The text that follows is a PREPRINT.

Please cite as:

Fearnside, P.M. 1996. Socio-economic factors in the management of tropical forests for carbon. pp. 349-361. In: M.J. Apps & D.T. Price (compiladores) Forest Ecosystems, Forest Management and the Global Carbon Cycle, NATO ASI Series, Subseries I "Global Environmental Change," Vol. 40. Springer-Verlag, Heidelberg,Germany. 452 pp.

The original publication is available from: Springer-Verlag, Heidelberg,Germany.

SOCIO-ECONOMIC FACTORS IN THE MANAGEMENT OF TROPICAL FORESTS FOR CARBON

Philip M. Fearnside
National Institute for Research in the Amazon (INPA)
C. P. 478
69011-970 Manaus, Amazonas
BRAZIL

KEYWORDS/ ABSTRACT: plantations/ silviculture/ logging/ global warming/ greenhouse effect/ carbon sequestration/ tropical forest management/ carbon dioxide/ climate change mitigation

Tropical forest management response options to global warming include sustained harvest of timber, extraction of non-timber forest products, silvicultural plantations, agroforestry, managed secondary succession and forest maintenance (including both reserve protection and policy changes affecting deforestation). Socio-economic factors affect carbon management projects, and vice versa, and can negate carbon benefits and cause hardship for local populations. Forest maintenance has significant carbon benefits, as well as other environmental and social advantages. Prerequisites include understanding causes of deforestation.

I.) TYPES OF FOREST MANAGEMENT FOR CARBON

A.) TIMBER MANAGEMENT

1.) Carbon benefits of timber management

Forest management most commonly refers to timber management. In the tropics, this includes selectively logging a forest at a specified intensity on a cycle of sufficient duration to maintain a sustainable flow of harvestable wood. Theoretically, standing biomass of natural forests under these regimes can keep carbon out of the atmosphere that would otherwise be released through

deforestation. Some modifications in management practices can contribute to maximizing the standing stock of biomass, for example, by refraining from thinning stands of non-commercial species through poison girdling, and by allowing trees to grow larger before harvesting them. Programs to reduce logging impacts on unharvested trees also help reduce emissions that occur through logging damage (Putz and Pinard, 1993). In addition to carbon held in forest biomass and soil, wood products derived from logging represent pools of carbon kept out of the atmosphere for periods of years or decades, depending on the end use of the wood. Hardwoods for furniture and construction have the longest lifetimes, and therefore the greatest carbon benefits. Unfortunately, logging normally functions as a prelude to deforestation regardless of whether it is stamped as "sustainable management" in official documentation.

2.) Socio-economic effects on management

Socio-economic factors can undermine sustainability of management schemes and thereby reduce their true carbon benefits. Estimates of the probability of socio-economic or political factors interrupting a carbon sequestration management program would of necessity be approximate, but this kind of estimate is nevertheless routinely produced for commercial decisions. Adjusting carbon calculations would require weighting each year's expected sequestration by the expected probability of its taking place in practice, in a manner similar to that used to adjust for risk and uncertainty in Bayesian calculations of expected monetary value (e.g. Raiffa, 1968). Experience indicates that timber management plans have low chances of actually producing the carbon benefits expected. Accepting calculated carbon benefits for such proposals at face value is equivalent to expecting to win a million-dollar lottery by buying a one-dollar ticket, neglecting to allow for the minuscule probability of winning the prize.

Socio-economic factors are often critical in preventing

management of tropical forests for timber production from being sustainable in practice, even if silvicultural parameters indicate technically viability. Logging roads provide access routes for pioneer farmers who enter to clear land for agriculture, often outside of government control. Logging firms themselves can sacrifice future sustained yield by acceleration and/or abandonment of management cycles. Because a number of countries (including Brazil) require plans for sustainable management as a precondition for granting logging permits, a strong motivation is set in place for logging firms to promise the government anything it wants to hear, even if they have no real intention of following the planned management system over the long term.

Many systems of sustainable timber management proposed and/or implemented in tropical countries are technically unpromising. An example is a proposal for sustainable management announced in 1993 by the governor of Brazil's State of Amazonas that would cut trees leaving 60-cm-high stumps, to theoretically resprout. In Malaysia, a country that claims all forest exploitation is already sustainable, a high probability of forest management systems proving unsustainable is suggested by a comparison of timber cut with the approximate amounts that could be produced sustainably in the "permanent production forests." Wood offtake exceeds sustainable yield by 39-85% in Peninsular Malaysia, 96-161% in Sabah and 77-236% in Sarawak (calculated from Burgess, 1989: 150). Although overharvesting is likely as at least part of the explanation for these discrepancies, some wood offtake also comes from conversion of forest to agriculture.

The argument is frequently made that sustainable forest management (usually taken to mean logging) prevents forest from being willfully destroyed. It is argued that tropical countries must obtain a financial return from their forests, otherwise they will replace them with agriculture. Logging must therefore be encouraged, together with research to find uses for woods from more tree species and to identify sustainable harvest rates and

cutting cycle lengths. The potential long-term profits from logging are expected to result in the countries following these sustainable techniques.

The hope placed in the beneficial effect of increasing profits to loggers is based on two expected chains of events. First, increased profit to loggers results in increased tax revenues, employment, and other benefits to governments; the governments are therefore expected to ensure the long-term continuation of these benefits by instituting restrictions on logging intensity. The second chain of events expected is that greater profit will motivate the loggers themselves to take an interest in guaranteeing continuation of the income stream, leading to investment in long-term production by restriction of logging intensity.

Unfortunately, these two chains of events represent an incomplete view of the real-world system. Increasing profit to loggers has other effects that act in the opposite direction, leading to increase of logging intensity and destruction of the resource. Increased profit to loggers also leads to an increase in area logged. Only long-term profits act to lower logging intensity. Wood harvested by increasing logging intensity swells short-term profits to loggers, which motivates loggers to invest in further increasing logging intensity. This reduces to two opposing positive feedback relationships. One, acting through long-term profits, leads logging intensity to be maintained at a reduced level indicated by the maximum sustainable harvest derived from the growth rate of the trees; the other, acting through short-term profits, leads to greater logging intensity. Such a situation is invariably unstable, leading to one extreme or the other. Which way the balance goes depends on the strength of the forces on each side. However, it is not a mystery as to which side is the stronger, as indicated by the obvious lack of commercial-scale forest management systems in the world today. Poore et al. (1989: xiv) surveyed management throughout the

tropics and concluded that "the extent of tropical moist forest which is being deliberately managed at an operational scale for the sustainable production of timber is, on a world scale, negligible."

The root of the problem lies in the rapid discounting of future returns applied in financial calculations, leading to decisions to harvest natural populations at unsustainable rates. This occurs when the discount rate is more than twice the maximum reproductive potential of the population (see Clark, 1973, 1976 for mathematical proof). Growth rates of tropical trees are controlled by biological factors having nothing to do with rates of financial return obtainable on investments in other parts of the economy. These biological limitations place sustainable management for timber at an inherent disadvantage (Fearnside, 1989a).

The contrast between Southeast Asia and Amazonia indicates a lack of factual basis for the theory that increasing profits to loggers leads to sustainable management. For various reasons, forests of Southeast Asia are commercially more valuable and easier to manage than those in Amazonia (Fearnside, 1989a). If raising the commercial value of forest leads to sustainable management, one would expect Southeast Asia to be a paradise of sustainability. On the contrary, Southeast Asian forests are being destroyed more rapidly than those in Amazonia precisely because Asian forests are more valuable. Higher value increases motivation to destroy the forest more than it increases motivation to sustain production.

In addition to the problem of discount rates, most forest in Brazilian Amazonia is effectively an open-access resource, repeating the tragedy of the commons at each site brought under exploitation. Sawmills in Amazonia can be moved when forest is exhausted in any particular place. Many sawmill operations migrated from Espírito Santo to northern Mato Grosso after the Atlantic forest dwindled in their former home (only about 4% of

the Atlantic forest remains). Sawmills are now moving from northern Mato Grosso to other parts of the Amazon region.

The danger of forestry management plans being used to legitimize activities that in reality will lead to destruction of forest (and to greenhouse gas emissions) is increased by the presence of corruption. Papua New Guinea is the best-documented example (Marshall, 1990). The political value of offering forests for destructive use also contravenes any management scenario that might be devised on the basis of data on silviculture and markets. Making global warming response proposals on the assumption that corruption and local politics are irrelevant is exceedingly naive.

Corruption, although the subject of minimal quantitative study and little open discussion, is a critical socio-economic factor in determining the effectiveness of global warming response options in the forest sector. Why, for example, is Costa Rica the focus of so much more international interest for carbon offset projects than Zaïre, even though Zaïre is a much more important country in terms of tropical forests? The notoriety of Zaïre for corruption (e.g. Witte, 1993) is surely an important part of the answer.

3.) Socio-economic impacts of management

Timber management precludes use of the land for agriculture. This means that agricultural populations must have alternative locations to cultivate, or must turn to other professions to support themselves. It is worth noting that large areas of already cleared land exist in Brazilian Amazonia, and that the tendency to establish agricultural settlement areas in forests on public lands is explained by political expediency rather than physical limits. The path of least resistance is to decree settlement areas on public land, most of which is forested, rather than to expropriate private lands. Even in other parts of the tropics, where agricultural populations are proportionally much larger, the argument that maintaining native forest represents a

threat to the poor is fallacious (Fearnside, 1993a).

4.) Recommended role of timber management

Timber management offers some opportunities for carbon offsets, as in reducing logging impact on the remainder of the forest. However, the more central question of promoting expansion of timber management into presently undisturbed areas requires considerable caution. In practice, plans for sustainable management of tropical forests for timber frequently result instead in destruction of forest. Better results may be obtainable by trying to substitute plantation-grown wood as much as possible for natural forest logging. Rather than by promoting timber management, the key to maintaining carbon stocks in natural forests is likely to lie in designing systems to provide compensation for the environmental services they provide, including carbon storage. Maintenance of standing forest as a form of management will be discussed later.

B.) NON-TIMBER FOREST PRODUCTS (NTFPs)

1.) Carbon benefits of management for NTFPs

Non-timber forest products, or NTFPs, are an important source of revenue and of unique products. Most have the great advantage over timber of not destroying or significantly damaging forest when extracted. Proposals for managing forests for these products are of two types: extractive reserves, where only NTFPs may be harvested, and mixed management systems where both timber and NTFPs are exploited. Brazil has a system of extractive reserves in which populations of rubber tappers and other extractivists are granted use rights to forest on the condition that only NTFPs be removed, with an allowance for a limited amount of subsistence agriculture (Allegretti, 1990; Fearnside, 1989b). The proposal for extractive reserves originated with the extractivists themselves, rather than being handed down from above as is the

norm in Amazonian development planning. The financial value of the NTFPs sold from the reserves, while very important to sustaining the extractivist population, is not the rationale for the government's creation of these reserves. The reserves are justified as a means of maintaining the forest for its environmental functions, which is why the reserves are created by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) rather than by the National Institute for Colonization and Agrarian Reform (INCRA). Brazil's extractive reserves, important as they are, occupy a minuscule fraction of the forest area--about 0.6% as of 1993 (Brazil, IBGE, 1993: 116-125). Carbon stored in the reserves is one argument for their expansion (Brown et al., 1992).

Mixed management systems for timber and NTFPs have been initiated in several locations, including an experimental system under study by the International Tropical Timber Organization in Brazil's state of Acre. NTFPs can be critical factor in making combined timber/NTFP management financially attractive (Perez et al., 1993: 53).

2.) Socio-economic effects on management

When NTFPs are harvested by a resident population, as in the case of Brazil's extractive reserves, these people are an integral part of the management system. This has the advantage of providing a dedicated interest group to defend the forest against encroachment. It also implies a certain level of impact on the forest through expansion of the area each household uses for subsistence agriculture and through increase in the number of households through reproduction or immigration of population. The population is also subject to the ever-present temptation to produce cash crops from agriculture or to sell timber. How these forces are handled by local associations of extractivists and by government agencies that oversee reserves will have important impacts both on the management of the existing reserves and on the

extent to which this land use eventually expands. The land tenure arrangement of Brazil's extractive reserves removes the possibility of land becoming a commodity rather than an input to production; were this precaution not taken, financial returns of extractive use would compare unfavorably with deforestation (Hecht, 1992: 395). Since the first extractive reserve was created in 1988, the results of this land use have been much better in terms of maintaining forests, with their carbon stocks, than have common alternatives such as logging and/or cattle ranching.

3.) Socio-economic impacts of management

Management of forests for NTFPs can have positive effects on local populations, as collection occupies a substantial amount of labor and more financial returns accrue to the local population than is usually the case with timber. In the case of extractive reserves in Brazil, the social organization required to request, establish and manage the reserves has numerous collateral benefits for the population involved by allowing them to improve other social services, such as education and health care.

4.) Recommended role of NTFPs

Collection and management of NTFPs are beneficial additions to timber management schemes. However, intense controversy arises when the reverse suggestion is made: to add timber harvesting to projects designed for sustainable extraction of NTFPs. This is because, in practice, adding timber harvesting to extractive reserve management plans can lead to destruction or degradation of forest for the same reasons that forests are destroyed or degraded through pure timber management. In Brazil, the National Council of Rubber Tappers (CNS) has therefore opposed moves to allow timber management in extractive reserves. Allowing timber harvesting undermines the principal argument upon which the

creation of extractive reserves is based, which is environmental benefits of the reserves rather than commodity production.

C.) SILVICULTURAL PLANTATIONS

1.) Carbon benefits of plantations

Silvicultural plantations are classified as "managed forests" by the Intergovernmental Panel on Climate Change (IPCC) (Kupfer and Karimanzira, 1991). Plantations have been the focus of most response options undertaken in the forestry sector in tropical countries, such as those funded by the Global Environment Facility (GEF). Plantations maintain some carbon in standing biomass of planted trees and also direct carbon to wood product pools.

In the humid tropics the amount of carbon held in standing stock is invariably much less than native forest, but more than in uses such as agriculture or pasture. The greatest potential carbon benefits of plantations, however, are by means of fossil fuel substitution when biomass is used as fuelwood, charcoal or, in the future, liquid biofuels such as methanol (Fearnside, In press).

2.) Socio-economic effects on plantations

Socio-economic factors can act in various ways to cause "leakage" from plantation projects, or the negation of carbon benefits by events that the project sets in motion beyond its defined borders. One example is provided by the controversy surrounding plantations that the World Bank is considering funding to supply charcoal to pig iron smelters in Brazil's Grande Carajás area. Private pulp mills that are being set up in the area are likely to offer a higher price for plantation-produced wood than can be expected from charcoal makers. Subsidized plantation owners would be likely to sell their wood to pulp mills. The pig iron smelters, whose licensing and access to subsidies are legitimized by the plantation plans, would then obtain charcoal

made from native forest wood, provoking carbon emissions and other impacts. The inherent attraction of free wood from native forest makes charcoal manufacture for pig iron a continual threat to remaining forests in eastern Amazonia (Anderson, 1990; Fearnside, 1989c).

Population displacement can lead to "leakage" of carbon benefits. If former residents of plantation areas move to clear new plots in tropical forest, they will provoke substantial carbon emissions. This was one of the concerns affecting a proposed carbon offset plantation in Ecuador, from which the Global Environment Facility withdrew its commitment of support in 1993.

Markets for wood products exert a strong influence on plantation operations and their carbon benefits, including "leakage" of the benefits of carbon offsets in wood product pools. This is because expansion of plantations at one location will subsequently increase global supplies of wood products, thereby making prices lower than they otherwise would be, and at other unsubsidized locations would cause marginal plantations to be abandoned and/or would discourage initiation of new plantations. To the extent that the economic "invisible hand" functions as expected, no net global gain in carbon stocks would result from subsidizing plantations other than the small gain from time lags as the subsidized plantations grow prior to their first harvest, and as additions to wood product pools and areas of unprofitable unsubsidized plantations remain in place for a time while a new equilibrium is established.

3.) Socio-economic impacts of plantations

Conversion of land to plantations can deprive local populations of their means of support (Barnett, 1992). Plantations can involve displacement of local populations occupying the sites prior to initiating the schemes. Depending on the social system surrounding use of plantation output, socio-economic conditions that develop can be highly undesirable. In

the case of plantations for charcoal in Brazil, the industry's competitiveness depends on maintaining most of the labor pool under sub-human conditions through a system of debt slavery (Pachauski, 1994; Ribeiro, 1994; Sutton, 1994).

Plantations in some parts of the world take over commons that are traditionally used by local populations. In India, for example, "social forestry" programs have often benefitted wealthy landholders and paper mills at the expense of rural poor (Centre for Science and Environment, 1985: 51-62; Shiva et al., 1985). These plantations often occupy public roadsides or unplanted portions of private landholdings that traditionally provide firewood and animal fodder to poor villagers. In India, the choice of Eucalyptus deprives the poor of useful supplementary products such as foliage for fodder (Saxena, 1989: 82). Poor people have sometimes reacted by ripping Eucalyptus seedlings out of the nurseries (Joyce, 1988). India's social forestry program was launched with the avowed objective of helping the poor (see Eckholm, 1979: 48-56).

In Thailand plantations on common lands could result in eviction of hundreds of thousands of people if industrial plans are fully realized (Koohacharoen, 1992). Employment in plantations can only support about one local family per 20 ha of trees, according to an estimate by Royal Dutch Shell in reference to its planned 200,000 ha of plantations in Thailand (Lohmann, 1990: 10). Silviculture expansion in Thailand illustrates well the gulf between analyses of such programs from the standpoint of carbon benefits as opposed to their impact on the local population: the Thai program has been lauded as a model for carbon sequestration throughout the tropics because of its low establishment costs (Dixon et al., 1994).

4.) Recommended role of plantations

Plantations have a legitimate place in efforts to combat global warming. The place of plantations is constrained, however,

by the comparative costs and benefits of other options, such as maintenance of native tropical forests, and by the socio-economic impacts of plantations. For a variety of reasons, the tendency has been to overestimate the carbon benefits of plantations and underestimate their social impacts, while the reverse tendency applies to forest maintenance calculations (see Fearnside, In press).

D.) AGROFORESTRY

1.) Carbon benefits of agroforestry

Agroforestry refers to the combination of trees (either planted or unplanted) with other trees, arable farming, or grazing. This land use maintains a larger stock of carbon than pasture or arable farming. However, if native tropical forest is sacrificed to implant agroforestry, then the effect on carbon stores would be negative. A large carbon credit is often claimed for agroforestry on the basis of its assumed role in slowing deforestation. These benefits are often exaggerated, because much deforestation is not related to subsistence farming, especially in Brazil (Fearnside, 1992a).

2.) Socio-economic effects on agroforestry

The extent to which agroforestry can be expanded is severely limited by markets for the products. Were any significant portion of Brazilian Amazonia converted to agroforestry, for example, markets would be quickly saturated. Input requirements also limit expansion (Fearnside, 1992a).

3.) Socio-economic impacts of agroforestry

Agroforestry projects generally have greater benefits for local population than do silvicultural plantations of trees such as Eucalyptus. Agroforestry systems have the great advantage of

being appropriate for small farmers and of producing a variety of products throughout the year. This maximizes direct use of the products and use of family labor. The diversity of crop species planted minimizes effects of swings in commodity market prices and risks of biological problems (such as insect outbreaks or disease). Offering a stable economic base for small farmers is an important objective for social reasons, independent of environmental benefits.

4.) Recommended role of agroforestry

Agroforestry has real carbon benefits. The priority attached to it for carbon sequestration, however, depends strongly on the forces underlying deforestation in each location. In Brazilian Amazonia, the priority of promoting agroforestry would be low as an anti-deforestation measure (Fearnside, 1992a).

E.) MANAGED SECONDARY SUCCESSION

1.) Carbon benefits of managed succession

Managed secondary forests have been suggested as an option for use of degraded lands, such as the growing areas of abandoned cattle pastures in Brazilian Amazonia. The carbon store in managed secondary succession is greater than what would be present if the secondary forests were cut for arable crops or pasture. However, immediate cutting of secondary vegetation is often not the most likely alternative in the absence of management programs.

2.) Socio-economic effects on management

"Management" of secondary succession implies a reclassification of this vegetation from an "unproductive" to a "productive" status. Such a reclassification, both in the legal sense and in the public relations sense, can be very useful to firms (and nations) eager to improve their image as destroyers of

tropical forests. In Brazil, ranch owners are anxious not to have their abandoned pastures considered as "unproductive" because land so classified is subject to higher taxes, and because it increases chances that their land will be taken by the government for agrarian reform. If secondary forest can be reclassified as "managed" with a minimal investment, it would be much cheaper as a means of maintaining claim to these large land holdings than would the most common alternative at present: investing in either reclearing and burning or bulldozing and fertilizing to replant cattle pasture. These considerations would be likely to result in a willingness to embrace managed secondary succession projects greatly in excess of what might be justified by expected financial returns from selling the commodities produced, or even from expected environmental return from carbon storage.

3.) Socio-economic impacts of management

Secondary forests can produce biomass and other products useful to humans (Brown and Lugo, 1990). This option has the advantage of requiring little investment and physical inputs. In Brazilian Amazonia, however, it should be remembered that most secondary forests are growing in degraded cattle pastures and produce less in all respects than do similar forests in shifting cultivation fallows.

An important issue in deciding policy on encouraging different land-use systems is the question of who is to be benefited. Most secondary forests in Brazilian Amazonia are in the hands of large ranchers, many of whom have long enjoyed generous government subsidies for clearing forest and planting pasture. Should these same ranchers receive additional subsidies? The prospect of granting additional subsidies to these landholders to manage the secondary succession that now occupies their degraded pasture sites implies an official commitment to perpetuating the existing highly skewed distribution of land tenure in the region. At the time of the last agricultural

census, 62.3% of private land in the region was in properties over 1000 ha in area, while only 11.1% was in properties under 100 ha in area (Brazil, IBGE, 1989: 297). The socio-economic impacts of this distribution of land tenure are many (Fearnside, 1985).

4.) Recommended role of managed succession

Any promotion of managed succession in Brazilian Amazonia should be restricted to small farmers. Better options exist for carbon storage through maintenance of standing native forest.

F.) MAINTENANCE OF STANDING FOREST

1.) Carbon benefits of forest maintenance

Capturing the value of environmental services of standing forest, including the value of storing carbon, must be viewed as a form of forest management. In addition to their role in averting global warming, forests have great value (for which no one is paying) in maintaining biodiversity and, in the case of Brazil, in supplying the hydrological cycle that provides rainfall to much of the country. Measures designed to slow deforestation can easily be justified on the basis of carbon benefits (Fearnside, 1992b). These measures also have socio-economic consequences.

2.) Socio-economic effects on forest maintenance

Socio-economic factors can lead to "leakage," negating the benefits of forest protection achieved through reserve establishment and through some types of deforestation reduction policy changes. If establishing a reserve simply means that potential deforesters move elsewhere to continue clearing, then little or no net carbon gain is achieved. The benefits of forest maintenance proposals can therefore only be assessed at the level of programs, nations, or the world--not with project-level analyses. Little progress has been made on estimating the most

likely costs of forest maintenance, let alone assessing the uncertainty attached to such an estimate. Deforestation is strongly influenced by government policy decisions that have little direct connection with financial costs (Fearnside, 1987).

Socio-economic factors increase uncertainty of both costs and expected benefits of forest maintenance projects. This is true of both reserve establishment and programs to reduce deforestation, but is especially important for the latter. Unlike plantations, for which accumulated experience makes the costs and benefits relatively well known, forest maintenance is fraught with unknowns. Many depend on the outcome of struggles between opposing political and economic interest groups. For example, if heavy taxes were applied to speculative profits from land sales in order to remove one of the primary forces behind deforestation, those expecting to realize such profits would surely object. The fact that the main impediments to forest maintenance are in the realm of political will rather than financial expense makes this option attractive from the monetary cost-effectiveness standpoint for carbon offsets. The same fact also explains why more has not been done to slow deforestation. Political barriers, while they must not be underestimated, should not simply be accepted as immutable. The loss that forest destruction represents needs to be translated into a force of appropriate strength directed at changing the key policies that lie within the government's control (see Fearnside, 1989d).

3.) Socio-economic impacts of forest maintenance

One of the most persistent myths about deforestation in Brazilian Amazonia is that it is primarily done by the poor. In 1990 and 1991, only 30.5% of the clearing was done by small farmers (defined in Brazilian Amazonia as having less than 100 ha of land), while almost 70% was done by medium and large ranchers (Fearnside, 1993b). Distribution of property sizes alone explains 74% of the variance in deforestation rates among the nine

Amazonian states. This means that deforestation in Brazil could be slowed tremendously at minimal social cost--up to 70% without even touching any small farmers. It should be recognized that Brazil is different from most other tropical areas, and that such great gains could not be so easily achieved elsewhere without either inflicting hardship on the poor or providing alternative means for their support.

Employment is often the first question raised in discussions of forest preservation in protected areas. Would it not be better to hand out the land as agricultural lots to support part of the unemployed population? The answer to employment depends very much on what is to be done with money that is brought in by the environmental services of the forest. If the sums involved are large, as the true importance of the services implies they should be, then there is substantial scope for creating employment. One form of employment is guarding the reserves themselves. It is important to realize that this form of employment can only sustain a limited number of people, and that these are not the same people who would receive lots if the land were to be handed out for agricultural settlement instead of being made into a reserve. However, for the true "local" inhabitants (rubber tappers, etc.) already in the interior, this is an important option. Often these people would not have other opportunities for employment. Additional rural employment could be generated in scientific research, for example, if programs were established to botanically collect, map, and measure trees in large areas in the reserves, followed by monitoring of tree mortality, regeneration, phenology and other factors. In addition, population distribution in Brazilian Amazonia is now predominantly urban. Employment in urban centers is, in some ways, easier to create. Activities linked to forest maintenance would be preferable. For example, laboratories could be set up in Amazonian cities to analyze plant secondary compounds obtained from forest reserves.

4.) Recommended role of forest maintenance

The large potential carbon benefits, parallel benefits of other environmental services, and relatively low financial requirements of forest maintenance all indicate this as the top priority for forest management for carbon. If done with a view to maximizing benefits for local populations, socio-economic effects could be positive, both in the short and long term. Policy changes to slow deforestation would have more immediate payoffs in reducing carbon emissions than establishing protected areas. A prerequisite for evaluating benefits of such changes is a sound understanding of causes of deforestation and incorporation of this understanding into models capable of generating reliable forecasts under different policy scenarios.

II.) THE PLACE OF SOCIO-ECONOMIC FACTORS IN CARBON OFFSETS

Socio-economic factors constrain the potential scale to which forest management options for carbon can expand. These factors also affect the carbon benefits if the projects are successful, and the probability of success. Much depends on social costs of the management schemes. Insufficient attention to socio-economic factors has resulted in a tendency for carbon proposals to underestimate social costs in some cases (such as plantations) and overestimate them in others (such as controlling deforestation in Brazilian Amazonia). The benefits of plantations are often overestimated because "leakage" caused by socio-economic factors is ignored. Tendencies in evaluating forestry response options are summarized in Table 1.

TABLE 1: TENDENCIES IN EVALUATING FORESTRY RESPONSE OPTIONS

Response options	Carbon benefits if successful	Poten-tial scale	Prob-ability of success	Social costs

Timber management	+	0	++	0
Non-wood products	-	+	0	0
Plantations	+	+	0	-
Agroforestry	+	+	0	0
Managed succession	+	0	0	0
Forest maintenance:				
a.) Protected areas	+	+	+	0
b.) Deforestation reduction policies	-	-	+	+

\+ = overestimated
\- = underestimated
0 = OK

Most of the foregoing discussion has dealt with negative aspects of relations between socio-economic factors and forest management: the impediments socio-economic concerns pose to management and the detrimental effects of management on local populations. One might be led to believe that management of native forest and establishment of plantations should automatically be ruled out as global warming response options. I hasten to add that these impediments and impacts are only part of the suite of considerations that must be weighed in judging proposed expansion of these activities. Also important are the supply of each nation's domestic demand for wood products, the avoidance of global warming impacts, and the impacts of other alternatives for supplying wood and combating the greenhouse effect.

While response options in the forestry sector can have harmful socio-economic impacts, it should never be forgotten that inaction also has impacts. Impacts of global warming are not restricted to damaging the economies of a few rich countries, even

if this constitutes a major motivation behind the willingness of industrialized nations to invest in response options around the world, including forestry options in the tropics. Effects of global warming will also be felt each time a tropical storm hits the mudflats of Bangladesh or a drought hits famine-prone areas of Africa. Global warming could result in millions of deaths in these places over the next century (Daily and Ehrlich, 1990).

Global warming must be addressed on a scale sufficient to solve the problem: it is not reasonable to conclude that all possible countermeasures have undesirable effects, therefore we will do nothing. Forestry responses in the tropics cannot substitute for the large reductions that must occur in emissions from fossil fuels burned in the industrialized countries. The interest of industrialized countries in funding management in tropical forests as a response to the greenhouse effect offers an opportunity for tropical countries to achieve a variety of environmental and social goals in addition to those related to avoiding global warming impacts. However, extreme care is needed, both on the part of international funders and recipient nations, to insure that forest activities implemented under the banner of global warming abatement do not provoke unacceptable socio-economic impacts. Because global warming responses have social as well as financial costs, it is essential that there be international equity in sharing social costs. It is not enough for the wealthy nations to be willing to pay a large part of the financial costs of combating global warming: they must also be willing to accept some of the social costs.

III.) CONCLUSIONS

Forestry responses to global warming in the tropics can have substantial socio-economic consequences, some are beneficial to local populations but many are detrimental. Socio-economic factors also strongly influence the attractiveness of different response options and the likelihood of their achieving expected

levels of carbon benefit. In general, slowing deforestation has been underrated while other options have been overrated as a means of countering global warming. Plantations have greater social impacts and less economic benefits than many proponents believe. Slowing deforestation has substantial ancillary benefits in maintaining other environmental services of the forest. In the case of Brazil, most deforestation is done by cattle ranchers, and great reduction of clearing could be achieved with no effect on feeding local populations. In many other parts of the tropics, where the role of small farmers is greater, alternative means of supporting local populations must accompany programs designed to slow forest loss. Decision-making on management of tropical forests for carbon must give proper weight to socio-economic factors if forestry projects are to benefit local people and to function effectively to avert global warming.

IV.) ACKNOWLEDGMENTS

Funds from the Pew Scholars Program in Conservation and the Environment were used for travel in Asia. I thank S. V. Wilson and four anonymous reviewers for comments on the manuscript.

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