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Linking Solutions to Climate Change and Biodiversity Loss Through the Kyoto Protocol's Clean Development Mechanism

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The Kyoto Protocol's Clean Development Mechanism creates an opportunity to motivate investments in projects that reduce greenhouse-gas emissions by helping developing countries conserve and restore their forests. Properly designed and implemented, forest-based CDM projects could support climate, biodiversity conservation and sustainable development objectives by paying the incremental costs of protecting parks and watersheds, reducing the impacts of logging, restoring forests on degraded lands, and other measures. This report highlights several key challenges and strategies for realizing the potential of CDM projects to support these objectives.

Tropical forests are globally significant reservoirs of both carbon and biological diversity. Yet land conversion for agriculture—coupled with fires, and high-impact logging and mining—continue to rapidly destroy, fragment, and degrade forests across the tropics. Collectively, these activities contribute more than 15 percent of annual anthropogenic emissions of carbon dioxide, the principal greenhouse gas and drive the marked decline and extinction of forest species and genetically distinct populations (Brown et al. 1996, Orians et al. 1995, Hughes et al. 1997, Laurence et al. 1997). A principal obstacle to slowing current trends is that markets generally fail to capture the values of biodiversity, carbon storage, and the other "ecosystem services" that tropical forests provide. Because these values are typically unmonetized and primarily benefit the broader national and global community, individual and industrial forest users rarely have sufficient financial incentives to protect and more sustainably use forest resources. (Pearce and Moran 1994, Kishor and Constantino 1993, Myers 1997).

The Clean Development Mechanism (CDM) of the recently negotiated Kyoto Protocol creates a significant new opportunity to correct this market failure by motivating payments for the carbon storage and sequestration values of tropical forests. Through the CDM, the ratified Protocol would allow public and private sector entities from industrialized countries to receive credit towards their greenhouse gas (GHG) emissions reduction obligations by investing in energy and land-use change and forestry (LUCF) projects that achieve "certified emissions reductions" in participating developing countries. CDM projects are also required to assist developing countries in their efforts to achieve sustainable development (UN FCCC 1997).

The Protocol leaves many details of the CDM's operation to be determined by upcoming climate negotiations. Among these are the specific types of LUCF measures that will be approved for crediting. Prospective measures fall into two broad categories. The first encompasses site-specific projects and broader policy measures that directly reduce carbon emissions. These include

- slowing deforestation by protecting natural forests under threat of conversion to agriculture or pasture
- slowing forest degradation by protecting natural forests from anthropogenic fire and high-impact logging and mining
- substituting biomass energy sources for fossil fuels

The second category encompasses site-specific activities and broader policy measures to sequester carbon in biomass, thus reducing *net* emissions.[1] These include

- restoring natural forests by expanding their area or carbon density in deforested or degraded forest areas
- expanding the area or carbon density of agroforests and plantations

Properly designed and implemented, CDM projects incorporating any of these measures can both help stem climate change and promote sustainable development. However, the rapid pace of deforestation and forest degradation in many tropical countries and the irreversibility of the loss of forest biodiversity lead us to focus here on the opportunities and policy options for motivating CDM projects that achieve these goals through financing the conservation, restoration, and ecologically sound use of tropical forests.

Investments through the CDM have considerable potential to pay the incremental costs of park and watershed protection, reduced-impact logging, and restoration of forests on degraded lands. In a recent pilot project, for example, three US energy companies financed the conversion of a 634,000 hectare timber concession into an extension of Bolivia's Noel Kempff Mercado National Park (USIJI 1997), located in a region of globally outstanding biological distinctiveness (Dinerstein et al. 1995). Their investment of US $7 million helped buy out the concessionaire, establish a park endowment, and support ecotourism and other economic development initiatives with local communities. It also supports monitoring and verification of the projected 15 million tons of carbon (Mt C) that the project, if successful, will accrue over its 30-year duration.

> ***A principal obstacle to slowing forest loss and degradation is the failure of markets to capture the values of the "ecosystem services" that tropical forests provide.***

Between 2000–2010, a dedicated effort could prospectively slow deforestation and promote forest restoration on 47 million hectares (ha) in the tropics, an area nine times the size of Costa Rica. This would reduce and offset emissions of ~1,500–4,500 Mt C (Trexler and Haugen 1994), a substantial fraction of the 4,000–6,000 Mt C deviation from business as usual that industrialized countries committed, under the Kyoto Protocol, to achieve by 2008–2012 (Bolin 1998). However, the actual scale of forest-based CDM projects is likely to be well below this potential, in part because of the availability of many competitively priced measures to reduce fossil-fuel emissions (Interlaboratory Working Group 1997; Union of Concerned Scientists and Tellus Institute 1998). But carbon-offset investments in tropical forests on a considerably more modest scale could still provide substantial conservation and sustainable development cobenefits. At $10–20/ton C, CDM investments for only 20 percent of potential forest conservation and restoration measures in the tropics would be comparable to the ~$500 million per year currently provided by grants and loans for tropical forest and biodiversity conservation through the World Bank, Global Environment Facility, and major bilateral donor agencies (table 1).[2]

Unfortunately, the prospects for crediting any forest-based measures under the CDM are highly uncertain, as a result of some policymakers' concerns about the technical feasibility and the appropriateness of LUCF projects. For example, some countries interpret the CDM's mandate to achieve "certified emissions reductions" as excluding crediting for reforestation and other measures to sequester carbon in biomass. Some Brazilian officials have also opposed crediting for projects to slow deforestation out of concern that external pressure to take on such projects might infringe on national sovereignty over decisions affecting the use of forested lands. In response, a broad coalition of forest scientists, private sector firms, and nongovernmental organizations (NGOs) in both the United States and developing countries is seeking to ensure that responsible LUCF projects are included among the policy options available to the cooperative, international efforts to mitigate global climate change (UCS et al. 1998).

We believe that building effective forest-based projects through the CDM—projects that both reduce or offset carbon emissions *and* promote environmentally sustainable development—will require the following:

- a set of technically sound, internationally-sanctioned guidelines for securing carbon emissions reductions through forest-based CDM projects
- mechanisms to encourage the voluntary participation of developing countries in CDM projects
- policy incentives that encourage private-sector investments in projects that provide significant forest and biodiversity cobenefits

TABLE 1:

Current Annual Investment in Forest and Biodiversity Conservation in Developing Countries from Major Bilateral and Multilateral Donors

Funding Organization	Amount (Millions of 1997 US$)
The World Bank	356[a]
The Global Environment Facility	23[a]
The European Union	100[b]
U. S. Agency for International Development	17[c]
Total Annual Investment	496

Sources:
a) World Wildlife Fund, www.panda.org/news/press/news_130.html
b) J. Vasconcelos, European Union Representative to Brazil, personal communication
c) U.S. Agency for International Development, Research and Reference Services.

Securing Carbon Emissions Reductions Through Forest-Based CDM Projects

Several analyses indicate that site-specific changes in forest carbon stocks and flows can be measured accurately and reliably (Hamburg et al. 1997, Winrock International 1995, IGBP Terrestrial Carbon Working Group 1998). Further, such measurements can be made with a level of effort comparable to measuring carbon savings in many energy-sector projects (Trexler and Associates 1998).

In order for LUCF and energy sector projects to receive credits for reducing GHG emissions, both must demonstrate "additionality," that is, they must demonstrate that their credited emissions reductions would not have occurred in the project's absence. They must also account for and reduce carbon "leakage," the potential displacement of emissions from the project site to another area. This can be a particular challenge for LUCF projects designed to slow deforestation: site-specific activities to protect forests that fail to address the fundamental social, economic, and policy drivers of land-use change run the risk of simply redirecting forest loss elsewhere.

For LUCF projects, these challenges can be substantially met by developing sound standardized guidelines for determining three key project parameters (Brown et al. 1997):

- **baseline**—the land-use changes and carbon fluxes likely to take place in the project's absence
- **duration**—the time period over which project activities must be sustained in order to accrue carbon credits
- **boundaries**—the spatial scale over which a project might influence land-use changes and carbon fluxes

The ability to accurately measure forest carbon baselines and boundaries would be substantially enhanced by helping developing countries strengthen their capacity to monitor national and regional changes in forest cover. A comprehensive program for monitoring land use—using remote sensing, ground measures, and models—would also help these countries assess the conservation status of threatened forests and meet their GHG reporting obligations under the Framework Convention on Climate Change (FCCC). Such a monitoring program could be established by integrating the programs of several current international LUCF research initiatives, with added costs financed through multilateral institutions such as the Global Environment Facility (Skole et al. 1997, UN FCCC 1992).

Industrialized countries should ensure that funding for CDM projects will be in addition to levels already committed for development assistance.

A forthcoming report on land-use change and forests by the Intergovernmental Panel on Climate Change is expected to set the standards for evaluating the technical feasibility of forest-based carbon offset measures.[3] These standards should require precision and accuracy comparable to those for energy-sector projects (MacDicken 1997), without creating prohibitively high transaction costs for investors. One way to reduce transaction costs is, initially, to assess and credit only carbon accumulation in plant biomass. Thus measurements of soil carbon would not be required, since doing so, while technically feasible, can be prohibitively costly. As soil carbon increases with increasing aboveground biomass, unmeasured changes would simply be an uncredited environmental dividend of a project (Trexler and Associates 1998; Lugo and Brown 1992; S. Brown, personal communication).

Standard protocols for verifying project credits and an internationally accepted accreditor of verifiers will also be needed. A useful verification protocol has already been independently developed by one private firm (SGS Forestry 1997). For LUCF projects, potential accreditors include the Secretariat of the FCCC and the Forest Stewardship Council. The latter is an independent accreditor of organizations that certify timber products from well-managed forests.

Encouraging Developing Country Participation

In the Kyoto Protocol negotiations, developing countries rightly insisted that industrialized countries make the first commitments to reduce their GHG emissions. However, all countries will ultimately need to take on emission limitations in order to mitigate serious climate change (Bolin 1998, Austin et al. 1998). The CDM offers an opportunity for developing countries to meaningfully participate in emissions reductions while gaining a new source of financing and technology to support their domestic goals of environmentally sustainable development. Developing countries may also negotiate a share of project carbon credits, and either use them toward their own future binding emissions limits or sell them in order to finance other domestic conservation and development objectives. Bolivia, for example, has negotiated a 49 percent share of the total offset credits from the Noel Kempff Mercado pilot carbon offset project, with the rest going to the investing companies.[4]

Many developing countries, however, may be reluctant to endorse the CDM—and forest-based carbon offsets in particular—if they perceive that industrialized countries will pressure them to participate in specific CDM projects or that CDM project financing will simply substitute for current bilateral and multilateral development assistance (Zollinger and Dower 1996, Ruck and Bals 1998). Industrialized countries should take several steps to address these concerns. First, they should reaffirm the voluntary basis of developing country participation, such that national sovereignty over the selection of prospective CDM investments will be fully respected. They should also help ensure that the CDM's supervisory executive board has equitable North-South representation. And, perhaps most importantly, industrialized countries should confirm that CDM project financial flows will be in addition to committed levels of development assistance.

Realizing the Biodiversity and Other Cobenefits of Forest-Based CDM Investments

LUCF projects that are designed to reduce or offset emissions of greenhouse gases have considerable potential to make either negative or positive contributions to biodiversity conservation and other objectives of environmentally sustainable development. At the negative end, measures potentially supportable through the CDM include draining wetlands and planting permanent monocultures of exotic species in sites where natural or assisted restoration of indigenous forests is feasible.

One method of minimizing the risk of negative environmental impacts is to ensure that the independent third party project review couples verification of carbon credits with certification of environmentally and socially sound practices. For example, the Forest Stewardship Council's certification guidelines for timber production forests (FSC 1996) could be usefully broadened to include the broader range of LUCF measures available to offset carbon emissions. One important challenge will be to identify where CDM project investments should support efforts to promote management for long-term timber production. This could be done by financing, for example, the incremental costs of measures to reduce damage to unharvested trees, lengthen rotation cycles and limit harvest volumes.

Such measures can result in substantial emissions reductions over most current tropical logging practices, but care will need to be taken to ensure that poor practices are not unintentionally rewarded by paying for improvements over a low baseline (Brown 1998). Moreover, efforts to manage tropical forests for sustained timber production may often provide fewer carbon and biodiversity benefits than alternative measures. For example, CDM investments to protect logged forests from both future harvests and land conversion could conserve more carbon on-site and yield greater biodiversity cobenefits than sustained-yield harvesting, provided that timber harvests are not simply displaced to another site (Frumhoff and Losos 1998, Rice et al. in press).[5]

Projects that successfully conserve standing forests can yield substantially higher near-term carbon credits than many alternative LUCF measures, leading some observers to suggest that they will be highly attractive to investors (Brown et al. 1997). If so, prospective CDM investors would be fortuitously attracted to LUCF projects with considerable potential to provide biodiversity as well as climate benefits. But the attractive prospect of gaining higher near-term carbon credits through investments in forest conservation projects could be offset by a number of factors. Among these are potentially higher project transaction costs (e.g., for monitoring necessary to ensure against potential leakage), higher risks of project failure (due to the difficult social and political dynamics common in regions experiencing rapid deforestation), and lower potential for direct financial returns than alternative measures (see box 1 and table 2). Indeed, there is considerable potential for investments in other LUCF measures, such as short-rotation monoculture plantations, that can produce offsets at a net profit to investors (Trexler and Haugen 1994, table 2).

Verification of carbon credits should be linked to certification of environmentally and socially sound practices.

TABLE 2:

Estimated Net Costs of LUCF Carbon Offset Measures

Project	Discount Rate	Net Cost ($US 1997) / ton carbon
Brazil[a]	12%	
Plantation: Pulp		-7.2
Plantation: Charcoal		-0.5
Plantation: Sawlogs		-14.7
Forest Management		Net Carbon Loss
Thailand[b]	10%	
National Parks		1.7 to 3.3
Wildlife Sanctuaries		2.3 to 4.3
Watershed Protection Areas		0.9 to 5.4
Community Woodlot: Eucalyptus		1.0
Semi-Public Plantation: Eucalyptus		-3.8
Private-sector Plantation: Eucalyptus		-13.0
Semi-Public Plantation: Teak		-2.5
Community Plantation: Teak		-18.5
Agroforestry: Eucalyptus/Maize		-1.2
Agroforestry: Eucalyptus/Fruit Trees		-25.6
Tanzania[c]	10%	
Protected Area		1.3
Agroforestry: Eucalyptus/Maize		-1.8
Public Plantation: Eucalyptus		0.1
China[d]	Not Indicated	
Plantation		-12.4 to 1.8
Agroforestry		-13.1 to -1.4
Mexico[e]	10%	
Natural Forest Management: Temperate		-8.3
India[f]	12%	
National Parks		10.4
Natural Regeneration of Degraded Forest (w/ harvesting)		-1.8
Enhanced Regeneration of Degraded Forest (w/ harvesting)		-0.4
Agroforestry		-4.5
Community Woodlot		-0.8
Soft Wood Plantations		-1.6
Timber Plantation		-0.6

Sources: a. Fearnside, 1995; b. Wangwacharajul and Bowonwiwat, 1995; c. Makundi and Ati, 1995; d. Xu, 1995; e. Masera et al., 1995; f. Ravindranath and Somashekhar, 1995. Negative net costs indicate net profits. Studies cited used a wide range of methodologies. Prices adjusted from 1995 to 1997 using an implicit inflator of 1.0409, per the *Economic Report to the President 1998*: Washington, D.C., US Government Printing Office.

BOX 1

What Types of Forest-based CDM Projects Will Be Most Attractive to Investors?

CDM projects that seek to reduce carbon emissions by slowing deforestation and forest degradation could produce substantial biodiversity and other sustainable development cobenefits as well. Moreover, Brown et al. (1997) and Stavins (1995) have suggested that projects designed to conserve natural forests are often highly cost-effective carbon-offset investments and, in particular, are more cost-effective than investments in industrial plantations. Should this generally be the case, policy incentives to motivate investments in projects aimed at slowing deforestation and forest degradation might be unnecessary. However, a consideration of investor incentives suggests that their attraction to these potentially high cobenefit projects may often be tempered by other factors.

Suppose that all potential types of land-use change and forestry (LUCF) projects are included for crediting under the CDM, subject to verification and certification of carbon credits and environmental and social soundness. Suppose further that risks and transaction costs are roughly equivalent across different project types and that carbon credits are awarded as they accrue.[6] Under these conditions, the interest of prospective investors in different types of CDM projects is likely to be affected by two key factors: how quickly they need to offset their emissions liabilities and the prospective costs or profits associated with different project types. Investors with substantial near-term carbon liabilities are likely to invest in projects, such as forest conservation, that provide carbon credits quickly but at a net cost. By contrast, those with relatively modest near-term liabilities are likely to invest in projects, such as managed plantations, that provide carbon credits relatively slowly, but at a net profit.

Consider first the investor whose carbon-emissions liability is, at least initially, relatively modest, or who can afford to accrue credits over a period of several years. Investors in this category include those that are currently implementing plans to offset future carbon emissions in advance of anticipated deadlines for carbon-emission reduction. (The total size of this investor pool will also depend on how quickly the Protocol is ratified and enters into force—the more quickly, the longer that investors have until the 2008–2012 period by which emissions reductions must be achieved.) This type of investor has the option to choose the project—or portfolio of projects—that will not only yield carbon credits but provide a positive financial return.[7]

From a strictly financial perspective, both managed plantations and agroforests in developing countries can be attractive investments. Properly planned and implemented, they often can more than offset the costs of land acquisition, tree planting, and management, as well as produce positive revenues (e.g. Kanowski et al. 1992, table 2). Indeed, financial attractiveness may be one factor fueling the rapid growth of plantations in many developing countries. Between 1980 and 1995, the area dedicated to plantations in Latin America, Africa, and Asia more than doubled, from 40 to over 80 million hectares. During the same period, more than 200 million hectares of natural forests were converted to agricultural land (including, in some cases, plantations) and pasture (FAO 1997).

In contrast, measures to conserve natural forests in developing countries are rarely profitable, despite substantial efforts by donor agencies and conservation organizations to develop nondestructive revenue-generating activities such as ecotourism and the harvest of nontimber forest products (Kramer and Sharma 1997, BCN 1997). Conservation measures will therefore tend to be relatively unattractive investments with respect to expected financial returns (table 2). This is also true of measures to protect carbon stores by reducing the destructive impact of logging in tropical production forests. Boscolo et al. (1997), for example, estimate that damage to unharvested trees at a project site in Sabah, Malaysia, can be reduced from 40 to 15 percent at a cost of $150/ha and $5 ton C. While this may be financially more attractive than many energy-sector measures to reduce carbon emissions in industrialized countries, it does not stack up well against profitable plantations (table 2).

Managed plantations have some apparent drawbacks as CDM carbon offset investments, however. The total amount of carbon that accumulates per hectare in plantation biomass is typically far less than that in the biomass of natural forests (Schroeder 1992, Putz and Pinard 1993). Moreover, it may prove difficult to accurately track and credit any additional carbon benefits that might be gained off site through harvested wood or cardboard and paper products (e.g., Blum et al. 1998; Mikales and Skog 1997, Marland et al. 1997). However, concerns over the per-hectare carbon sequestration potential of plantations should often be mitigated by the fact that if the investor has chosen properly, a profitable return should be expected from each investment, making the cost of carbon sequestration negative. If land availability is not a limiting factor, investors should be able to increase the number or size of profitable investments until their carbon-reduction goals are met. The Toyota Motor Corporation, for example, has recently announced that it will establish up to 5,000 hectares of eucalyptus plantations in Australia as a carbon offset. These plantations are projected to generate more than $100 million per year by producing woodchips for paper manufacturing.

The most important constraint on the relative attractiveness of plantations to prospective CDM investors is that the carbon credits for plantation projects will often be delayed relative to most other LUCF and energy-sector measures. Plantations contain negligible amounts of biomass at the outset, and accumulate carbon relatively slowly over the course of a harvest rotation (Schroeder 1992). This constraint is likely to make plantations relatively unattractive options to investors that need immediate carbon credit to offset large volumes of emissions in the short run. Investors in this category are likely to include power utilities that find it costly to quickly modify existing power-generating technologies, and therefore will seek to buy time for the turnover of capital stock. (Rapid change in energy technology, such as conversion of utilities from coal to natural gas fuels, can entail substantial costs due to investments in existing infrastructure.)

These investors may be quite willing to forego potential profits in return for near-term carbon credits, seeking CDM measures that enable them to do so at a lower cost than through domestic measures or emissions trading. Projects that successfully protect forests under imminent threat should often fit this bill, as they can reduce emissions more quickly than plantations and many other prospective CDM investments (Trexler and Associates 1998).

It is impossible to accurately predict what proportion of prospective CDM investors will need to quickly offset carbon liabilities and what proportion will be able to avail themselves of more profitable alternatives. However, even investors with a need to offset emissions quickly may shy away from projects designed to slow forest loss and degradation in regions of relatively high risk of project failure and limited institutional capacity. Unfortunately, the need for sound investments in conservation and sustainable development are often greatest in these regions, many of which contain highly threatened forests with globally and regionally significant biological value (Olson and Dinerstein 1998). Well-constructed policy incentives may thus be necessary to encourage sound CDM investments in conserving and restoring forests in high-risk, high co-benefit sites (see main text and box 2).

Intensively managed plantations can help stabilize soils and provide a source for biomass fuels and other wood products. If developed on the basis of environmentally sound guidelines, they may be an effective part of the mix of LUCF carbon-offsetmeasures. But there is little evidence that industrial plantations provide significant habitat for native species or substantially reduce pressure on natural forests (Johns 1997). Therefore, key policy incentives may be needed to motivate investments through the CDM in projects that do provide significant forest and biodiversity cobenefits. Potential strategies include

- ***Reducing investor risk.*** Risks of losses due to individual project failure might be reduced for investors through the creation of share-based carbon offset "mutual funds", diversified portfolios of LUCF and energy-sector CDM projects. These could eliminate the risk exposure of relying on the success of a single project (Brown et al. 1997). Investor purchases of carbon-offset credits can be further supplemented by an insurance mechanism to replace credits lost due to project failure, an initiative Costa Rica has developed on a national scale (Global Environmental Change Report 1997). For forest conservation projects, the risk of individual project failure could be further lessened by locating projects in sites that are a few years removed from current deforestation fronts, and by combining site-specific activities with measures to strengthen national or regional land-use policies (Fearnside 1997).

- ***Reducing investor costs through cofinancing high cobenefit, high risk projects.*** The Global Environment Facility and other donors could help finance the basic infrastructure necessary for countries to attract projects in regions of high conservation value, for example, through strengthening national capacity to monitor changes in forest cover. Local governments and conservation NGOs might also be willing to leverage CDM investments that pay the incremental costs of protecting or restoring watersheds and other valued ecosystem services. For instance, the $5 million cost of restoring the 4830 hectare watershed for the city of Ilheus in Brazil's biologically rich Coastal Atlantic Forest could be divided among the municipality, concerned NGOs, and a private investor seeking carbon offset credits (box 2).

- ***Strengthening linkages between the Climate and Biodiversity Conventions***. Since their common emergence in the 1992 Earth Summit, the FCCC and the Convention on Biological Diversity have developed along largely separate tracks and without reference to one another. However, recent meetings of both Conventions produced decisions aimed at encouraging improved coordination with the other.[8] For the FCCC, the outcomes of this process should include commitments to avoid climate mitigation activities that reduce biodiversity and to facilitate financing and crediting for CDM projects that meet objectives of both Conventions. These objectives would be furthered by the creation of a body, modeled on the IPCC, to provide sound scientific guidance to the policies of the Biodiversity Convention.

> ***Many CDM investors may be more attracted to industrial plantations than to forest conservation projects.***

As a means of mitigating global climate change, forest-based carbon offsets through the CDM can only modestly complement a primary emphasis on reducing fossil-fuel emissions. Properly designed and implemented, however, that complement can also serve as a powerful tool for helping developing countries finance ecologically and socially sustainable alternatives to destructive forest land-use practices. If designed on the basis of sound technical guidelines, supported by strong national and regional land-use policies, and pursued on the basis of mutual benefit and voluntary cooperation between industrialized and developing countries, CDM projects can contribute substantially to the conservation and restoration of tropical forests and their biological diversity.

BOX 2

Leveraging Investments in CDM Projects with Substantial Cobenefits

Many forest conservation projects protect biological diversity, soil resources, watershed integrity. They can also provide sources of local income, for example, when forests are managed for nontimber forest products or tourism. The following example demonstrates how environmental and sustainable development cobenefits can be used to leverage financing for CDM forest conservation projects.

Brazil's Atlantic Forest is one of the most endangered and biologically important ecosystems on the planet (Olson and Dinerstein 1998). The forest in this region is under intense pressure for conversion to agriculture and pasture. The local population is suffering from the stress of failing cocoa markets—the backbone of the regional economy. On the surface, the area exhibits the typical forces that promote deforestation. Closer examination reveals that it is ideal for applying conservation measures that provide multiple environmental and societal benefits.

The city of Ilheus, with a population of 223,500 is located in the heart of this region. It relies on proper watershed management to protect its drinking water and fishery from contamination by agricultural pesticides. Restoring forest cover to 4,830 hectares would both protect this watershed and provide critical habitat for the endemic golden-headed lion tamarin (*Leontopithecus chrysomelas*), a highly endangered primate. Moreover, the cost of reforestation—approximately US$5 million dollars—is far less than the tens of millions of dollars in water-treatment measures that may be required in the absence of improved watershed protection (Hardner, 1996). However, even with clear environmental and societal benefits and relatively modest costs, the proper financing and organization to reforest and protect this watershed is lacking.

This is an ideal opportunity for a forest-based CDM project. With the participation of three stakeholder groups—the municipality of Ilheus, involved conservation groups, and the investor seeking a carbon offset—the financial burden would be eased: a US$5 million project could be divided among three entities. In doing so, a healthy water supply would be maintained, critical habitat for biodiversity protected, and atmospheric carbon sequestered.

Distinguishing similar opportunities requires two types of analyses. First, social benefit/cost analyses can monetize the cobenefits to local society of forest conservation and restoration projects. Second, assessments of biodiversity impact/priority of conservation projects can guide international donor cofinancing. Further development of work in this area promises to reveal a variety of options for facilitating conservation programs through forest-based CDM investments.

NOTES

1. LUCF measures within and between these categories are often difficult to separate in practice, and projects may typically include several of them. For example, forests under imminent threat of land conversion are often already substantially degraded by logging and other human impacts. An effective project to protect such a forest would both reduce emissions directly and promote sequestration as the forest recovers biomass. Similarly, a project designed to substitute biomass for fossil fuels (reducing emissions directly) may often entail expanding the scale of managed plantations (sequestering carbon). And even monocultures of commercial plantation species can be used to jump-start the process of restoring natural forests (e.g., Parrotta et al. 1997ab, Lugo 1997, Keenan et al. 1997).

2. Precise estimates of future financial flows into the CDM are impossible, due to the dynamic nature of the market and of the political forces that will affect those flows. Estimates must consider several factors. The first is the cost-effectiveness of CDM projects relative to alternative investments in carbon emissions reduction. The CDM has been created on the assumption that the cost of emissions reduction will often be lower in developing countries than in industrialized countries. This is reasonable, since energy infrastructure and efficiency are generally less developed in developing countries, and the costs of land and labor are lower.

   A second, closely related factor is the *substitution price* of comparably priced carbon reductions at home. For those with profitable, or low-cost opportunities to reduce emissions domestically—for example through improvements in energy efficiency—the marginal costs of reducing emissions through the CDM may be higher than those of making domestic reductions. For others, CDM investments should be financially attractive means of reducing emissions. However, their attractiveness is likely to diminish over time as the marginal costs of emissions reductions in developing countries rise after the least expensive CDM opportunities are seized. Moreover, the substitution price for domestic reductions should decrease as carbon emissions costs are internalized into the pricing system in industrialized countries, spurring innovation and cost savings for adoption of new energy technologies (DeCanio 1993; Interlaboratory Working Group 1997).

   Third, carbon offset investments in developing countries are currently subject to *transaction costs* as high as 30 percent (World Bank 1997), costs that may change substantially as the rules and markets for CDM offsets develop. For example, the development of carbon offset investment funds that broker CDM investments might substantially reduce transaction costs (e.g., Brown et al. 1997, World Bank 1997). A carbon-offset fund would probably charge a uniform price per unit carbon offset through the CDM and use existing international project investment infrastructure to minimize costs. However, transaction costs might also be affected, either positively or negatively, by the development and implementation of standardized guidelines for measuring, monitoring, and verifying carbon stocks and flows in CDM projects.

   Fourth, there is the *risk of project failure* due to project-level factors (such as fire or disease in many LUCF projects) or national-level issues associated with developing economies such as inadequate infrastructure, improper enforcement of agreements and regulations, or political and economic instability. Indeed, perceived risk, coupled within weak institutional capacity to identify and attract projects, may initially limit the participation of many developing countries in the CDM unless donors provide support for the basic infrastructure necessary to attract project investments (see main text). A carbon offset investment fund could serve to dilute risk through diversification across many projects in different countries. But investment portfolios containing high-risk investments are still likely to be avoided if alternative investments with comparable financial and carbon offset benefits at lower risk are otherwise available.

   One interesting attempt to quantify the prospective financial flows through the CDM into developing countries uses a computable general equilibrium model that estimates the volume of carbon trade between nations under varying carbon-mitigation agreements (van der Mensbrugghe, 1998). Considering only energy sector investments, assuming that all countries participate, and starting in 2000, the model projects that the equilibrium cost of carbon credits will be approximately $10/ton in 2000, $27/ton in 2005, and $44/ton in 2010, in 1997 dollars. Under this scenario, developing countries would receive all industrialized country investments in carbon emissions mitigation that exceed these costs. According to van der Mensbrugghe's (1998) analyses, this could produce more than $20 billion per year in CDM investments by 2010.

3. The IPCC Special Report on Land-Use, Land-Use Change and Forestry, and Carbon Emissions is scheduled for completion in mid-2000.

4. Margo Burnham, personal communication. The details of the offset sharing arrangement are described in Article 8.4 of the Comprehensive Agreement for the Noel Kempff Mercado Climate Action Project, signed 9 March 1998.

5. The Noel Kempff Mercado Project in Bolivia is an example of a carbon offset investment financing the protection of a former timber production forest. The relative carbon benefits of measures to promote long-term

timber production would be increased by accurate measurement and crediting of carbon stored offsite in durable wood products**.**

6. Some researchers have argued that carbon emissions reduced or offset in the future are not equivalent to those reduced or offset today, and therefore deserve to be discounted. Analyses incorporating a discount rate show, for example, a reduced cost-effectiveness of plantations and forest restoration, where much of the carbon is not sequestered for several decades into the future, relative to forest protection and many energy-sector projects (e.g., Fearnside 1995, Stavins 1995, Trexler and Associates 1998). However, including such a carbon discount rate in the guidelines for emissions crediting under the Kyoto Protocol would be inappropriate. Currently, the shape of the climate change damage function is not understood; that is, scientists do not yet know the specific relationship between changes in atmospheric concentrations of greenhouse gases, climate change, and consequent harm to the biosphere (Trexler and Associates 1998). Thus there is no basis for determining whether, and to what extent, differences exist in the marginal impact of carbon emissions reduced or offset one year, five years, or twenty years from now. For simplicity, a discount rate to carbon crediting should not be designated until such differences can be estimated with reasonable accuracy.

7. As with profitable energy sector projects, profitable plantations may face the challenge of passing a strict test of "additionality" under the Kyoto Protocol—that their emissions reductions would not be achieved, but for the presence of the CDM investment. Reductions might be considered additional, for example, if start-up costs are prohibitively high in the absence of new financing through the CDM. But reductions gained through activities that would have been carried out in the absence of CDM investments should not be credited, and sound guidelines for tests of additionality under the CDM will need to be established.

8. At the May 1998 4th Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in Bratislava, Slovakia, delegates requested the Executive Secretary to "liase and cooperate" with the Secretariat of the Framework Convention on Climate Change (FCCC) in order to ensure that forest-based measures to mitigate climate change also help achieve the objectives of the CBD. The COP also requested the Executive Secretary to "strengthen relationships" with the FCCC and the Kyoto Protocol "with a view to making implementation activities and institutional arrangements mutually supportive" (http://www.biodiv.org/cop4/FinalRep-/finrep.html). At the FCCC's June 1998 negotiations in Bonn, Germany, the Convention's Secretariat was similarly requested by its Subsidiary Body for Scientific and Technological Advice (SBSTA) to liase with the Secretariat of the CBD and other international bodies such as the Food and Agricultural Organization. The SBSTA also requested the IPCC in its forthcoming special report on LUCF carbon sequestration measures to examine the implications of LUCF strategies for biodiversity and other environmental and socio-economic effects. (http://www.unfccc.de/fccc/ docs/sbsta.htm#9).

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