ISSN: 1381-2386

THE POTENTIAL OF BRAZIL'S FOREST SECTOR FOR MITIGATING GLOBAL WARMING UNDER THE KYOTO PROTOCOL

Philip M. Fearnside
Instituto Nacional de Pesquisas
da Amazônia-INPA
(National Institute for Research
in the Amazon-INPA)
Av. André Araújo, 2936
C.P. 478
69011-970 Manaus-Amazonas
BRAZIL
Tel: +55 (92) 643-1822
Fax: +55 (92) 642-8909
Email: PMFEARN@INPA.GOV.BR

For submission to:
Mitigation and Adaptation Strategies for Global Change

10 March 1999
14 March 1999
2 April 1999
8 April 1999
10 April 1999
8 Oct. 1999
11 Oct. 1999
25 Oct. 1999
Revised 2 Feb. 2001

ABSTRACT

Activities in Brazil's forest sector have substantial potential for mitigating global warming as well as additional environmental and other benefits. Silvicultural plantations of different types, reduced impact logging, and deforestation avoidance all have potential mitigation roles. The magnitude of the annual emission from recent rates of deforestation in Amazonia, which averaged 392×10^6 Mg C/year over the 1981-1990 period, presents an opportunity for carbon benefits through reducing current rates of deforestation. Measures related to Amazonian deforestation have greater potential carbon benefits than do options such as plantation silviculture, but much depends on how benefits are calculated. Procedures are needed for assessing the environmental and social impacts of Clean Development Mechanism projects.

Key Words: Clean Development Mechanism, CDM, Emissions trading, Kyoto Protocol, Global Warming, Deforestation, Brazil, Amazonia

1. INTRODUCTION

Brazil's forest sector offers unique opportunities for carbon (C) offsets under the Clean Development Mechanism (CDM), which was created under Article 12 of the December 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change (UN-FCCC, 1997). Much of the language of the Protocol will require further interpretation to clarify how CDM projects will function in practice (Schlamadinger and Marland, 1998; Trexler and Kosloff, 1998; Watson et al., 2000). Because the Protocol allows CDM projects to begin earning credits as early as 2001, work on this subject is proceeding at a frenetic pace. The nature and magnitude of opportunities for Brazil will depend on how the Protocol is interpreted, and how carbon credits will be counted.

Brazil has both the largest remaining area of high-biomass tropical forests and the largest current emission from its rate of annual clearing of these forests. These facts mean that any measures that result in a reduction in deforestation rates in Brazil would avoid greenhouse gas (GHG) emissions and maintain carbon stocks. Brazil is unique in having a huge stock of carbon in standing forest that is not at risk of being released into the atmosphere on the very short term, but which could be expected to be released over longer time horizons. If and how maintenance of such carbon stocks should be credited represents a major unresolved issue in global climate negotiations (Fearnside, 1997a). The phrase "enhancement of sinks," in the sense of increasing the flows into sinks, does not capture Brazil's most important potential contribution to mitigation, which is in the maintenance of stocks (i.e., keeping the carbon where it is). The present paper examines the potential role of Brazil's forest sector in mitigating global warming and the barriers that may greatly reduce the role that the country is willing to play in the coming decades.

2. DEFORESTATION IN BRAZILIAN AMAZONIA

LANDSAT satellite data interpreted at Brazil's National Institute for Space Research (INPE) indicate that by 1998 the area of forest cleared in Brazilian Amazonia had reached 548.9 X 10^3 km^2 including approximately 100 X 10^3 km^2 of "old" (pre-1970) deforestation in Para and Maranhao (Brazil, INPE, 1999, 2000). The originally forested portion of Brazil's Legal Amazon Region is about the size of Western Europe, and the area that has been deforested so far is the size of France. Deforestation rates have varied widely over time (Fig. 1).

[Figure 1 here]

Interpretation of the causes of deforestation suggested by Brazilian deforestation data strongly influences any conclusions that may be drawn regarding whether it is feasible to reduce deforestation and what countermeasures might be most effective. Eduardo Martins, the head of the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) interpreted these data as indicating that deforestation is now primarily the work of landless peasants and small farmers (Traumann, 1998). INPE has interpreted the numbers for 1997 and 1998 in the same way (Época, 15 February 1999). Were this the case, substantial reductions in clearing rates would not be possible, or would be difficult and expensive, without aggravating poverty in the region. However, four independent lines of evidence indicate that it is still the rich, rather than the poor, who are responsible for the bulk of Brazil's deforestation:

a.) Macroeconomic changes: One indication is the close correspondence of the major swings in deforestation rates with macroeconomic changes that affect investors rather than small farmers using family labor. The decline in deforestation rates from 1987 through 1991 can best be explained by Brazil's deepening economic recession over this period. Ranchers simply did not have money to invest in expanding their clearings as quickly as they had in the past. At the low point in 1991, investors were still without access to much of their funds because then-president Fernando Collor had frozen bank accounts in the country in 1990. The peak in 1995 is best understood as a reflection of economic recovery under the "Plano Real", a set of economic reforms implanted in July 1994 that resulted in larger volumes of money suddenly becoming available for investment, including investment in cattle ranches. The decline in deforestation rates from 1996 to 1997 is a logical consequence of the Plano Real having sharply cut the rate of inflation. Land values reached a peak in 1995, and fell by about 50% by the end of 1997. Falling land values make land speculation unattractive to investors.

b.) Spatial distribution of clearing: The second line of evidence that medium and large ranchers are the major deforestation agents is the distribution of clearing activity among the region's nine states; this indicates that most of the clearing is in states that are dominated by ranchers: the state of Mato Grosso alone accounted for 26% of the 11.1×10^3 km^2 total in 1991. Mato Grosso has the highest percentage of its privately held land in ranches of 1000 ha or more: 84% at the time of the 1985 agricultural census. By contrast, Rondonia--a state that has become famous for its deforestation by small farmers--had only 10% of the 1991 deforestation total, and Acre had 3%. The number of properties censused in each size class explained 74% of the variation in deforestation rate among the nine Amazonian states in both 1990 and 1991. Multiple regressions indicate that 30% of the clearing in these years can be attributed to small farmers (properties <100 ha in area), and the remaining 70% to either medium or large ranchers (Fearnside, 1993).

c.) Size of new clearings: The third line of evidence is data released by INPE (Brazil, INPE, 1998) indicating that only 21% of the area of new clearings in 1995, 18% in 1996, and 10% in 1997 were <15 ha in area. Note that these values refer to the areas of new clearings, as distinct from the areas of the properties in which the clearings are located. Small-farmer families are only capable of clearing about 3 ha yr^{-1} using family labor (Fearnside, 1980), and this is reflected in deforestation behavior in settlement areas (Fearnside, 1984).

d.) Property-level studies: The fourth line of evidence is direct observations and interviews with farmers and ranchers. A property-level study of 202 land holdings distributed among different size classes and among five sub-regions in Brazil's "arc of deforestation" that extends from Paragominas (Para) to Rio Branco (Acre) concluded that in the 1994-1995 period only about 25% of the clearing activity was in properties of 100 ha or less (Nepstad et al., 1999). Together, these lines of evidence indicate that it is a myth that the bulk of Brazil's Amazonian deforestation is done by people who are clearing to feed themselves. The predominant role of medium and large ranchers in Brazilian Amazonia means that deforestation could be substantially reduced without worsening the plight of the poor.

3. MAGNITUDE OF BRAZILIAN EMISSIONS

Brazil's Amazonian deforestation makes a significant contribution to global warming by any valid calculation. However, a long series of official pronouncements has tended to understate the magnitude of deforestation and the impact that it has on global warming (see Fearnside, 1997b, 1999a). Just prior to the 1992 United Nations Conference on Environment and Development (UNCED or ECO-92) in Rio de Janeiro, INPE vice director Gylvan Meira Filho announced that Amazonian deforestation contributed only 1.4% of global CO_2 emissions (Borges, 1992). Although highly influential in Brazilian policy circles, the study in question has never been published in the scientific literature. My estimates produce values triple this figure (Fearnside, 1997c, 2000a), mainly because the INPE estimate ignored the approximately two-thirds of forest biomass that is not oxidized at the time of the initial burn (Fearnside et al., 1993). Shortly before the 1997 Third Conference of the Parties (COP-3) to the UN-FCCC held in Kyoto, INPE acting director Volker Kirchhoff announced that Brazil produced zero emissions from deforestation and less than 1% of the global total from all sources (ISTOÉ, 1997). This remarkable conclusion (which has also never been published in the scientific literature) was reached by both ignoring decomposition and other emissions subsequent to the initial burn and by a belief that the "crops" planted following deforestation absorb all carbon emitted. Unfortunately, only about 7% (rather than 100%) of the carbon emitted by deforestation is eventually reabsorbed by the landscape that replaces the forest (Fearnside, 1996a, 1997c; Fearnside and Guimarães, 1996). The landscape that replaces the forest is a patchwork of land covers, mainly cattle pasture and secondary vegetation of different ages growing in abandoned pastures. None of the major uses approaches the original forest in biomass and carbon store per hectare.

The two most commonly used ways of expressing GHG emissions from deforestation are "net committed emissions" and the "annual balance." Net committed emissions refers to the long-term net result of converting a given area of forest (such as the 13.8×10^3 km^2 cleared in 1990) to the equilibrium landscape that will eventually replace it. In contrast, "annual balance of net emissions" or "annual balance" refers to the balance in only a single year but covers an entire landscape (such as Brazil's 5×10^6 km^2 Legal Amazon), which includes a mosaic of patches cleared in different years. Net committed emissions from deforestation in 1990 was 267-278 $\times 10^6$ Mg C yr^{-1} for low and high trace-gas scenarios, while the annual balance for deforestation was 354-358 $\times 10^6$ Mg C yr^{-1} for deforestation and 62 $\times 10^6$ Mg C yr^{-1} for logging for the 4×10^6 km^2 originally forested portion of Brazil's Legal Amazon. The annual balance was higher than net committed emissions in 1990 because logs were still decaying from the years of faster deforestation that preceded that year (Fearnside, 1996b).

Because Brazil's annual deforestation rates have undergone swings of 50% or more over the past decade, the choice of the inventory period can have a significant effect on the emissions result (Table 1). Brazil's national inventory is being done for the 1990-1994 period, which coincides with the dip in deforestation rates centered on 1991. Were years either before or after this interval included, the resulting emissions estimate would be higher.

[Table 1 here]

Net committed emissions from deforestation can be expected to vary in direct proportion to the average annual deforestation rate for the period chosen (ignoring slight differences caused by differences in the amount of biomass present per hectare at the locations deforested in different years). The emission from deforestation, excluding hydroelectric reservoir formation, was 270 × 10^6 Mg C yr^{-1} as CO_2-carbon equivalent for the 1990-1994 period being used for Brazil's national inventory (based on average deforestation rate in the period as compared to 1990, using the average of low and high trace-gas scenarios from Fearnside, 2000a, updated from Fearnside, 1997c), while the corresponding value for the 1986-1995 decade would be 393 × 10^6 Mg C yr^{-1}. In addition to deforestation, there are also emissions from logging and from fire damage to standing forest, neither of which is to be included in the emissions total for Brazil's inventory (José Domingos Gonzales Miguez, public statement, 22 October 1998) (Note: affiliations of all cited individuals are given in the Appendix). Additional emissions come from permanent clearing of secondary forests (not counted as deforestation in INPE's LANDSAT estimates), emissions of trace gases from recurrent clearing of shifting cultivation fallows and degraded pastures, and clearing of cerrado (central Brazilian savanna) and of additional ecosystems other than Amazonian forests.

The potential net committed emission from converting all of Brazil's Amazon forest to the landscape that replaces it is very large: 77 × 10^9 Mg C (Fearnside, 2000a). This is 10% higher than the 70 × 10^9 Mg C total gain that could be obtained from complete implementation of the Kyoto Protocol plus a decline in Annex B (i.e., developed) country emissions from fossil fuels from 2010 through 2100 at 1% yr^{-1} compounded annually (Marland, 1998)

The average annual net committed emission from land-use change over the 1981-1990 period was 0.556 X 10^9 Mg C in Brazil (Fearnside, 2000b). The total for all of the tropics was 2.4 X 10^9 Mg C yr^{-1} (Fearnside, 2000b; based on reinterpretation of data from FAO, 1993, for countries other than Brazil). This value is 50% higher than the 1.6 X 10^9 Mg C yr^{-1} used by the IPCC for this emission (Schimel et al., 1996) and 41% higher than the 1.7 X 10^9 Mg C yr^{-1} used in the IPCC's Special Report on Land Use, Land-Use Change and Forestry (Bolin et al., 2000: 32). Among other reasons for large emissions, the biomass of many tropical forests (especially in Brazil) is higher than previous estimates had assumed. Land-use change emissions from Brazil, which were responsible for 23% of the total emissions from tropical land-use change over the 1981-1990 period, are summarized in Table 2.

[Table 2 here]

The magnitude of this emission is clear from its position as a contribution to global warming larger by half than the notoriously damaging US emission. Considering the 6.4 X 10^9 Mg C yr^{-1} global fossil fuel emission in 1995 (Marland, 1998), The US percentage of the 8.8 X 10^9 Mg C combined total for fossil fuel and 1981-1990 tropical land-use change is 18%, while the pan-tropical land-use change emission represents 27%. The size of the contribution of tropical deforestation offers a great opportunity for mitigation by decreasing the rate of forest loss, especially in Brazil where most of the clearing is for low-productivity cattle ranches.

4. OPPORTUNITIES FOR BRAZIL UNDER THE CDM

4.1. Deforestation Avoidance

Brazil stands to gain a great deal by finding ways to use efforts to reduce deforestation as a source of carbon offsets. Current expectations of the price to be paid per ton of carbon permanently sequestered range from US $5 to US $35 (Michael J. Walsh, public statement, 10 October 1998). The net committed emission from each hectare of deforestation in Brazilian Amazonia was 194 t for deforestation done in 1990; the value of this parameter can be expected to increase gradually as the deforestation frontier moves from the cerrado/forest boundary into the heart of the Amazon where biomass per hectare ("biomass loading" or "biomass density") is greater (Fearnside, 1997c). At 194 Mg C ha^{-1}, the value of avoiding deforestation corresponds to US $970 - 6.790 ha^{-1} of forest, with a midpoint of US $3.800 ha^{-1}.

The contrast of these values with current returns from cutting the forest is clear. The price of forested land in Brazilian Amazonia averaged approximately US $150 ha^{-1} over the 1997-1998 period. Although purchasing land is not proposed, the price of land is important as an indicator of what it can produce under the use options currently open to buyers--that is, selling the timber and converting the land to cattle pasture. The land price represents the net present value (NPV) of the income stream from deforestation, considering the discount rate employed by investors in their financial decisions. The value of the carbon benefits from keeping the forest are 6 to 45 times higher than the value of deforestation, while the value of the carbon emitted by 1990 deforestation was US \$1.3-9.3 billion, and that of the 1998 was US \$1.6-11.4 billion (Fearnside, 2000c).

The amount potentially available is substantial for any cheap and easily available mitigation option such as reducing deforestation. Considering a US \$20 t^{-1} carbon price, the US alone is expecting to spend US \$8 billion annually on the CDM (Article 12) joint implementation (Article 6) and emissions trading (Article 17) in order to meet its Kyoto targets (Jefferson Seabright, public statement, 10 October 1998).

4.2. Agroforestry

Agroforestry offers some possibility of storing carbon in the biomass of the vegetation, provided the agroforests are established in already deforested areas rather than cutting down higher-biomass forests. Some of the benefit claimed for agroforestry comes from avoiding deforestation that would otherwise be done by the farmers tending the agroforests. However, the scope for this benefit in Brazil is much less than is sometimes assumed because of the prominence of cattle ranchers in Brazil's deforestation (different from many other parts of the tropics). This means that measures aimed at containing deforestation by promoting agroforestry among small farmers can never achieve this goal, although agroforestry has important reasons for being supported independent of efforts to combat deforestation (Fearnside, 1995a).

4.3. Forest Management

Forest management for timber theoretically offers a possibility for carbon benefits by stocking carbon in wood products, while the managed forests regrow removing carbon from the atmosphere. Unfortunately, the carbon benefits from this strategy are illusory due to project effects beyond the boundaries adopted for its accounting (also known as “leakage”), such as by displacing wood products from other sources and due to the effect of large short-term emissions from decay of slash and of trees damaged during harvesting if any value is given to time (Fearnside, 1995b). "Leakage" from indirect effects of the project, often outside of the project's geographical, temporal or subject area boundaries, must be adjusted for if projects are to have benefits for climate (see Brown et al., 2000a).

4.4. Reduced Impact Logging

Another option is through reduced-impact logging. Simple changes in logging practices can greatly reduce the amount of ancillary damage and consequent emission (Johns, 1996; Pinard and Putz, 1996; Putz and Pinard, 1993).

4.5. Avoided Logging

Brazil ranks as the world's largest consumer of tropical forest wood, and satisfies 90% of its domestic demand from these natural forests (Smeraldi and Veríssimo, 1999). Most of this wood is for plywood, particle board, concrete forms, pallets, crates, and other uses that could easily be satisfied from plantation-grown sawlogs. As long as wood from Amazonian forest remains free for the taking, this will be cheaper than investing in plantations. The inevitable transition from natural forest to plantation supply for most of these uses will occur more quickly if areas are made unavailable for logging through creation of reserves and enforcement of regulations. Because such a transition is a future event, decisions relating to discounting of carbon benefits will be critical to the amount of credit that can be earned for measures that hasten the transition (eg, Fearnside et al., 2000).

Although avoided logging involves smaller amounts of carbon than does avoided deforestation, it has great advantages for immediate implementation under the CDM. Most important is the substantially lower uncertainty associated with logging. Much remains to be decided by the parties to the Kyoto Protocol regarding what (if any) types of forest-sector projects will be included under the CDM. The degree of certainty to be required of carbon accounting is a key question. Canada currently has a proposal before the Kyoto Protocol's Subsidiary Body on Scientific and Technical Advice (SBSTA) that would require 95% certainty (Canada, 1998), which, if adopted, would eliminate many options in the forest sector (Fearnside, 2000d).

4.6. Silvicultural Plantations

Brazil's proposals for combating global warming have tended heavily to plantation silviculture. Best known is the FLORAM Project, proposed by the University of São Paulo in 1990 to plant 20×10^6 ha of trees, mostly outside Amazonia, to sequester carbon (Ab'Sáber et al., 1990). The carbon benefits of plantations depend heavily on what is done with the harvested wood. Use for charcoal, which substitutes for mineral coal in Brazil's iron and steel industry, accrues substantial carbon benefits through fossil-fuel substitution, while use for pulp has much more modest carbon benefits (Fearnside, 1995b; Marland and Schlamadinger, 1997; Schlamadinger and Marland, 1996).

The expected impacts of climate change will reduce the benefits of plantations and increase the impacts of achieving given levels of offsets using this option (Fearnside, 1998, 1999b). The same also applies to options in native forest (Fearnside, 1995c).

5. OPPORTUNITIES FOR BRAZIL UNDER EMISSIONS TRADING

Why doesn't Brazil join Annex B of the Kyoto Protocol? While other countries can only reduce emissions by curtailing use of fossil fuels, thereby reducing industrial output, over 80% of Brazil's emissions are from deforestation (almost all of which results in cattle pastures that rapidly degrade and produce little for the country's economy). If Brazil were to join Annex B (and Annex I of the UN-FCCC), it could then be engaged in emissions reductions under Article 6 of the protocol and in emissions trading under Article 17, rather than in project-based activities under the CDM of Article 12. The problems of within-country "leakage" from project-based initiatives would be solved.

The CDM, which is the only channel available to Non-Annex B countries, applies only to projects, not to accounting for emissions at the national level. The carbon sequestered or the emissions avoided must therefore be shown to have resulted from the specific project that was implanted with this purpose. In the case of reducing deforestation rates, it is very difficult to demonstrate this effect, which is known as “additionality.” Moreover, it is still not known whether this kind of activity will be included in the CDM. In contrast, countries that are members of Annex B can engage in emissions trading under Article 17 of the Protocol. For this, the calculation will be based on what is agreed for Articles 3.3 and 3.4, which deal with deforestation, afforestation and reforestation (Art. 3.3) and “other activities”, possibly including logging, soils, and other sources. The quantity of emissions that can be traded under Article 17 would be based on national inventories, without needing to prove the effect of specific projects. The “assigned amount” represents the quantity of carbon that any given Annex B country would be allowed to emit without penalty and, if less than this amount is emitted, would result in a surplus that translates into tradable credits. For Brazil the inclusion of emissions from deforestation in the assigned amount is guaranteed by Article 3.7 (the "Australia clause"), thereby insuring that the benefits of reducing deforestation would result in tradable credits. The assurance offered by inclusion of forests for countries like Brazil under article 3.7 being already decided, as contrasted with the still-pending decisions on inclusion of native forest conservation under the CDM, represents a significant difference.

Because emissions trading will only begin with the first commitment period (2008-2012), while the CDM could start in 2001 because of the "banking provision" in Article 12, one might think that countries like Brazil should stay out of Annex B until just before the beginning of first commitment period. This would allow taking advantage of the CDM while it is the only option available, and then allow larger benefits to be reaped from emissions trading later. However, an important reason for joining now is that non-Annex B countries are largely left out of the discussion and decision-making on interpretation of the Protocol, particularly in SBSTA where many of the key decisions are taken. If Brazil waits until the first commitment period is approaching, many of the important decisions will have already been made, and Brazil may find that major opportunities for the country have been closed off (Fearnside, 1999c).

6. ENVIRONMENTAL AND SOCIAL IMPACTS OF MITIGATION

Some options under consideration for global warming mitigation would create substantial environmental and social impacts (Fearnside, 1996c). An example is silvicultural plantations for charcoal production. In Brazil, a system of "debt slavery" is closely associated with the charcoal industry, whereby whole families are held (under threat of death) to work in making charcoal for a patron to whom they owe inexorably mounting debts for food and other supplies they receive on credit (Fearnside, 1999d; Pamplona and Rodrigues, 1995; Pachauski, 1994; Sutton, 1994). One might hope that the possibility of international carbon benefits could provide an inducement for ending this system.

Another important example is the hydroelectric dams proposed for construction on Brazil's Xingu River. These dams would flood extraordinarily large areas of forest and indigenous land (see Santos and de Andrade, 1990, and Fearnside, 1989a, 1996d for discussions of impacts). Belo Monte Dam (formerly known as Kararaô), the first dam planned, would have modest impact by itself but would justify construction of the remaining five dams, especially the one originally known

Babaquara, now renamed the "Altamira Dam" and listed in Brazil's current decennial plan for completion in 2013 (Brazil, ELETROBRÁS, 1998: 148). Except for a brief period during the high-water season, a substantial part of Belo Monte's 11 MW of installed capacity would not be useable without the highly damaging upstream dams. Brazil's current system of environmental impact assessment has no mechanism for dealing with the impacts of a chain of related development projects, as opposed to the direct impacts of a single project (Fearnside, 2001).

Whether international review, certification and monitoring would be implemented for impacts of CDM projects, as opposed to only for carbon benefits, is still an unsettled issue. This author has advocated a broad system of monitoring impacts and mitigation activities (Fearnside, 1997b). However, many professionals involved in debates over the CDM are so involved in their efforts to combat global warming that they tend to forget that there is more to life than carbon. This includes some international non-governmental organizations (NGOs) in the field, which have expressed the view that environmental impact studies of CDM projects would be unnecessary because these organizations would be able to raise such a public clamor if objectionable projects were proposed that these would not be executed. Unfortunately, there is an element of hubris in thinking that the publicity and lobbying prowess of NGOs is sufficient to stop any environmentally or socially damaging CDM projects. Damaging projects are not rare in Brazil and elsewhere today, even in the absence of additional financing through the CDM.

In Brazil, the current system of environmental impact reports (RIMAs), useful though it is when contrasted to the situation preceding its initiation in 1986, is not capable of averting major environmental and social impacts (eg., Eve et al., 2000; Fearnside and Barbosa, 1996a,b). The added protections of a procedure for independent assessment of the environmental and social implications of CDM projects, and for international approval of projects on this basis, are therefore not made superfluous by either Brazil's internal environmental assessment system or the existence of international NGOs.

It is important to remember that the CDM is not only intended for implementation in Brazil, but in developing countries worldwide. Many of the over-150 other countries that have signed the UN-FCCC have no effective internal environmental controls at all. It is therefore important that the CDM contain safeguards against automatic acceptance of local interpretations of what are environmentally and socially acceptable impacts.

One objection sometimes raised to having a review of environmental and/or social impacts is that the bureaucracy necessary for such a filter would make the CDM unworkable. However, this fear would appear to have little basis given the ability of the World Bank and other multilateral development banks to process and execute large numbers of loans without dispensing with a review of environmental and social impacts.

Another objection sometimes raised to including environmental and social impact assessment in the CDM is that it implies a loss of national sovereignty and would therefore be unacceptable to developing countries such as Brazil. However, it should be remembered that reviews of CDM project impacts are no different than the review process that already exists for World Bank loans. Brazil and other countries vie with each other for these loans, such that it would be more than a little hypocritical for these same countries to claim that an external environmental review is an affront to their sovereignty. In the case of Brazil, the G-7 Pilot Program to Conserve the Brazilian Rainforest (PP-G7), financed by the G-7 countries and in large part administered by the World Bank, is specifically intended to help Brazil reduce deforestation.

Sovereignty is guaranteed by the fact that all CDM projects will pass though a national agency, assuring that nothing will be requested that does not meet the country's criteria for sustainable development and other priorities. It should be emphasized that the same sovereignty guarantees should apply on the other side--that is, the Annex B (developed) countries financing CDM activities have the right to assurance that their own environmental and social standards will not be violated by the projects. There are two largely overlapping sets of projects: those acceptable to Brazil and those acceptable to the financing countries. Most projects (say, cogeneration from bagasse, energy efficiency improvements, etc.) will fall in the overlapping area easily accepted by both sides. If Brazil should consider avoiding deforestation as too threatening an option to include, then no other country will be able to force Brazil to accept this. By the same token, for example, should Brazil want carbon credits for hydroelectric dams on the Xingu River (a possibility that has been implied by officials on more than one occasion), then this would be likely to fall outside the range of acceptable projects for financing countries.

7. IMPEDIMENTS TO BRAZILIAN RECOGNITION OF DEFORESTATION

Brazil’s foreign ministry has so far opposed inclusion of projects to reduce tropical deforestation in the CDM. Other sectors within the Brazilian government have recognized some of the potential benefits that could be gained for the country from changing this position. At the "Meeting of the Ministers of Environment and Forestry of the Amazonian Countries on Clean Development Mechanism (CDM)," held in Cochabamba, Bolivia, 14-15 June 1999, the final statement of the meeting recommends that "conservation of natural forests" be included under the CDM. This was signed by José Sarney Filho, Brazil's Minister of the Environment, although the official position of Itamaraty (Brazil's foreign ministry), still opposes inclusion of this kind of project.

The conspicuous absence of deforestation from Brazil's official pronouncements on the CDM and related climate matters needs to be understood in terms of Brazil's particular sensibilities. In Brazil, many--probably most--people believe in the existence of a worldwide conspiracy intent on taking Amazonia away from Brazil, for example by "internationalizing" the area under an arrangement similar to that in Antarctica (e.g., Reis, 1982). A sociological survey of the population in Brazilian Amazonia revealed that 71% of respondents agreed with the statement "I am afraid Amazonia will be internationalized" and 75% agreed that "Foreigners are trying to take over Amazonia" (Barbosa, 1996). It is natural that people raised from infancy hearing this theory will accept it as above questioning.

Environmental concerns over Amazonian deforestation are seen as a mere smokescreen for this alleged plot. While a range of visions exists as to how "internationalization" might occur, a significant part of the population in all social and educational strata believes that soldiers (usually assumed to be of US origin) are poised to invade Amazonia to stop Brazil from developing the region. Non-Brazilians generally react to this theory with incredulity and are consequently prone to assume that such a belief could not possibly cause national leaders to forego billions of dollars in potential revenue and to maintain development policies that destroy the country's most valuable resources. Unfortunately, such an assumption is unwarranted.

Lack of a real threat of "internationalization" of Amazonia is of little importance; it is the fact that the "internationalization" theory is the paradigm through which events are interpreted in Brazil that influences the course of history. It is also important to realize that such paradigms can change.

A second possible rationale for the Foreign Ministry's resistance to recognizing the importance of deforestation avoidance as a climate mitigation option is that Brazil should wait until the price is right. This hypothesis as the explanation of the Foreign Ministry's position has been suggested by the Acre state government's environmental advisor Carlos Vicente (public statement, 22 October 1998). It is worth noting that the desire to wait for a better price for carbon has a possible solution, as shown by the Noel Kempff Mercado reserve expansion project in Bolivia initiated in 1998 (Brown et al., 2000b). In the case of the Bolivian reserve, half of the carbon credits generated by the project remain the property of the Bolivian government for future sale at market rates, an arrangement that contrasts with the fixed payments established in forest protection carbon offset initiatives now underway in Costa Rica.

The information in the present paper suggests strongly that recognizing the importance of deforestation and giving deforestation avoidance a high priority among global warming mitigation measures would be very much in Brazil's national interest.

8. CONCLUSIONS

Brazil's major opportunity for mitigating global warming under the Kyoto Protocol lies in reducing deforestation. This task faces difficult-but-not-impossible hurdles. While substantial credit could be earned through the Clean Development Mechanism, the requirement of additionality makes emissions trading an easier means of gaining credit for reducing deforestation rates. Because Brazil's deforestation emissions are so large, and because the remaining area of standing forest that might be deforested is also very large, the total amount of credit that might be earned in this way is very much greater than what could be earned through projects such as implanting silvicultural plantations. To take advantage of emissions trading, Brazil would have to join Annex B of the Protocol and accept commitments to limit future emissions. However, the meager economic benefits of the ranching system that drives most clearing in Brazilian Amazonia today mean that these reductions could be achieved if political will were focused on this task. The economic value of carbon benefits could be much greater than that from the sale of traditional commodities derived from deforestation.

ACKNOWLEDGMENTS

An earlier version of this discussion was presented at the Air & Waste Management

Association (AWMA) Second International Specialty Conference on Global Climate Change, Washington, DC, 13-16 October 1998 (Fearnside, 1999e). Brazil's National Council of Scientific and Technological Development (CNPq AI 350230/97-98 and 523980/96-5) and the National Institute for Research in the Amazon (INPA PPIs 5-3150 and 1-3160) provided financial support for the research. R. Dixon, S.V. Wilson, P.L.M.A. Graça and two anonymous reviewers made valuable comments.

AFFILIATIONS OF CITED PERSONS

Individuals mentioned and affiliations at the time of the cited statements:

Volker Kirchhoff: Acting director, National Institute for Space Research (INPE), São José dos Campos, São Paulo

Eduardo Martins: President, Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), Brasília

Gylvan Meira Filho: Vice director, National Institute for Space Research (INPE), São José dos Campos, São Paulo

José Domingos Gonzalez Miguez: Special Assistant for the United Nations Convention on Climate Change, Ministry of Science and Technology, Brasília [Responsible for Brazil’s national inventory]

José Sarney Filho: Minister of the Environment, Brasília

Jefferson Seabright: Director, Office of Energy, Environment and Technology, United States Agency for International Development (USAID), Washington, DC

Michael J. Walsh: Senior Vice President, Environmental Financial Products, Chicago, Illinois

REFERENCES

Ab'Sáber, A., Goldemberg, J., Rodés, L., and Zulauf, W.: 1990, 'Identificação de áreas para o florestamento no espaço total do Brasil', Estudos AVANÇADOS **4**(9), 63-119.

Barbosa, L.C.: 1996, 'The people of the forest against international capitalism', *Sociological Perspectives* **39**(2), 317-332.

Bolin, B. R.Sukumar, P. Ciais, W. Cramer, P. Jarvis, H. Kheshgi, C. Nobre, S. Semenov and W. Steffen.: 2000, 'Global perspective', in, R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo and D.J. Dokken (eds.) Land Use, Land-Use Change and Forestry: A Special Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, U.K. pp. p. 23-51.

Borges, L.: 1992, "Desmatamento emite só 1,4% de carbono, diz Inpe", O Estado de São Paulo 10 April 1992, p. 13.

Brazil, ELETROBRÁS. (Centrais Elétricas Brasileiras S.A.). 1998. Plano Decenal 1999-2008 ELETROBRÁS, Rio de Janeiro, Brazil.

Brazil, INPE (Instituto Nacional de Pesquisas Espaciais): 1998, Amazonia: Deforestation 1995-1997, INPE, São José dos Campos, SP, Brazil. Document released via internet (http://www.inpe.br).

Brazil, INPE (Instituto Nacional de Pesquisas Espaciais): 1999, Monitoramento da Floresta Amazônica Brasileira por Satélite/Monitoring of the Brazilian Amazon Forest by Satellite: 1997-1998, INPE, São José dos Campos, São Paulo. Document released via internet (http://www.inpe.br).

Brazil, INPE (Instituto Nacional de Pesquisas Espaciais): 2000 'Monitoramento da Floresta Amazônica Brasileira por Satélite/Monitoring of the Brazilian Amazon Forest by Satellite: 1998-1999' (INPE: São José dos Campos, SP [available via internet: http://www.inpe.br] (9 May 2000).

Brown, S., and 17 others. 2000a. Project-based activities. Pages 283-338 *in* R. T. Watson, I.

R. Noble, B. Bolin, N. H. Ravindranath, D. J. Verardo, and D. J. Dokken, editors. Land Use, Land-Use Change, and Forestry. Cambridge University Press, Cambridge, U.K.

Brown, S., M. Burnham, M. Delany, R. Vaca, M. Powell, and A. Moreno. 2000b. Issues and challenges for forest-based carbon-offset projects: A case study of the Noel Kempf climate action project in Bolivia. Mitigation and Adaptation Strategies for Global Change **5**:99-121.

Canada. 1998. In: UN-FCCC, Subsidiary Body on Scientific and Technical Advice (SBSTA), Report FCCC/SBSTA/1998/Misc.6/ADD1, additional submissions by the Parties (available at http://www.unfccc.de).

Época: 15 February 1999. "Amazônia: Um golpe mais forte na floresta", Época [São Paulo], No. 39, p. 19.

Eve, E., Arguelles, F.A. & Fearnside, P.M.: 2000, 'How well does Brazil's environmental law work in practice? Environmental impact assessment and the case of the Itapiranga private sustainable logging plan', Environmental Management **26**(3): 251-267.

FAO (Food and Agriculture Organization of the United Nations): 1993, Forest Resources Assessment 1990: Tropical Countries (FAO Forestry Paper 112). Rome, Italy, FAO, 61 pp. + annexes.

Fearnside, P.M.: 1980, 'Land use allocation of the Transamazon Highway colonists of Brazil and its relation to human carrying capacity', in F. Barbira-Scazzocchio (ed.), Land, People and Planning in Contemporary Amazonia, University of Cambridge Centre of Latin American Studies Occasional Paper No. 3, Cambridge, U.K., pp. 114-138.

Fearnside, P.M.: 1984, 'Land clearing behaviour in small farmer settlement schemes in the Brazilian Amazon and its relation to human carrying capacity', in A.C. Chadwick and S.L. Sutton (eds.), Tropical Rain Forest: The Leeds Symposium, Leeds, U.K., Leeds Philosophical and Literary Society, pp. 255-271.

Fearnside, P.M.: 1989a, 'Brazil's Balbina Dam: Environment versus the legacy of the pharaohs in Amazonia', Environmental Management **13**(4), 401-423.

Fearnside, P.M.: 1989b, ‘A prescription for slowing deforestation in Amazonia’, Environment **31**(4), 16-20, 39-40.

Fearnside, P.M.: 1993, 'Deforestation in Brazilian Amazonia: The effect of population and land tenure', Ambio **22**(8), 537-545.

Fearnside, P.M.: 1995a, 'Agroforestry in Brazil's Amazonian development policy: The role and limits of a potential use for degraded lands', in M. Clüsener-Godt and I. Sachs (eds.), Brazilian Perspectives on Sustainable Development of the Amazon Region, Paris, UNESCO, and Carnforth, U.K., Parthenon Publishing Group, pp. 125-148.

Fearnside, P.M.: 1995b, 'Global warming response options in Brazil's forest sector: Comparison of project-level costs and benefits', Biomass and Bioenergy **8**(5), 309-322.

Fearnside, P.M.: 1995c, 'Potential impacts of climatic change on natural forests and forestry in Brazilian Amazonia', Forest Ecology and Management **78**, 51-70.

Fearnside, P.M.: 1996a, 'Amazonian deforestation and global warming: Carbon stocks in vegetation replacing Brazil's Amazon forest', Forest Ecology and Management **80**(1-3), 21-34.

Fearnside, P.M.: 1996b, 'Amazonia and global warming: Annual balance of greenhouse gas emissions from land-use change in Brazil's Amazon region', in J. Levine (ed.), Biomass Burning and Global Change, Volume 2: Biomass Burning in South America, Southeast Asia and Temperate and Boreal Ecosystems and the Oil Fires of Kuwait, Cambridge, Massachusetts, MIT Press, pp. 606-617.

Fearnside, P.M.: 1996c, 'Socio-economic factors in the management of tropical forests for carbon', in M.J. Apps and D.T. Price (eds.), Forest Ecosystems, Forest Management and the Global Carbon Cycle, NATO ASI Series, Subseries I "Global Environmental Change," Vol. 40, Heidelberg, Germany, Springer-Verlag, pp. 349-361.

Fearnside, P.M.: 1996d, 'Hydroelectric dams in Brazilian Amazonia: Response to Rosa, Schaeffer & dos Santos', Environmental Conservation **23**(2), 105-108.

Fearnside, P.M.: 1997a, 'Environmental services as a strategy for sustainable development in rural Amazonia', Ecological Economics **20**(1), 53-70.

Fearnside, P.M.: 1997b, 'Monitoring needs to transform Amazonian forest maintenance into a global warming mitigation option', Mitigation and Adaptation Strategies for Global Change **2**(2-3), 285-302.

Fearnside, P.M.: 1997c, 'Greenhouse gases from deforestation in Brazilian Amazonia: Net committed emissions', Climatic Change **35**(3), 321-360.

Fearnside, P.M.: 1998, 'Plantation forestry in Brazil: Projections to 2050', Biomass and Bioenergy **15**(6), 437-450.

Fearnside, P.M.: 1999a, 'Forests and global warming mitigation in Brazil: Opportunities in the Brazilian forest sector for responses to global warming under the "Clean Development Mechanism"', Biomass and Bioenergy **16**(3), 171-189.

Fearnside, P.M.: 1999b, 'Plantation forestry in Brazil: The potential impacts of climatic change', Biomass and Bioenergy **16**(2), 91-102.

Fearnside, P.M.: 1999c, 'Como o efeito estufa pode render dinheiro para o Brasil', Ciência Hoje **26**(155), 41-43.

Fearnside, P.M.: 1999d, 'Environmental and Social Impacts of Charcoal in Brazil', pp. 177-182. In: M. Prado (ed.) Os Carvoeiros: The Charcoal People of Brazil. Rio de Janeiro, Brazil, Wild Images Ltd. 182 pp.

Fearnside, P.M.: 1999e, 'The potential of Brazil's forest sector for mitigating global warming under the Kyoto Protocol's "Clean Development Mechanism', in, J.D. Kinsman, C.V. Mathai, M. Baer, E. Holt & M. Trexler (eds.) Global Climate Change: Science, Policy, and Mitigation/Adaptation Strategies. Proceedings of the Second International Specialty Conference, Washington, DC, 13-15 October 1998, Sewickley, Pennsylvania, U.S.A., Air & Waste Management Association (AWMA), pp. 634-646.

Fearnside, P.M.: 2000a, 'Greenhouse gas emissions from land use change in Brazil's Amazon region', in, R. Lal, J.M. Kimble & B.A. Stewart (eds.) Global Climate Change and Tropical Ecosystems Advances in Soil Science, Boca Raton, Florida, CRC Press, pp. 231-249.

Fearnside, P.M.: 2000b, 'Global warming and tropical land-use change: greenhouse gas emissions from biomass burning, decomposition and soils in forest conversion, shifting cultivation and secondary vegetation', Climatic Change **46**(1/2), 115-158.

Fearnside, P.M. 2000c, 'Effects of land use and forest management on the carbon cycle in the Brazilian Amazon', Journal of Sustainable Forestry **12**(1/2), 79-97.

Fearnside, P.M. 2000d, 'Uncertainty in land-use change and forestry sector mitigation options for global warming: plantation silviculture versus avoided deforestation', Biomass and Bioenergy **18**(6), 457-468.

Fearnside, P.M. 2001, 'Environmental impacts of Brazil's Tucuruí Dam: Unlearned lessons for hydroelectric development in Amazonia', Environmental Management **27**(3), 377-396.

Fearnside, P.M. and Barbosa, R.I.: 1996a, 'The Cotingo Dam as a test of Brazil's system for evaluating proposed developments in Amazonia', Environmental Management **20**(5), 631-648.

Fearnside, P.M. and Barbosa, R.I.: 1996b, 'Political benefits as barriers to assessment of environmental costs in Brazil's Amazonian development planning: The example of the Jatapu Dam in Roraima', Environmental Management **20**(5), 615-630.

Fearnside, P.M. and Guimarães, W.M.: 1996, 'Carbon uptake by secondary forests in Brazilian Amazonia', Forest Ecology and Management **80**(1-3), 35-46.

Fearnside, P.M., Lashof, D.A. & Moura-Costa, P.: 2000, 'Accounting for time in mitigating global warming through land-use change and forestry',. Mitigation and Adaptation Strategies for Global Change **5**(3), 239-270.

Fearnside, P.M., Leal Filho, N. & Fernandes, F.M.: 1993, 'Rainforest burning and the global carbon budget: Biomass, combustion efficiency and charcoal formation in the Brazilian Amazon', Journal of Geophysical Research (Atmospheres) **98**(D9), 16,733-16,743.

ISTOÉ [São Paulo]: 1997, "A versão do Brasil", 15 October 1997, p. 98.

Johns, J.S., Barreto, P. & Uhl, C.: 1996, 'Logging damage in planned and unplanned logging operations and its implications for sustainable timber production in the eastern Amazon', Forest Ecology and Management **89**, 59-77.

Lashof, D.A. and Ahuja, D.R.: 1990, 'Relative global warming potentials of greenhouse gas emissions', Nature **344**, 529-531.

Marland, G.: 1998, 'Historical and Projected Global Greenhouse Gas Emissions', presented at the Second International Specialty Conference on Global Climate Change, Washington, DC, 13-16 Oct. 1998.

Marland, G. and Schlamadinger, B.: 1997, 'Forests for carbon sequestration or fossil fuel substitution? A sensitivity analysis', Biomass and Bioenergy **13**(6), 389-397.

Nepstad, D.C., Moreira, A.G. & Alencar, A.A.: 1999, Flames in the Rain Forest: Origins, Impacts and Alternatives to Amazonian Fires, Brasilia, Brazil, World Bank, 161 pp.

Pachauski, F.: 1994, "Trabalha, escravo", ISTOÉ [São Paulo] 4 May 1994, pp. 32-35.

Pamplona, G. and Rodrigues, A.: 1995, "História sem fim: Um ano depois da denúncia de ISTOÉ, carvoeiros ainda trabalham como escravos no norte de Minas", ISTOÉ [São Paulo] 21 June 1995, pp. 46-47.

Pinard, M.A. and Putz, F.E.: 1996, 'Retaining forest biomass by reducing logging damage', Biotropica **28**(3), 278-295.

Putz, F.E. and Pinard, M.A.: 1993, 'Reduced-impact logging as a carbon-offset method', Conservation Biology **7**(4), 755-759.

Raiffa, H.: 1968, Decision Analysis: Introductory Lectures on Choices under Uncertainty, Reading, Massachusetts, Addison- Wesley, 312 pp.

Reis, A.C.F.: 1982, *A Amazônia e a Cobiça Internacional*. 5th. ed. Rio de Janeiro, RJ, Brazil, Civilização Brasileira.

Santos, L.A.O. and de Andrade, L.M.M. (eds.): 1990, Hydroelectric Dams on Brazil's Xingu River and Indigenous Peoples, Cultural Survival Report 30, Cambridge, Massachusetts, Cultural Survival, 192 pp.

Schimel, D. and 75 others: 1996, 'Radiative forcing of climate change', in J.T. Houghton, L.G. Meira Filho, B.A. Callander, N. Harris, A. Kattenberg and K. Maskell (eds.), Climate Change 1995: The Science of Climate Change, Cambridge, U.K., Cambridge University Press, pp. 65-131.

Schlamadinger, B. and Marland, G.: 1996, 'The role of forest and bioenergy strategies in the global carbon cycle', Biomass and Bioenergy **10**(5/6), 275-300.

Schlamadinger, B. and Marland, G.: 1998, 'The Kyoto Protocol: Provisions and unresolved issues relevant to land-use change and forestry', Environmental Science and Policy **1**, 313-327.

Smeraldi, R. and A. Veríssimo. 1999. Hitting the Target: Timber Consumption in the Brazilian Domestic Market and Promotion of Forest Certification. Amigos da Terra-Programa Amazônia, São Paulo, Instituto de Manejo e Certificação Florestal e Agrícola (IMAFLORA), Piracicaba and Instituto para o Homem e o Meio Ambiente na Amazônia (IMAZON), Belém, Brazil. 41 pp.

Sutton, A.: 1994, Slavery in Brazil--A Link in the Chain of Modernization, Oxford, U.K., Oxford University Press.

Traumann, T.: 1998, "Os novos vilões: Ação dos sem-terra e de pequenos agricultores contribui para o desmatamento da Amazônia", Veja [São Paulo], 4 February 1998, pp. 34-35.

Trexler, M.C. and Koslof, L.H.: 1998, 'The Kyoto Protocol: What does it mean for project-based climate change mitigation?', Mitigation and Adaptation Strategies for Global Change **3**(1), 1-58.

UN-FCCC (United Nations Framework Convention on Climate Change): 1997, 'Kyoto Protocol to the United Nations Framework Convention on Climate Change', Document FCCC/CP/1997;7/Add1 (available in

English at http://www.unfccc.de and in Portuguese at http://www.mct.gov.br).

FIGURE LEGENDS

Figure 1 - Extent (A) and rate (B) of deforestation in Brazil's Legal Amazon region (Fearnside, 1997b; Brazil, INPE, 1998, 1999, 2000).

Table 1: RELATION OF INVENTORY PERIOD TO DEFORESTATION RATE

Description	Period	Average deforestation rate (10^3 km^2/year)	Change in deforestation rate relative to 1990-1994 (%)
Brazilian national inventory	1990-1994	13.7	0
UN-FCCC standard	1990	13.8	+ 1
FAO (1993) data period	1981-1990	19.6	+ 45
Average since 1990	1990-1998	16.5	+ 20
Decade centered on 1990	1986-1995	19.9	+ 45

Table 2: AVERAGE ANNUAL EMISSIONS FROM LAND-USE CHANGE IN BRAZIL 1981-1990[a]

	Biomass C loading (t C/ha)			Area cleared (10^3 ha yr^{-1})	Carbon in biomass cleared (10^9 t C yr^{-1})	Carbon in charcoal (10^6 t C yr^{-1})	Carbon in replacement landscape (10^9 t C yr^{-1})	Soil carbon release to 1 m depth (10^9 t C yr^{-1})	Net committed emission (10^9 t C yr^{-1})
	Above-ground	Below-ground	Total						
CLEARING EMISSIONS									
Amazon forest	154.3	48.9	203.2	1988.2	0.404	-8.74	-0.025	0.023	0.392
Cerrado	6.9	21.3	28.2	1705.9	0.051	-0.31	-0.008	0.014	0.056
Other ecosystems	17.6	12.1	29.7	432.6	0.013	-0.22	-0.002	0.003	0.014
Total from clearing	79.0	33.6	112.7	4126.7	0.468	-9.27	-0.035	0.040	0.462
CATEGORY CHANGE EMISSIONS									
Category changes[b]									0.094
TOTAL EMISSIONS									
Total from land-use change									0.556

(a) Data sources and derivation given in Fearnside (nd-a)
(b) Not all logging emissions are captured by changes among land-use categories as defined by FAO (1993). For example, thinning a forest from 50% to 30% crown cover will cross the 40% crown-cover limit that distinguishes open from closed forest, but thinning from 90% to 50% crown cover would be undetected.

Table 3 : PROJECT-LEVEL FINANCIAL AND CARBON COSTS AND BENEFITS OF MITIGATION[a]

	Activity	Average carbon stock (t C ha^{-1}) [b]	Baseline carbon stock (t C ha^{-1}) [b]	Carbon benefit (t C ha^{-1}) [b]	Establishment cost (US$ ha^{-1})	NPV ha^{-1} @ 12% yr^{-1}	Cost/t C (US$ NPV/t C) [c]	IRR (% yr^{-1})
MITIGATION OPTIONS								
	Deforestation avoidance	223.9	21.4[d]	202.5	?[e]	?[e]	?[e]	?[e]
	Plantations for pulpwood	45.5	21.4[d]	24.1	625	165.93	6.88	14.6
	Plantations for charcoal	201.5	21.4[d]	180.1	625	81.34	0.45	13.3
	Plantations for sawlogs	64.6	21.4[d]	43.3	625	612.56	14.16	17.6
	Avoided sustainable forest management[f]	223.9[g]	209	15.0	0	--	--	--
	Sustainable forest management vs unsustainable logging	209	191[h]	18.0	1814.7	-479.19	--	3.8
	Avoided unsustainable logging[f]	223.9[g]	191[h]	32.9	0	--	--	--

	Sustainable forest management vs forest[f]	209	223.9[g]	-15.0	1814.7	-479.19	--	3.8
BASELINE ACTIVITIES								
	Remaining forest in 1990	223.9[g]			0	0	--	--
	Unsustainable logging	191[h]			1811	961	--	infinite
	Extensive ranching	21			307	-261.23[i]	--	-13.7[i]

(a) For supporting documentation and derivation of values, see Fearnside (1995b). NPV=net present value; IRR=internal rate of return.

(b) Soil carbon to a depth of 20 cm under forest or equivalent under other land uses.

(c) Only values without discounting of carbon are given; results can be significantly altered by discounting (Fearnside, 1995b).

(d) Deforested landscape.

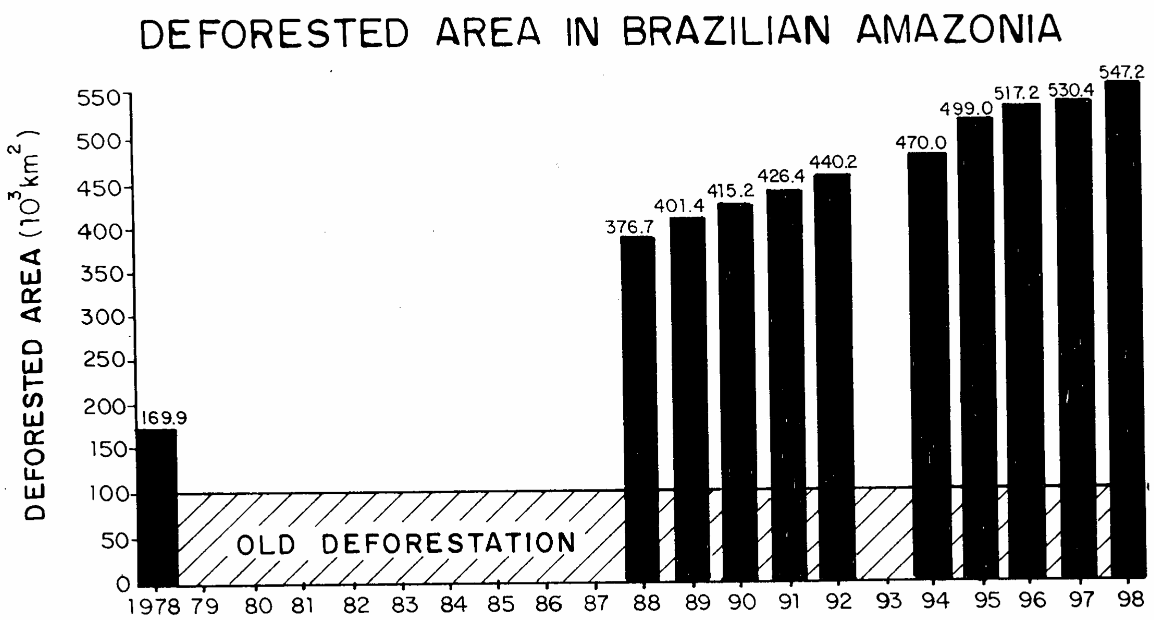
(e) The cost of slowing deforestation varies widely depending on the measures taken. Some of the most obvious measures are free or would save the government money (Fearnside, 1989b).

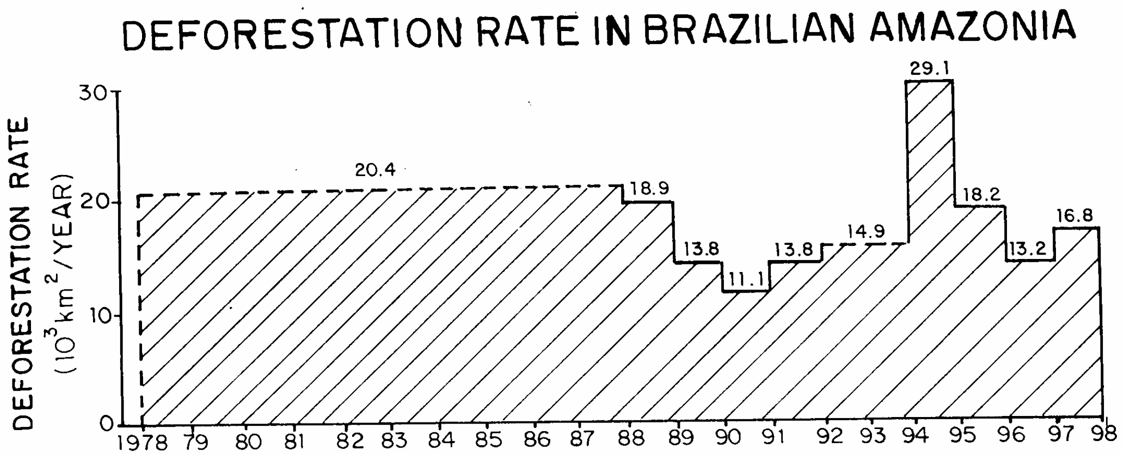
(f) Does not include risk of fire, which could greatly increase the carbon emission of logging in both sustainable and unsustainable management systems.

(g) Remaining forest in 1990.

(h) Unsustainable logging.

(i) Note that these calculations for ranching do not include profits from land speculation, logging, remaining government subsidies, money laundering and other sources of income that can make seemingly unprofitable ranches attractive.


DEFORESTED AREA IN BRAZILIAN AMAZONIA
DEFORESTED AREA ($10^3 km^2$)
550
500
450
400
350
300
250
200
150
100
50
0
169.9
376.7
401.4
415.2
426.4
440.2
470.0
499.0
517.2
530.4
547.2
OLD DEFORESTATION
1978 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98


DEFORESTATION RATE IN BRAZILIAN AMAZONIA
DEFORESTATION RATE
($10^3 km^2$/YEAR)
30
20
10
0
20.4
18.9
13.8
11.1
13.8
14.9
29.1
18.2
13.2
16.8
1978 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98