Technical Specification: AF-CAFE-TROP1

System: Improved coffee plantation (cafetal mejorado)
Variation: *Cedrela odorata* L. (cedro),
Swientenia macrophylla (caoba)

Summary[1]

This system involves enrichment planting of timber trees to provide shade in coffee plantations and aims to buffer small-scale farmers coffee price fluctuations through diversifying production. The price of coffee can be very variable in Central America creating significant problems for small scale producers. Through the use of timber trees to provide shade income from coffee plantations can be improved as well as increasing carbon sequestration.

Ecology[2,3,4]

Coffee grows best in areas of 600-1200 masl with mean temperatures of 18-22ºC without frost risk in the winter. In Mexico it is grown in mid altuitude canyons and slopes of mountain ranges. Although new varieties of intensively grown coffee can be grown in direct sunlight small-holder cultivation in Mexico generally involves planting coffee under sparse canopy of shade trees sometimes intercropped with bananas.

Cedrela odorata is a fast-growing, high-value timber tree that is native to large areas of Central and South America from southern Mexico to Bolivia, 28ºS–26ºN. It is found naturally at altitudes between 0 and 1500 masl, and where mean annual rainfall is between 1200-3000 mm per year, where the mean annual temperature is 20-32ºC. It will grow on light, medium or heavy soils but thrives on free draining, fertile soils. *Cedrela odorata* is a light demanding species that thrives in open spaces or large clearings in highly diverse tropical broadleaved forests but in much of its native range the gene pool has been severely depleted due to the high demand for its valuable timber. *Cedrela odorata* is grown as a plantation tree throughout the tropics (see additional information).

Classification of climate/ site productivity

Climate is classed as optimal and sub-optimal based on available ecological information and experiences within the project. (The use of this system in areas classified as sub-optimal for climatic conditions is not recommended.)

Optimal	Tropical, humid 300-1200 masl 1200 - 2250 mm/yr
Sub-optimal	Subtropical/temperate, subhumid <300 or >1200 masl <1200 mm/yr

Site productivity is inferred from locally reported soil conditions for the site[5].

	High	**Medium**	**Low**
Soil type	Deep (>30cm), well drained, brown-black, few stones	20-30cm depth, heavy clays or sandy	Thin (<20cm), stoney, compacted soils or oxidised clays

Management objectives[6]

The objective is to produce high quality timber while maintaining optimum levels of shade for coffee production. Most small scale coffee production in Mexico uses chalum (*Inga* spp.) as a shade tree which also serves as fuelwood. The recommended species will accumulate more biomass than Inga trees but cast less shade thus allowing greater stocking density. Excellent results have been achieved with a mix of *Cordia alliodora*, *Cedrela odorata* and *Inga* spp. in coffee plantations in Costa Rica.

Potential income[7]

The value of cedro and hormiguillo timber at the saw mill is US$78/$m^3$, costs of harvesting and transportation are approximately US$ 33.09 /m^3. If the net value of standing timber is assumed to be US$35/ m^3, 150 m3 timber /ha would give a total net income of approximately US$5,000 US$ /ha at then end of the 25 year rotation. (Volume estimated from average reported yield).

Costs of implementation[8]

Estimated costs per ha over the rotation are: establishment US$115, maintenance US$63 and opportunity cost (lost production from land) US$600-750 depending site quality

Management operations

Timber species are planted in the cafetal as additional shade trees and around the plot as a live fence.

Establishment[9]

1. It is important to obtain good quality planting stock, which should be ready for planting at the beginning of the rainy season.
2. Making holes for seedlings – large holes 30cm diameter and depth produce better conditions for root development, the topsoil is more fertile and should be placed in the bottom of the hole for better rooting. In very compact soils holes may be dug after the start of the rains.
3. Planting spacing in the cafetal should be 10x10m and additional trees planted around the plot as a live fence at a spacing of 4m to give a total of 180 stems per ha
4. The roots of seedlings should be pruned just prior to planting to help root development

Maintenance

1. Weeding should be carried out twice per year until canopy closure.
2. Pruning is vital to maintain tree form where there is evidence of *Hypsipyla* attack (see additional information below)

Thinning and harvest

1. No thinning is necessary at this initial spacing
2. The harvest should take place in year 25

Re-establishment

1. The system is re-established by planting new seedlings after harvest.

Carbon sequestration potential[10,11,12,13,14]

Carbon sequestration potential over 100 years with a crop rotation of 25 years on an average quality site with optimal climatic conditions is 39 tC/ha above an initial soil and vegetation carbon baseline of 103 tC/ha. (For details of carbon flux see appendix 1).

Carbon sequestration potential is based on average net carbon storage in biomass and forest products. Carbon storage is calculated using the CO2FIX model (Mohren and Klein Goldewijk 1990, Mohren et al 1999). Details of the parameters used (basic wood carbon content; initial soil carbon content; timber production; total tree increment relative to timber production; turnover rate; humification factor; litter and humus residence time; product allocation for thinnings and expected lifetime of products) are given in de Jong et al 1996. The model uses an assumed annual timber production of 7.5m3/ha for planted trees; details of the productivity data are given in de Jong et al 1995. (For details of model inputs see appendix 2).

The soil baseline (75 tC/ha) is based on de Jong et al 1996. The vegetation baseline (28 tC/ha) is based on Ambio 2002. The baseline assumes that current land use would continue unchanged and that the long term average carbon storage would be the same as current carbon stock.

Monitoring[11]

Monitoring targets for the first 3 years are based on establishment; the whole plot must be established by the third year with at least 85% survival of seedlings. Thereafter monitoring targets are based on DBH, the expected DBH at the time of monitoring is based on a predicted mean annual diameter increment on which carbon sequestration estimates are based.

Year	**Indicator**
1	At least 33% plot established
2	At least 66% plot established
3	Whole plot established, 85% survival At least 180 stems /ha planted
5	Average DBH not less than 9cm
10	Average DBH not less than 18cm
15	Average DBH not less than 26.5cm

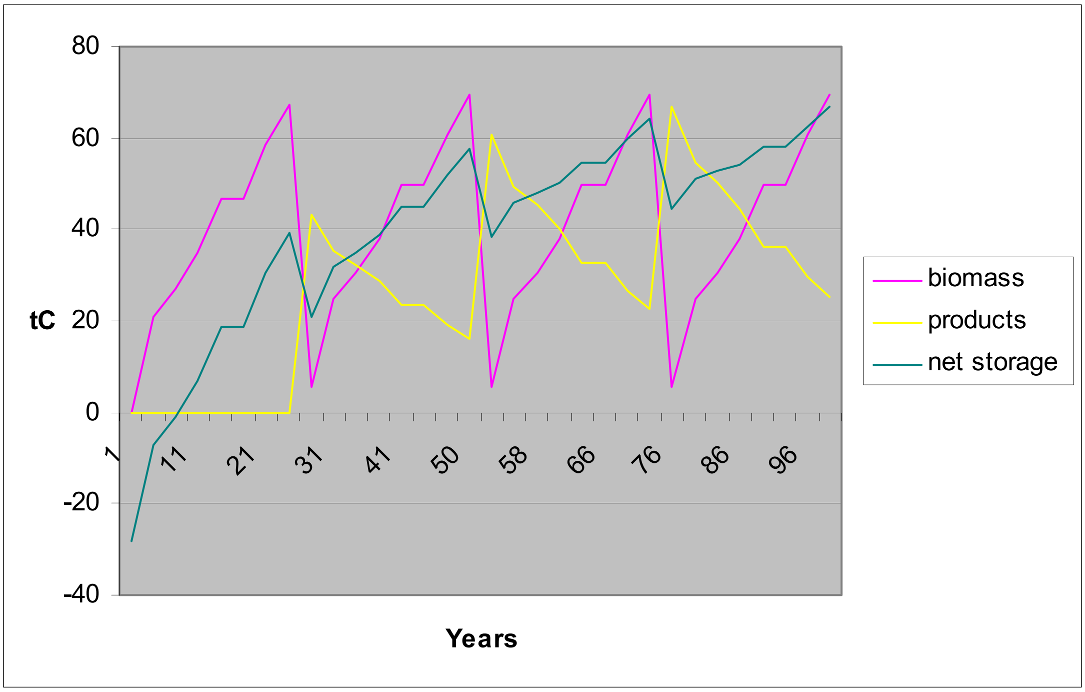
Additional information[4,15]

The most important pest on plantation of Cedrela odorata and one of the most important factors in establishment is the shoot borer *Hypsipyla grandela*. The larvae of the moth develop in the apical bud of young mahogany trees causing the shoot to die. This does not kill the tree but this leads to the growth of several subsidiary shoots. If not pruned this will lead to forking of the main stem and drastically reduce the value of the timber. However if damaged shoots are removed the tree will continue to grow with good form and the length of saleable timber much increased. Pruning of subsidiary shoots must take place within one or two years of *Hypsipyla* attack as the removal of older branches will put the tree at risk of disease. One means of reducing the occurrence of the shoot borer is to use a mixture of species.

Although not conclusively proven, planting fast growing species with the *Cedrela* may help prevent infestation through reducing the chances host location. Chemical and biological means of control do exist but at high the cost. The advantage in small scale plantations of mahogany is that the farmer can quickly spot damaged trees and prune the shoots where necessary during routine maintenance. After approximately 5 years the trees become less susceptible to the shoot borer. It is extremely important that farmers are given training in pruning trees if they are to realise the full value of this species.

Appendix 1 Carbon storage figures

Year	biomass	products	total storage	net storage	accumulated tCyr
1	0	0	0	-28	-28.00
6	20.96	0	20.97	-7.03	-115.58
8	26.99	0	26.98	-1.02	-123.63
11	34.75	0	34.76	6.76	-115.02
16	46.86	0	46.87	18.87	-50.94
21	58.35	0	58.34	30.34	72.09
25	67.14	0	67.14	39.14	211.05
26	5.62	43.2	48.83	20.83	241.03
31	24.66	35.22	59.89	31.89	372.83
33	30.45	32.46	62.9	34.9	439.62
36	37.94	28.72	66.66	38.66	549.96
41	49.7	23.42	73.12	45.12	759.41
46	60.93	19.09	80.03	52.03	1002.29
50	69.58	16.22	85.79	57.79	1221.93
51	5.62	60.57	66.19	38.19	1269.92
56	24.66	49.39	74.05	46.05	1480.52
58	30.45	45.51	75.96	47.96	1574.53
61	37.94	40.27	78.21	50.21	1721.78
66	49.7	32.83	82.53	54.53	1983.63
71	60.93	26.77	87.71	59.71	2269.23
75	69.58	22.74	92.31	64.31	2517.27
76	5.62	66.83	72.46	44.46	2571.66
81	24.66	54.49	79.16	51.16	2810.71
83	30.45	50.22	80.67	52.67	2914.54
86	37.94	44.43	82.37	54.37	3075.10
91	49.7	36.23	85.93	57.93	3355.85
96	60.93	29.54	90.47	62.47	3656.85
100	69.58	25.09	94.66	66.66	3915.11



Appendix 2 - CO2Fix Inputs

Stand parameters		
Rotation length (yr)		25
Number of rotations		4
Adjustment of assimilate to account for non-optimal site conditions	Foliage	1
	Branches	1
	roots	1
Initial biomass (Mg/ha)	Foliage	0
	Roots	0
	Litter	0
	Soil humus	150
	Branches	0
	Stems	0
	Deadwood	0

Tree Growth Table				
Age (yr)	Stem increment (m3/yr)	Dry weight increment relative to stem		
		needles	Branch	roots
0	7.5	0.7	0.6	0.7
10	7.5	0.4	0.4	0.4
15	7.5			
20	7.5	0.4	0.4	0.4
25	7.5			

Tree species Parameters		
Basic density of stemwood (kg/m3)		500
Carbon content of dry matter (kg/kg)		0.5
Turnover of various biomass components (1/yr)	Needles	0.5
	Branches	0.05
	Roots	0.07
Mortality as a fraction of trees per year (1/yr)		0.02
Average residence time of carbon in wood products (1/yr)	Dead wood	10
	Energy	1
	Packing	5
	Construction	25*
Humification and decomposition coefficients (yr)	Humification	0.1
	Litter decomposition	1
	Humus decomposition	100
Carbon content of stable soil humus (kg/kg)		0.5

Thinning and harvest table					
Thinning age	Fraction stem removed	Dead wood	Energy	Packing	Construction
	0	0	0	0	0
	0	0	0	0	0
Final harvest		0	0	0	1

* Differs from de Jong et al 1996 as is set to equal the rotation length

References

[1] This specification is based on a system used in Chiapas, Mexico
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[4] Moguel, P. y V.M. Toledo. 1996. El café en México: ecología, cultura indígina y sustentabilidad. *Ciencias* 43:40-51.
[5] Site class characteristics are based on surveys conducted with farmers in the region
[6] Montenegro, J. G. Ramírez y H. Blanco-Metzier. 1997. Evaluación del establecimiento y crecimiento inicial de seis especies maderables asociadas con café. *Agroforestería en las Américas (Costa Rica)* 4(13):14-20.
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[8] Data adapted from Tipper R., de Jong B., Ochoa-Gaona S., Soto-Pinto M., Castillo-Santiago M., Montoya-Gomez G. and March-Mifsut I. (1999) Assessment of the cost of large scale forestry for CO2 sequestration: evidence from Chiapas, Mexico. IEA Greenhouse Gas R&D Programme
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[12] de Jong B., Soto-Pinto L., Montoya-Gomez G., Nelson K., Taylor J. and Tipper R. 1996. Forestry and agroforestry alternatives for carbon sequestration: a study from Chiapas, Mexico. In: W. Adger, D. Pettenella and W. Whitby (eds) *Climate Change Mitigation and European Land Use Polices*. CAB International pp.269-284
[13] de Jong B., Montoya-Gomez G., Nelson K., Soto-Pinto L., Taylor J. and Tipper R. (1995) Community forest management and carbon sequestration: a feasibility study from Chiapas, Mexico. *Interciencia* 20(6):409-416
[14] Ambio 2002
[15] Newton A., Baker P., Ramnarine S., Mesen J. and Leakey R. 1993. The mahogany shoot borer: prospects for control. *Forest Ecology and Management* 57: 301-328