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COMMUNITY FOREST MANAGEMENT AND CARBON SEQUESTRATION: A FEASIBILITY STUDY FROM CHIAPAS, MEXICO

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SUMMARY

Although forestry and agroforestry are recognized as promising land-use alternatives for reducing the increasing levels of global atmospheric carbon, the viability of carbon sequestration projects at the land-user level has rarely been evaluated We present the results of a feasibility study to: (1) evaluate the interest of local communities in a carbon sequestration project and how they would organize themselves for the proposed forestry project; (2) identify the carbon sequestration potential of the agroforestry/forestry systems that are both ecologically viable and preferred by local farmers (3) determine the social constraints of and potential for, such projects,- and (4) assess the economic potential of the carbon offsets estimated for such systems. This project was carried out by an interdisciplinary team of scientists and farmers in two ecological regions: the Tojolabal and Tzeltal zones of Chiapas, Mexico. Five systems with high carbon sequestration potential were considered technically and socially viable for each region. Initially, all participants will plant trees on an individual basis in their coffee plantation, fallow, and pasture lands, or in their maize fields. The estimated amount of carbon sequestered ranged from 46 7 to 236 7 tons of carbon per hectare (tC/ha). Net income benefits due to converting fields from maize cultivation to farm forestry ranged from $500-1000/ha depending on the value assigned to the sequestered carbon.1 Forests and farm woodlands that are sustainably managed have substantial economic and carbon sequestration potential. The principal barrier to communal forest management appears to be sociopolitical rather than economic. Because forest management requires long-term investments, good planning is essential and includes community control of projects, selection of appropriate tree species, and management techniques that are specific to the ecological and social conditions of the area. 1 All references to dollars in this report refer to U.S. dollars ($US). KEY WORDS / Community Forestry / Carbon Sequestration / Agroforestry / Social Organization

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At the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, a non-legally binding statement of principles was adopted for the management, conservation, and sustainable development of multiple-use forests. The statement documents the importance of incorporating environmental costs and benefits into market mechanisms to achieve forest conservation and sustainable development both domestically and internationally. However, economic variables accounting for the costs of We environmental impacts of different land-use scenarios -are not included in most macro or micro-economic land-use analyses for developing countries. Traditionally, economic analyses that evaluate forest ecosystems include only the stumpage values of standing trees for wood production (De Jong and Montoya, 1994). Recently, there has been a greater effort to include ecological benefits such as soil conservation (e.g. Pimentel *et al*., 1995), biodiversity preservation (Tacconi and Bennett, 1995), and carbon sequestration (Trexler, 1991) in economic analyses.

Emissions resulting from human activities are substantially increasing the atmospheric concentration of greenhouse gases: carbon dioxide, methane, chlorofluorocarbons (CFCs), and nitrous oxide. These increased emissions could enhance the greenhouse effect, and thus increase the average temperature of the earth's surface (IPCC, 1990). Carbon dioxide is currently responsible for over half of the enhanced greenhouse effect and is likely to continue to be the most important causal factor in the future. Identified sources of carbon emissions include burning of fossil fuels, cement production, and land-use conversion (Cook *et al*., 1990).

Mexico is among the top ten countries in carbon releases from forest clearing (Detwiler and Hall, 1988) Recently, climatic and meteorological changes in Mexico have been linked to deforestation and to the prediction of global warming associated with the greenhouse effect (Liverman, 1991). Carbon sequestration scenarios developed by Masera (1994) suggest that Mexico can significantly reduce its net carbon emissions to the atmosphere through management of native temperate and tropical forests and reforestation of degraded areas. The potential role of forests in carbon sequestration has also been evaluated by a number of other authors (Marland, 1988; Andrasko *et al*, 1991; Houghton *et al*., 1991; Sedjo and Solomon, 1991). Although they are preliminary, these analyses suggest that forest conservation, establishment, and management, as well as agroforestry, could contribute to global carbon sequestration and conservation while providing goods and services for rural communities of many countries. Forestry and agroforestry can compensate for greenhouse gas emissions in two ways: (1) they can create new sinks for carbon dioxide by increasing the mass of woody material within growing trees and within the timber that is harvested for the production of durable products; and (2) they can protect the endangered natural forests and soils which are carbon stores.

Estimates of the biological and economic potential of forest management practices for controlling the concentration of carbon dioxide in the earth's atmosphere are highly speculative. Dixon *et al*. (1993) roughly estimate that economically viable forest and agroforestry management practices could conserve and sequester 1 gigaton of carbon per year (GtC/yr), worldwide; the marginal cost of implementing these options is estimated to be $10/tC. Trexler (1991) identifies a range of forestry policy options for U.S. forests that could reduce emissions by 0.75 to 1.15 GtC/yr at a marginal cost of $30-50/tC. A number of private projects sponsored by power generators have claimed sequestration costs of less than $5/tC (FACE, 1994), with some less than $1/tC (Swisher, 1991).

Although forestry and agroforestry are recognized as promising land-use alternatives for reducing the increasing levels of global atmospheric carbon in the short-term, the viability of carbon sequestration projects at the land-user level has rarely been evaluated. We present the results of a feasibility study that was carried out in order to: (1) evaluate the interest of local communities in a carbon sequestration project and how they would organize themselves for the proposed forestry project; (2) identify the carbon sequestration potential of the agroforestry/forestry systems that are both ecologically viable and preferred by local farmers; (3) determine the social constraints of, and potential for, such projects; and (4) assess the economic potential of the carbon offsets estimated for such systems. The project was carried out by an interdisciplinary team of scientists and farmers in two distinct indigenous and ecological regions, the Tojolabal and Tzeltal Zones of Chiapas, Mexico.

Description of the study areas

The state of Chiapas is located in southern Mexico, where diverse physiographic and climatic factors combine to create one of the richest and most varied floras in the country (Miranda, 1975). Tropical rain forests, coniferous forests, and montane rain forests are among the important vegetation types. These forests are not only ecologically important, but are also a significant element of the economies of the indigenous rural residents. The majority of these rural residents are subsistence or semi-subsistence farmers who rely heavily on forest resources for fuelwood, construction materials, food supplements, and fabric dyes.

The feasibility study was carried out with the members of the Unión de Crédito Pajal Ya Kac'tic (Pajal), an organization of farmers. One of the two study zones is predominantly Maya Tojolabal and the other is predominantly

Maya-Tzeltal; these are two of the principle indigenous groups in Chiapas. These particular zones were selected by Pajal, based on their biological potential for forest resources as well as the interest demonstrated by Pajal members in these zones. Five communities from each region have been participating in the feasibility study, and all communities but one have maintained interest throughout the project. All the participating communities retain legal land tenancy titles as ejidos. ("Ejido" is a term used for the productive grouping of people with land in common ownership). The two regions are briefly described below.

Tzeltal region

In the Tzeltal region, maize, beans, and calabash are the primary annual crops that are grown to satisfy local needs, while coffee is the commercial product. Pigs and, to a lesser extent, cattle are the principal commercial animals, while chickens and turkeys are maintained in the home gardens for subsistence. Forestry activities are restricted to the cutting of trees for fuel and for the construction of houses and fences, all for subsistence or trade at the community level. Because slash-and-burn agriculture is still the main practice, forestry and maize production are strongly connected; fallow periods range from three to 20 years. For farmers who use fertilizers, the average per-hectare production is 1000 kilograms (kg) of maize and 400 kg of beans, as well as some calabash and other foods for household consumption. Only a few plots of mature forest can be found in the region.

The five Tzeltal communities - Chapullil, Segunda Cololteel, Alan Cantajal, Muquenal, and Jol-Cacualhaóare - are located in the municipality of Chilón and form part of the ejido San Sebastian Bachajón. These communities lie at an average altitude of 800 meters hove sea level. Although only fragments of primary evergreen rainforest remain in the communities, participants have shown great interest in using agroforestry systems to improve their land management practices. The total land area of the five communities is 2,387 hectares (ha). Together, the communities have 907 inhabitants, of which 170 are members of Pajal.

Tojolabal region

Agricultural production in the Tojolabal region is limited to maize and beans for household consumption. Pesticides and fertilizers are widely used, and mechanical soil preparation is common. On average, per-hectare production is 1000 kg of maize and 400 kg of beans. Each family Owns approximately three to four head of cattle, which are sold when the farmer needs cash. Grazing occurs on communal land, which is a combination of pasture land, secondary shrub and forest land, and mature forest. Forestry is restricted to selective harvesting for household purposes, such as house building, fuelwood, and fencing. Some wood products are sold at the communal level, and there is local interest in commercializing forest products for a larger market. In the past, standing trees were sold to nearby saw mills.

The five Tojolabal communities - Jusnajab, Yaluma, Lomantan, Bajucu, and Palma Real - are located in the municipalities of Comitán and Las Margaritas. Each community is an ejido. These communities lie at an average altitude of 1600 meters above sea level, and enjoy a subhumid, subtropical to temperate climate. Based on local decisions, there are well-preserved extensions of the pine-oak forests that are exploited for consumption within each community. The total land area of the five communities is 9,281 ha. Together, the communities have 5,336 inhabitants, of which 439 are members of Pajal.

Methodology

Two representatives from each community were elected by participants in group meetings held to promote the project. Guided by the advice of other community members who chose to participate, and with the technical assistance of researchers from El Colegio de la Frontera Sur (ECOSUR) and Pajal, these two representatives then gathered information and designed community agroforestry/forestry options. They also helped to collect information required for the biomass study and social characteristics.

Two workshops for the representatives and scientist advisors were held in February and June, respectively. In the first workshop, participants focused on assessing the potential of forest management systems in biological, technical, social, and economic terms. This was the first time that the concept of carbon sequestration was presented as a potential component of a forestry project. ECOSUR scientists and Pajal technicians explained the social and technical implications of agroforestry and farm forestry alternatives, while the community representatives presented a detailed description of their land-use systems, the tree species in each region, and how they manage these species. They explained their major land-use constraints and the farm forestry and agroforestry alternatives they considered feasible. Between the first and second workshops, site visits for the personnel of ECOSUR and Pajal were organized by the representatives. Each community representative collected data on: (1) the interest of community members in a farm forestry and agroforestry project; (2) how much land the community would have available for each activity (3) the system(s) that community members would prefer, including species selection and tree distribution within the systems; and (4) social demographics, the history of previous development projects, and options for organizing the community. During the second workshop, the results of the first workshop, the visits, and data collected by the representatives were evaluated and then used in the final deign of each community proposal.

Selection of appropriate forestry and agroforestry land-use alternatives

The agroforestry and forestry alternatives presented by ECOSUR were discussed with community representatives during the first workshop. Additional alternatives were presented by the representatives during the second workshop and discussed with the ECOSUR staff and the Pajal forestry manager. The following variables were included in the system analysis: (1) area available to plant a tree or shrub component; (2) species or species combinations; (3) current land-use system in which trees would be planted; (4) planting design; and (5) availability of the planting material.

Estimation of Carbon Sequestration

There are a number of difficulties involved in estimating the quantity of carbon that might be sequestered or conserved by a given project, and these difficulties multiply in the context of social forestry interventions. It is relatively easy to measure carbon storage in the growing stock of a forestry plantation system. The carbon content of above-ground biomass is approximately 50% of dry weight, and adequate measurement techniques exist to monitor or predict the growth of even-aged stands of many commercial tree species. However, in agroforestry projects that involve the growth of multiple species of different ages in complex arrangements with perennial or annual crops, such prediction of biomass accumulation is more difficult. In the context of social forestry, it is likely that trees will provide a number of end products (such as fuelwood, poles, construction timber, and bark) and that each product will have a different carbon-storage profile. Some products may also have an additional carbon-balance impact through market substitution; for example, this is the case where wood replaces energy-intensive materials such as cement or steel in construction. Changes in the soil carbon are not well understood. Many soils that are transferred from agricultural production to forestry will accumulate carbon under tree cover.

In this study, to obtain preliminary data on the carbon sequestration potential of forestry and agroforestry projects, we evaluate the growing potential of the above-ground carbon in the trees added to the current land-use system. Calculations of increased carbon storage are based on the mean annual increment (MAI) in diameter. The MAI in the Tojolabal region was calculated by taking the average annual increase in diameter of Pinus trees under different growing conditions. A carbon storage equation for the Pinus trees, relating carbon content of the trees with diameter at breast height (DBH), was constructed through statistical analysis of biomass data (Brown, unpublished data). In the Tzeltal region, the MAI was determined by dividing the average DBH of the 10 largest, fast growing species in forest fallows by the age of the fallow. The regression equations to estimate carbon content for broad-leaved species were adapted from biomass equations published by Brown *et al*. (1989) and assume the carbon content to be 50% of the weight of the dry biomass. Estimates of the total carbon sequestration potential of the selected systems are based on the number of trees at the end of the rotation (NFINAL) multiplied by the estimation of carbon sequestered by each tree at the end of the rotation period.

In addition, the carbon sequestered by the trees harvested during periodic thinnings is calculated by multiplying the number of trees cut during thinning by the carbon content estimation of each tree, based on their respective growth and biomass equations.

The equations used to estimate the amount of carbon sequestered per tree are listed below; in the equations, "Ctree" represents the kilograms of carbon sequestered per tree.

(1) Broad-leaved trees of Tojolabal region:

Ctree = 0.5*(34.4703 - 8.0671*DBH + 0.6589*DBH2) (after Brown *et al*., 1989)

(2) Pinus and Cupressus trees in Tojolabal region:

Ctree = 0,5*(0.196*DBH2.266)

(3) Broad-leaved trees of Tzeltal region:

Ctree = 0.5*(13.2579 - 4.8943*DBH + 0.6713*DBH2) (after Brown *et al*., 1989)

Costs of carbon sequestration

The cost of carbon sequestration for each system is the cost of adding the forest component to the current system in each region, plus the cost of establishing and maintaining the system, plus the opportunity costs associated with the lost benefits of alternative systems, minus the benefits of forest product sales. The systems to be changed included pasture, maize fields, abandoned coffee plantations, tree and shrub fallow, and degraded pine forests. The costs include labor, equipment, and planting stock. In this paper, the cost of carbon sequestration for fallow enrichment is calculated. Labor costs are based on local minimum wages. Exchange rates are 6.00 New pesos (N$) per U.S.

dollar (US$). The costs are represented on a per-hectare basis, as are the carbon sequestration potentials. The interest rates used to adjust costs to present date are 5, 10, and 15%. Dividing the total costs by the carbon sequestration potential of the system determines the final cost of each ton of carbon sequestered.

The economic costs of carbon fluxes in the current systems have been omitted from the calculation. For the following reasons, estimates of the economic costs of global warming are also excluded: first, predictions of future climatic conditions are still speculative; second, climate change and the resulting physical damage will depend upon the growth of economies, human population, and developing technologies; and, third, the valuation of economic damage depends upon moral and ethical considerations such as the value of human lives saved and loss of national territories. Carbon storage is just one of a number of services provided by a managed forest, and the cost of providing these services as separate components depends upon the "terms of trade" implicit within any given agreement between a service provider (individual farmer, forestry company, farming community) and a carbon emitter (an industrial enterprise or government).

Assessment of social constraints and opportunities

Community representatives served as both informants and researchers on social variables. They supplied information on social, cultural, economic, and production systems within the community using three tools: a written survey, group discussion, and an open-ended set of questions. The initial written survey recorded basic socioeconomic data covering demographics, production systems, land tenure, community history, and municipal political structure. During the first training course, two representatives from each community (twenty farmers in total) spent four hours in a guided group discussion about the social and organizational components of a forestry project. The representatives were led through an analysis of organizations and groups in their communities that might support or block the forestry project, an evaluation of past community projects and reasons for their success or failure, and a discussion of various designs for working together (as individuals, as a group, or through communal organization). Finally, the representatives returned to their communities with a series of open-ended questions related to the role of the Pajal, community conflict, and plans for project expansion. These surveys were evaluated at the final workshop.

Results and Discussion

Sustainable management of semi-natural forest

The main areas of seminatural forest are located in the Tojolabal region. These forests are dominated by pine trees, with some oak. Although the forests are natural in origin, the species composition, age distribution, and form of the trees have been affected by human activities; therefore, they are classified as semi-natural. Despite the substantial economic potential of semi-natural forest management, it appears that the principal obstacle to the management of the communal forests is social rather than economic. Most farmers preferred to initiate individual tree plantations or agroforestry systems before attempting the difficult task of organizing the management of communal forest.

Feasibility of the selected (agro) forestry systems

As a result of the workshops in which representatives of the communities discussed the forestry and agroforestry alternatives to substitute for current management systems within individual plots, the following systems were selected:

For the Tzeltal region:

(1) live fences around pasture land,

(2) fallow enrichment with fast-growing timber species,

(3) coffee mixed with fast-growing timber trees,

(4) maize with Cedrela in strip planting, and

(5) maize fields with live fences.

For the Tojolabal region:

(1) fallow enrichment with Pinus and Cupressus,

(2) plantations on degraded pasture land,

(3) maize with Cupressus as a Taungya System[2],

(4) maize fields with live fences, and

(5) plantations on fallow land.

The areas available in each community and region, according to the current land-use system, are presented in Table I. In the Tzeltal region, 93.5 ha are available for the farm forestry project; in Tojolabal, 78 ha have been set aside for the project. The growth potential of communal forest management and farm forestry in the selected communities is up to 2,387 ha in the Tzeltal region and up to 9,281 ha in the Tojolabal region. In each region, an increase in the number of participating communities can be expected once the project proves successful.

Table I ACTUAL AND POTENTIAL LAND AREA AVAILABLE FOR FARM FORESTRY IN EACH COMMUNITY, ACCORDING TO PRESENT LAND-USE, AS DEFINED BY COMMUNITY RESIDENTS.

COMMUNITY	LAND-USE	ACTUAL AREA (ha)	POTENTIAL AREA (ha)
		Tzeltal region	
Alan Cantajal	Forest	0	20
	Fallow	10	24
	Maize fields	3	34
	Coffee	5	68
	Pasture	0	2
Chapullil	Forest	0	35
	Fallow	15	65
	Main fields	3	80
	Coffee	15	50
	Pasture	0	16
Segunda Cololteel	Forest	0	0
	Fallow	2.5	45
	Maize fields	0	60
	Coffee	7.5	100
	Pasture	1	13
Jol-cacualha	Forest	0	500
	Fallow	1	140
	Maize fields	0	400

	Coffee	15.5	72
	Pasture	0	10
Muquenal	Forest	5	100
	Fallow	3.5	200
	Maize fields	2	100
	Coffee	3.5	198
	Pasture	1	55
TOTAL		93.5	2387
		Tojolabal region	
Yaluma	Forest	0	600
	Fallow	5.5	410
	Pasture	0.5	250
	Maize fields	0	1500
Lomantan	Forest	0	1500
	Fallow	20	340
	Pasture	10	6
	Maize fields	5	400
Palma Real	Forest	20	100
	Fallow	0	0
	Pasture	0	400
	Maize fields	0	300
Jusnajab	Forest	5	2575
	Fallow	10	200
	Pasture	2	100
	Maize fields	0	600
TOTAL		78	9281

Carbon sequestration potential of the selected systems

We calculate the carbon offset of the selected systems based on the MAI in DBH. The MAI of the Tojolabal region varied according to land-use history. We found a MAI of 0.55 ± 0.05 centimeters per year (cm/year) for the intensively grazed and burned pasture land with dispersed Pinus trees. Extensively used pasture land with Pinus trees showed a MAI of 1.45 ± 0.21 cm/year, while the trees in mature forests had MAIs of 1.38 ± 0.18 cm/year. To calculate carbon sequestration potential, we used a mean MAI of 1.4 cm/year, which we expect to be viable under appropriate management strategies. The MAI for the Tzeltal region was approximately 2 cm/yr, with little fluctuation. Therefore, we used this average to calculate the carbon sequestration potential of the region.

To produce harvestable trees of 40 to 50 cm DBH, we estimate a rotation cycle of 30 years for the Tojolabal region and 25 years for the Tzeltal region. In systems where the trees will be planted densely, we accounted for one or two thinning operations, eight and 16 years after planting. Carbon estimates for these thinnings are based on the number of trees to be harvested and the calculation of carbon sequestered by each tree. To account for local variation in soil fertility and varying management practices, we included a sensitivity analysis based on a 25% variability of the MAI.

Estimations of carbon sequestration for the proposed agroforestry systems in the two regions are summarized in Table II. Our estimations do not account for the necromass, litter, roots, and organic material added to the systems by the trees, since these depend on the biomass status of the plot at the time of planting, the system to be used, and the management strategies during plot development. Including the carbon sequestered by the tees cleared in the thinnings, the total amount of carbon sequestered ranged from 46.7 to 183.5 tC/ha for the Tojolabal region, and from 72.3 to 194.2 tC/ha for the Tzeltal region.

Table II ESTIMATIONS OF CARBON SEQUESTRATION IN TC/HA OF THE PROPOSED AGROFORESTRY SYSTEMS FOR THE TOJOLABAL AND TZELTAL REGION (N_{FINAL} = NUMBER OF TREES AT THE END OF THE ROTATION).

System							
(Tree spacing)	Carbon in trees				Carbon in thinnings		Total
Tojolabal region	30 Year rotation				8 Years	16 Years	
	N_{FINAL}	tC /ha	-25%	+25%	tC/ha	tC/ha	
Enriched fallow (2 * 7 m)	250	116.8	60.9	193.7	1.8	16.9	135.5
Plantation (2 * 3 m)	250	116.8	60.9	193.7	4.8	61.8	183.5
Live fences (4 m)	100	46.7	24.3	77.5			46.7
Taungya(4 * 4 m)	250	116.8	60.9	193.7	1.4	16.9	135.0
Tzeltal region	25 Year rotation						
	N_{FINAL}	tC/ha	-25%	+25%			
Live fences (4 m)	100	72.3	38.7	116.5			72.3
Plantation and fence with coffee	180	130.2	69.6	209.7			130.2
Strip planting in maize fields (10 * 3 m)	250	180.8	96.7	291.2	2.7		183.5
Enriched fallow (10 * 2 m)	250	180.8	96.7	291.2	13.3		194.2

Economic costs of carbon offset projects

Our current estimates of the cost of the proposed carbon sequestration projects are based on the discounted fixed and variable costs of implementing new farm forestry or agroforestry systems, plus the opportunity cost to farmers of diverting land from low-productivity maize production, minus the expected income from future timber production from stands manned under a continuous cover regime. In Table III, we compare the cost of sequestering carbon by fallow enrichment in each region, based on an expected carbon sequestration level of 194.2 tC in the Tzeltal region and 135.5 tC/ha for the Tojolabal region.

Calculations are based on a complete rotation of the forest plantation, and assume the establishment of an enriched fallow each year of the rotation cycle. Costs and benefits are thus calculated from year zero to year 49 for the Tzeltal region and from year zero to year 59 for the Tojolabal region. Discount rates of 5, 10, and 15% are used. total cost per tC/ha ranges from $4.88 to $7.42 in the Tzeltal region and from $9.66 to $12.69 for the Tojolabal region. The higher cost of sequestration in the Tojolabal region is due to higher implementation and opportunity costs, longer rotation, and lower production levels. Although these costs can serve as a guideline for setting a price for carbon sequestration, it is important to emphasize that the implementation strategy for the proposed project, which is based on local control, voluntary participation, and development of systems that serve beneficiaries' needs, may reduce local costs and increase local benefits. However, the question of whether the net benefits accrued by adopting this "participatory strategy" should be reflected in a lower price to the emitter or increased benefits to the participants is open to debate.

Public costs and benefits of community forestry and carbon sequestration

Discount rate. Because of the long time period required to develop forestry projects and to mitigate carbon dioxide emissions using forestry projects, their costs and benefits are highly sensitive to the discount rate used in the cost-benefit calculation. A key problem of discounting over time periods greater than 50 years is discrimination against future generations, since discounting presumes that meeting the needs of the current generation is more important than meeting the needs of future generations. Essentially, discounting involves imposing a major cost on the future for the sake of a relatively small gain today. Where there is concern for inter-generational equity, the use of discount rates higher than 1 or 2% indicates that an environmental issue such as global warming is not perceived as a significant problem (Pearce, 1992). In order to assess the proposed projects, however, we use the higher discount rates that are typically used in current economic analysis.

Table III APPROXIMATE COST OF CARBON SEQUESTRATION FOR FALLOW ENRICHMENT BASED ON A TOTAL CARBON IN THE ABOVE-GROUND TREE COMPONENT OF 194.2 TC/HA IN THE TZELTAL REGION AND 135.5 TC/HA IN THE TOJOLABAL REGION. THE CALCULATIONS DO NOT ACCOUNT FOR C-POOLS AT THE START OF THE PLANTATION OR THE EFFECT OF THE PLANTATION ON THESE C-POOLS.

Discount rate	A. Fixed + variable Costs / ha	B. Opportunity Costs /ha	C. Income / ha (A+B-C)	Net Cost /ha ($US)	Net cost /tC ($US)
Tzeltal region (194.2 tC/ha)					
5%	865	1342	765	1442	7.42
10%	559	763	161	1161	5.98
15%	451	536	40	947	4.88
Tojolabal region (135.5 tC/ha)					
5%	1250	1060	591	1719	12.69
10%	1000	585	94	1491	11.00
15%	918	409	18	1309	9.66

Effectiveness of new farm forestry plantations or agroforestry systems. Three measures of cost-effectiveness were used to assess the small farm-scale forestry projects:

(1) Discounted income-expenditure for the government (per hectare) (Figure 1)

(2) Economic benefit of replacing low-productivity maize production with farm forestry (Figure 2)

(3) Unit economic benefit per unit of government expenditure (Figure 3)

For each of the above measures, the following simplified farm/ growth expenditure model was use? It was assumed that low-productivity maize production (1000 kg/ha) is replaced in year zero by trees which grow at a MAI of 12 cubic meters per year. Harvesting begins at year 30. The farmer receives $120/ha as a planting grant and subsequently an annuity of. $80/ha until the commencement of harvesting. The analysis includes the possibility of the government receiving additional benefits for the carbon sequestered annually by the trees (ranging from $0 - 10/tC). The value of sawn timber is estimated at $60 per cubic meter, while the value of maize is assumed to be $120/ton. The effect of varying the value of carbon sequestration from $0 - 10/tC was evaluated for each case. Net benefits and costs were evaluated for a range of discount rates. The following results were obtained:

1. Discounted income-expenditure for the government.

This assumes that the cost of incentives and planting grants will be offset by increased tax revenues from forestry activities. The level of tax revenues from forestry is 15% of total output. In addition, the effect of raising funds from the sale of carbon credits at the rate of $0 - 10/tC was also examined. Figure 1 shows that when the government receives no income from the sale of carbon credits, the cost of forestry establishment ranges from $500 -1000/ha for discount rates greater than 3%. However, if the government is able to levy a charge on carbon emitters of $10/tC, there is a net profit at discount rates of up to 5% and, at discount rates greater than 5%, the cost of forestry establishment is negligible.

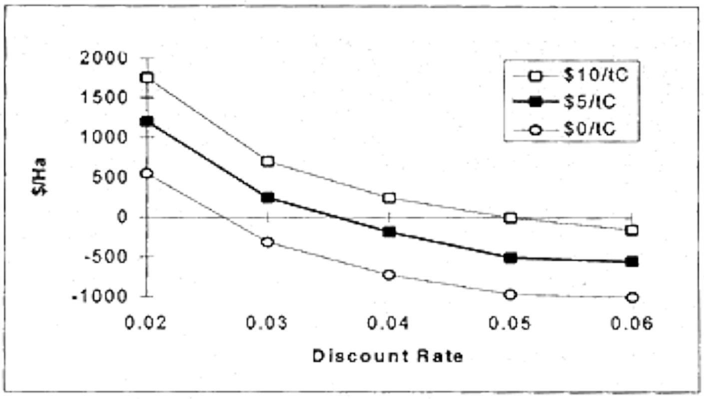

Fig. 1

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2. Net income benefits as a result of changes in productivity.

Figure 2 shows the economic benefit of replacing low-productivity maize production with farm forestry, as determined by the net change in productivity, over a range of discount rates and at three price levels for carbon sequestration. The calculation of net change in productivity does not account for the labor inputs into either maize or forestry production because they are expected to be similar. Even without valuing the carbon sequestered by the forestry system, the economic cost of converting milpa to forestry is positive at discount rates up to 12%. At a discount rate of 10%, the value of conversion ranges from $500-1000/ha, depending on the value assigned to the sequestered carbon.

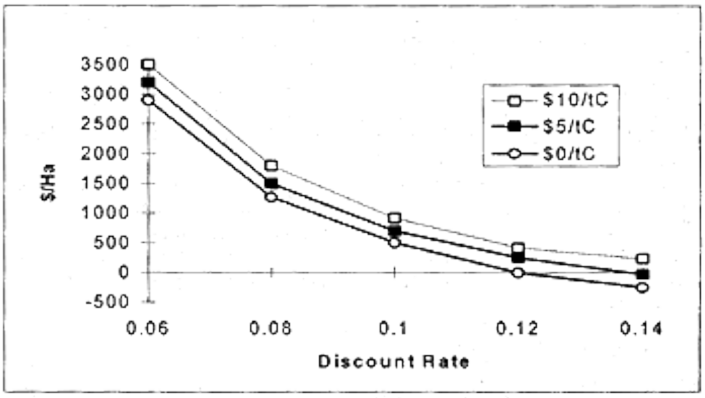

Fig. 2

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3. Benefit - cost ratio.

Figure 3 shows the economic benefit per unit of public expenditure. Using a public discount rate of 10% and a charge of $10/tC sequestered, the benefit-cost ratio is one to one. At lower public discount rates, high levels of economic benefit per unit expenditure are achievable.

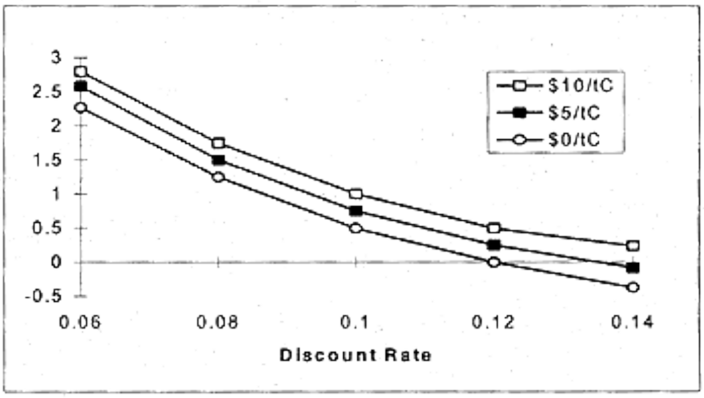

Fig. 3

Social constraints related to forestry project implementation

Project Beneficiaries. Currently, the direct beneficiaries of a forestry project will be the members of Pajal in each community and, indirectly, their families. For the first years, Pajal members have designed individual agroforestry projects that are advantageous because of their simplified social organization, but limit the distribution of benefits.

A women's agroforestry component of the project addresses this weakness by directly targeting the needs of women. To date, 141 women in seven communities have expressed interest in participating in an agroforestry project to improve their home gardens. Currently, it is the middle- and upper-income farmers of the community who are participating in the forestry project. Land-less members of the community will not benefit from the project unless they are targeted for the necessary day labor.

Some sociopolitical barriers will have to be overcome in order to extend the benefits of the project to a greater percentage of community members. In the majority- of communities, Pajal members are not ejidal authorities and have had a difficult time obtaining the support of local authorities.

The community representatives have designed the farm forestry and agroforestry project around "felt needs". In consultation with the other producers participating in the program, the representatives identified their needs based on tree and forest products and created a project to address these needs.

We do not know what priority the community would give to a forestry project if they were given a broader range of development options. The carbon sequestration goal will only succeed if it is one component of a broader agroforestry/forestry project that meets the immediate needs of the participants.

Social Organization. In the initial phase of the project, all participants will plant trees on an individual basis in their coffee plantations, fallow land, pasture land, or maize fields. In the Tzeltal region, participants will work cooperatively to organize seedbeds, tree nurseries, and marketing of wood products, but tree management and ownership will be on an individual basis.

In the Tojolabal region, two levels of social organization are proposed. Individual producers will plant tree seedlings (obtained from a nearby government nursery) in their respective fields, but most tasks will be carried out with reciprocal work exchange. In these communities, work exchange is a long standing tradition that will strengthen the overall forestry project. In time, the communities want to develop shared infrastructure for processing and marketing the wood products.

The second level of social organization will address the communal aspects of the project. Most of these communities have communal forests, and they are all willing to evaluate the potential for a forestry program in these forests. However, all decision making must occur at the level of the assembly and no one is going to jump into a costly forestry project without a great deal of discussion. It is too early to speculate about the social viability of a project for communal land.

Conclusions and Recommendations

Most previous forestry initiatives in Chiapas have sought to prevent destruction of natural forests by restricting exploitation, or have promoted tree planting as a means of ameliorating environmental damage. Little attention has been paid to the potential for developing sustainable, productive systems of farm/community forestry or agroforestry. We conclude that deforestation is inevitable unless local populations perceive tangible economic benefits from standing forests, and that these benefits can only be realized on a sustainable basis where there is local capacity to organize, plan, and manage forest exploitation in a rational manner. This assumption is broadly applicable to the development of productive small-scale farm woodlands, agroforestry systems based upon existing cash crops such as coffee, and the management of communal areas of natural forest.

Because forest management requires long-term investments, good planning is essential and includes community control of projects, selection of appropriate tree species, and management techniques that are specific to the ecological and social conditions of the area. Whether the proposed project involves sustainable management of a large area of communal forest or establishment of a small farm woodland, the quantity, quality, timing, and distribution of both inputs and outputs must be carefully considered. As such, forestry development will only succeed if communities, groups, and individual farmers take responsibility for planning, implementing, managing, and monitoring the progress of their own projects. Non-governmental farmers' unions and indigenous organizations are in the best position to provide farmers with the necessary training, promotion, and planning assistance.

Applying this approach in our feasibility study leads us to conclude that many farmers are interested in starting small-scale forestry or agroforestry activities on their own land, but consensus for managing communal areas of natural forest is much harder to achieve. Social and political divisions often require some degree of resolution before ad hoc or legal exploitation of the common resource can be controlled.

The costs and benefits associated with bringing a particular area of semi-natural forest under sustainable management will depend upon the particular circumstances in each location. Where forests are in good condition and subject to low levels of exploitation, improved forestry practices may stimulate immediate short-term benefits in terms of increased annual harvests and increased productivity.

Where forests are severely damaged, the costs of reparative actions may outweigh the benefits for several years. Whether a sustainable management system is achievable will largely depend upon factors such as the sociopolitical situation and the quality of forest management support and training. In most cases, however, improved management of semi-natural forest is likely to yield significantly greater net economic benefits than the establishment of new forestry plantations because of: (1) the relatively low initial costs where a system is already established; (2) the standing timber which is a capital asset that can help finance development; (3) the lower opportunity costs where agricultural production is not affected; and (4) increased natural conservation in terms of biodiversity, watershed protection, and soil conservation.

Sustainably managed forests and farm woodlands have substantial economic and carbon sequestration potential, but only if managed carefully. A program based upon these principles could be implemented by a team made up of farmers' organizations (such as Pajal) and independent technical advisers who would promote the idea of local forest management and farm forestry throughout the region by developing a network of local promoters. These promoters should be given training and financial support to enable them to develop initial ideas for natural forest management and farm forestry/ agroforestry within their own or neighboring communities.

The technical advisers could assist with detailed forestry development plans. In essence, the plans would specify the project that each community or group wishes to implement, how the community proposes to go about it, who would receive the benefits of the project, and what assistance would be required. These plans would be managed by the communities and would be presented to government agencies such as the Ministry of Agriculture or the Ministry of the Environment, Natural Resources, and Fisheries. The Pajal staff and community promoters would be responsible for implementing the project while technical advisors at ECOSUR would be responsible for monitoring and evaluating the implementation of the project as well as its impacts.

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NOTES

1. All references to dollars in this report refer to U.S. dollars ($US).
2. Taungya is a sequential system, with maize and trees together in the first years, until the tree canopy does not allow for maize to grow.

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