Policies for national-level avoided deforestation programs: a proposal for discussion

Background paper for Policy Research Report on Tropical Deforestation

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Note: ***This paper should be viewed as a work in progress and is intended to stimulate discussion on a topic of current interest.*** *The findings, interpretations, and conclusions expressed in this paper are solely those of the author. They do not necessarily reflect the views of the World Bank, its Executive Directors, or the countries they represent.* *I am grateful to Franck Lecocq, Ian Noble and Lucio Pedroni for helpful comments. All errors are mine.*

1 Why forest carbon makes sense for climate and for forests

1.1 Forest carbon: the ungrasped opportunity

Throughout the developing world, farmers cut down trees for sometimes small and ephemeral gains, creating croplands and pastures worth perhaps a couple of hundred dollars a hectare. As those trees burn and rot, they release CO_2 to the atmosphere, up to five hundred tons per hectare or more. Meanwhile, the European market currently[1] places a value of \$32/ton on abatement of CO_2. In other words: the farmers are sacrificing a \$15000 asset to create one worth \$200. (And that \$15000 doesn't include the value of biodiversity or other environmental attributes.) There seems to be a great opportunity for arbitrage here: the industrial societies could pay the poor farmers for forest conservation some amount between \$200 and \$15000 per hectare, and both parties would gain. But this opportunity remains ungrasped. Why? What are the obstacles? Can they be overcome?

This brief note reviews some of the obstacles and suggests some solutions. As a starting point for discussion, it sketches one possible approach to national level programs for deforestation reduction.

1.2 What's a more valuable use for forestland: pasture or environmental services?

Let's look in more detail at the 'arbitrage' argument, since this is the key reason why it is to everyone's advantage to find policies to promote forest conservation. Forests and woodlands are converted to agriculture for profit. Sometimes the per-hectare profit is

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[1] (based on pointcarbon.com, 7 February 2006).

relatively large, as in the case of soybeans or palm oil. In this case society gains quite a lot from forest conversion, and that gain has to be weighed against the carbon impacts (and other environmental and social impacts). But quite often, forests are converted to relatively low value uses.

At the Latin American frontier, much forest is being converted to low value pasture. Land markets, where they exist, give us a good reading on this value, which incorporates the expected future revenue stream as well as capital appreciation due to expected future regional development. According to Fundacão Getulio Vargas, pastures in the Amazonian state of Pará were worth US$200/ha at the end of 2004; those in Rondônia were worth a little more, US$318. This is consistent with reported prices of $300 (with a $12 to $500 range) for Bolivian pastures in lowland forest areas (Merry et al. 2002) and $150 to $500 for relatively remote Ecuadorian land (Olschewski and Benitez 2005). However, these values overestimate the profitability of converting forest land, because they do not deduct the cost of forest clearance and pasture establishment. Merry et al. report that the cost of clearance and establishment, net of revenue from timber sales, is an average of $267. This suggests that the profits from clearance are sometimes barely positive, a couple of hundred dollars at most. (On the other hand, there are examples of places – for instance, in Brazil's cerrado – where converted woodlands command thousands of dollars per hectare due to favorable agricultural prospects.)

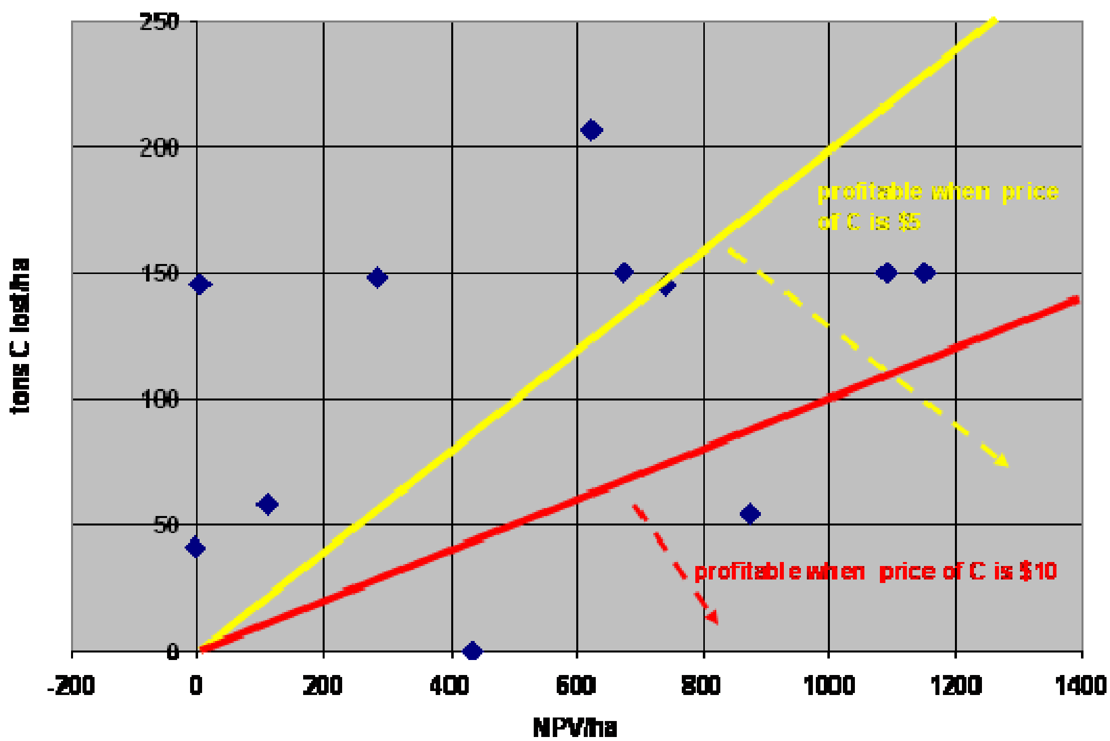
Where land markets are not active, estimates have to be made on the basis of studies of farm revenues. Rigorous data on profitability, carbon storage, and biodiversity have been assembled by the ASB (Alternatives to Slash and Burn) project for a number of different land use systems in the moist forests of Brazil, Cameroon, and Indonesia.(Tomich et al. 2005) For each land use, researchers computed the net present value of profits and the amount of carbon stored.

Figure 1 plots, for selected land uses, profitability versus the carbon lost in creating the land use. (For Brazil and Cameroon, I assumed that native forest was converted; for Indonesia, I used managed community forest as a baseline.)

The plot shows tremendous variability in the potential cost of conserving carbon. At one extreme, traditional pasture management in Acre, Brazil entails a loss of 145 tons of carbon per hectare, but creates only $4/ha in land value and 11 days/ha/year of employment. So the cost of conserving carbon, in principle, is just $0.03/ton C (or less than $0.01/ton CO_2). Rubber agroforestry in Sumatra, as traditionally practiced, also yields virtually no land value, just managing to repay the opportunity cost of labor. The most profitable land use, oil palm in Cameroon, entails a carbon loss of 150 tons per hectare, confers a land value of $1090, and provides 150 days of employment; here the theoretical cost of conserving carbon is $7.27/ton C.

Another way of looking at these data is to ask: is it worthwhile, after allowing for the damages caused by carbon release, to convert forest to these uses? To make this assessment, we need to assign a cost to carbon emissions. A modest cost estimate is $5/ton C (=$1.36/ton CO2), within the range of observed non-Kyoto compliant carbon prices. If we assess carbon damages at that rate, then only the land use systems below the yellow line are socially profitable. If carbon abatement is valued at $10/ ton C, then the only socially profitable land uses are the two below the red line. Both of these are experimental land use systems not in widespread use due to economic or social barriers (community forest management in Acre; rubber agroforestry with improved clonal rubber stocks in Sumatra, Indonesia).

Figure 1 Deforestation is unprofitable in many land systems when carbon costs are accounted for



Source: Based on Tomich et al 2005

To sum up, at very low carbon values, it's socially preferable to keep land under forest rather than convert it to typical low-productivity pasture or annual cropping. At moderate values, carbon competes even with relatively high value plantation crops. A challenge for avoided deforestation policies is to tap the value of carbon to make sure that poor people benefit from the potential exchange.

1.3 Forest carbon: a useful component of a comprehensive climate change mitigation portfolio

Halting all deforestation --even if that were possible -- would not by itself achieve the UNFCC goal of stabilizing the amount of greenhouse gases in the atmosphere.

But *no* single line of action will be sufficient to achieve that goal. Pacala and Socolow (2004) outline fifteen potential options for reducing emissions over the next half century. Each option reduces emissions by about 25 billion tons. Seven to ten activities of this magnitude would be required to stabilize greenhouse gases in the atmosphere[2]. Reduced deforestation and increased reforestation constitute one of the fifteen options. So while forest carbon is no panacea for mitigating climate change, it could be part of the prescription.

And it could be an important part if it is cheap. Cheapness is a virtue. We don't know how much it will cost to mitigate climate change. And we don't know how much mitigation is enough. More stringent targets for atmospheric CO_2 concentration provide better insurance against catastrophic climate 'surprises', but each part per million reduction will cost more than the last. Because the risks are difficult to quantify precisely, it is hard to achieve global agreement on how much to spend and on how to divide up the bill. Against this background, anything that reduces the cost of a global mitigation strategy will increase the chance that the strategy is embraced.

1.4 Why carbon finance makes sense for forests and rural development

Forests may play a relatively small role in climate change mitigation, but climate change mitigation might play a large role in financing forest maintenance.

Sathaye et al. estimated the potential of avoided deforestation to contribute to carbon abatement for different levels and trends of carbon price. Relatively modest prices for carbon could, in principle, deter conversion of one to two million square kilometers of forest by 2050, preventing the release of 8 to 15 billion tons of carbon. A $100/ton price of carbon (approximately the level prevailing on the European carbon market in December 2005 – perhaps temporarily) would induce conservation of five million square kilometers by 2050, abating the release of 47 billion tons.

Just to illustrate the potential order of magnitude involved, the $100/ton C scenario would imply payments to the forest sector of $100 billion/year over the next half century. Forest carbon would have the added advantage of providing a range of local and global cobenefits that would otherwise be difficult to finance. These include the conservation of globally significant biodiversity and of forests with spiritual or other difficult-to-monetize values. Most importantly, the revenue from carbon can be used to intensify and improve agriculture in a way that complements forests instead of replacing them. In fact, this is essential to the success of an avoided deforestation program.

[2] That is, to hold atmospheric concentrations of CO2 to 500 parts per million.

2 Addressing concerns about avoided deforestation

The UN Framework Convention on Climate Change is responding to a submission by Costa Rica and Papua New Guinea to examine options for reducing emissions from tropical deforestation, including credits for reducing emissions below a national-level baseline. To gain acceptance, these options will have to address, in practical ways, the objections which kept avoided deforestation out of the Kyoto Protocol. Here is a list of the most important concerns – and some ways to deal with them. (This draws on and expands the discussion of (Chomitz 2002)).

2.1 *"Forest carbon makes mitigation too cheap"*

Problem: At first glance, this objection is hard to understand. Cheapness, as noted before, is a virtue. If we want people, firms, or countries to undertake actions for global benefit, it will be easier to persuade them if we can reduce the cost of those actions.

But there are two serious concerns underlying this objection. First is the concern that forest carbon projects or arrangements will be cheap but ineffective, for reasons to be discussed below. This would be doubly a concern if institutional arrangements allowed these projects to displace more effective ones in the energy sector. The second concern has to do with how the world community frames and approaches climate targets over the long run. Part of the value of a cap-and-trade system such as the Kyoto Protocol is the effective price it puts on carbon emissions, since this will motivate long term changes in capital stock and investments in research and development. Introduction of a new source of emissions reductions could be used either to allow the world to meet a more stringent cap, or to reduce the cost of meeting a pre-established cap. The latter approach would result in a lower price on carbon and so might not stimulate as rapid a transformation to a low-carbon economy.

Solution: Forest carbon could be integrated into a comprehensive, long-term climate mitigation program. Its potential cost efficiency could be used to increase mitigation efforts, rather than to reduce the cost of achieving an inadequate target.

2.2 *"Deforestation avoidance has to be permanent to be useful, but it's impossible to secure permanence"*

Problem: Here's a troubling paradox: buyers of forest carbon want permanent agreements, but sellers want temporary ones.

On the buyers' side, the problem is this. Since mitigating climate change requires stabilizing CO_2 concentrations, many people assume that each project to reduce CO_2 emissions has to have a permanent effect. Many energy projects have permanent impacts. Replace a diesel generator with a windmill, and less fuel will be burned this year. Even if the windmill breaks, and the old generator is put back in service next year, the CO_2 emissions reductions are already accomplished. The atmosphere is a little cleaner than it would have been without the windmill. Forest conservation, on the other hand, is riskier. Forests can burn. Climate change may imperil tropical forests if temperatures rise and rainfall decreases. And drastic changes in politics or markets, it is feared, may lead the heirs of today's forest owners to repudiate decades-old conservation commitments. In view of these risks, buyers worry that it is impossible to sign an agreement today that securely guarantees carbon sequestration into the distant future. And without such a guarantee, they see no benefit in sequestration or reduced deforestation.

Sellers, on the other hand, may not want to sign such an agreement, precisely because it closes off future options. Agricultural technologies and markets change rapidly, and expanded transport networks can transform development possibilities for formerly remote regions. So forest owners may not want to commit to conservation forever.

Solution: Recognize that avoided deforestation is valuable even without a guarantee of permanence.

Carbon sequestration doesn't have to be permanent in order to be part of a climate change mitigation program. There are three ways in which temporary commitments to carbon sequestration usefully buys time to act on climate change.

1. Temporary sequestration buys insurance against catastrophe in the face of uncertainty

The climate system is unstable. Small changes to it can trigger large and irreversible impacts, such as those that apparently shifted the Sahara from heavily vegetated to desert (Foley et al. 2003);(Schneider 2004);). There's a reasonable fear that too much CO_2 in the atmosphere, or a too-rapid rise in CO_2, could have the same kind of catastrophic effect. But we don't now know the thresholds beyond which such a catastrophe could occur. In the face of such ignorance, it is prudent to buy insurance – that is, to try to keep CO_2 levels low, and rising slowly.

(Gitz et al. 2006) have demonstrated that forest carbon could be a crucial, cost effective element of a long term climate mitigation program. In their model, inexpensive forest carbon plays an insurance role for the next few decades. At that time, the world may be better able to assess the risk of catastrophe. If a dangerous threshold is then imminent, the world could continue to rely on forests as a carbon sink, or could step up investments in geological carbon sequestration.

2.Temporary sequestration could be a wooden bridge to a clean energy future.

Under current Kyoto rules, developed countries need to meet limits on total carbon emissions. They can park their carbon temporarily in trees, but when the contract for carbon storage is up, they need to put that carbon someplace else – or equivalently, reduce carbon emissions someplace else. This will work nicely as a strategy if, at the end of the contract term, there are new, cheaper opportunities for storing carbon or reducing emissions.

Translated from project scale to global scale, this suggests that a temporary, renewable decision to protect forests could serve to buy time for technological advance. The strategy would be to protect currently-threatened forests that have low opportunity costs. Over time, those opportunity costs might rise if there is increased pressure for agricultural expansion.

More rapid development of emissions-reducing technologies would then give forest holders the option to substitute energy emissions reductions for continued forest maintenance. (But, as the next section suggests, the forest holders at that time might choose not to exercise that option.) The more rapidly cheap energy-emission-reduction technologies are developed, the more quickly this option becomes available.

There are two broad types of technologies which may have experienced underinvestment in research, development, and demonstration (R,D&D).

First, we would expect private underinvestment in precisely the kind of R&D which might most help the developing world – R&D that results in technologies that save money, are easy to copy and difficult to patent. Some existing examples of these technologies or discoveries include:

- Development of efficient, locally appropriate, technologies for building heating, cooling, and insulation, together with policies that provide incentives for building owners to conserve energy
- The use of urban tree planting, and use of light colored rather than dark colored paving and roofing material, to substantially reduce a city's temperature and thus reduce demand for electricity for air conditioning.
- Demonstration of the feasibility and acceptability of imposing toll charges for use of center city roadways, as a means of decreasing urban transport congestion

Second, there may be private underinvestment in basic research and development aimed at high-risk, high return breakthroughs in energy technology. The international consortium for research on nuclear fusion is an example of public R&D directed at these opportunities, but there may be many more

In short, from the viewpoint of the world community at large, it makes sense to approach global climate change mitigation through a program that uses not-necessarily-permanent avoidance of deforestation as one means of buying time for investments in energy R&D to bear fruit. There is no need to tie the two approaches together at a project level, but rather to move towards simultaneous global implementation of avoided deforestation and more vigorous R&D.

<u>3. Temporary sequestration could turn out to be permanent</u>

Over the past two centuries, many developed countries have undergone a forest transition: deforestation for agriculture, followed by farm abandonment and regeneration of the forest. According to Rudel et al. (2005), rebounds in forest cover have also occurred or are underway in Bangladesh, China, Costa Rica, Cuba, Dominican Republic, Gambia, Peninsular Malaysia, Morocco, Puerto Rico, Rwanda, and South Korea. One important mechanism for this is rising labor demand. Initially, poor settlers seek to eke out a living at the forest frontier. The lands they clear have poor soils, are distant from markets, and yield only a marginal return to labor. But as long as labor is plentiful and cheap, clearance continues. When the labor market tightens, people abandon the marginal lands for better opportunities in urban areas or in more productive agricultural lands. The forests may then naturally regenerate, or be replanted. However, the returning forests may not have the same carbon density or biodiversity as the original forests. In the worst case – especially in fragile tropical soils subject to compaction or fire – the forest may be irreversibly lost. In this case, the forest transition leaves behind areas of degraded grasslands rather than regenerated forests.

The well-documented history of the forest transition suggests that "temporary" sequestration could bridge the trough of the transition and end up being permanent. That is, many places face temporary pressures to convert forests for small gains. A twenty to forty year effort to halt deforestation would not involve large opportunity costs, so that equitable compensation could be arranged. At the end of that period, a combination of rising wages and increasing appreciation of biodiversity values could well prompt a re-evaluation of the desirability of forest conversion. The forest-owner, and the host country may not want to exercise the option for conversion at that time.

To sum up: 'temporary' efforts to avoid deforestation provide a valuable climatic service and may end up to be permanent.

2.3 "If you protect one forest, someone will just cut down another"

Problem: In the bigger scheme of things, does it do any good to protect a particular forest plot from conversion to agriculture, or to reforest a working pasture? Won't market pressures just push someone else to deforest some other plot, to meet the economy's demands for food and employment?

This problem is called 'leakage' or 'slippage', and it occurs in many contexts where a project acts locally, but has distant repercussions. It's a concern in existing policies that seek to retire marginal farmland to prevent erosion, or to shore up commodity prices – do the farmers retire one field and open another? It also occurs in projects intended to reduce energy use and associated carbon emissions: switch a city from coal power to wind, and you nudge down the price of coal slightly. Elsewhere, millions of people respond by increasing their coal consumption a bit. It can add up to a large proportional diminution of the putative gains at the project site.

Solution: Leakage from forest protection won't necessarily be hectare-for-hectare.(Chomitz 2002), as a naïve view would suggest. Suppose, for instance, that a forested property is about to be converted to pasture, but is protected instead. The immediate effect is to drive up the price of beef a scintilla, and to set a small amount of capital and a smaller amount of labor looking for other opportunities. One possibility is that the cowboys and ranchers move to an adjacent forest plot and set up a ranch there. But it is also possible that another ranch, possibly a distant one, intensifies a bit, adding a few animals and a few farmhands. This is especially likely if the protected forest would have been used for low intensity grazing. In addition, the slight upward pressure on beef prices may nudge some consumers towards chicken. In sum, leakage will be smaller if other parts of the economy can intensify production and absorb the freed-up capital and labor; and if consumers are relatively sensitive to the price of beef (or whatever commodity is affected by the forest project.)

Studies find in fact that leakage can be far less than 100%, even absent any effort to control it. Wu (2000) studied the US Conservation Reserve Program, which pays farmers to revegetate erosion-prone land. Wu found leakage of about 20% in terms of area, and 9% to 14% in terms of erosion prevention. In other words, for every five hectares of land put into the program, one hectare of forest was converted to agriculture outside the program. But the newly converted land was less erosion-prone than the protected land. Murray et al (2004) simulate the impacts of a hypothetical US program that would protect forestland from agricultural conversion, putting it instead under sustainable timber management. Depending on exactly where the program was implemented, the carbon leakage rates ranged from -4.4% (implying a *gain* in carbon sequestration outside the program) to 73.4%. The difference in outcome could be attributed to differences in whether the system responds through extensification (land conversion) vs. intensification (higher productivity).

The solution to leakage, then, is to neutralize it by simultaneously encouraging agricultural intensification in nonforest areas – intensification which soaks up the labor, commodity supply, and capital that was diverted by forest protection.

2.4 "It's too expensive to monitor carbon"

Problem: It takes a fair amount of effort to measure the amount of carbon in a tree, let alone a farm. Measuring changes over time adds another layer of complexity. Is it really affordable to reckon the impact of carbon sequestration efforts?

Solution: Measuring forest carbon, in a district or in a nation, involves two steps (to oversimplify a bit). The first is estimating about how much carbon there is in a tree of a given size, based on its volume and characteristics. The second involves counting the number of trees of different sizes, and multiplying by the amount of carbon in each tree. The second step could be accomplished by painstakingly tallying every tree – a difficult job even in a small forest. Technology is making this approach cheaper. For instance, techniques exist to take aerial stereoscopic pictures and assign computers to recognize trees and estimate their volumes. Still, the cost per tree or per hectare is significant; the airplane has to cover the countryside in many low-altitude swathes.

However, the use of statistical techniques potentially offers huge economies of scale in carbon measurement. (Chomitz 2002). Statistics can be used to estimate the number or volume of trees based on a sample. And statistical methods have a remarkable property, familiar from the field of household surveys: the accuracy of the estimate depends on the size and representativeness of the *sample*, not on the size of the *population* that is being sampled. With 2000 interviews one can accurately assess mean household income -- for a city, a province, or a nation. Hence there are huge economies of scale, in costs per ton, of measuring carbon stock changes at a national level as opposed to a project level. While the statistical issues in drawing appropriate samples can get extremely complicated, the principle is clear: enlisting a few clever statisticians can drastically reduce the number of fieldworkers or aircraft needed for carbon measurements.

3 Components of a system for avoiding deforestation for climate benefits:

The solutions are mutually supportive. They strongly suggest working at a national level, in order to incorporate leakage neutralizing policies and to drastically reduce the costs of carbon monitoring. Here are some potential steps towards setting up avoided-deforestation programs in developing countries. The elements of the system are:

- Agreement by some industrialized countries to finance avoided deforestation programs and basic R&D for energy-related emissions reductions
- Development of national 'forest carbon infrastructure' : systems for forest and carbon monitoring, including 'win-win' steps to reduce excessive deforestation
- Strategic emphasis on neutralizing emissions and on not-necessarily-permanent deforestation reductions.
- Elaboration of the forest carbon infrastructure into certified national programs for deforestation avoidance. These would specify international incentive payments as a function of forest carbon emissions against a target. National programs would specify plans for leakage neutralization.
- Incentive payments would be 'pay as you go', based on annual reduction levels against a reference level.

3.1.1 Develop sources of global finance to promote avoided deforestation and R&D for energy-related emissions

National level programs would require global finance. There are different possible avenues for doing this. One is within a Kyoto framework. Some countries accept a cap on emissions but can meet that cap by purchasing emissions reductions abroad, including those from national-level averted deforestation. This approach could lead to a market for forest-carbon based emissions reductions, with pricing dependent on supply and demand.

Alternatively, a global agreement could set up an incentive fund to pay for forest-based emissions reductions and sequestration. This might well be negotiated in parallel with a separate donor commitment to invest in energy-related basic research and development. As explained earlier, there is a natural complementarity between temporary measures to sequester carbon and long-term efforts to reduce energy-based emissions.

3.1.2 Support national 'carbon infrastructure' programs.

A first step lays the groundwork for incentive payments by building capacity and creating the necessary physical and institutional infrastructure. These investments, supported by donor financing, would include 'win win' investments that will tend to reduce deforestation pressure in any case. Carbon infrastructure would include the following:

- Institutions and hardware for monitoring forest cover, forest and land fires, and carbon. Initially, this could track land cover and land cover change, providing rapid, indicative measures of change. Later it could be elaborated into a more comprehensive and accurate carbon monitoring and measurement system. It would combine new remote sensing technologies such as MODIS with ground based observations. Such a system has the potential to do far more than provide the carbon readings necessary for incentive payments. It aid in land use planning, forest fire prevention, and forest law enforcement. To facilitate this, the monitoring system would map the boundaries of protected areas, forest concessions, indigenous areas, and the largest private properties. This information could be used immediately by public authorities to facilitate enforcement of forest laws and to improve management of publicly owned forest lands. Public disclosure of this data would build public awareness of the issues and might help build constituencies for enforcement of laws against illegal forest conversion or logging.

- Programs to reduce accidental fires, in places where this is a problem.
- Programs to improve tenure security in forested areas
- Programs for intensification of agriculture in nonforested areas, and to encourage off-farm employment in forested areas.
- Pilot programs of incentives for deforestation reduction
- Globally-financed monitoring and evaluation to encourage rapid learning at the domestic and international level

3.1.3 Recognize the link between avoided deforestation and agricultural intensification

The next step is to build on the carbon infrastructure, planning a strategy for carbon gains through avoided deforestation and through natural regeneration, assuming that incentive payments will be available. The strategy relies on two elements to make it attractive both from a development viewpoint and a climate viewpoint. First, it does not rely on permanent commitments, allowing countries to leave open their long term options for land use. In some cases – for instance, the creation of national parks or the protection of sensitive watersheds – a perpetual commitment to forest protection may be perfectly aligned with national priorities. In other cases, such a commitment may be undesirable. However, a plan to maintain a forest for 20 to 80 years is comparable to the commitment implied in dedicating land to plantations, to long-rotation forest concessions, or to urban development.

Such forest protection (broadly construed to include forest management as an alternative to agricultural conversion) is not by itself adequate to conserve carbon and may not by itself receive strong domestic support. The first problem is leakage, discussed earlier. The second problem is that payments for forest protection may result in gains for landowners, but uncompensated losses for others (labor, sawmill owners). Even if benefits are in aggregate positive, a narrow base of beneficiaries could be insufficient to secure support for the program.

The solution to the first problem helps also with the second. The first problem is solved by 'neutralizing' leakage. This entails some combination of intensifying agricultural or timber production elsewhere, to fill the gap created by forest reservation; and of absorbing the capital and labor that would otherwise have been engaged in forest clearance. There are many ways to do this. For instance, road improvements in less-forested areas could lead to agricultural intensification and increased demand for labor, reducing migration to the forest frontier. In the Philippines and Vietnam, for instance, intensification of rice production in lower watersheds has apparently attracted labor from upper watersheds, reducing deforestation of upland forests at least temporarily. (Muller and Zeller 2002; Shively and Pagiola 2004) More rapid, and more labor-intensive development outside the agricultural sector will put upward pressure on wages, reducing net migration to forested areas.

The combination of forest protection and intensification of agricultural production is essential from the environmental viewpoint –neither would be fully successful alone. And from the viewpoint of political economy, the combination creates a broad constituency of beneficiaries who could be supporters for program implementation.

3.1.4 Develop a certified national program for deforestation reduction

The strategy could be translated into a blueprint of domestic institutions, policies, and programs for reducing emissions from deforestation and, probably, for increasing carbon storage in agriculture/forest landscapes. This program translates national-level receipt of incentives for reduced deforestation into incentives for forest owners to contribute to the achievement of these reductions. One approach to doing this would be via a direct pass-through of national incentives to individual property owners. But this approach has some disadvantages. It doesn't address the problem of illegal deforestation or deforestation on public land. It doesn't facilitate government policies that can affect entire landscapes. It fails to recognize the contribution of agricultural intensification in reducing leakage and facilitating emissions reductions. And measurement, monitoring, and transactions costs are prohibitively high at the property level, especially for small properties.

An alternative is to delink incentives to the nation from incentives for individuals and firms. The national government can use revenues from incentive payments to fund a diverse portfolio of interventions in different sectors and locations. Such interventions might for instance include:

- Incentive payments to communities or localities for reduced deforestation or for natural regeneration
- Improving tenure security
- Enforcement of regulations against illegal deforestation or logging; setting up taxation of large scale land clearance
- Promotion of off-farm employment.
- Intensification of agriculture in favorable areas, placed to attract or divert labor from marginal lands at the forest fringe
- Strategic planning of road improvements
- In federal countries with revenue-sharing, variants of Brazil's 'ecological value added tax'. Suppose that federal tax revenue is redistributed to provinces or districts based on a formula typically including population, output, or poverty. The formula could be modified to reward agricultural employment or production but to penalize deforestation or a proxy (such as fires in forest areas). This would tend to encourage agricultural intensification.

These programs might then be certified for participation in a globally financed incentive program. Certification might also facilitate grants or loans from donors or international financial institutions to invest in setting up the programs. Programs would have to meet certain criteria in order to be certified for funding. These might include social or environmental safeguards. For instance, the monitoring system would have to eliminate any perverse incentives to replace natural forests with planted ones.

3.1.5 Create national-level incentives for deforestation reduction and carbon storage

Funders and recipients of incentives will be keenly interested in how prices and quantities are set. The framework envisions a negotiated reference level (RL) of emissions or net emissions. Incentives would be offered for reductions below the reference level. The key parameters to be negotiated are: how to set the RL, how much to reward reductions below the RL, and how or whether to discourage emissions above the RL.

First: how to set the RL? If set above the unobservable baseline level of emissions, then the country will receive rents – pure transfers unrelated to emissions reductions. If these are too large, funders may decline to participate. But if the RL is set too far below the baseline, the deforesting countries may decline.

Here are three options, each with advantages and disadvantages.

1. *Set RLs to reflect historical levels of emissions.* The chief problems here are lack of data, together with changing economic conditions. Some countries may have reliable time series data on changes in land cover, based on a combination of remote sensing data and forest inventories. In other cases it may be more difficult to piece together appropriate data, making the determination of historical rates subject to considerable judgment.

2. *Use simple rules of thumb to estimate current deforestation rates, where historical data are lacking.* For instance, there is a very strong tendency for deforestation rates to decline sharply with distance from roads. It is relatively easy to obtain remote sensing measures of current forest cover and to overlay these on maps of the existing road network. One could then apply standardized rules – assuming for instance a 2% annual deforestation rate within 5 km of the road network, 1% in the band from 5 km to 10 km, and 0 outside. This approach would be less apt where deforestation results from clearing by large enterprises, such as plantations or ranchers, who can invest in their own roads.

3. *Compute a normative RL.* The normative estimate would be based on a standardized estimate of the rate of increase of agricultural production, adjusted for an estimate of the rate of increase of agricultural productivity, and mean carbon content of forest land at the agricultural margin. Separate estimates could be made for logging-related emissions, and for the rate of abandonment of current lands. A normative RL would tend to reward countries that are already making efforts at reducing deforestation,

without introducing perverse incentives to increase deforestation so as to get more credits.

None of these approaches yields a simple, undebatable answer. A further issue, common to all, is whether to allow year-to-year adjustments to the RL based on prevailing agricultural prices or weather.

Second, how to price the reductions below the target, and how to deal with the temporary nature of the reductions? The system can be made fungible with Kyoto, or independent. Let's start with an independent scenario, where the reductions result from national-level incentives and are not tied to the Kyoto carbon market or its successor. In that case, funders and recipients could negotiate a payment amount per period per ton per year. The calculations would be made as follows. Reductions in year t would be calculated as:

$R_t = RL - E_t$

where E_t is measured net emissions. R could be positive (meaning a reduction against the reference level) or negative (implying emissions above the reference level). (In practice, net emissions would probably be measured only once every five years, to increase accuracy and decrease cost. Annual levels would be determined by linear interpolation.)

Incentive payments would be made periodically, perhaps in conjunction with five-year measurement periods. The payment at time T would be:

$$\max(0, P\sum_{t=1}^{T} R_t)$$

where P is the price per ton per year, and t=1 marks the beginning of the first measurement period. In other words, the country gets credit for each year it keeps each ton out of the atmosphere. If R has an average value of 5 in the first measurement period, and 10 in the second, it receives 5P per year for the first period and 15P per year for the second. If R has an average value of 5 in the first measurement period, and a mean value of -5 or below in the second, it receives 5P per year for the first period and nothing for the second.

Would this lead to strategic behavior by participating countries? For instance, would a country have an incentive to delay or 'pulse' deforestation? One response is that, in the ton-year context, temporarily delaying deforestation is a service that should be rewarded. The value of the delay is factored into the price P (about which more below), which also provides an incentive to keep conserving. (A system which paid in advance for a perpetual conservation commitment would be at greater risk, since it might not be possible to enforce the commitment.) Beyond that, however, delaying deforestation might not be rewarding, for several reasons. First, it is hoped that some of the reductions will come from reducing unwanted deforestation such as accidental forest fires. Second, the certified program for reductions will put into place projects and systems that will tend to dampen the demand for deforestation. Third, within any year or period there are increasing marginal costs of deforestation, due to limited supply of labor and capital and a limited forest perimeter on which to work. So individuals or nations do better to spread deforestation out over time rather than to 'pulse' it.

There is no firm basis in physics or economics for setting a precise value for P; an analogous discussion of the relative value of 'ton-years' was inconclusive in the early years of Kyoto negotiations. However, it is clear that P is positive, because delaying emissions is valuable, and because there is a significant chance of 'unintended permanence.' In the presence of uncertainty about these effects, P would have to be decided by negotiation. A natural reference point, however, would be the current rate of interest times the market or normative price of a carbon allowance. This is the rental value of a permanent allowance. For example, the current price of carbon on the ETS is approximately €25/ton CO2. At 6% interest, this implies a payment of €1.50 per ton per year for an annual reduction. At this rate, averting the deforestation of a hectare of moist rain forest might return a few hundred euros per year. A price based on 6% of €2.50/ton CO2 might still return an amount comparable to the annual payment rate in Costa Rica's payment for environmental services program. Lower interest rates (3%?) might also be justified in terms of the long term nature of the investment.

This approach could be transformed into a Kyoto-fungible one by setting an 'exchange rate' between cumulative net emissions and permanent tons. Again, setting it at, say, 3% of a permanent reduction might be a starting point for discussion.

4 Conclusion

The obstacles to setting up avoided deforestation programs are considerable, but the potential benefits are also large. This note suggests one possible approach, in which the solutions to those obstacles might be self-reinforcing; they are summarized in the table below. Many details would remain to be worked out.

The policies discussed here will require fairly sophisticated institutional capabilities, and so may not be immediately applicable to all forested countries. However it would be possible to imagine sequential steps that start with setting up 'carbon infrastructure' and proceed to pilot tests of particular nation-to-individual incentives. These early stages might be rewarding to participating countries and beneficial to the global climate while providing information that would help better to design global incentive programs.

Table 1 How policy components address implementation issues

	Permanence/ contributes to long run climate mitigation	Acceptability to hosts	Leakage	Monitoring
Bundle with commitment to R&D	X			
Invest in agricultural intensification	X	X	X	
National level baselines			X	X
Temporary commitments by hosts		X		
Focus on marginal areas with ephemeral pressure, risk of irreversibility	x	x		
Catalyzing technology diffusions	x	x		

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