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The Potential of Brazil's Forest Sector for Mitigating Global Warming under the Kyoto Protocol's "Clean Development Mechanism"

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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 presents an opportunity for carbon benefits through reducing current rates of deforestation. Measures related to Amazonian deforestation have much greater potential carbon benefits than do options such as plantation silviculture, but much depends on how benefits are calculated. Items of unfinished business include application of a time preference weighting (as by a discount rate) for carbon, acceptance of program (as opposed to project) approaches to slowing deforestation, application of a Bayesian calculation of the probability of success to adjust for wide differences among options, and procedures for assessing the environmental and social impacts of climate mitigation projects.

INTRODUCTION

Brazil's forest sector offers unique opportunities for carbon 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). Much of the language of the protocol will require further interpretation to clarify how CDM projects will function in practice.[1,2] Because the protocol allows CDM projects to begin earning credits in 2001, work on this subject is proceeding at a frenetic pace. The nature and magnitude of these opportunities will depend on how the protocol is to be interpreted, and how carbon credits will be counted. A number of these issues will be discussed in the current paper.

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.[3] 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).

DEFORESTATION IN BRAZILIAN AMAZONIA

LANDSAT satellite data interpreted at Brazil's National Institute for Space Research (INPE) indicate that by 1996 the area of forest cleared in Brazilian Amazonia had reached 517.1

$\times 10^3$ km^2 (12.9% of the 4×10^6 km^2 originally forested portion of Brazil's 5×10^6 km^2 Legal Amazon Region), including approximately 100×10^3 km^2 of "old" (pre-1970) deforestation in Pará and Maranhão. 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.

Over the 1978-1988 period, forest was lost at a rate of 20.4×10^3 km^2/yr (including hydroelectric flooding), the rate declined (beginning in 1987) to a low point of 11.1×10^3 km^2/yr in 1990-1991, and climbed to 14.9×10^3 km^2/yr in 1992-1994; the rate then jumped to 29.1×10^3 km^2/yr in 1994-1995, and fell to 18.2×10^3 km^2/yr in 1995-1996; a preliminary estimate for 1997 indicates a deforestation rate of 13.0×10^3 km^2/yr.[4, 5]

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. Recently, 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.[6] 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. 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 June 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 fall in deforestation rates in the years after 1995 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.

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 indicates; 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 last (1985) agricultural census. By contrast, Rondônia--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.[7]

The third line of evidence is data released by INPE[5] indicating that only 21% of the area of new clearings in 1995 and 18% in 1996 were under 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/year using family labor[8], and this is reflected in deforestation behavior in settlement areas.[9]

The fourth line of evidence is direct observations and interviews with farmers and ranchers. A property-level study of 202 properties distributed among different size classes and among five sub-regions in Brazil's "arc of deforestation" that extends from Paragominas (Pará) 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.[10] Together, these lines of evidence indicate that it is a myth that the bulk of Brazil's Amazonian deforestation is done by people are clearing to feed themselves. The predominance of medium and large ranchers in Brazilian Amazonia means that deforestation could be substantially reduced without worsening the plight of the poor.

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.[4, 11] Just prior to the 1992 United Nations Conference on Environment and Development (UNCED or ECO-92) in Rio de Janeiro, INPE announced that Amazonian deforestation contributed only 1.4% of global CO_2 emissions.[12] My estimates produce values triple this figure[13, 14], mainly because the INPE estimate ignored the approximately two-thirds of forest biomass that is not oxidized at the time of the initial burn.[15] Shortly before the 1997 Third Conference of the Parties (COP-3) to the UN-FCCC held in Kyoto, INPE announced that Brazil produced *zero* emissions from deforestation and less than 1% of the global total from all sources.[16] This remarkable conclusion 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 of the carbon that is emitted. Unfortunately, only about 7% (rather than 100%) of the carbon emitted by deforestation is eventually reabsorbed by the landscape that replaces the forest.[13, 17, 18]

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 region), which includes a mosaic of patches cleared in different years. Net committed emissions from deforestation in 1990 was 267-278 $\times 10^6$ t C/yr for low and high trace-gas scenarios, while the annual balance for deforestation was 354-358 ' 10^6 t C/yr for deforestation and 62×10^6 t C/yr 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.[19]

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. 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. The average deforestation rate over the 1990-1994 period was 13.7×10^3 km^2/year, a value almost identical to the rate for 1990 of 13.8×10^3 km^2/yr, the rate for the decade 1981-1990 was 19.9×10^3 km^2/yr (45% higher), the rate for 1990-1996 was 16.5×10^3 km^2/yr (20% higher), and the rate for the decade 1986-1995 was 19.9×10^3 km^2/yr (45% higher). 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 t C/yr 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[14],

updated from earlier estimates[13]), while the corresponding value for the 1986-1995 decade would be 393 × 10^6 t C/yr. 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.[20]

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, pastures and savannas, and clearing of *cerrado* (central Brazilian savanna) and other 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: 74 × 10^9 t C.[21] This is approximately the same as the 70 ´ 10^9 t 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 compounded annually.[22]

The average annual net committed emission from land-use change over the 1981-1990 period was 0.455 × 10^9 t C in Brazil (of which 0.384 was from Amazonian deforestation and 0.071 was from other ecosystems).[21] The total for all of the tropics was 2.4 × 10^9 t C/yr[21], based on reinterpretation of data from the FAO Forest Resources Assessment[23] for countries other than Brazil--a value higher than the 1.6 × 10^9 t C/yr used by the IPCC for this emission.[24] Considering the 6.4 × 10^9 t C/yr 1995 global fossil fuel emission[22], inclusion of tropical land-use change emissions reduces the US percentage of the total from 25% to 18%. The pan-tropical land-use change emission represents 27% of the total; the magnitude of this emission is clear from its position as a contribution to global warming even greater than the notoriously large US emission. 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.

OPPORTUNITIES FOR BRAZIL UNDER THE CDM

Deforestation Avoidance

Brazil stands to gain a great deal by finding ways 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.[25] The net committed emission from each hectare of deforestation in Brazilian Amazonia is approximately 200 t; the value for 1990 was 194 t C/ha of deforestation, and this will gradually increase 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.[13] At 200 t C/ha, this the value of avoiding deforestation corresponds to US$1000-7000/ha of forest, with a midpoint of US$4000/ha.

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 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 7 to 47 times higher than the value of deforestation, while the value of the 1990 deforestation was US$1.4-9.7 billion.

The amount potentially available is substantial for any "low-hanging fruit" (*i.e.*, cheap and easily available) CDM options such as reducing deforestation. Considering a US$20/t carbon price, US alone is expecting to spend US$8 billion annually on CDM or other "flexibility

mechanism" options in order to meet its Kyoto targets.[26] The US can well afford to pay such a price: the cost to the US of achieving its Kyoto commitments by 2010 wholly through domestic options has been calculated at US$276/t of carbon.[27]

Agroforestry

Agroforestry offers some possibility to store 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.[28]

Reduced Impact Logging

Forest management for timber offers two possibilities for carbon benefits. One is 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 leakage 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.[29] "Leakage" refers to the benefits that a project might have for global climate being wholly or partially negated by indirect effects of the project, often outside of the project's geographical, temporal or subject area boundaries.

The second option is through reduced-impact logging. Simple changes in logging practices can greatly reduce the amount of ancillary damage and consequent emission.[30-32]

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 of Amazonia, to sequester carbon.[23] 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.

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.[24, 35] The same also applies to options in the native forest.[36]

UNFINISHED BUSINESS IN LAND-USE CHANGE AND FORESTRY

Projects versus Programs

One of the key items yet to be defined concerning the CDM is the admissibility of programs, as opposed to free-standing projects, for carbon credit. Projects must be within the reach of individual countries or corporations, making plantation silviculture a likely choice. Combating deforestation, however, requires more wide-ranging activities that are not easily

accomplished as projects. Programs avoid many of the leakage problems of project-based mitigation.[29]

Discounting Carbon

Agreement on a discount rate or other time-preference weighting arrangement for carbon is fundamental to comparing forestry options with fossil fuel substitution.[11, 29] The discount rate chosen should be consistent with choices for global warming potentials.[37] Discounting carbon need not be the same as money, although some advocate that the same rate should be applied. The implications of discount rates as high as those for money are substantial for the relative impacts of different activities, including hydroelectric dams.[38]

Discounting is also needed to establish an equivalence between silvicultural plantations and avoided deforestation. "Sinks" in general have been criticized as temporary and therefore inherently less beneficial than avoiding fossil fuel emissions. Lashof and Hare[39], for example, have argued that credits from "biotic sinks" under the Protocol carry a risk perverse effect on atmospheric CO_2 concentrations. I would argue, however, that this reasoning applies only to silvicultural plantations, and within the category of plantations it applies only to their role in carbon sequestration (as distinct from fossil fuel substitution). Lashof and Hare's argument is that, by allowing countries to emit more carbon from fossil stocks into the active carbon pool (biosphere + atmosphere), the increases in biotic carbon stocks that have been encourage under the Protocol as carbon offsets 1) have a risk of subsequent release into the atmosphere (which fossil carbon stocks do not have), and 2) reduce the options available for future responses in the forest sector because the capacity of these options to absorb carbon will have been saturated. However, I would argue that, in the case of avoiding tropical deforestation, the result is more like reducing fossil fuel carbon emissions than it is like carbon sequestration in plantations. Carbon stocks in areas of high-biomass tropical rain forests are very unlikely to be allowed to regenerate to their present levels if these forests are cut down. Most of the carbon released from deforesting these areas is, therefore, just as permanent an addition to what might be called the "most active carbon pool" (*i.e.*, atmospheric carbon plus carbon in rapidly cycling stocks such as plantation biomass) as is release of fossil carbon. Allowing Annex B countries under the Kyoto Protocol to offset fossil fuel carbon emissions by helping tropical forest countries avoid deforestation has kept carbon out of this "most active pool" in the same way that avoiding fossil carbon emissions would, and has avoided a carbon release that is just as irreversible as fossil fuel combustion.

Probability of Success

A key difference between different global warming response options is wide variation in the probability of success. Plantations are well understood and of low risk, but have only modest carbon benefits compared to avoiding deforestation. A Bayesian approach is needed to compute the expected monetary value of different options, by multiplying the value associated with each outcome by the probability the outcome occurring.[40] Even in the face of a low probability of success for deforestation avoidance it can be advantageous to invest in this approach rather than relatively safe plantation silviculture options.

Environmental and Social Impacts of Mitigation

Some of the options under consideration for global warming mitigation would create substantial environmental and social impacts.[41] An example is silvicultural plantations for charcoal production, which have much greater carbon benefits through fossil fuel substitution than do plantations for pulpwood.[29,42,43] 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 the food and other supplies they receive on credit.[44-46] One might hope that the possibility of international carbon benefits might 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 of indigenous land.[47-49] Belo Monte (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 (for which a different name will undoubtedly be chosen). Belo Monte's 8.4 MW of installed capacity would be largely useless without the highly damaging upstream dams: Belo Monte's firm power without Babaquara would be only 1.6 MW. Brazil's current system of environmental impact assessment is incapable of dealing with the impacts of a chain of related development projects, as opposed to the direct impacts of a single project.

Whether international review, certification and monitoring would be implemented for these impacts, 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.[4] Many of the 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 in the world 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.[50, 51] 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 by the existence of international "watchdog" NGOs.

It is important to remember that the CDM is not only intended for implementation in Brazil, but in developing countries around the world. Even if one assumes that Brazilian government is run by saints, several of the over 150 other countries that have signed the UN-FCCC have no effective internal environmental controls at all. Some even have plans for stockpiling other countries' nuclear and/or toxic wastes as their vision of "sustainable development." 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 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 such a review is 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 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), which is financed by the G-7 countries and 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, if, for example, Brazil should 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 of the range of acceptable projects for financing countries.

IMPEDIMENTS TO BRAZILIAN RECOGNITION OF DEFORESTATION

Why doesn't Brazil join Annex B of the Kyoto Protocol? Brazil would have much to gain as one of the few countries in the world that could reduce its emissions by half or more with beneficial results for the national economy. While other countries can only reduce emissions by curtailing use of fossil fuels and 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, 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 "leakage" from project-based initiatives would be solved. Brazil could assume a leadership role in fighting global warming and help induce other countries to commit to cutting emissions further than they have so far agreed to do; Brazilian President Fernando Henrique Cardoso could get the Nobel Peace Prize, and Brazil could get its seat on the UN Security Council. Why isn't this dream scenario happening? Some background information on Brazil is appropriate.

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 and mythologies. 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. It is natural that people raised from infancy hearing this theory will accept it as above questioning. Recently, this author's seven-year-old daughter returned from school with the information that "the Americans are trying to buy Amazonia"--she had heard it from her first-grade teacher.

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 green-helmeted soldiers (usually assumed to be of US origin) are poised to come parachuting into 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.

The situation can perhaps be best understood by remembering the parallel case in the United States, where, for about forty years following World War II, a large part of the population and much of the country's leadership believed that communists were hiding under every bed and that the world was on the verge of falling to the reds like a line of dominoes. The extent to which that view of the world was based on mythology or reality is much less important than the fact that people believed it. People's belief that the world was organized in that way is what influenced major historical events over several decades. In a similar way, the reality of a threat of "internationalization" of Amazonia, or lack of it, is of little importance; it is the fact that the "internationalization" theory is the paradigm though 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 was expressed by a Brazilian diplomat in a comment overheard by Brazilian environmentalist Carlos Vicente[52]: "*Não queremos queimar o nosso casife agora*" ("We don't want to burn out our potency now"), meaning that Brazil should wait until the price is right. 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 reserve expansion project in Bolivia initiated in 1998. In 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.

A number of Brazilian officials have taken public stands against consideration of deforestation, for example condemning forest maintenance projects as a form of "blackmail" and as similar to the practice of Chicago gangsters extorting protection payments from their victims. It quickly becomes personally impossible to reverse one's position in such a situation regardless of the weight of evidence that may be presented in favor of a change. Despite obstacles, changes can occur in response to shifts in the perception of national interest. 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.

CONCLUSIONS

Brazil's major opportunity for mitigating global warming under the Clean Development Mechanism lies in reducing deforestation. This task faces difficult-but-not-impossible hurdles. A variety of unfinished business must be addressed to make forest-sector mitigation options viable and fairly compared with options in the energy sector. The timing and duration of benefits vary greatly among options, making the choice of a discount rate for carbon (zero or otherwise) a critical factor. Strong arguments exist for applying a discount rate greater than zero to carbon; indeed, some form of time-preference weighting represents the only way that most forestry options can meaningfully be compared with fossil fuel combustion avoidance options. Definition of the boundaries of analysis strongly influences conclusions on forest-sector options, benefits calculated at the project-level often being negated by "leakage," as when farmers prevented from clearing in a protected area simply move their deforestation activities to another part of the forest. Program-level assessments of benefits are needed, as are mechanisms through which contributions can be made to program-level activities (as opposed to free-standing projects, such as stands of planted trees). This also represents a means of dealing with the great discrepancies in the probability of success among mitigation options: plantations are relatively secure in producing carbon benefits (but the magnitude of potential benefits is modest), whereas deforestation avoidance carries a much higher chance of yielding no measurable benefits (but a

much higher payoff if successful). A Bayesian approach to risk and uncertainty is needed in evaluating the relative benefits of the various options. Also needed is a careful evaluation of the social and environmental impacts of each option before it is promoted as "clean development."

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