Neem tree is slow in comparison to some of the other potential charcoal trees. It also does not like weed competition and must be kept reasonably clean during the first year following planting. In open field plantings where no inter-cropping is practiced, this is a definite disadvantage, but in inter-cropping situations, it would allow for multiple harvests before the trees cover the land and make inter-cropping impossible. Although the tree is a light demander, it has been planted with success in small openings made in the dry forest, and seems to compete with the existing vegetation reasonably well. This practice would allow for the introduction of a higher value tree without completely destroying the existing micro-climate, or further aggravating erosion problems. The typical growth habit of neem is to develop extensive roots before increasing leaf space. This tendency indicates that the plant will probably survive well then planted with the speedling, rootrainer, or other small container systems.

In areas of moderate rainfall, the Neem will reach a height of sixteen feet, and a diameter-breast height (dbh -- four feet, three inches from the ground) of between five and eight inches by the end of the fourth year. Considering the tendency of this tree toward low multiple-branching trunks, the wood volume per tree should be equivalent to the four-inch trunk of the taller species such as leucaena or cassia. There is a question as to whether or not this tree can be crowded into a close spacing arrangement and maintain the high yields of other species that are potential charcoal producers.

The wood of the Neem tree is medium-hard, varying in density from .68 to .80. To date an experimental charcoal burn has not been carried out for this species, but its similarity in all respects to its close relative (Swietienia mahogoni), indicates that it will produce a reasonably good charcoal. The wood can also be used for the production of furniture, and in cottage industry being extremely durable, and seldom attacked by insects. The tree coppices readily from the stump, and is resistant to animal damage.

The bark produces tannin that can be used in the preparation of leather, and the seeds contain an oil that when extracted can be used as a fuel for lamps and as a lubricant for machinery. The seed is also the source of Azadirachtin, a new triterpenoid that has a feeding and growth disruptive effect on a number of insect species.

2. Leucaena leucocephala

This leguminous tree is noted for its extremely rapid growth (particularly in fertile well-drained soils with adequate rainfall) and its ability to adapt and continue growing even in many marginal soils and environments. According to Benge, the Giant varieties of Leucaena will produce as much as 240 meters^3 of wood per hectare in two years. Following his calculation of 8 meters^3 of wood per metric ton of charcoal, this would be fifteen tons of charcoal per hectare per year (500 sacks per hectare per year). Fast growth also means short nursery rotations (two months from seed to planting in the field) and reduced weeding costs in the field, since the tree is soon tall enough to compete with the surrounding weeds. Leucaena like Neem does not like poorly drained soils. It also adapts poorly to acid soils, or soils with a high aluminum content.

The wood produced by Leucaena varies in density from .68 to .90 with a marked increase in density in heartwood that is more than three years old. However, our experience with a two year old leucaena tree indicates that even a young tree produces an excellent quality charcoal that competes with most charcoals presently on the market. The wood can also be used as a medium weight lumber, or in paper and pulp production.

Leucaena is a lowland tree that grows well only from sea level to 500 meters. It grows best in areas where rainfall varies from 600 to 1700 millimeters, but it has been noted as dominant vegetation in areas having as little as 250 mm. It has potential as a forage tree being quite palatable to most animals, but there is a problem of mimosine toxicity if the foliage is consumed in too large quantities over a long period of time. It is presently believed that the plant can be used regularly as forage if the intake does not surpass 30% of the total diet. It is high in protein, and gives good weight gains.

While the palatability of Leucaena is a potential strength, it is probably also the greatest single factor limiting its success in Haiti. In order to grow Leucaena, there must be a high degree of land control and surveillance for a minimum of one year in moist environments, and two years in drier climates. For subsistence farmers, the best way of obtaining this control is probably to inter-crop Leucaena with other agricultural produce. In this situation, the land owner (or tenant who is farming the land) will be very diligent in making sure that animals do not enter the planted area. My experience is that in areas where this cannot be done, a non-edible tree (such as Cassia siamea) will ultimately be more successful. I have mixed the Leucaena with the Cassia in several plantations here in the north. Where animal control has been good, the Leucaena gives a much more rapid initial growth, but where animal control has been poor, the Cassia are now fifteen and eighteen feet tall, while the leucaena are stunted bushes from repeated brousing.

The Leucaena coppices with an extreme rapidity. I have seen three inch diameter trees (18 months of age) reproduce their total volume within five months of being destroyed by fire. It remains to be seen whether or not the other species will be able to compete in this particular aspect, and this ability is a definite plus for Leucaena.

3. Cassia siamea

Cassia, like leucaena, does best on well drained alluvial low-land soils, and prefers areas of moderate rainfall (between 700 and 1800 millimeters), although it will survive under more adverse conditions. The wood is hard (density between .66 and .84) and makes excellent charcoal. My experience with this tree indicates that at close spacings, this tree will yield 27 m^3 per hectare per year, which is only a quarter of the more optimistic estimates for Leucaena leucocephala. However, having watched the two species grow side by side for several years, it is my prediction that the trees will be within twenty to twenty-five percent of each other in volume increments, with the Leucaena holding the definite growth advantage.*/

The main advantage of the Cassia over Leucaena is that it is extremely resistant to animal damage. The leaves and seeds are bitter, and to some extent toxic (having been known to cause death to hogs when eaten in large quantities). This means that in areas where the land control is poor or non-existent, the damage to trees by brousing animals will be greatly reduced. Cassia is reputed to coppice rapidly, and should be a good choice for charcoal from this point of view. The bark of Cassia, like Neem is a source of tannin, and its leaves have been dried and used as a supplement for animal feeds.

4. Eucalyptus camaldulensis

The adaptability of Eucalyptus camaldulensis is its greatest strength. While it gives extremely rapid growth in areas where rainfall is plentiful, it is recognized by tropical foresters as the tree that will give very good results in dry areas. In some instances it has been known to do well with as little rainfall as 250 mm. per year (withstanding six to seven months of drought) while on the other hand, it gives good growth in humid areas, even sustaining standing water on a periodic basis with no adverse effects. It grows well in Haiti all the way from sea level to 4000 feet, making it one of the most flexible species in terms of altitude tolerance.

E. camaldulensis produces a hard wood (density from .75 to .95) which makes good charcoal. In traditional plantations (spacing of five to six meters, and rotations of eight to ten years) the tree produces 15 m^3/ha/yr. (the same is listed for Cassia siamea in this traditional rotation pattern). It is my impression from trees grown in the Limbé area, that the E. camaldulensis will compete successfully with the Cassia siamea for volume increment on the close spacing, short rotation basis. E. camaldulensis coppices readily,

---

*/ This estimate is in concurrence with the National Academy of Science Publications, Leucaena--Promising Forage and Tree Crop which states that the average annual increments are expected to be between 30 and 40 m^3/ha/yr.

and grows with a narrow bowl, making it a good choice for inter-cropping since there will be penetration of light for a longer period of time.

A disadvantage of the E. camaldulensis is that it requires more sophisticated nursery techniques, since the seed is very fine, and can easily be destroyed if not handled properly. I do not consider this to be an insurmountable difficulty. It is also broused by animals (although not asreadily as the Leucaena), and needs protection.

5. Casuarina equisatifolia and cristata

The Casuarina (commonly called Australian Pine) is another tree that will grow well in adverse conditions. While it is not a leguminous tree, it is reputed to raise the nitrogen content of the soil significantly. It can survive five to six months of drought, and succeeds on as little as 600 mm. of rainfall per year (as with other species, higher rainfall gives more rapid growth). It produces a wood that can be sawn, used as posts, or for fuel wood. Our experience with Casuarina indicates that it gives a higher quality charcoal than any of the other trees in this report.

The tree regenerates well when cut (particularly the cristata) and is calculated to give an annual production of seven to ten cubic meters per hectare per year when cut on an eight to fifteen year (traditional wide spacing) rotation. Once again, my experiences in Limbé indicate that this tree will compete well with the Cassia siamea for volume production on a close-spacing, short rotation cycle.

This tree grows well in sandy soils, like the Eucalyptus will support standing water on a periodic basis, and possibly most important of all, has a high resistance to salt. I have observed this tree growing on sand spits within twenty feet of the sea. This tree might offer hope of an economic return on soils that will grow nothing else because of a salt problem.

NURSERY ORGANIZATION

One of the basic choices that must be made as a project begins is the organizational structure that will be used to produce the trees. Should the nurseries be large centralized operations that transport trees to the site, or should they be small decentralized units that are localized in the community where the planting will take place? After having worked with both of these systems, I must state my bias; the tendency for disorganization and consequent failure in the localized community nursery is so great that it cannot be considered as a viable alternative for a project of any scale. In the year that I helped administrate the Cooperative effort at O.M.S. (formerly, Oriental Missionary Society) we had twenty or twenty-five nurseries that were supposed to produce 100,000 plants. The reasons for failure were as follows:

1. At the organizational meetings, members would contract to produce a certain number of trees, and then later, for various personal reasons, they would decide not to produce.

2. Sacks were filled, and seedlings transplanted, but insufficient watering led to failure, or very poor nursery stock.

3. Sites that were supposed to have regular water sources (never dry) turned out to have only seasonal sources, and dried up during the hot summer months.

4. People could not keep the neighbors animals out of their nurseries. Chickens ate seeds, and cows and pigs trampled sacks.

5. There was a tendency to produce more than the desired number of the trees that were easy to produce, and not to produce the more difficult ones, so that species balance was completely out of kilter.

At the end of the year, the Cooperative purchased trees from a near-by centralized nursery in order to meet its quota.

There are people in Haiti (I am thinking in particular of the Mennonites) who have had a degree of success with decentralized nurseries. These nurseries, however, were viewed as "educational tools". People were given plastic sacks and seed, and allowed to produce as many trees as they liked; there were no production quotas. If you got four thousand trees for the year, that was four-thousand more than zero, and therefore, a positive input. I believe that this was an effective tool for orienting communities toward tree planting, but if the demand had been placed upon this system to produce two-hundred-thousand trees (even by finding more nurseryman, to make more nurseries) I do not believe that it could have produced them. In conclusion, there are enough hurdles to be crossed in creating an effective tree planting program in Haiti, and we should not make out task more difficult by complicating one of the simplest tasks before us; that of producing trees in a nursery.

NURSERY TECHNIQUES

Any reforestation program has four choices for getting from the seed to the planted forest. They are (1) direct seeding, (2) bare-root planting, (3) planting in plastic bags, and (4) mini-containers.

1. Direct Seeding

Direct seeding has the advantage of skipping the nursery operation entirely. The field is prepared as if any other crop were to be planted, and the seed is sown directly in place. This is an inexpensive system, but the risk of failure is high. I have considered using this system in the mountains in inter-cropping situations, but the land owner quite often does not do his own weeding, and an inexperienced laborer would be likely to pull the seedlings out. Beyond this problem, as we move toward the drier parts of the island, the possibility of failure for this system will increase dramatically.

2. Bare-Root Planting

Bare-foot planting has been practiced in forestry for centuries, and while it is still widely practiced in temperate regions, its use in tropical climates is more limited. Neem, Cassia siamea, and Leucaena have all been successfully transplanted bare-root, but the system would not be easily adapted to Eucalyptus or Casuarina. Mr. Turkoz, the director of the FAO forestry project in Limbé has had extensive experience with bare-root planting of Cassia Siamea in the Upper Volta of Africa. In a situation where there are two months of continuous rain, and then ten months of drought, he has obtained a very high (90%) success rate by planting at the beginning of the rainy season. However, both my experiences, and the experiences of FAO here in Haiti indicate that where there is not a definite extended period of rainfall, the percentages are much lower. My own plantings with this system have given about a 40% take.

For bare-root planting, the seeds are placed in raised beds at about four by four inch spacings. The tree must be a minimum of ½ inch in diameter before it is moved into the field, and any closer spacing would cause stunting. Weeding these seed beds is usually a more expensive procedure than weeding an equivalent number of plastic sacks. The trees can only be moved to the field when both the ground at the planting site, and at the nursery site is saturated. The trees are dug up carefully with iron bars (unless the process is mechanized, in which case a cutter attached to a tractor cuts the tap root about six inches below ground level). The leafy part of the plant is stubbed back to about six inches above ground level, and the long tap-root likewise is cut to six or eight inches below ground level. The stubs are then bundled in quantities of 25, 50, or 100 wrapped carefully in moist shavings, and moved to the field to be planted the same day. The main advantage of this system over plastic sacks is transportation costs, and handling costs in the field, but I would not recommend this system unless circumstances make all other systems impossible. If the plants are uncovered for only a few minutes in the sun, the failure rate will increase dramatically: therefore this system will only work if there is constant supervision of both nursery and in the field planting procedures.

3. Plastic Sacks

Growing nursery seedlings in plastic bags and moving them to the planting site with the soil and roots intact has become a standard forestry procedures over the last two decades. Using this system you can produce a healthy, vigorous eighteen to twenty-four inch seedling that will compete well with the weeds, and that can be placed in the ground with little or no damage. Since the bags are only used once and then thrown away, they are convenient administratively. I have found that the smallest size of plastic sack that will produce healthy and uniform nursery stock is about three inches in diameter, and eight inches in depth (capacity approximately one quart).

The eight inch depth is sufficient to allow for the development of a straight tap-root, and the three inch diameter is the minimum space for the development of uniform leaves on all plants. If this space is reduced by any significant margin, some plants will be crowded out while others take over.

The main draw-back of the plastic sacks is the expense of handling, transportation, and planting in the field. This becomes an even more pertinent consideration in charcoal plantations where there are an increased number of trees per hectare, and the product (charcoal) is a high bulk, low cost-per-volume item. The trees, with the balled earth intact weigh about two-and-one-half pounds each, so a thousand plants is a heavy pick-up load. If the trees have to be carried any distance from the road to the planting site, the costs will quickly become prohibitive.

4. Mini-Containers

Over the last five to eight years, as labor and transportation costs have increased, U.S. based forestry operations have had to work toward more efficient systems of nursery production. It was the consensus of most interested parties that there had to be a better way than bare-root planting to reduce the field costs. The end result was that various types of mini-containers were developed especially for the requirements of forest production. The general principle of the mini-container is to use a small space, filled with a minimal amount of enriched compost or nursery mix to produce a small seedling (6 to 10 inches high, and 1/8 inch in stem diameter) that becomes so root bound that it will retain the container shape when removed. The root formation, rather than being a long tap root with a few runners, becomes a modified tap root, with masses of root hairs that bind the rootball. This modification greatly increases the nutrient collecting capacity of the seedling, and contributes to rapid growth when transplanted in the field. Particularly when used in sites where the soil is well prepared, (plowed or worked with a hoe) this system is very effective. It should be said that since the mini-container seeding is so small, it may have limitations on drier sites where a minimal size should be achieved before the beginning of the dry season.

The two considerations of proper plant development when working with the container system are (1) available root space and (2) sufficient leaf space. The root space is not as critical to plant development as the leaf space. In order to have proper leaf space in the mini-containers, plants should not be crowded together closer than 65 plants per square foot (2.2 square inches or 1.48"x 1.48"). If they are,the trees will be tall and whippy resulting in heavy losses in transplanting. Of the two systems with which I am familiar, the Speedling (with 50 plants per square foot) is a perfect spacing, while the Number Five Rootrainer, having 104 plants per cubic foot is too close, and demands a secondary spacing system. Since I believe that the mini-container will be quite interesting to USAID, in that they will provide a nursery system that is cheap, readily transportable, and easy to handle, in the field, I am going to take time at this point to do a comparison of the two systems.

The Speedling offers a square conical shaped root-space measuring 1½ inches on a side at the top, and tapering to about 3/8 inches at the bottom. The depth of the cell is five inches, allowing the roots to develop to a

good depth. The container (which is made of stero-foam, and is quite fragile to handle) is 14 inches by 26 inches, and has 128 cells. As it has been mentioned earlier, the leaf space is adequate, and no further spacing devices are necessary. The containers can be set on blocks so that air will pass under them to get the proper effect of air pruning.

The main disadvantages of Speedlings are (1) it is very fragile and can be destroyed without careful handling, (2) it is a little more expensive than rootrainers, and (3) it is bulky and demands storage space. Its advantage over the rootrainer is that it is ready to use when you receive it, and does not demand the construction of secondary spacing systems. I would consider that ten uses would be the upper limit of the life of the Speedling in Haiti.

Rootrainers are flat thin plastic cells that come flattened out and piled together for ease of shipping and storage. The cells come in books connected in units of three, four, five and six, depending on the cell size. In this study, only the Number five Rootrainer will concern us. The books are layed flat, each side containing half of the five cells, and when they are folded together, they form the completed cell. The number five cell measures 1" x 1 3/8 x 4". The two larger surfaces of the cell have lines or grooves running vertically down them to reduce the tendency for circular rooting, while at the same time stimulating a constant sub-division of root hairs, thus creating a more efficient collecting system. The available leaf space of the No. 5 Rootrainer is not sufficient for good development of the tree, so a secondary spacing system must be developed. The Turnbull Mission at Fermathe has developed a series of wire baskets with spacers that will hold sixty to eighty plants when full. When the plants begin to get crowded, every other book is removed, thus giving twice the original leaf space. The system works well, but costs about $37.50 per thousand plants, thus doubling the total investment. In Limbe, we have used a system where blocks are layed on the ground and capped with cement, and wooden frames with nylon string streached across them from the spacers. We figure that the total cost of this system is about $8.00 per thousand plants.

The Rootrainer is not as fragile as the Speedling, and I have even moved my plants into the field and planted without excessive damage to the containers. This could not be done with Speedling. Speedlings do have better top space (leaf-space) and are one inch deeper, all adding up to the conclusion that they will give a little taller, thicker, and possibly hardier plant.

In planning for nursery capacity versus per year production quotas, several things should be considered. While the mini-containers are capable of producing a crop of seedlings every two months, the trees must be planted with the rains, which means that in any given area there will be from one to three planting seasons within the year. If the root trainers were limited to producing trees only for the area immediately surrounding the nursery we would be limited to using the containers at between 1/6 and 1/2 of their productive capacity. This would mean that in order to produce 100,000 seedlings per year, it would be necessary to have a container capacity of between 17,000 and 100,000, and the per use cost figure would have to be amortized over a two

to six year period. This would mean a huge investment overhead in container systems.

This figure can be somewhat reduced by maintaining centralized nurseries that deliver seedings for areas all over Haiti, thus allowing a more continuous use of the containers and a resulting decrease in overhead costs. However, at best, we should not plan on more than four uses per year, which means that for a 100,000 per year production capacity, we will need a container capacity of 25,000 plants. At this level it will still take two and one half years to amortize the costs of the speedling system and 18 months to amortize the rootrainer system. For this reason, it might be wise to look not only at per use cost, but also at the capital investment necessary for each system.

I will now do two comparison of the mini-container systems. The first will be a comparison of the capital investment necessary to establish a nursery with the two systems, and the second will be a per use cost breakdown. The costs cited do not include administrative overhead.

Capital Investment Necessary for Speedlings vs. Rootrainers

Item	Speedling Cost per 1000	Rootrainer Cost per 1000 Cells
Purchase & Shipping	$39.06	$12.00
Cement Blocks	4.80	9.80
Spacers (wood & nylon string)	0.00	8.00
Cement coating on blocks	0.00	2.00
Total	$43.86	$31.80

Per Use Nursery Cost for Speedling vs. Rootrainers

Item	Speedling Cost per 1000 Cells	Rootrainer Cost per 1000 Cells
Depreciated cell use (ten uses for Speedling and six for Rootrainer	$3.90	$4.00
Blocks (10 uses)	0.48	0.99
Spacers (8 uses)	0.00	1.00
Cement Coating on blocks	0.00	0.20
Labor (filling & transplanting & watering	2.00	2.00
Nursery Mix	5.00	5.00
Transportation (25 mile radius)	2.00	2.00
Cost at Farm Gate	$13.38	$15.18

The two systems seem to be quite competitive in cost, and if capital to invest is not a problem, the speedling is probably the best choice. I say this with the reservation that the Speedling is fragile, and must be handled with care.

In concluding this section on nursery procedures, I would like to include a chart showing the relative costs of the different planting systems.

COST PER 1000 PLANTS FOR VARIOUS NURSERY CONTAINERS

Type of Container	Container Cost per Use	Filling with Soil or Mix	Maintenance in Nursery	Transportation	Farm Gate Price
Bare Root*	$00.00	$2.00 (1)	$3.00	$2.00	$7.00
Plastic Bag	$10.00	$15.00	$5.00	$20.00	$53.00
Mini-Container	$4.00	$ 5.00	$4.00 (2)	$2.00	$15.00

(1) In case of Bare Root, represents preparation of Beds.
(2) Includes depreciated cost of blocks and spacers

* While the Bare Root system is cost-effective, it has severe disadvantages in administration, handling and survivability when compared to the mini-containers.

TECHNICAL ASPECTS OF PLANTING IN THE FIELD

In most cases, land preparation will involve a complete clearing of the land. It is advantageous to the young plants if the land is plowed, or worked with a hoe. The worked soil will allow for the quick penetration of roots for the collection of moisture and nutrients, thus contributing to initial rapid growth.

It takes about 40 man-days to clear one carreau of land with a hoe. Using an estimated average wage rate on agricultural enterprises of $1.00 per day, the cost for a peasant owner for clearing would be $40.00/carreau. If no inter-planting occurs, it is impractical to pay the price of working the entire land space, but I would recommend that the holes be dug somewhat larger than the size of the container, and granulated back into the hole as the tree is planted. This will allow for the quick penetration of roots into the surrounding earth.

The cost of planting in the field varies with the types of container used. Plastic sacks will consume 64 man-days per carreau, while mini-containers and bareroot plantings will take about 20 man-days per carreau. These figures assume that the plants will be planted within ½ mile of the unloading site, thus minimizing the man-hours involved in carrying plants.

Maintenance costs consist of three ring weedings. In the Humid Forest, all three weedings will occur the first year, but in the Dry Forest they will be spread out over a two year period. A man can weed about 250 plants per day, which comes to 12.8 man-days per carreau per weeding, or a total of $38.40 to weed the land surface three times. Other than an occasional pruning of crooked or branching stems, no other maintenance costs would be necessary.

The only other aspect of field techniques that might concern us is the question of spacing. This is a multi-pronged issue involving the habits of tree growth and development, the effects of "crowding", and the viability of potential wood markets. In traditional charcoal plantations, the trees have been planted at five or six meters distance, and cuttings have been made on an eight to ten year rotation. This gave a mature tree with hard wood, which made high quality charcoal. This was done for the most part in areas where land space was not a prime consideration; there was an abundance of land, and relatively low population densities. Neither was time a prime consideration, since the land involved, as well as the capital invested came from the public sector.

In the project we are considering, much of the land will belong to the private sector, and at least part of the costs (even if only in the form of labor) will also be carried by a group of people who can ill afford long-term investments. For this reason, it is important that the spacing be designed for fast cutting and/or intermediate profits in terms of multi-land use concepts.

The curve of volume increment in trees grown in uncrowded conditions is somewhat flat the first year, and then picks up speed rapidly as the leaf and root space increase. Given an unlimited amount of sunlight (no crowding from surrounding vegetation) this increased volume per year pattern continues for anywhere from eight to twenty years (or more in some species) at which point it begins to level off as maturity approaches. The secret to a well managed forest is to space the trees so that the desired volume is achieved right at the point where the curve would begin to flatten either because of crowding from other trees in the forest, or because of maturity. For our purposes, the flattening of the curve will be caused by crowding.

Finding the point at which this leveling off of growth occurs is complicated by the fact that each tree species has a different tolerance for crowding, and can only be scientifically determined by field tests. However, over the years, I have observed hardwood trees planted at various spacings, and I believe that some general guides can be developed from my experience. My general rule has always been as follows:

(1) With spacings of one meter by one meter crowding begins when the tree has a one inch diameter.

(2) With spacings of 1½ meters by 1½ meters, crowding begins at two inch diameters.

(3) At spacings of 2 meters by 2 meters, crowding begins at four inch diameters.

(4) At spacings of 2½ meters by 2½ meters, crowding begins at six inch diameters.

While I have never before attempted to interpret this "rule of thumb" mathematically, what it seems to indicate is that in close spacing situations Crowding begins when the trunk diameter in inches is approximately equal to the number of square meters of space available to the tree. It is at this point, or shortly after that the trees should be harvested (either by thinning or a complete harvest) in order to obtain the highest volume yields per hectare.

Following this rule of thumb, if we want to do an early thinning in the charcoal forest for firewood at, say 1.5 inches average diameter, the tree spacing should be at 1.5 meters by 1.5 meters, or certainly not closer than one meter by two meters.

This moves us right into the economics of the situation. A one meter by two meters spacing will give 5000 trees per hectare or 6450 per carreau. If the trees were trimmed for firewood when they had 1.5 inch average diameters, at an average height of twelve feet, each pole would have 254.34 cubic inches, weighing (in the case of Cassia siamea) 6.79 lbs. when air dried. Since only half of the trees would be cut (3225 trees), the total weight of the poles would be 21897.75 lbs. (9.95 tons) of

firewood. While there would be about a 20% weight increase in weighing the branches, we should allow for an average death rate of 30% of the trees, which would give a 20% reduction in volume*, negating this factor.

The price of firewood sold by the truck-load in Cap Haitien comes to $10.00 per ton in town ($50.00 per truckload holding about five tons of wood), and $7.00 per ton ($35.00 per truckload) in the outlying areas. These costs do not include transportation costs, which add two to three dollars per ton to the price of the wood, but they are retail prices. The price of wood sold in packets comes to 9¢ per pound, or $19.80 per ton, but there is probably no good way of breaking into this type of market. The producer should not plan on getting more than eight dollars a ton, which would come to $79.60 per carreau. Not counting the cost of land clearing, an additional 3.31 cents per plant would be necessary to produce these poles bringing the additional costs to $105.92. This hardly seems a worthwhile venture.

Another possible use of early thinnings is poles. There is an almost unlimited market in and around urban centers for poles. They are used as supports in most cement construction, and are also widely used as cheap lumber by poor people. The poles presently sell for about $0.25 each, averaging three inches in diameter, and twelve feet in length. If trees on the above spacing (1 meter x 2 meters) could be nursed to that size by a slight over-crowding**, the excess poles produced would be worth $651.00 on the retail market. Assuming 100 poles cut and hauled out per man-day, it would cost about $25.80 per carreau to cut and load the poles. A truck can carry about 625 poles, so working within a 20 mile radius and calculating $25.00 per load, transportation would be about $100.00 per carreau. If the producer could get 80% of the retail price he could cover the transportation costs, and still have an income of $395.00 per carreau. Since the additional costs of producing these poles in a charcoal forest is $105.92 (no land clearing costs included since it is assumed that the charcoal forest would have been planted anyway at wider spacings), this would bring an added profit to the charcoal forest of $289.08 per harvest. In order to compete with the mangrove market, such poles must have certain desirable characteristics, such as the ability to hold nails without splitting, and good tensile strength. Nonetheless, the pole market offers a promise of increasing income in a charcoal forest, or even as a separate forestry endeavor.

---

* When one tree is removed in a close spacing situation, the available light and nutrients are consumed by the surrounding trees, so there is not a one-to-one death-volume loss ratio.

** According to my calculations, the spacing for a 3" pole with no crowding should be 1.5 meters x 2 meters.

FIVE EXPERIMENTAL CHARCOAL BURNS

Since most of the calculations concerning charcoal production in this study were originally from secondary sources, and particularly since some of the species that we are speaking of are introduced species, and thus untested for the quality and/or volume of charcoal they produce, I felt that it might be a good idea to do some measurements and make a little charcoal with the species in question. Of the five species being recommended for charcoal forests, the only species that I was unable to obtain for an experimental burn was the Neem.

A few words should be said about the method of charcoal coaling used in the experiments. It seemed that the fairest test could be obtained by using the time-tested system of the local peasant which is an earth kiln. A man was found locally who had extensive experience in charcoal production. He was employed to do the burns, and the whole process was carefully monitored by me. The wood was cut into pieces about 24" long, weighed, measured, and then carefully assembled in a "tent" formation on a piece of cleared ground. As I learned in the process of this work, one of the very important considerations is to make sure that the wood is stacked closely, with as little air space between pieces as possible. It was because the burns were so small in size, that wood from other sources (filler wood) had to be added to fulfill this requirement. These smaller pieces of wood are usually completely consumed in the process of carbonization, and thus add very little to the weight or volume of charcoal produced. I was at first quite concerned that this would be a handicap for me in determining how much charcoal was produced by the original tree, and how much was produced by the filler wood, but my mind was soon set at ease. An experienced charcoal maker can easily distinguish the types of charcoal that come from any one burn by their hardness, how shiny or dull they are, and by the characteristic wood formation of the various species. At the end of each burn we sorted the charcoal into two piles; one pile for the tree being measured, and one pile for the filler wood. It was a learning experience for me; I was amazed to discover how simple it is to recognize mahogany, casuarina, tcha tcha, or Cassia siamea charcoal on sight. I consider the sorting process to be 90% accurate, with the possibility of error flowing equally in both directions. Following are charts of the separate burns, and results obtained.

Burn # I --- Casuarina cristata

Wood Diameter	Length	Cubic inches	Weight	Cubic Inches per pound
4.5 "	36 "	572.26	20 lbs.	23.61
4 "	42 "	527.52	20 lbs.	26.37
3.5 "	40 "	384.65	18 lbs.	21.30
3 "	39 "	275.53	14 lbs.	19.63
3 "	37 "	261.40	10 lbs.	26.14
2 "	40 "	125.60	6 lbs.	20.93
2.5 "	38 "	186.43	7.5 lbs.	24.85
2 "	39 "	122.46	4.3	28.47
Totals		2455.85 (1.43 cubic ft.)	103.30	Average Cu. in. per lb.= 24.54

Filler wood --- 71 lbs.

Casuarina cristata, according to Puerto Rician Woods*, has a green wood weight of 72 lbs. per cubic feet, with a 42% moisture content, and an air-dry weight of 64 lbs. The tree produced 1.43 cubic feet of wood weighing 103.30 pounds, wet weight, which would be 59.91 pounds dry weight. The final sorting produced 21.5 lbs. of Casuarina charcoal, and 5.75 pounds of filler wood charcoal. The weight conversion for Casuarina, then was 35.88 and the filler wood, 8.09%. If this tree size and conversion rate were averaged in a plantation, it would take 3.09 trees to produce a 30 kilo sack of charcoal. At a 2m x 2m spacing, a carreau would produce 1036 sacks of charcoal. It should be mentioned that the Casuarina was considered a superior charcoal, rivaling in quality the much prized Gaiac, or Watapanna charcoals that demand higher prices on the market today.

* Franklin R. Longwood, USDA Handbook No. 249, USDA, July, 1974.

Burn II --- Cassia siamea

Wood Diameter	Length	Cubic Inches	Weight	Cubic Inches per Pound
4.5 "	58 "	921.58	38 lbs.	24.26
4 "	53 "	665.68	21 lbs.	31.70
3.25"	48 "	397.99	17 lbs.	23.41
3 "	40 "	282.60	11 lbs.	25.69
2.5 "	34 "	166.81	5.5 lbs.	30.32
2.5 "	36 "	172.62	6.75 lbs.	26.16
1.75"	33 "	79.33	3.25 lbs.	24.41
2 "	35 "	109.90	5 lbs.	21.98
2 "	38 "	119.32	5.75 lbs.	20.79
2 "	30 "	94.20	4.5 lbs.	20.93
2 "	34 "	106.76	5.5 lbs.	19.41
Six pieces between one and two inches			5.5 lbs.	
Totals		3996.75 cu. in. (2.31 cubic ft.)	159.25 lbs.	

Filler wood --- 64 lbs.

The final sorting of this wood produced 37.5 pounds of cassia, charcoal, and 5.75 pounds from the filler wood. Calculating the moisture less in air-dried Cassia at 40%, this leaves a conversion rate of 39.52% for the test tree. The filler wood produced 5% of its green weight. If this tree was taken as an average in a charcoal forest, it would take 1.76 trees to produce a sack of charcoal (30 kilos). On a two meter by two meter spacing, this comes to 1818.18 sacks per carreau. As with the Casuarina, the Cassia charcoal was distributed to nursery employees to test its merit as a cooking fuel. The results were that it is considered to be a very good charcoal, comparing favorably with Mahogany, oak, and Red Mangrove. It however, would not commend the price of Gaiac or Watepanna as would the Casuarina.

Burn III --- Cassia siamea

Wood Diameter	Length	Cubic Inches	Weight	Cubic Inches per Pound
4.5 "	21 "	333.82	13 lbs.	25.67
5 "	21 "	412.12	18 lbs.	22.89
4 "	23 "	288.88	13 lbs.	22.22
3 "	24 "	169.56	6 lbs.	28.26
3 "	26 "	183.69	8 lbs.	22.96
3 "	24 "	169.56	8 lbs.	21.19
2 "	26 "	81.64	5 lbs.	16.32
2 "	21 "	65.94	4 lbs.	16.48
4 "	23 "	288.88	9 lbs.	32.09
Totals		1994.09 (1.15 cu. ft.)	84.lbs.	21.99
From same tree — 20 pieces from 1" to 2"			18 lbs.	Average cu. in.
125 pieces under 1"			27 lbs.	Per Pound = 21.99

Filler wood (also cassia) = 68 lbs.

In burn no. 3, the test tree was completely and carefully used. With all small branches included, the weight was 129 pounds. Another 68 pounds of filler wood was added, bringing the weight total to 197 lbs. (118.20 lbs. air-dry). If the conversion rate is simply calculated on this basis, then the conversion rate is 22.8%, but if it is allowed that fifty-nine pounds of that wood (35.40 lbs. air-dried) were less than one inch in diameter, and thus would contribute very little to the charcoal produced, then the percentage would go up significantly. Let us say that this portion of the burn produced a 10% conversion rate, or 3.5 lbs. of charcoal. If this is so, then 82.00 lbs. of air-dried wood produced 24.5 lbs. of charcoal, or 29.58% conversion. If 24.5 pounds of charcoal could also be said to represent the test tree, then it would take 2.72 trees to produce a 30 kilo sack of charcoal, giving a per carreau production of 1176.47 sacks per harvest.

Burn IV --- Leucaena leucocephala

Wood Diameter	Length	Cubic Inches	Weight	Cubic Inches per Pound
4 "	32 "	401.92	20.75 lbs.	19.37
3.5 "	25 "	240.41	13 lbs.	18.49
3.5 "	27.5 "	264.45	10.25 lbs.	25.79
2.75"	18.5 "	109.78	6 lbs.	18.29
3 "	19.5 "	137.76	7.5 lbs.	18.36
2.5 "	24 "	117.75	6.75 lbs.	17.44
2.25"	18.25 "	72.56	2.75 lbs.	26.37
2.25"	15 "	59.61	2 lbs.	29.80
1 "	16.25"	12.75	1.25 lbs.	10.20
15 lbs. from 1" to 2"		307.95 (Averaged)	15 lbs.	
9 lbs. less than 1"		184.77 (Averaged)	9 lbs.	
Totals		1909.72 (1.15 cu. ft.)	93 lbs.	Average cu. in. Per lb. = 20.53

Filler added = 70 lbs.

The Leucaena produced 1.3 lbs. of charcoal, and left four pounds of wood unburned. The filler wood produced 6.5 lbs. of charcoal (9.2% conversion - green weight). Figuring a 40% weight less, the 93 lbs. of green Leucaena weighed 55.8 lbs. Since the four pounds of uncooked wood was well dried out by the heat, the converted dry weight was 51.8 pounds. This is a 25% conversion rate for the burn; however, it was the feeling of the man who cooked the charcoal that this burn gave less charcoal than usual, because the mound collapsed during the night allowing some of the wood to burn completely. He estimated roughly that it should have given about one forth more than we actually got. This would have added another 3.25 lbs. of charcoal, increasing the conversion rate to 31.37%.

The Leuceana tree (which was only 24 months old) produced 1.15 cubic feet of wood. If the actual growth and conversion rates were averaged over a carreau of land, it would take 5.12 trees to produce a sack of charcoal for a total of 630 sacks per carreau. In spite of the fact that the Leuceana tree was only two years old, it made a superior quality charcoal. The opinion of those who used it was that while it was not quite as hard as the Casuarina charcoal, that it would still compete successfully with Gaiac or Watapanna charcoal.

Burn V --- Eucalyptus camaldulensis

Wood Diameter	Length	Cubic Inches	Weight	Cubic Inches per Pound
4 "	29 "	364.29	12 lbs.	30.35
5 "	25 "	490.63	18.25 lbs.	26.88
4 "	30 "	376.80	15.25 lbs.	24.30
3 "	32 "	226.08	12.5 lbs.	18.08
3 "	32 "	226.08	10.5 lbs.	21.53
2.5 "	23 "	112.84	3.5 lbs.	32.24
2 "	23 "	72.22	2.5 lbs.	28.88
1.5 "	27 "	47.68	2 lbs.	23.84
1 "	23 "	18.05	1.5 lbs.	12.03
2 "	24 "	75.36	2.5 lbs.	30.15
Wood less than 1" —		297.96 (Averaged)	12 lbs.	
Totals		2307.00 1.33 cu. ft.	92.5 lbs.	Average cu. in. Per lb.= 24.83

Filler wood --- 120 lbs.

The charcoal of the Eucalyptus camaldulensis (a three year old tree) was considered by the users to be about the same in quality as the Cassia siamea. The tree produced 20 lbs. of charcoal, which comes to a 36.03% conversion rate. The filler charcoal weighed 7.25 lbs., for a green conversion rate of 6.04%. If the four inch tree were representative of trees cut in a charcoal plantation, a carreau planted at 2 meters by 2 meters would produce 961 sacks of charcoal.

Other information that has come to me as a result of this study concerns a local classification system for charcoal quality. Almost any wood can make charcoal, but the harder, denser woods make a better charcoal. Commercial charcoal trees can be divided into three catagories:

1. Superior -- Very hard charcoal usually having a shine and often leaving a black mark when rubbed across a hard surface. Gaiac, Watapanna, Bayahena Leucaena, and Casuarina all fall within this group. This quality charcoal is prized for its ability to burn hotter and longer than other charcoals, and sells for ten to twenty percent more than lower quality charcoals.

2. Very Good -- This charcoal is a little softer than the above mentioned varieties, but it is considered that it burns hot enough and long enough to be considered quite adequate. Candelone, Chene, Acajou, Red Mangrove and Cassia siamea, and fall in this group. Cassia is near the top of this category, being surpassed in quality only by acajou.

3. Passable, but light --- These charcoals, comprised of mango, bois d'ombre, Tcha Tcha, and White Mangrove are used when nothing else is available, or the prices of all others are considered too high. There will usually be a price adjustment of 20% less than the superior quality charcoal, and 10% less than the medium quality.

In conclusion, the average conversion rate of charcoal in the five burns was 33.20%. The average tree (all having 4" diameters) gave 1.47 cubic feet of wood which, if prorated out in a carreau basis, would give 1125 sacks of charcoal, if the trees were planted at 2 meters by two meters, and there were no losses. Assuming, however that we might average 30% loss of trees in the plantation, we would probably see a decrease in charcoal production of about 20%. There would not be a one to one correlation since the trees are tightly spaced and a growth reducing a situation exists. If some of these trees die, thus leaving openings where light can penetrate, the surrounding trees will increase in growth until their leaves have filled in the space. For this reason, we will base our calculations in this study on the basis of a 30% tree loss, and a 20% reduction in the productivity of a given land space. This means that we can use the production figure of 900 sacks of charcoal per carreau, when the spacing is 2 meters by 2 meters, and the average stem is four inches in diameter (dbh).

APPROPRIATE SITES FOR CHARCOAL FORESTS

In assessing any given land site as appropriate or inappropriate for charcoal forests, the two areas of concern are (1) physical (soils, rainfall, altitude), and (2) economic (can the charcoal forest compete with the present land use system? are there constraining factors such as time lag which might make the new use unworkable? are the constraining factors off-set by increased earnings for those who work the land?). I would like to handle the physical considerations first, and then move into a discussion of the economic considerations.

For purposes of this study, I do not think that it is necessary to go into a discussion of soils and soil types. The tree species that we have selected for charcoal production are extremely hardy, and except for some special limitations (most of which have been mentioned as we dealt with the individual species) they will adapt to most types of soil. The main factors limiting their growth will be soil depth, and available moisture.

In terms of broad climatic considerations, the Holridge Map of Life Zones (see OEA study on Haiti - 1972) offers a system that is quite well suited to our discussion. Of the nine life zones listed, there are two that are of potential interest for charcoal production in Haiti. They are the Sub-Tropical Dry Forest, and the Sub-Tropical Humid Forest, and together comprise well over 50% of the land surface of Haiti. I have sub-divided these areas into flat-lands and mountains, and for the Humid Forest, there will be a further sub-division into Windward and Leeward slopes (North-east and South-west respectively). This is in recognition of the fact that there is a substantial difference in rainfall and resulting agricultural practices on the opposing sides of the mountain slopes.

The Sub-Tropical Dry Forest stretches from sea level to 500 meters altitude, and receives from 500 to 1000 mm. of rain annually. The normal vegetation is a dense spiny forest with the trees usually not exceeding a height of 15 meters. The more common tree species would include Prosopis juliflora, (bayahonde, Cephalocereus rovenii, Pictetia aculeata, Guaiacum officinale (Gaiac), and Leucaena glauca. Some of the better agricultural soils of Haiti are included in this configuration, but because of lack of sufficient moisture for traditional agricultural practices, they are not exploited to their potential. This area is presently one of the main sources of charcoal for the country, and is a prime candidate for an intensive and rational program of charcoal production.

The Sub-Tropical Humid Forest stretches from sea level to 800 meters altitude, and receives between 1000 and 2000 mm of rain annually. The typical over-story vegetation includes a broad variety of tropical hard-woods including Swietenia mahogoni (small leafed mahogany), Simuraba glauca (Bois Blanc, or Frene), Lysiloma latisiliqua (Tavernon), and Microcatalpa longissima (Haitian Oak). This zone covers more area than any other ecological configuration in Haiti, and is also the most important agriculturally. Most of the subsistence farming carried on in Haiti occurs in this area, as well as the large sugarcane plantations. Charcoal production should not be ruled out in this area, but careful planning should consider the food producing potential of any given

site, to insure that there is not a developing competition between food and energy resources. The mountainous areas of the Humid Forest would seem to offer one of the more rational sites for charcoal production. Where rainfall is sufficient, subsistence farming is carried on on these slopes, but the result is usually severe erosion, loss of fertility, and increasing loss of water-retention capacity. In many parts of Haiti (particularly the Northwest) this syndrome has lead to pseudo-drought with the water retaining capacity of the land impaired, and a resulting decrease in agricultural productivity. The focus in the Humid Forest will be on the mountainous areas, with the assumption that the low-land areas, while having the capacity to produce trees faster than the mountainous areas, are better suited to food production.

I would now like to consider the question of whether or not charcoal forests can compete with the existing land use patterns in these areas of interest. In order to explore this possibility, it is necessary to take a look at present land uses in these areas, and consider their present earning potential. Since there are different cropping patterns in different areas, and different risk factors, I have divided the areas into four categories which are as follows: (1) Dry Forest -- Flat Land, (2) Dry Forest -- Mountains, (3) Humid Forest -- Mountains -- Windward Slopes, (4) Humid Forest --Mountains -- Leeward Slopes.

The prices of foodstuffs for this study are based upon the price that a farmer would get selling his produce at the farm gate. They are based upon an average price of the product during the time when it is most plentiful. The costs of production are simply assumed to equal the number of work days to produce the crop times a wage rate of one dollar per day.

It is also assumed that there will be no inputs of fertilizers or insecticides. Costs are calculated for the price of seed and plant material. The income projections will be based on the following price and production assumptions:

Crop	Peasant cost of production	Production Volume	Unit Price	Income per Carreau	Profit per Carreau
Millet	$80.00	425 Marmit	$0.50	$212.50	$132.50
Corn	$70.00	350 Marmit	$0.50	$175.00	$105.00
Beans	$75.00	170 Marmit	$1.60	$272.00	$197.00
Manioc	140.00	55 Charge	$5.00	$440.00	$300.00
Pois Congo	$70.00	600 Marmit	$0.20	$120.00	$ 50.00*
Patate	$70.00	45 Charge	$6.00	$270.00	$200.00

*Pois Congo can be harvested twice a year for an indifinite time period (up to three years) 600 marmits represent two harvests in one year.

I would now like to present a chart for calculating the present income levels in Dry Forest Agriculture. The assumption will be that while the rainfall in most of the Dry Forest area is bi-modal (Dr. Norton D. Strommen)* just as in most other parts of Haiti, that the low bi-modal peak does not usually furnish sufficient rainfall for two planting seasons. It will be assumed for the question of grazing that it will take six carreaux of unimproved Dry Forest land to bring one cow to maturity ($200.00 Value) in twenty four months on unimproved land. While more animals than this can be grazed on this land space, the growth of all animals will be retarded in direct relationship to the intensity of over-grazing. If milk is produced, there is more value, but the land space, again would have to be increased to accomodate the increased protein intake of the lactating animal. For purposes of this study, I will therefore hold the above value as static. The survival potential is the measure of potential failure rate of the crop within the given conditions. It should have the effect of measuring not only total failure, but also reduced production due to insufficient moisture. A twenty percent reduction will be computed for each succeeding year of cropping since the soil will become depleted, and there will probably be no inputs of fertilizer. The first year computation pre-suppose a false fallow (two or three years of grazing) preceding the first planting.

*See " a study of the Caribbean Basin Drought/Food Production Problem"

Dry Forest -- Flat Land

Crop	Plantings Per Year	Survival Potential	Profit Margin yr. 1	Profit Margin yr. 2	Profit Margin yr. 3	Profit Margin yr. 4	Profit Margin yr. 5	Profit Margin yr. 6
Millet	1	70%	$132.50 X .70= $92.75	$106.00 X .70 = $74.20	$84.50 X .70= $59.36	Grazing $33.33	Grazing $33.33	Repeat Cycle
			6 months Grazing $16.66	6 Months Grazing $16.66	6 Months Grazing $16.66			
Corn	1	60%	$105.00 x .60= $63.00	$84.00 x .60= $50.40	$67.20 X .60= $40.32	Grazing $33.33	Grazing $33.33	Repeat Cycle
			8 Months Grazing $22.22	8 Months Grazing $22.22	8 Months Grazing $22.22	Grazing $33.33	Grazing $33.33	Repeat Cycle
Pois Congo	1	60%	$100.00 x .60 = $60.00	$150.00 x .60 = $90.00	$120.00 x .60 = $72.00	Millet $92.75	Millet $74.20	Repeat Cycle
			two harvests but no grazing	no grazing no cost for replanting	no grazing no cost for replanting			
Beans	1	55%	$197 x .55= $108.35	157.60 x .55= $86.68	$126.08 x .55 = $69.34	Grazing $33.33	Grazing $33.33	Repeat Cycle
			Nine Months Grazing= $24.55	Nine Months Grazing $24.99	Nine Months Grazing $24.99			

Five Year Averages of Land Use Approaches

(1) Millet — Grazing $68.59
(2) Corn — Grazing $57.40
(3) Pois Congo — Millet $77.70
(4) Beans — Grazing $81.20

In the Dry Forest mountains, the beans will fade out of the picture all together, leaving millet, corn, pois congo, and grazing as the main agricultural activities. Because of shallower soils and reduced moisture, it would not be out of order to expect a 15% decrease in the productivity of all agricultural enterprises. If this were the case, the annual production values would look something like this:

(1)	Millet-Grazing--	$58.22
(2)	Corn-Grazing --	$48.79
(3)	Pois Congo-Millet--	$66.05

It might be instructive at this point to make a few projections about the growth of charcoal trees in this environment. The production goal in a charcoal forest on any land site is to bring the tree stems to an average four inch diameter. We will assume that 70% of the trees will survive, and in areas where there is heavy potential loss, we will compensate our calculation with an extra cost for replanting. We will assume a static production figure for one carreau of four inch dbh stems of 900 sacks (27 tons) of charcoal per harvest. Time lapses between planting and harvest, and recutting will vary depending upon the life zone - land configuration, and two harvests must always be included in the calculation in order to get a fair look at profit margins without planting costs.

In the Dry Forest Flat Land configuration , we should plan on five years from planting to first harvest, and three years to an equivalent volume cutting of the first coppice. The coppice production should maintain itself at this level for two or three more cuttings before it begins to taper off because of the age and deteriorating condition of the stump.

Let us now look at some very basic cost-benefit information about peasant charcoal production in the Dry Forest. For purposes of completing this information, we will assume that the producer will sell his charcoal at $1.40 a sack. (The price of charcoal in the Capital is presently $3.00, with transportation costing from $0.30 to $1.00, and two or three middlemen between producer and retailer, each making an average profit margin of about $0.20 per sack. While the land that is being planted to charcoal will in all likelihood be inter-cropped, we will assume for this part of the study that that is not the case. (Chart page 29).

The mountains of the Dry Forest will yield less volume per year because of less available moisture, and shallow soil. If we assume similar costs in a mountain planting, but calculate a seven year lag between planting and harvest, with a four year cutting cycle after that, the first cutting would show a profit of $71.73, and the first four year cycle would show a profit of $166.22 per year. This would seem to compare quite favorably with our estimate of present land use profits.

If, however the land is inter-cropped, the profit margins should be somewhat higher than this level. I would now like to present a chart for inter-cropping trees and millet in both the flatland and mountains of the Dry Forest. (Chart page 30).

Dry Forest — Flat Land

Cost		Benefit	
Year 1		**Year 1**	
Land prepared (40 man-days)	$40.00	No benefits	
Trees purchased at Farm gate	48.00		
Trees planted	20.00		
Trees ring-weeded twice	25.60		
Dead seedlings replaced	27.20		
Year 2		**Year 2**	
Trees ring-weeded once	12.80	No benefits	
Years 3 to 5		**End of Year 5**	
No major inputs		900 sacks of charcoal (27 tons) sold at $1.40 each	$1,260.00
Harvest-end of year 5 labor cost of 585 man-days	$585.00		
Total Costs = $758.60		Total benefits = 1260	
Total profit = $501.40 ($100.28 per year)			
CYCLE II			
Year 1		**Year 1**	
Pruning	$10.00	No benefits	
Year 2		**Year 2**	
No inputs		No benefits	
Year 3		**Year 3**	
Harvest	$585.00	Harvest	$1,260.00

Total Profit = $665.00 ($221.66 per year)

DRY FOREST -- Trees and Millet

Item	Flatland		Mountain	
	Cost	Benefit	Cost	Benefit
Year 1				
Land prepared	$40.00		$40.00	
Trees Purchases	48.00		48.00	
Trees Planted	20.00		20.00	
Millet Seed & Planting	10.00		10.00	
Garden Weeded Twice	30.00		30.00	
Trees Replanted (30% deaths) Purchases & Planting	27.20		34.00	
Harvest Millet @ 6 months				
(212.50 @ 70% potential)	10.00	$148.75		
(212.50 @ 55% potential)			$10.00	$116.88
	$185.20		$192.00	
Year 2				
Land Prepared	$40.00		$40.00	
Millet Seed & Planting	10.00		10.00	
Garden Weeded Twice	30.00		30.00	
Harvest Millet @ 6 months	10.00		10.00	
56% potential				$93.50
44% potential				
	$90.00	$119.00	$90.00	
Year 3				
Land Prepared	—		$40.00	
Millet Seed & Planting	—		10.00	
Garden Weeded Twice			30.00	
Harvest Millet @ 6 months			10.00	
35.2% potential				$74.80
			$90.00	
Year 4				
No Inputs or Benefits				
Year 5				
Harvest	$585.00	$1,260.00	—	—
Year 6				
No Inputs or Benefits				
Year 7				
Harvest	—	—	$585.00	$1,260.00
Totals	$860.20	1.527.25	957.00	$1,545.18
Profits	$667.55	(133.51 yr)	588.18	(84.03 per yr)

The flat lands show a per year profit increase of $33.23, and the mountains $13.82 when the trees are inter-cropped. The apparent small gains are because of the fact that all man-hours are registered in dollars and cents, and there is a heavy labor input to produce the gardens. There would be no inter-cropping in the second cycle, so profits would resemble the second cycle models described on page 29 and 30.

There are some variables which I have not attempted to measure in this study. I have noticed over the years (and this is confirmed by various tenant farmers) that even in mahogany plantations, the drier sites will produce better gardens when the trees are three or four years old (ten to fifteen foot saplings and giving partial shade. Experiments have shown that Leguminous trees planted on such sites often have extremely beneficial affects on the food crops that are planted with them. I am also of the opinion, that because of improved land preparation, there will be a higher survival rate in inter-cropping situations than where only trees are planted. Even though these variables were not measured, they are worth mentioning in passing.

The Humid Forest

Peasant cropping patterns in the Mountains of the Humid Forest can be broken down into two basic models or patterns. The first occurs on the windward (North East) side of the mountain ranges, and the second occurs on the leeward (South West) slopes. The windward side of the mountain ranges in Haiti receives considerably more precipitation than the leeward side, and therefore lands itself to complex inter-cropping systems that capitalize on the available moisture. According to Pedro Sanchez*, inter-cropping is far from a random process. It is a highly sophisticated technique for the maximum utilization of available light, and according to experiments done in Mexico, will usually yield a land equivalent ratio of 1.5, and an income equivalent of 1.3 as compared to mono-cropping on the same land surface. While any particular crop within the system will give less than 100% yield, the sum total of all crops quite consistently surpasses the potential of any single crop.

I will now present two model cycles of mixed cropping in the Windward Mountains of the Humid Forest. Since there are endless variations on the theme, we should keep in mind that these are only models that will perhaps give us an idea of the income generating potential of this particular area.

---

* Properties and Management of Soils in the Tropics, John Wiley and Sons, New York, 1976.

TWO MODELS OF MIXED CROPPING IN THE WINDWARD HUMID TROPICS

Model One				Model Two			
Period	Crop	Percentage of Full Crop	Profit	Period	Crop	Percentage of Full Crop	Profit
Year One	Manioc	60%	$153.00	Year One	Beans	70%	$ 6.53
	Patate	30%	48.00		Corn	30%	$25.20
	Beans	20%	27.58		Manioc	30%	$76.50
	Pois Congo	15%	6.37		Pois Congo	10%	$ 4.25
	Corn	15%	12.60				
	Total		$247.55				$202.48
Year Two	Patate	60%	$76.80	Year Two	Patate	50%	$64.00
	Manioc	40%	81.60		Manioc	50%	$102.00
	Corn	20%	13.44		Beans	20%	22.06
	Pois Congo	20%	6.80		Corn	20%	13.44
	Total		$178.64				$201.50
Year Three	Corn	60%	32.25	Year Three	Corn	60%	32.25
	Manioc	30%	48.96		Patate	30%	30.72
	Pois Congo	30%	16.32		Manioc	30%	48.96
	Patate	20%	20.48		Pois Congo	30%	16.32
	Total		$118.01				$128.25
Year Four	Grazing*		$100.00	Year Four	Pois Congo	100%	$ 85.00
Year Five	Grazing		$100.00	Year Five	Pois Congo	100%	$85.00
Year Six	Repeat Cycle			Year Six	Grazing (then repeat Cycle)		$100.00

The survival potential variables used in computing profits are as follows (1) Corn- 80%; (2) Beans - 70%; (3) Patate - 80%; Manioc - 35% and Pois Congo - 85%.

* The land-grazing ratio in the Humid Tropics is one head (cattle) per carreau on unimproved pasture.

In the foregoing chart, Model One gives an average annual income of $148.84 per carreau. The second chart gives an average of $133.70. In comparing this with charcoal plantations, I would assume that the desired average four inch tree diameters could be produced in four years. Assuming that the production costs would vary by no significant margin, from the Dry Forest Sites, we could then assume that a profit of $501.40 ($125.35 per yr.) would be generated on the first cutting cycle with no inter-cropping, and the two year rotation cycle would yield a total profit of $665.00 ($332.5 per year). It appears, therefore that the first cutting will pay for planting the forest, and at the same time, will maintain mountain subsistence incomes at about their same level, while the second rotation will show a clear increase in income. It should be further assumed, that in the Humid Forest, we would also see some marginal gains by inter-cropping trees with food produce.

The Leeward Humid Forest

In traveling over the Massif du Nord between Cap-Haitien and Port-au-Prince, it is remarkable to note the pronounced differences between the North-Eastern and South-Western slopes of the mountains. The North-Eastern slopes are green and lush. The gardens are laced with varying versions of the intricate planting patterns that we have discussed in our models of mixed cropping. In breaking over the crest, going south, we are immediately faced with a funnel of hot air blowing up from the valley below, and cannot help but remark that the grass is usually dry, and that planting patterns have changed dramatically. Instead of sweet potatoes and beans clinging to moist mountains, we are faced with the dry rustle of pure stands of ripening millet, and occasional pockets of less than vigorous Pois Congo.

The most important reason for this marked difference is quite simply rainfall. As clouds move in from the north, they drop most of their rain on the lower mountain slopes, and are often depleted before they reach the mountain crest. Another factor that contributes to this condition is that the southern exposure receives more sun than the northern exposure. Following are two model cropping cycles for the Leeward Humid Tropics.

CROPPING CYCLES FOR THE LEEWARD HUMID TROPICS

Model 1

Period	Crop	Survival Potential	Percentage of Full Crop	Profit
Year 1	Millet	75%	100%	$99.38
	Grazing * (6 months)	—	—	$37.50
Year 2	Millet	75%	100%	$79.50
	Grazing (6 monhts)	—	—	$37.50
Year 3	Millet	75%	100%	$63.60
Year 4	Grazing	—	—	$75.00
Year 5	Grazing	—	—	$75.00
Total				$467.48
Average Yearly Profit = $93.50				

*Grazing on the Leeward Mountains is calculated at 75% of the Windward side.

Model 2

Period	Crop	Survival Potential	Percentage of Full Crop	Profit
Year One	Millet	75%	100%	$99.38
	Grazing (6 months)	—	—	$37.50
Year Two	Millet	75%	70%	$55.65
	Pois Congo	75%	50%	$20.00
Year Three	Millet	75%	50%	$31.80
	Pois Congo	75%	70%	$76.80
Year Four	Pois Congo	75%	100%	$46.50*
Year Five	Grazing	75%	—	$75.00
Total =				$382.93
Average Yearly Profit = $76.59				

* The Congo Beans in this case have a higher income value, because they are an established crop demanding very low labor inputs.

By now, it is clear that a pattern is developing; the Leeward Slopes of the Humid Tropics do not produce the high yields of the Windward Slopes, but they produce more than the Dry Forest. This is to be expected since the productiveness of subsistence agriculture (as well as trees) is largely a function of rainfall and soil depth. Without belaboring the point further, we should assume that tree production on these slopes for the production of charcoal will compete in dollars and cents with the present land use, and that the cutting cycles will fall somewhere between those of the Windward Slopes, and the Dry Forest Flatland configurations.

Charcoal Production in Large Plantations

Presently in Haiti there are rumours of the possibility of investment in large plantation scale charcoal production. While USAID programs are geared toward the small farmer, it would be good for them to know whether or not the small farmer can compete with the large scale producer. The large-scale producer of charcoal will work on a somewhat different economy than the subsistence producer. His per-hour labor costs will be higher than in the inter-peasant relationships. It will not be practical for him to inter-crop, and he will not be able to utilize mountainous terrain. For convenience as well as economy, he will introduce a higher level of technology including tractors and charcoal ovens.

According to "Charcoal Making for Small Enterprises" published by the International Labor Office in Geneva (1975), two metal kilns costing $2,000.00 each, with a labor input of 130 man-days per months, will produce twelve tons of charcoal per month when operated efficiently. According to the same publication, this same labor input will produce six tons of charcoal per month (roughly 50%) with the earth kiln method. Assuming that the cost of the kiln is now about $2,500.00 and has a life of five years, it will produce about 360 tons of charcoal before it is amortized. Since our production is calculated on 27.25 tons per carreau per rotation (900 sacks), this means that the depreciation figure per carreau on the kiln comes to $189.23. We will also assume for our calculations, that labor costs will average $1.60 per day. Since much of the employment will be on a part-time and piece-work basis, it is assumed that wages will not be the legal minimum wage. At the same time, social and institutional pressures on large operation will probably keep wages from going much below the $1.60 level. For this study, we will also assume that the harvesting will be done with hand tools. While the introduction of a buzz saw or a chain saw might have dramatic implications for the man-hour formula, it is my belief that because of initial high costs, the inability to replace parts, and the rapid depreciation due to misuse, these tools will not have a dramatic advantage over comparatively low cost hand labor. The following chart is an estimate of the production costs and profit margins for large scale plantations in both the Dry Forest Flatland, and Humid Forest Flatland configurations.

Plantation Production on Dry and Humid Forest Sites

Period	Item	Dry Forest		Humid Forest	
		Cost	Benefit	Cost	Benefit
Year 1	Prepare Land				
	Prepare Land	$85.00		$85.00	
	Purchase Trees	48.00		48.00	
	Plant Trees	32.00		32.00	
	Weeding Trees				
	(1) Twice	40.00			
	(2) Three Times			60.00	
	Trees Pruned			5.00	
	Replant for Deaths	28.00		20.00	
Year 2	Weed Trees Once	20.00			
	Trees Pruned	5.00			
Year 3	Harvest				
	(295 man-days)			$472.00	
	Depreciation on Kiln			$189.23	$1,260.00
	Charcoal Sold (1.212 sacks)				
Year 4	No Major Inputs				
Year 5	Harvest				
	(1) 295 man-days	$472.00			
	(2) Depreciation on Kiln	$189.23			
	(3) Charcoal Sold		$1,260.00		
Totals		$919.23	$1,260.00	$911.23	$1,260.00
Total Profits -- Cycle One		$340.77		$348.77	
Annual Profit		$68.15		$116.25	
Projected Profits -- Second Cycle -- No Planting Costs		$666.00		$666.00	
Second Cycle Annual Profit		$222.00		$333.00	

I have not dealt with the issue of land costs in this study because I am assuming that most of the potential charcoal producers already own (or control through leasing etc.) the land that has charcoal producing potential. Some of this land is idle or used only for light grazing, while some of it may be in other plantation type crops that cannot compete with the profit margins of charcoal. As the focus of this study indicates, it is my belief that a much more pertinent question than land costs is the comparison of charcoal with existing crops. In terms of large plantations, the four most likely candidates for such a study are coffee, cacao, sugarcane, and sisal.

Coffee and Cacao

Serge Lecussi owns and operates what is considered by many to be one of the finest coffee and cacao plantations in the north of Haiti. He calculates his per carreau production at a thousand pounds per carreau for both coffee and cacao.* Since they sell for the same price ($0.50 per pound), our calculations are made simple. The gross income for coffee or cacao would be $500.00 per carreau. The operational costs to be extracted from this are as follows:

(1)	Two cleanings per year	$60.00
(2)	Labor at harvest	50.00
	Total	$110.00

This means that once establishment costs are paid, that the profit is $390.00 per year per carreau. There is a time lag of four years before production begins, and six to eight years, before returns become significant. Coffee and cacao will presently compete with charcoal in per carreau returns, but it should be remembered both of these crops are subject to international fluxuations in price, as well as varying levels of government regulation.

Sugar Cane

Dr. Norton Strommen's study on Drought in the Caribbean (1979) indicates that the average production level of sugar cane in Haiti is estimated at 30 tons per hectare (38.4 tons per carreau). Here in the north this commodity sells for $9.50 per ton, $5.00 of which is consumed in labor and transportation at harvest. An established field of cane, then, leaves a profit margin of $4.50 per ton, or $173.25 per carreau per year. Establishment costs are about $160.00 per carreau, and the fields must be plowed and replanted every four to six years in order to maintain productivity. This means that profits on cane fields producing 38 ton range from $128.00 to $134.00 per year. Considering the fact that this crop is usually grown on deep alluvial soils with substantial amounts of rainfall, charcoal should compete quite well with this crop in dollar per year returns.

---

* Mr. Lecussi's records are in general agreement with the French experience with coffee and cacao in Africa. See: Memento de l'Agronome, Techniques Rurales en Afrique published by Secrétariat d'Etat aux Affaires Etrangères. République Française.

Sisal

Another large plantation crop that has been grown successfully in Haiti is Sisal. This is a dry land crop, and grows quite well in the moister part of the Dry Forest configuration (minimum rainfall - 700 mm.). Since the plant only yields about 3% fiber, transportation costs of moving the green material from the field to the decorticator are one of the big expenses. There are also large expenditures of energy in the processing and drying of the fiber. While I was not able to get precise information on sisal, Serge Lecussi, who was the Head of Field Operations at Plantation Dauphin for ten years, said that when he left (ten years ago) the price of fiber was $0.10 a pound. They were at that time producing 1650 lbs. of fiber per carreau, and were happy if they made a profit of $50.00 per carreau. Mike Shank, the present Director of Field Operations, told me last year that their goal was to make a profit of $60.00 a carreau. I do not think that there is any question about the ability of charcoal to compete with sisal.

Possible Relationships Between USAID and the Private Voluntary Organizations

I have been asked to comment on the question of possible relationships between USAID and the Private Voluntary Organizations (PVOs) in Haiti. For purposes of this discussion, Private Voluntary Organizations will refer not only to the larger organizations that are presently the recipients and distributors of food stuffs received from the U.S. Government, but we will also include all of the various religious and philanthropical organizations based throughout the country of Haiti. These groups and individuals, usually found in small local communities, are the key to any attempt to involve PVOs in a reforestation program.

While these people are usually over-worked and under-staffed, they have the unquestionable advantages of (1) credibility within their particular communities, (2) a willingness to see a worthwhile project carried through, (3) an already developed "infrastructure" that usually includes vehicles and personnel on (these items would have to be paid for from project funds in a standard project approach), and (4) on the site inspection, evaluation, and carry-through of project procedures and goals. While this does not add up to an automatic project success, it probably provides us with an "Early Warning System" that will tell us when things are not going just right. The diversification of the project into many hands also gives us a great reservoir of creative potential for establishing successful project patterns.

It is my opinion that with a little oversight from a trained forester, most PVOs can manage the technical aspects of nursery production and planting in the field. The new mini-container systems will greatly reduce the administrative load placed upon the PVOs to plant a given number of trees. My own experience in Limbé indicates that while planting a thousand trees up in the mountains used to be a major undertaking demanding constant supervision, that a thousand seedlings in rootrainers can be accomplished at a leisurely pace by two or three semi-skilled workers.

The financial needs of the PVOs will usually be limited to funds for labor, and the purchase of supplies necessary to the establishment and operation of a nursery. While "Food for Work" programs will work well for those who are set up to handle them, they are clumsy administratively, and unacceptable to the workers in areas where the PVOs have traditionally dealt in cash.

The PVOs are usually not adequately staffed to handle reams of paperwork, so the procedures for requesting and reporting should be streamlined to minimize the administrative load of PVOs involved in reforestation projects.

USAID should make very clear to all involved PVOs that there are certain operating assumptions that must be met if they are to receive U.S. Government Funding (such as no hiring discrimination according to religious affiliation etc.). Only PVOs who agree in advance to follow these guidelines should be considered for funding. Beyond those general guidelines, projects including PVOs should be flexible to allow for their differing circumstances and administrative philosophy.

In conclusion, the PVOs represent a wealth of experienced, community based, dependable people who have already indicated their committment to the welfare of the Haitian People. Their potential contribution should not be over-looked in the development of a broad-based community level reforestation program.

APPENDIX

INFORMATION GATHERED ON CHARCOAL MARKETS

Croix des Bouquets

1. Transportation Costs to Port-au-Prince
   a. By truck from Port-de-Paix — $1.00 per sack
   b. By boat from Mole St. Nicolas to Cité Simone — 0.60 per sack

2. Prices in Port-au-Prince
   a. Purchased from truck by wholesaler — $2.60 per sack
   b. Wholesaler sells the retailer — $3.00 per sack
   c. Retailer to customer — $3.20 per sack

3. Miscellaneous information
   a. Boats carry 1000 to 2000 sacks of charcoal (30 to 60 tons)
   b. Trucks carry 200 sacks of charcoal (6 tons)

The Cap-Haitian Charcoal Market

In order to gain information about the Cap Haitian Charcoal Market, I took a scale to the East side of the Cap Haitian Bridge, where all charcoal for the town is distributed. The charcoal comes in to this site both by truck and by donkey, with the latter being the most common means of moving this commodity. I interviewed several sellers about prices and weighed 19 random sacks after making sure that I had been quoted a fair marked price for them. The resulting prices can be considered as retail prices since there are no door to door retailers as are found in Port-au-Prince.

Weight	Price per Sack	Price per Pound	Comments
40 lbs.	$1.80	4.5¢	
39 lbs.	$2.20	6.15¢	Watapanna
20 lbs.	$1.20	6.00¢	Watapanna
40 lbs.	$2.00	5.¢	
38 lbs.	$2.00	5.26¢	
80 lbs.	$3.80	4.75¢	
66 lbs.	$3.20	4.84¢	
40 lbs.	$1.60	4.¢	
40 lbs.	$1.60	4.¢	
48 lbs.	$2.00	4.16¢	
42 lbs.	$2.00	4.76¢	
26 lbs.	$1.40	5.35¢	
40 lbs.	$1.40	3.5¢	
40 lbs.	$1.40	3.5¢	
32 lbs.	$1.40	4.37¢	
55 lbs.	$3.60	6.54¢	Watapanna
30 lbs.	$1.60	5.33¢	Watapanna
28 lbs.	$1.60	5.71¢	Watapanna
30 lbs.	$1.60	5.33¢	Watapanna
Average price per lb. = 4.90¢ or $3.27 per 30 kilos			

Bibliography

FAO Document by J.J.C. Amat, forestier, and W.Van de Moortele, Forestier, Reboisement, Lutte Contre l'Erosion et Mise en Valeur des Forets Naturelles en Haiti, FAO Rome, 1977

FAO Document by W. Van de Moortele, Forestier, Essais d'Introduction d'Essences Forestieres en Haiti, FAO Rome, 1979

Little, Elbert L. and Frank Wadsworth, Common Trees of Puerto Rico and the Virgin Islands, USDA Handbook, No. 249, USDA July, 1964.

Longwood, Franklin R., Puerto Rican Weeds, Their Machining, Seasoning, and Related Characteristics, USDA Handbook No. 205, USDA, Forest Service, November 1961.

National Academy of Sciences, Tropical Legumes: Resources for the Future, National Academy of Sciences, Washington, D.C. 1979.

National Academy of Sciences, Underexploited Tropical Plants with Promising Economic Value, National Academy of Sciences, Washington D.C., 1975

DAS, Haiti, Mission d'Assistance Technique Integrée, DAS, Washington, D.C. 1972

République Française, Secretariat d'Etat Affaires Etrangères, Memento de l'Agronome et Techniques rurales en Afrique, 1965

Sanchez, Pedro A., Properties and Management of Soils in the Tropics, John Wiley and Sons, New York, London, Sydney, Toronto, 1976.

Neem - World Crops & Livestock - March April, 1977

National Academy of Sciences, Leucaena, Promising Forage and Tree Crop for the Tropics. National Academy of Sciences, Washington D.C. 1977.

USAID Report by National Oceanic and Atmospheric Administration Center for Environmental Assessment Services, "A study of the Caribbean Basin Drought/Food Production Problem", May 1979.

USDA Joint Report of Forest Products Laboratory, Southeastern Forest Experiment Station, and Lake States Forest Experiment Station, Charcoal, Production, Marketing and Use, July 1961

International Labour Office, Geneva, Charcoal Making for Small Scale Enterprises, 1975

Republique Française, Secretariat d'Etat Affaires Etrangères, Memento du Forestier, Techniques Rurales en Afrique

Republique Française, Ministère de la Coopération, Memento du Forestier, Techniques Rurales en Afrique, 1978

USDA Handbook No. 207, Present and Potential Commercial Timbers of the Caribbean. USDA, Washington, D.C., March, 1962.