SELECTION OF SPECIES FOR FUELWOOD PRODUCTION IN AGROFORESTRY COMBINATIONS

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1. PROSPECTIVES OF FUELWOOD AS ENERGY SOURCE

The demand for fuelwood in the Central American countries is rising as a result of declining economies and increases in the prices of oil-derived energy such as gas, kerosene, diesel and bunker.

Not only is fuelwood needed for domestic purposes, also several industries are using or intend to use fuelwood as their energy source. The vast majority of the rural population depends on firewood for their cooking and in several areas wood has become so scarce that the housewives have to buy their daily ration of firewood. In other cases several hours are spent every day to gather and transport the firewood needed for the cooking of meals. (6, 7, 8).

There is no indication that this situation is going to change soon; on the contrary, declining national economies with high inflation rates call for an increase in national production and a reduction of the imports. Despite the fact that only Guatemala is producing some oil, one may suppose that virtually all Central American countries will try to reduce their oil imports, possibly by means of price increases and reduction of subsidies on oil-derived products. Thus it is very probable that the demand for fuelwood will increase considerably during the next decade.

The fact that fuelwood is commercialized in many villages is an indicator of the increasing shortage of this commodity. The phenomenon is mainly found in and around the big cities such as Managua, Guatemala, San Salvador and Tegucigalpa, but fuelwood sales may also be found in the smaller towns. This is especially the case in areas with higher population density, where the actual land use pattern does not permit the production of fuelwood in appreciable quantities per unit of land area. for example, the cotton growing areas around León and Chinandega in Nicaragua, sugar cane zones, areas of banana production and areas where intensive animal production or agri-horticulture is practiced. On the other hand, it is estimated that 300,000 ha of forest are cut anually in Central America and Panama as a result of the tendency to clear areas for agricultural production. Since population pressure normally is

not very high in those areas, the supply of fuelwood exceeds the demand and, consequently, considerable volumes of potential fuelwood are left to rot or are burned to clean the land. In nearly all cases the long distance to the nearest fuelwood market center makes the operation economically unattractive because of high transportation costs. Experience with fast and efficient techniques to transform the fuelwood into charcoal are limited in Central America and, furthermore, charcoal is not a widely accepted energy source for cooking; this prevents its use as an important alternative energy source for domestic purposes. However, there is a growing interest in the use of charcoal for several types of industry (4).

During the last decade the use of propane gas and electricity for cooking increased, and the use of kerosene remained more or less constant. However, it is very unlikely that this tendency will continue during the next decade, especially in rural areas, because of the fact that both propane gas and electricity will be subject to more price increases, and that an important investment has to be made for the purchase of the stove and other equipment. This last point is also true for the installation of a biogas plant, although tests are being carried out with cheaper biodigestor designs.

From the facts mentioned above, it can be concluded that fuelwood is the most important energy source in the rural parts of Central America, and that it is not very likely that this will change in the near future(1). Furthermore, there appear to be certain areas with a big fuelwood scarcity, mainly in those which have a pronounced dry season and in highlands where the population pressure is high (The MITRE Corporation. Fuelwood Supply for Managua, Nicaragua. In process)

2. THE ROLE OF AGROFORESTRY SYSTEMS IN FUELWOOD PRODUCTION

The high population density and the intensive land use related herewith make it difficult to produce the firewood in a typical fuelwood plantation --an intensively managed monoculture. An alternative can be provided by those agroforestry systems where fuelwood producing species are combined with annual or perennial crops or with grasses. Promising traditional agroforestry systems in Central America are nearly invariably found on better than marginal sites. Examples are the coffee and shade combinations, the association of alder trees with pastures and the systems of cacao and shade trees. Spectacular positive results of agroforestry systems on marginal

sites should not be expected unless the contrary has been proven. Some examples of the agroforestry activities on marginal sites on poor soils and steep slopes are the pine forests in Guatemala, Honduras and Nicaragua, where cattle grazes on the lower vegetation. In Nicaragua cattle also grazes in a type of wooded savannah in the area around Las Maderas, where the trees are harvested for fuelwood.

In any case, when a combination of trees and crops is engaged, one has to be sure that the tree characteristics do not negatively affect the development of the crop. Desirable tree characteristics are:

1. Accepted/known by local farmers.
2. Local seed source (can be made) available.
3. Producer of fuelwood, posts, fodder, fuits, honey, etc.
4. Nitrogen fixation.
5. Deep root system.
6. Resistant to thinning/lopping for shade regulation.
7. Resprouts after cutting or damages (fire, cattle).
8. No alelopathy.
9. Low in moisture demand.
10. Leaf fall of tree should be compatible to crop development.
11. Vertical growth of the stem and development of an open crown.

3. SITE SUITABILITY OF SELECTED SPECIES

In order to know whether a forestry species is adapted or not to a certain site, species trials have to be carried out if the species does not occur naturally in the area. Experience can be transferred from one analogous area to another but major plantations should not be started without testing the species. Specific guidelines on this subject can be found in Webb, Wood and Smith (12). Frequently, farmers have experience with locally known species. These species should be included in the agroforestry combinations as well as in species selection trials. If trials of species have been carried out in the past, every effort should be made to retrieve the original information and subsequent evaluation data. If the data have not been published, it is possible that valuable information from personnel who was involved in the establishment and/or management of the trial can be obtained.

Since the species to be tested are going to be used in agroforestry systems, i.e. with local farmers, the trials should also be used for demonstration purposes. A set of species trials with a high number of failed species will not be a helpful tool in convincing the farmer that agroforestry may be a worthwhile alternative.

The number of species should be limited to those which seem to be most adapted to the ecological conditions of the area according to published studies. Ten to twenty species can be considered an adequate number to be tested in replicated trials. The number of species to be tested should be smaller on those sites where protection against cattle and fire cannot be provided. This is also the case if the project duration is short (three years, for example), and if the site conditions are very marginal. Some of the publications on species selection are mentioned in the list of references (2, 3, 5, 9, 12).

The farmer will have to decide on the selection of the type of crop to be associated with the tree species. When a non-legume is going to be planted as the agricultural crop, preference should be given to leguminous fuelwood trees. Very little is known on specific tree-crop interaction, but it has become clear that the trees and the crops should be planted nearly at the same moment. Annual and perennial crops are difficult to establish and show poor growth in an already existing forest plantation. If an alley-cropping system is used, where strips of crops are alternated with strips of trees, care should be taken from the beginning to leave sufficient space for the agricultural crop. When the trees are affecting the growth of the agricultural crop, they will have to be pruned back. They will be harvested (by clear-cutting) when they reach the required size for firewood. Tops, thin branches and leaves may be left between the trees as a mulch, or they may be incorporated into the soil where the agricultural crop is grown and serve as a "green manure", to prevent the extraction of too many nutrients from the soil (10).

In general terms, firewood can be produced in the following five different categories of agroforestry systems:

1. Trees associated with annual crops
2. Trees associated with perennial crops
3. Trees and pasture
4. Live fences
5. Windbreaks

Which category is most appropriate depends mainly on the actual land use and on the characteristics of the tree species.

4. PROMISING TREE SPECIES FOR DIFFERENT ZONES

Some of the most important and promising species for agroforestry systems related to firewood production, subdivided in different ecological zones for Central America, are presented below:

4.1 Hihglands (over 1500 m.a.s.l.)

The main agricultural activities in these areas are dairy farming and the production of horticultural crops. Agricultural crops such as wheat are only common in the highlands of Guatemala. In most cases the agricultural activities have an intensive character, in the sense that the farmers are working with a high input of labour and materials per unit of land area. A relatively high number of farmers in these areas have a high acquisition capacity and do not depend on firewood for cooking, when they do, they mostly have enough resources to buy the fuelwood. The farmer may have a need for firewood production when his enterprise is very small or his yields are low due to poor soils or deficient marketing. This is certainly the case in the highlands of Guatemala, where firewood is also needed for heating purposes.

Apart from the firewood production in pure plantations on sites not needed or not suited for agricultural or animal production or in existing natural vegetation, the farmer has several other agroforestry options such as:

a. Strip-planting between agricultural crops, for example with Alnus acuminata, Mimosa scabrella, or fruit trees.

b. Live fences of Alnus acuminata, Erythrina sp. or Eucalyptus globulus

c. Association of Alnus acuminata (in densities between 100 - 400 trees/ha) with pasture; Kikuyu grass is particularly suited but also cut-grasses may be used. (Ref. Combe, Taller Agroforestal).

4.2 Medium level highlands (700 - 1500 m.a.s.l.)

There is a much wider range of activities in this area than in the highlands. In several Central American countries the first settlements took place in this zone, and agriculture and industry have evolved here ever since. Like in the highlands, horticulture and dairy production are found here, but the most important agricultural crop is coffee. In general, the population is not limited to fuelwood for cooking, and the "modern atmosphere" influence of the urban center is strong, since firewood use is considered as something belonging to low income populations. (11). Land is expensive and the only areas that may be available for the plantation of trees are those where perennial crops or cattle cannot be managed profitably, or where housing developments are too expensive.

Existing sources of firewood such as sawmills and scrap wood from housing construction may satisfy part of the demand. The traditional agroforestry combination of coffee and shade trees is a very important source of firewood. Studies at CATIE have indicated that the yearly pruning of the coffee bushes alone yields an average of 1.1 metric ton of dry firewood per ha per year. The firewood production would be higher if the coffee is associated with shade trees which produce acceptable firewood such as Inga or Grevillea. The annual firewood production from Inga loppings is estimated at 1 - 2 m^3/ha/yr depending on Inga density and soil fertility. Thus, an average family of 6 persons, which consumes between 5 and 7 tons of firewood annually may be self-sufficient if the farm has 2 to 3 ha of coffee plantation and shade trees, provided the coffee plantation is managed correctly.

Apart from the species Inga and Grevillea, Casuarina or Juglans may also be used in combination with coffee. Other species for this zone are Eucalyptus grandis E. saligna and Alnus, the latter being recommended especially for the higher elevations (> 1400 m.a.s.l.).

4.3. Wet tropical lowlands (0 - 700 m.a.s.l.; rainfall > 2000 mm/yr)

Normally, this zone is not firewood-deficient due to aggressive natural growth of pioneer species on abandoned land. Exceptions can be found in those areas where the natural vegetation has been nearly completely cleared for agricultural production such as in banana or sugar cane plantations and intensive cattle grazing areas. There are ample possibilities for agroforestry production systems in the humid tropical lowlands, but only in rare cases such as in big colonization schemes, fuelwood production will have to be one of the main production objectives.

4.4 Semi-dry and dry tropical zones (0 - 700 m.a.s.l.; rainfall < 2000 mm/yr)

Fuelwood scarcity is most commonly found in this zone of Central America. High population pressure, the use of fire for land cleaning, and the dry period together with the type of land use, such as sorgo, corn, cotton production, and cattle grazing, all enhance the shortage of fuelwood. Windbreaks, live fences, and alley cropping seem to be the categories where successful agroforestry systems have been and are to be developed. Suggested species are:

Semi-dry (1000-2000 mm/yr)	Dry (< 1000 mm/yr)
Albizzia lebbek	Acacia sp. (native)
Azadirachta indica	Caesalpinia velutina (native)
Caesalpinia velutina (native)	Cajanus cajan (shrub)
Calliandra calothyrsus	Eucalyptus camaldulensis
Cassia siamea	Lysiloma seemanni (native)
Casuarina equisetifolia	Mimosa tenuiflora (native)
Diphysa robinioides	Parkinsonia aculeata
E. camaldulensis	Prosopis julifora (native)
E. citriodora	
Gliricidia sepium (native)	
Guazuma ulmifolia (native)	
Inga vera (native)	
Leucaena leucocephala (native)	
Simaruba officinalis	
Tectona grandis	

The majority of the species mentiones in paragraphs 4.1 - 4.4 have been only partially tested - if at all- on different sites. Experience with seed collection and storage, nursery techniques, soil requirements and silviculture is also limited in Central America. The Fuelwood and Altenative Energy Sources Project, which CATIE is implementing in close collaboration with the National Forestry Institutes, is planting small research and demonstration plots for fuelwood production for small farmers. Although some exotic species are used in this project, the native species are preferred due to several factors. Fresh seed from selected trees can be obtained annually at low cost. The trees can be propagated without the need for special nursery techniques, and, in most cases, the native species are well adapted to local soil conditions. Furthermore, the farmers accept the native species more easily since they know about their qualities.

A list of the species used by the fuelwood project is presented in Table 1. The appropriate ecological life zones are indicated for each species, their potential wood use is mentioned, and suggestions are made for the type of agroforestry combination in which the species can be used. A short description of the ecological zones used in Table 1 is presented in Table 2.

Table 1. Some selected species for fuelwood production in agroforestry combinations for different ecological life zones.

SPECIES	Suitability for ecological life zones (1)								Wood quality					Agroforestry potential				
	bh-T	bs-T	bms-T	bmh-P	bh-P	bs-P	bh-MB	bmh-MB	Fc	Lu	Po	Ch	Pu	C	AC	PC	LF	W
Acacia auriculiformis	x	x		x	x				✓+	o					x			
Albizia lebbek	x	x	x	x	x	x			✓+	+					x	x		
Alnus acuminata				x			x	x	—+	+		+	+	x	x			x
Azadirachta indica		x	x						—+	+	+				x			x
Calliandra calothyrsus	x	x		x	x				✓+	+					x			
Casuarina equisetifolia	x	x	x	x	x	x			✓++	+	+		+					x
Cordia alliodora	x			x	x				✓+	++		+		?	x	x		
Eucalyptus camaldulensis		x	x		x	x			✓++	o	+		o					x
Eucalyptus citriodora		x			x				✓++	+	+		o					x
Eucalyptus grandis				x	x		x	x	✓++	o	+	o	+					x
Eucalyptus saligna				x	x		x	x	✓+	+	+	o	+					x
Eucalyptus tereticornis		x	x		x	x			✓+	+	o		o					x
Gliricidia sepium	x	x	x	x	x	x			✓++	+	+				x	x	x	
Grevillea robusta				x	x	x	x		✓+	+		+				x		
Guazuma ulmifolia	x	x	x	x	x				✓++	+				x	?			
Inga vera	x	x		x	x				✓+	o					x	x		
Leucaena leucocephala	x	x	x	x					—++	o	+		+	x	x	x		x
Sesbania grandiflora	x	x		x	x				✓o				+		x			
Tectona grandis	x	x		x	x				✓+	++	+	+						

(1) See Table 2 for climatological details.

(2) Fc = Fuelwood and/or charcoal
Lu = Lumber
Po = Posts
Ch = Chips, Plywood
Pu = Paper pulp

++ = very good
+ = good
o = regular, with limitations

(3) C = Cattle pasture
AC = Annual crops
PC = Perennial crops
LF = Live fences
W = Windbreak

Adapted from:

BAUER, J. Especies con potencial para la reforestación en Honduras. COHDEFOR, 1982. 42 p.

Table 2. Climatological characteristics for ecological life zones

Biotemperatura media anual (°C)	Precipitación media total anual (mm)		
	500 - 1000	1000 - 2000	2000 - 4000
12 - 17		bh-MB bosque húmedo Montano Bajo	bmh-MB bosque muy húmedo Montano Bajo
17 - 24	bs-P bosque seco Premontano	bh-P bosque húmedo Premontano	bmh-P bosque muy húmedo Premontano
Más de 24	bms-T bosque muy seco Tropical	bs-T bosque seco Tropical	bh-T bosque húmedo Tropical

BIBLIOGRAPHY

1. BALANCE ENERGETICO Nacional; serie histórica 1965 - 1979. San José, Costa Rica, Programa Energético del Istmo Centroamericano, Proyecto RLA/76/012, 1980. 234 p.

2. FLINTA, C. Prácticas de plantación forestal en América Latina. Organización de las Naciones Unidas para la Agricultura y la Alimentación. Cuaderno de Fomento Forestal No. 15. 1960. 498 p.

3. FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. Prácticas de plantación de árboles en la sabana africana. FAO: Cuaderno de Fomento Forestal No. 19. 1975. 203 p.

4. GEWALD, N.J. y UGALDE, A.L. Informe del Seminario Móvil realizado en Costa Rica y Nicaragua. Turrialba, Costa Rica, CATIE. Serie Técnica. Informe Técnico No. 22. 1981. 70 p.

5. GOOR, A.Y. y BARNEY, C.W. Forest tree planting in arid zones. New York, Ronald Press, 1968. 409 p.

6. JONES, J. y OTAROLA, A. Diágnostico socio-económico sobre el consumo y la producción de leña en fincas pequeñas en Nicaragua. Proyecto Leña IRENA-CATIE. Turrialba, Costa Rica. 1981. 69 p.

7. LEMCKERT, A. El uso doméstico de leña en Costa Rica. Serie Técnica. Informe Técnico No. 9. Turrialba, Costa Rica, CATIE, 1981. 27 p.

8. LEMCKERT, A. y CAMPOS, J. Producción y consumo de leña en las pequeñas fincas de Costa Rica. Serie Técnica. Informe Técnico No. 16. Turrialba, Costa Rica, CATIE, 1981. 69 p.

9. NATIONAL ACADEMY OF SCIENCES. Firewood crops - shrub and tree species for energy production. Washington, D.C., NAS, 1980. 237 p.

10. RIEKERK, H. y PRITCHETT, W.L. Potential site consequences of growing wood for fuel. In Smith, W., ed. Energy in forestry production and use. Gainsville. University of Florida. School of Forest Resources and Conservation. Resources Report No. 5. 1978. pp. 65-79.

11. SISSON, A.B. Survey of fuelwood use in selected sites of Central America. Washington, D.C. AID Contract No. 596-463, 1979. 37 p. (mimeogr.)

12. WEBB, D.B., WOOD, P.J. y SMITH, J. A guide to species selection for tropical and subtropical plantations. Oxford. University of Oxford. Commonwealth Forestry Institute. Tropical Forestry Paper No. 15. 1980. 342 p.