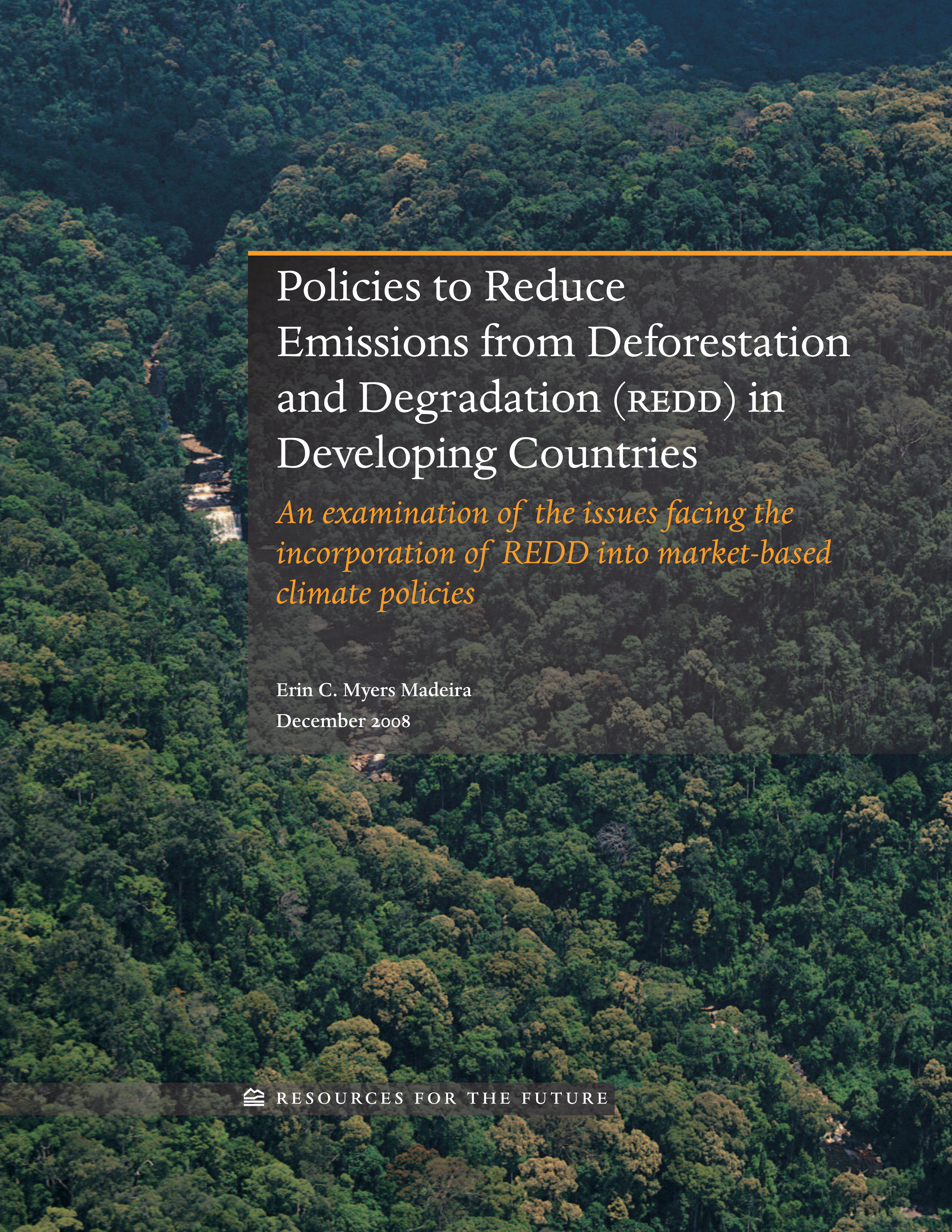


Policies to Reduce Emissions from Deforestation and Degradation (REDD) in Developing Countries

An examination of the issues facing the incorporation of REDD into market-based climate policies

Erin C. Myers Madeira

December 2008

RESOURCES FOR THE FUTURE

Policies to Reduce Emissions from Deforestation and Degradation (REDD) in Developing Countries

An examination of the issues facing the incorporation of REDD into market-based climate policies

Erin C. Myers Madeira

December 2008

Resources for the Future
1616 P Street, NW
Washington, DC 20036–1400

Telephone: 202-328-5000
www.rff.org

Editors:
Adrienne Foerster, RFF Assistant Editor
Sally Atwater

Design and production: Meadows Design Office Inc.,
Washington, DC, www.mdomedia.com

Printed in the United States of America

CONTENTS

ACKNOWLEDGMENTS

A number of colleagues provided invaluable support, feedback, and suggestions throughout the creation of this report, and I deeply appreciate the generosity with which they shared their time and experience. I would especially like to thank Ray Kopp and Billy Pizer who fostered my research on forest carbon, and without whom this report would not exist.

■ ■ ■

The Climate Policy Program at Resources for the Future (RFF) provides a framework for policymakers and stakeholders to better understand and address one of the most complex environmental issues of our time: climate change. The program has two core objectives: to develop domestic policies that are politically and economically viable and to articulate a new architecture for a global climate policy regime. Program scholars work to both support current policy efforts as well as fostering the evolution of these policies over time.

Forest Carbon is one four initiatives of the Climate Program. Its objective is to speed the development of large-scale global markets for forest carbon by conducting world-class, interdisciplinary research that helps create strong policy frameworks and accelerates private action, primarily through direct outreach to U.S. and international decisionmakers.

The Climate Policy Program at RFF is funded by contributions from foundations, governments, corporations, and individuals. Current supporters include: the Doris Duke Charitable Foundation, Smith Richardson Foundation, David and Lucile Packard Foundation, Simons Foundation, Foundation for Strategic Environmental Research (MISTRA), G. Unger Vetlesen Foundation, Alcoa Foundation, U.S. Environmental Protection Agency, Center for Environmental Markets at Goldman, Sachs & Co., American Honda Motor Company, Inc., Cargill, Inc., Duke Energy, Salt River Project, ExxonMobil Corporation, Honeywell International, Inc., Novelis, Inc., and Pacificorp.

For more information, contact Ray Kopp, senior fellow and director of the Climate Policy Program, at kopp@rff.org

Land-use changes account for approximately 20 percent of today's total greenhouse gas (GHG) emissions, more than the total transportation sector worldwide. Most of these emissions come from deforestation in developing countries where forests are being cleared for agriculture and timber. Currently, climate change policymakers are considering how to create incentives for reducing emissions from deforestation and forest degradation in developing countries, or REDD. This report examines the issues facing the incorporation of REDD activities into mainstream market-based climate policies, paying particular attention to REDD-generated carbon credits that could be traded in the regulatory market.

Forests and the Carbon Cycle

Forests play an integral role in mitigating climate change. Not only are forests one of the most important carbon sinks, storing more carbon than the world's oil reserves, they also constantly remove carbon from the atmosphere through photosynthesis, which converts atmospheric carbon to organic matter. However, while forests are absorbing atmospheric carbon, deforestation is putting carbon right back into the atmosphere at an annual rate of 5.9 Gt CO_2. In other words, 60 percent of all of the carbon that is absorbed by forests is emitted back into the atmosphere by deforestation.

Analyses examining the cost of REDD activities predict that abating deforestation is a low-cost means to achieve emissions reductions. Although the studies vary in their methods and assumptions, most analyses support the idea that substantial carbon benefits can be realized through REDD activities at low initial carbon prices, \$3/tCO_2 or less. In its conservative calculations, the Intergovernmental Panel on Climate Change (IPCC) estimates that 25 percent of deforestation emissions can be abated for less than \$20/tCO_2. For comparison, in the first quarter of 2008, carbon was trading at \$35/tCO2 in the European Union Emissions Trading Scheme (EU ETS).

Given the magnitude of deforestation emissions and predicted low cost to abate, there is general agreement that REDD activities are a cost-effective way of reducing greenhouse gas emissions, and thus emissions from deforestation should be addressed immediately (Nabuurs et al. 2007). In addition to the carbon benefits of REDD activities, abating deforestation can have significant sustainable development and environmental co-benefits, including biodiversity conservation, watershed protection, protection of fisheries, sustained income for local communities, and reduction of runoff, siltation, and flooding (Nabuurs et al. 2007).

Deforestation and International Climate Policies

Even though the United Nations Framework Convention on Climate Change (UNFCCC) specifically notes the important role that forests play in the carbon cycle, policy mechanisms to incentivize forest carbon activities have been limited. In 1997, the Kyoto Protocol laid out target emissions reductions and different mechanisms by which countries could achieve those targets. One option is offsets: an Annex I (industrialized) country (or a firm in that country) can pay another country (or firm) to reduce emissions and thus offset its own emissions. The Kyoto Protocol established the rules and financing structures for different types of offset mechanisms. At that time, the parties to the agreement excluded REDD activities from the offset mechanisms because of uncertainties about the magnitude of deforestation emissions and the ability to monitor deforestation.

As a result, REDD activities cannot be used by countries seeking to meet their obligations under the Kyoto Protocol, and REDD credits have been limited to the voluntary market, where only a handful of projects are generating credits. These credits are sold at a fraction of the regulatory market price to buyers seeking to reduce carbon emissions for reasons other than compliance with their Kyoto obligations; some companies, for example, may perceive market advantages in reducing their carbon footprints and improving their environmental image.

The outlook for REDD changed at the 2005 Conference of the Parties in Montreal. Costa Rica and Papua New Guinea, on behalf of the Coalition for Rainforest Nations, proposed to give developing countries access to the carbon market through credits generated from REDD activities. This proposal refocused attention on forest carbon and catalyzed the current debate about how best to achieve sustainable, environmentally robust emissions reductions through forestry.

In December 2009, the parties will meet in Copenhagen to negotiate new target emissions levels. Further, the parties will decide the mechanisms by which countries can meet those targets, including whether REDD will be encouraged through market-based incentives or accomplished through a fund. This report focuses on the policy design issues that must be resolved if credits from REDD activities will be incentivized by market-based climate policies, such as the incorporation of REDD credits into the regulatory market.

Policy Design Issues

Any REDD policy must ensure that emissions reductions are real, measurable, and verifiable, and any market-based mechanisms must ensure the integrity of both the emissions reduction and the carbon market. Issues discussed in this section are scope, monitoring, baselines, leakage, stakeholder interests, permanence, and the potential effect of REDD credits on the carbon market.

Scope

Broadly speaking, all REDD activities can be categorized as *projects, policies, or sector activities.*

- REDD projects would generate credits based on maintaining carbon stocks in a localized area. Many current REDD projects focus on forest conservation that creates reserves and parks to protect threatened forests. These place-based REDD projects preserve the carbon stocks on land that otherwise would be deforested.

- REDD policies would generate credits by reforming land-use policies to reduce deforestation. Agricultural subsidies, for example, often create incentives to deforest, and transportation networks provide access to clear forests and remove timber. Policy-based REDD activities would reform these policies so that they would discourage deforestation.
- Sector activities would generate credits by reducing net deforestation rates over an entire country. A country or province could commit to a target emissions cap in the forestry sector. For some developing countries, pursuing emissions targets in the forestry sector might be the most appealing and powerful way to participate in the global effort to mitigate climate change.

An international REDD policy does not necessarily have to limit itself to a single type of activity but could allow all three REDD activities, acknowledging that countries differ in the pressures on their forests and their abilities to manage and monitor the resource.

Related is the question of whether a REDD policy would be built around national commitments or project-based activities. National commitments appear better suited to reaching the goal of reducing carbon emissions, but because countries differ in their ability to implement REDD activities, a purely national system might discourage participation by subnational entities that are able and willing to participate. Hybrid approaches that allow subnational participation can be designed to be inclusive, accommodating the differences among countries while also addressing the magnitude of the problem.

Forests are complex ecosystems that simultaneously sequester, store, and emit carbon. An umbrella forest carbon policy that included REDD activities, forest conservation activities, and afforestation and reforestation (AR) activities would account for all of the carbon fluxes of forest ecosystems. However, it is complicated and time consuming to design a policy for just one of these functions. Although ecosystem-based management is ideal, the realities of crafting environmental policies might impede the creation of ecosystem-based policies.

Monitoring

In recent years, the international climate change community has grown increasingly confident about measuring deforestation and its associated emissions. A decade ago, concerns over the ability to monitor tropical deforestation and degradation drove some of the original reluctance to consider REDD as a measurable means of CO_2 mitigation. Now, many experts agree that the technology and methods exist to measure deforestation adequately, predominantly through remote sensing (DeFries et al. 2005; DeFries et al. 2006; UNFCCC 2006; Mollicone et al. 2007).

Measuring emissions from deforestation involves three steps:

- First, a forest inventory assesses the state and extent of a forest.
- Second, a monitoring program measures changes in that forest, ideally using a combination of remote sensing and on-the-ground field sampling. The complexity of the monitoring program depends on whether the program is measuring just deforestation or includes levels of forest degradation.
- Third, data on changes in forest cover are translated into data on forest carbon. Information on changes in forest cover is not useful unless the carbon content of that forest is also known. This can be achieved through extensive field sampling or, less accurate but more cost-effective, look-

up tables that estimate the carbon content for different types of forests (Houghton 2003a; Achard et al. 2004; FAO 2006; Mollicone et al. 2007).

Although the methodologies for conducting forest inventories are established, not all countries have reliable forest inventories (Step 1), and thus forest carbon inventories and forestry emissions cannot be calculated.

Baselines

Baselines are the yardstick by which countries measure whether they have reduced deforestation. A REDD program must exhibit quantitative reductions of deforestation rates below baseline scenarios. Although historical deforestation rates can be established based on existing remote sensing imagery, because of heterogeneity in countries' recent patterns of deforestation and in the availability of forest carbon inventories, finding a single baseline methodology appropriate for all would-be participants is difficult. Many regions and countries argue that historical rates don't indicate the current risk of deforestation. For example, some countries experiencing political instability have a low rate of deforestation because domestic turmoil suppresses access to forests and markets. They predict that deforestation pressure will increase if the domestic situation stabilizes, and thus the historical baseline underestimates the real pressure. Countries that have already taken action to prevent deforestation argue that they should be incentivized to keep their deforestation rates low.

Most of the proposed baselines are thresholds, meaning that deforestation is said to have decreased if it drops below a specific rate, or increased if it goes above. Some argue that this can be too rigid. Schlamadinger et al. (2005) suggest a target band, or range, that captures a country's most likely emissions levels. Within this band, countries would generate discounted credits. The discount rate applied to the credit would change with proximity to the target bounds. Below the lower bound, countries could generate full-value credits for incremental emissions reductions. The liberally set upper bound would lessen the risk of "runaway" noncompliance because a country would increasingly benefit from incremental decreases in emissions.

Mollicone et al. (2007) propose a global baseline against which national baselines could be compared to create incentives for both (a) countries with high deforestation rates to reduce their rates of forest conversion and (b) countries with low deforestation rates to maintain them. For countries in category (a), credits are generated based on decreases in national rates of deforestation; for countries in category (b), credits are based on the difference between the global reference rate and the national rate.

Leakage

Leakage is a risk for any GHG-mitigating project, whether in the energy sector or in the forestry sector. In the context of REDD, leakage means that preventing deforestation in one place might actually encourage deforestation somewhere else. The agents of deforestation, for example, might shift their equipment and labor to a nearby patch of unprotected forest. Or REDD activities could create market leakage by forcing up the market prices of timber, livestock, and crops, making deforestation somewhere else more profitable. Unless all global forests are included in a REDD policy, leakage cannot be eliminated; however, it can be minimized through careful project design. Further, leakage can be accounted for by requiring that a percentage of a project's REDD credits be held in reserve and not be sold. In this manner, the reserve account would offset or neutralize the leakage that was assumed to have taken place.

Stakeholder Interests

Design elements such as fungibility, liability, and permanence can either encourage or discourage market participation by potential suppliers, buyers, and project developers. Host country suppliers are concerned about maintaining sovereignty over land-use decisions, achieving sustainable development and other co-benefits, financing the initial capacity building needed to implement REDD activities, and equitably distributing benefits among stakeholders. Buyers—investment banks, firms subject to emissions caps, or Annex I countries—are concerned about risks, costs, and credit fungibility. Project developers and those who invest in projects are generally interested in the ease of doing business in the host country, established legal rights for carbon, and the ability to secure financing before the project begins generating credits.

Society as a whole is interested in environmental integrity. Ex post, third-party-verified REDD carbon credits ensure that the environmental integrity of the system is maintained. Front-end design standards may also contribute to the delivery of high-quality credits.

Permanence and Liability

Whether reduced emissions from deforestation can be considered permanent is part of the current debate about REDD. Concerns over permanence are rooted in the idea that emissions reductions are potentially reversible because of forests' vulnerability to fires, pest outbreaks, changes in management, and other natural and anthropogenic disturbances. The concern is that the gain from lower emissions in one year might be undone by exceptionally high emissions—rates higher than they would have been in the business-as-usual (BAU) baseline scenario—in a later year.

In response to concerns over permanence, three types of accounting mechanisms have been proposed to manage risks of impermanence in REDD credits.

1. *Buffers* and *reserve accounts* are arrangements in which a percentage of the credits that could be generated are held in reserve to counter the risk that deforestation will increase in the future. For example, if ex post verification determined that deforestation rates below the baseline had averted the emission of 100 tons of carbon, 70 permanent credits could be traded on the carbon market, and 30 would be deposited in the reserve account. The percentage of REDD credits to be deposited into the reserve account or buffer would be determined by the risk of the project and the number of years since the project's initiation. Reserve accounts have been employed by the Voluntary Carbon Standard (VCS) to manage risks of impermanence.

2. The *ton-year approach* is based on the premise that 1 ton of carbon released into the atmosphere decays over time until it is absorbed into the ocean or biosphere. The turnover time of carbon in the atmosphere essentially becomes the defining factor in determining "permanence." This is the equivalency factor that relates a ton-year to a permanent reduction. For example, if an emissions reduction of 1 ton must persist for 100 years to be permanent, a 1-ton emissions reduction

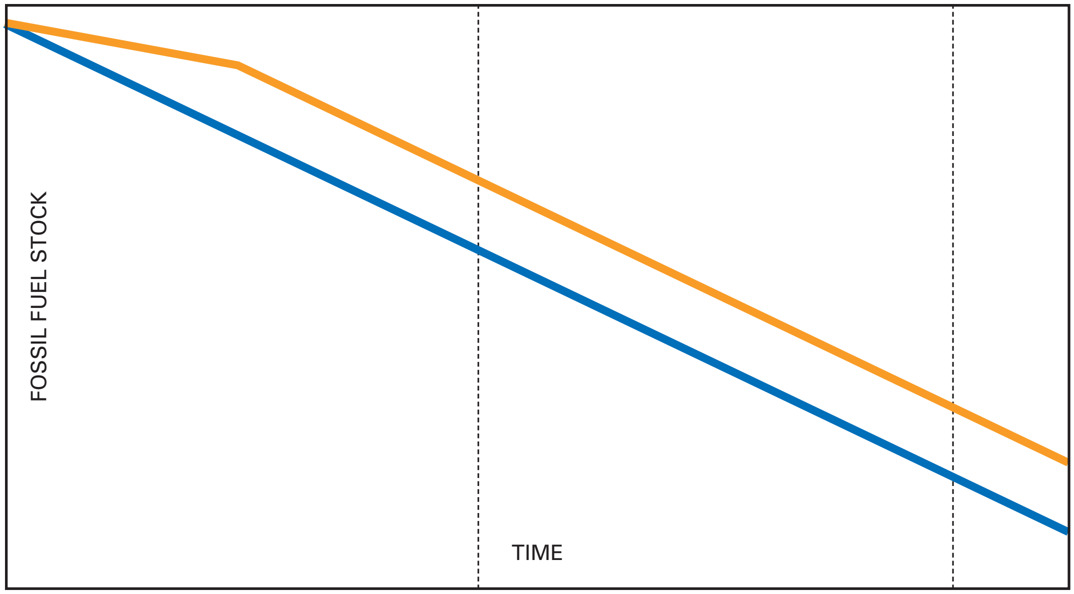


Figure i.
Effect of Light Bulb Use on Fossil Fuel Stocks

A: Baseline Stock (continued use of incandescent bulb)

B: Stock with one-time use of compact fluorescent

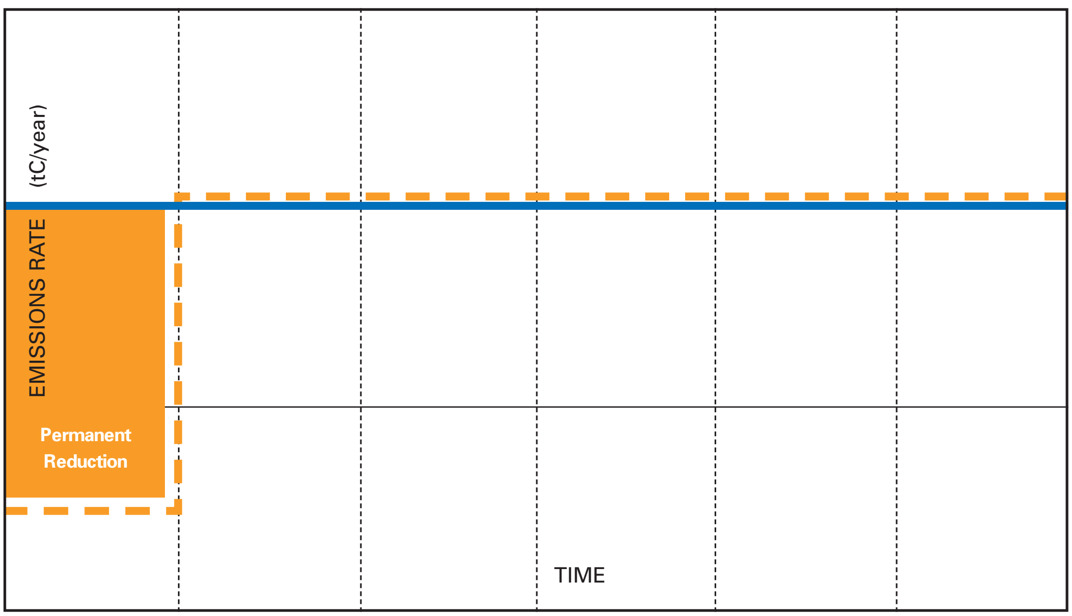


Figure ii.
Effect of Light Bulb Use on Emissions Rates

A: Baseline Emissions Rate

B: Emissions Rate with one-time reduction

Notes:

Series A in Figure i represents the time path to consumption of a fossil fuel stock using traditional incandescent bulbs, which results in a baseline emissions rate, shown in Figure i.

Series B illustrates a temporary reduction in emissions rates caused by the one-time use of compact fluorescent bulbs, followed by replacement with incandescent bulbs and a return to the original emissions rates. Even though the reduction in emissions rate is temporary, the savings experienced in the initial year are carried through to the end of the time period, and the atmosphere has less carbon in every time step than it would without the reduction in the initial time period. Thus, there is a permanent increase in the fossil fuel stocks in every time step and a permanent decrease in the carbon in the atmosphere.

for a 1-year duration would be worth 1/100th of a permanent ton. The ton-year approach has been criticized because emissions reductions from forestry would carry such a low value. For example, in the above scenario, forestry emissions would have to be reduced by 100 tons to generate just one full-value credit. This would increase the cost of REDD activities by 100.

3. REDD credits could follow the model of the clean development mechanism (CDM), in which credits generated by AR activities are temporary certified emissions reductions (tCERs). Forestry tCERs are valid for one five-year interval, after which they expire; new tCERs are issued upon reverification. The buyer would be responsible for finding a new source of emissions reductions upon the expiration of the tCERs. Essentially, the buyer has two options: purchase new tCERs that will expire in five years, or purchase permanent credits.

If carbon prices rise at the discount rate, temporary credits will have no value ($0). In this case, a buyer would always choose to purchase a permanent credit instead of a tCER, and there would be no demand for REDD tCERs at any price.

In the debate over permanence, the underlying question is whether lower emissions rates in one year are likely to lead to permanently lower levels of carbon in the atmosphere. Permanence here does not mean that a specific atom of carbon will remain in a forest or oil reserve forever. According to IPCC's Special Report on Land Use, Land-Use Change and Forestry, "To the extent that the emission displacement propagates forward until the end of the time horizon, the result is a 'permanent' savings" (Watson et al. 2000, 2.3.6.2). See Figures i and ii, which use the example of replacing a traditional incandescent bulb with a compact fluorescent just once, and then returning to an incandescent bulb.

All emissions reductions carry some risk of impermanence. For large-scale activities and national or subnational programs, the impermanence risks of REDD are not inherently different from those of avoided fossil fuel emissions, since there will likely be a portfolio of REDD activities simultaneously underway. Even if one activity failed, it is improbable that all the REDD activities would fail simultaneously and cause a spike in deforestation above the baseline. More likely, an unexpectedly high rate of deforestation in one area would be offset by successful REDD activities in another, resulting in net decreases in deforestation emissions. To create a spike in emissions and undo a previous period of low deforestation, routine events occurring under the baseline—burning, forest conversion—would have to occur at rates higher than the baseline rate, and it is not apparent why these rates would spike above the baseline rates.

Further, in large-scale REDD activities and national programs, reducing deforestation will require investments in new governance institutions and forestry management systems, just as reducing fossil fuel emissions requires capital investments in new technologies and information distribution. Once these processes are in place, there may be some institutional lock-in or institutional inertia that would also maintain deforestation rates consistently below their baseline and lessen the probability of future spikes in deforestation. As a result, risks of impermanence in large-scale REDD programs may be overstated.

Effect on the Carbon Market

REDD credits will probably decrease the overall cost of achieving emissions targets, offering large quantities of relatively low-cost credits. Although this is generally a good thing, in the absence of more aggressive emissions targets, REDD credits may also delay the development and implementation of low-carbon technologies in the energy sector. The displacement of low-carbon technologies could be ameliorated by tighter emissions targets, limits on the quantity of REDD credits allowed in the market, and/or price floors. The potential effect of REDD credits predicted by models will be dampened by delays in host countries' readiness to implement REDD projects.

Host Country Issues

Although the integrity of REDD credit schemes depends on their design (the main focus of this report), ultimately their success in achieving global emissions targets depends on host-countries' on-the-ground ability to implement the REDD activities. Readiness varies tremendously from country to country and province to province. For this reason, it is imperative that attention to host countries' capacity parallel efforts on the international design issues. A handful of new initiatives, including the World Bank's Forest Carbon Partnership Facility and the Brazilian Amazon Fund, have been launched to improve readiness among key developing countries.

Further, communities in forested regions in developing countries are some of the most important stakeholders because REDD policies will affect their livelihoods, and these stakeholders will likely be directly involved in the implementation and maintenance of REDD activities. Without their participation, achievement of the environmental and sustainable development goals targeted by REDD activities will be impossible. Efforts to link forest communities with REDD negotiations and planning at the international level will improve the chances for success.

The challenges facing the incorporation of REDD into mainstream climate change policies are not trivial. However, the potential rewards from getting it right stretch beyond the emissions reductions themselves and include the sustainable development of forest-dependent communities and the conservation of some of the world's richest forest ecosystems. This report explores issues that must be systematically addressed if an economically and environmentally sound REDD crediting scheme is to be developed.

CHAPTER 1

Introduction

Annually, land-use changes account for approximately 20 percent of total greenhouse gas (GHG) emissions, more than the total transportation sector worldwide. Most of these emissions come from deforestation in developing countries where forests are being cleared for agriculture and timber. Currently, climate change policymakers are considering how to create incentives for reducing emissions from deforestation and forest degradation, or REDD.

In this report, I examine the specific issues facing the incorporation of REDD activities into mainstream market-based climate policies, paying particular attention to REDD-generated carbon credits that could be traded in the regulatory market. I focus mainly on credit design and buyer country issues. These issues must be resolved to implement a REDD policy that would be environmentally robust, encourage participation by project developers and credit buyers, and provide an economically attractive option for developing nations considering how best to use their forests.

Chapter 2 provides background information on what role forests play in the carbon cycle and how climate change policies have until now dealt with emissions from deforestation. Although tropical deforestation is a longstanding environmental issue, the climate debate has focused new attention on the services rendered by tropical forests. As a result, the science surrounding deforestation has improved in recent years. The chapter provides an overview of the scientific literature on the magnitude of deforestation and the cost of REDD activities.

International climate change policies have not yet created incentives for REDD activities, partly because of uncertainties in earlier scientific studies about emissions from deforestation. Currently, no mechanism within the United Nations Framework Convention on Climate Change (UNFCCC) or Kyoto Protocol allows REDD activities to function as a means to achieve emissions targets. Chapter 2 offers a brief history of how international climate change policies have handled emissions from deforestation. In addition, the voluntary market for REDD credits and the consideration of REDD activities in U.S. climate change bills are discussed.

Deforestation and forest degradation are clearly a large source of global GHG emissions, prompting proposals to create incentives for REDD activities through mainstream market-based climate policies. Chapter 3 examines the issues that must be addressed to determine whether and how REDD could be incorporated into market-based mechanisms, such as the carbon market. Those issue are scope, monitoring, baselines, leakage, stakeholder interests, permanence, and the potential effect of REDD credits on the carbon market. Of course, the design of a REDD policy intertwines all these issues. I make an effort to analyze each individually, and I note where the significant interconnections lie and how decisions on one issue might resolve or further complicate other issues. For example, whether REDD policies are based on national participation or project-level participation will significantly affects the risks of leakage and impermanence.

My discussion of the specific issues draws upon existing literature and is intended to be a synthesis of the current debate. The one exception is my discussion of permanence. If REDD policies are based on national participation, then impermanence risks for REDD are not inherently different from those of fossil fuel emissions reductions. Permanence risks associated with forest carbon can be managed such that a reduction in forestry emissions is no different from a reduction in other emissions. I show how reductions in deforestation would be permanent as long as the baseline deforestation rate is not exceeded. Also in the subsection on permanence, I show how temporary REDD credits would have $0 value in a possible market scenario.

After examining the major issues facing the incorporation of REDD into market-based climate policies, I compare five proposed REDD policies, highlighting how they address issues differently.

As the REDD debate moves forward in the international climate change community and among buyer countries, it will be paramount to examine the different circumstances facing individual host countries to determine whether and how REDD activities could align with existing land-use goals. In Chapter 4, I summarize the most pressing host country issues. However, individual host countries face unique challenges and it is difficult to make generalizations.

CHAPTER 2

Background

Forests and the Carbon Cycle

Forests play an integral role in mitigating climate change. Not only are forests one of the most important carbon sinks, storing more carbon than the world's oil reserves, they also constantly remove carbon from the atmosphere through photosynthesis, which converts atmospheric carbon to organic matter. Covering more than 30 percent of the global land area in 2005, the UN Food and Agriculture Organization (FAO) estimates that global forests store 638 gigatonnes (Gt) of carbon (C) in their ecosystems, compared with approximately 750 GtC stored in the atmosphere. Of this forest carbon, 283 Gt (44 percent) is stored in forest biomass, and the remainder is stored in soil (46 percent), dead wood (6 percent), and forest litter (4 percent) (FAO 2006).

While forests are constantly removing carbon from the atmosphere, deforestation is pumping carbon right back into it. For many of us familiar with temperate forests that are stable or increasing in size, it is hard to imagine the magnitude of deforestation in the tropics. Carbon-rich tropical forests are shrinking at a relatively rapid rate and emitting carbon once stored within the organic matter. Annually, deforestation removes 13 million hectares (ha) of forest, or 0.2 percent of total forest area (FAO 2006). In the tropics, the annual deforestation rate is approximately 0.6 percent, three times higher than the global rate. In the period 1990–2005, 8.3 percent of tropical forest area was lost (FAO 2006; Butler 2007).

Carbon Emissions from Deforestation

Deforestation in developing countries is frequently driven by agriculture, logging, and road expansion. Rising prices for soy, palm oil, and beef make it increasingly cost-effective for developing countries to clear their forests and convert the land to agriculture. Often, burning is the cheapest and easiest way to clear the land. When forests are logged, only a fraction of the wood becomes dimensional lumber for eventual use in housing and other structures. The majority of the forest vegetation ends up as waste, and thus the majority of the carbon from the forest ends up in the atmosphere. Further, policies that expand road infrastructure provide access for loggers, farmers, and homesteaders to the previously inaccessible forest interior.

Deforestation and land-use activities including burning, decomposiiton of waste forest matter, soil degradation in cleared lands, and other land-use activities, emit approximately 1.6 GtC, or 5.9 Gt carbon dioxide (CO_2) (IPCC 2007), accounting for roughly 20 percent of global CO_2 emissions. For comparison, annual emissions from burning fossil fuel and making cement are approximately 6.4 GtC (IPCC 2007). Of course, forests are simultaneously absorbing carbon through photosynthesis, countering the effect of carbon emissions from deforestation. Forests and other terrestrial sinks annually absorb approximately 2.6 GtC. As a result, net carbon absorption rates by forests globally are approximately 1.0 GtC annually (IPCC 2007).

Figure 2.1 shows the individual emissions and absorptions from specific forestry activities (Baumert et al. 2005). Note the significantly greater effect of deforestation than afforestation and reforestation (AR) activities. Figure 2.1 does not include the absorption of carbon by forests *not* influenced by land-use activities, which may be large (Sierra et al. 2007).

Deforestation and land-use activities account for approximately 20 percent of global anthropogenic CO_2 emissions (IPCC 2000; WRI/CAIT 2008), accounting for more CO_2 emissions than the transportation sector (Figure 2.2). However, the exact magnitude of land-use change emissions is uncertain because of (a) uncertainty in the estimates of deforestation rates in some regions, and (b) uncertainty in the carbon storage capacity of different forests. Best estimates of emissions from deforestation in the tropics in the 1990s range from 0.9 GtC/year(Achard et al. 2004) to 2.2 GtC/year (Houghton 2003a). See Table 2.1 for more information on deforestation estimates.

In the Intergovernmental Panel on Climate Change (IPCC 2007) low estimate, land-use change and forestry (LUCF) emissions still account for 7.5 percent (0.5 GtC/year) of anthropogenic carbon emissions. Even the low estimate shows that LUCF emissions are greater than the estimated carbon sequestration by AR projects (Denman et al. 2007). In the IPCC's (2007) high estimate, LUCF emissions account for 30.4 percent (2.7 GtC/year) of carbon emissions (Denman et al. 2007). Although LUCF emissions have high uncertainty, the magnitude of these emissions—even under low estimates—is great, suggesting that LUCF emissions should not be dismissed on account of uncertainty.

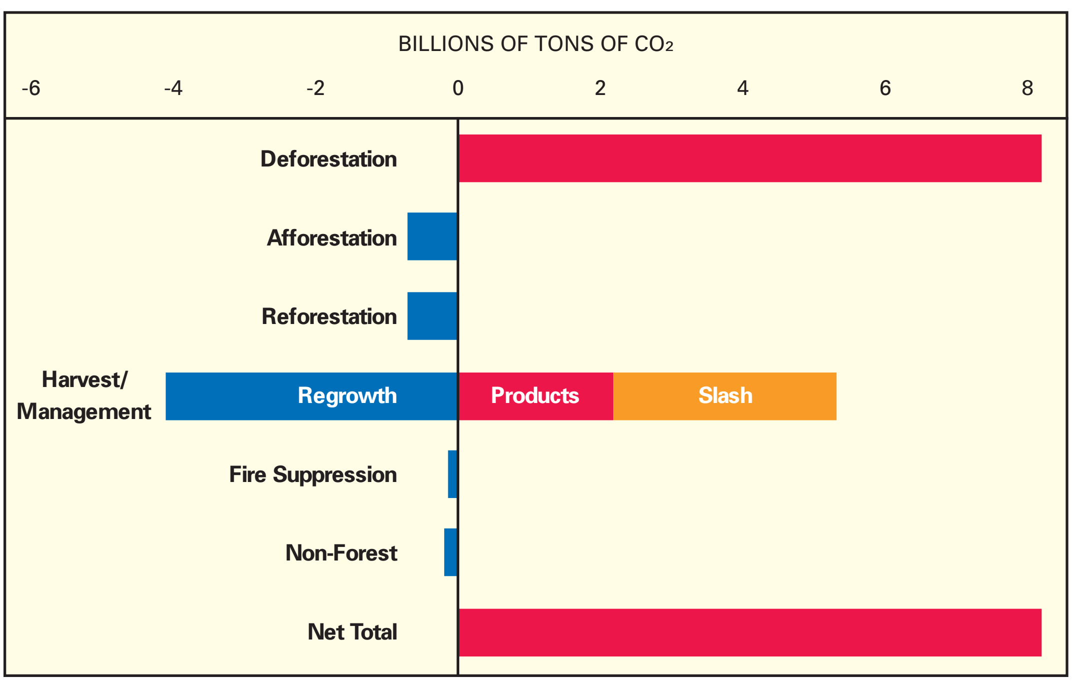


Figure 2.1 Annual Emissions and Absorptions from Select Forestry Activities

Notes: The magnitude of CO_2 emissions from deforestation is significantly greater than emissions or absorptions from other land-use change and forestry activities. Global estimates for the 1990s.

Source: Houghton 2003b, reproduced from Baumert et al. 2005.

Figure 2.2
CO_2 Emissions by Sector in 2000

Notes: According to the WRI/CAIT[1] database, LUCF emissions account for 22.7 percent of global CO_2 emissions. CAIT data on LUCF emissions come from Houghton (2003b).

Source: reproduced from WRI/CAIT 2008.

SECTOR	MTCO2	PERCENTAGE
Energy		
Electricity and heat	11,581.5	34.5
Transportation	5,089.0	15.2
Manufacturing and construction	4,748.4	14.2
Other fuel combustion	3,488.1	10.4
Fugitive emissions	190.6	0.6
SubTotal	25,097.6	**74.8**
Industrial processes	828.1	**2.5**
Land-use change and forestry	7,618.6	**22.7**
Total	**33,544.3**	

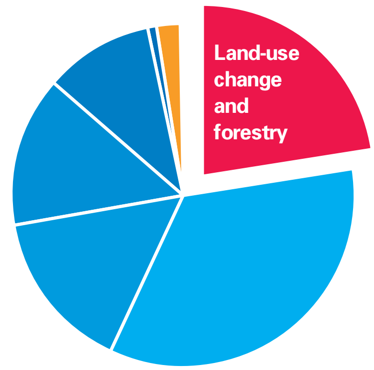


Table 2.1 Estimates of Land-to-Atmosphere Emissions Resulting from Land-Use Changes during 1990s

	TROPICAL AMERICAS	TROPICAL AFRICA	TROPICAL ASIA	PAN-TROPICAL	NONTROPICS	TOTAL GLOBAL
Houghton (2003a)	0.8 ± 0.3 {2.9 ± 1.1}	0.4 ± 0.2 {1.5 ± 0.7}	1.1 ± 0.5 {4.0 ± 1.8}	**2.2 ± 0.6 {8.1 ± 2.2}**	–0.02 ± 0.5 {–0.07 ± 1.8}	2.2 ± 0.8 {8.1 ± 2.9}
DeFries et al. (2002)	0.5 (0.2 to 0.7) {1.8; 0.7 to 2.6}	0.1 (0.1 to 0.2) {0.4; 0.4 to 0.7}	0.4 (0.2 to 0.6) {1.5; 0.7 to 2.2}	**1.0 (0.5 to 1.6) {3.7; 1.8 to 5.9}**	n.a.	n.a.
Achard et al. (2004)	0.3 (0.3 to 0.4) {1.1; 1.1 to 1.5}	0.2 (0.1 to 0.2) {0.7; 0.4 to 0.7}	0.4 (0.3 to 0.5) {1.5; 1.1 to 1.8}	**0.9 (0.5 to 1.4) {3.3; 1.8 to 5.1}**	n.a.	n.a.
IPCC AR4 best estimate (2007)	0.7 (0.4 to 0.9) {2.6; 1.5 to 3.3}	0.3 (0.2 to 0.4) {1.1; 0.7 to 1.5}	0.8 (0.4 to 1.1) {2.9; 1.5 to 4.0}	**1.6 (1.0 to 2.2) {5.9; 3.7 to 8.1}**	–0.02 (–0.5 to +0.5) {–0.07; –1.8 to 1.8}	**1.6 (0.5 to 2.7) {5.9; 1.8 to 9.9}**

Notes: Fluxes in GtC/year; {Fluxes in Gt CO_2/year in brackets}. Uncertainties are reported as ± 1 standard deviation. Numbers in parentheses are ranges of uncertainties.

Achard et al. (2004) and DeFries et al. (2002) rely heavily on remote sensing methodologies, which yield much more conservative estimates than Houghton's (2003a) bookkeeping methodology,which incorporates past calculations of sources and sinks with changes in forest area and forest biomass reported by the FAO Forest Resources Assessment 2000 (DeFries et al. 2002; Houghton 2003a; Achard et al. 2004; FAO 2006). The Intergovernmental Panel on Climate Change made a best estimate of global land-use change emissions of 1.6 GtC/year calculated from the mean of the DeFries et al. (2002) and Houghton (2003) studies (IPCC 2007).

Source: reproduced from IPCC AR4 WGI (Denman et al. 2007).

LUCF emissions are not evenly distributed around the globe but concentrated in a few tropical countries experiencing very high rates of deforestation. Brazil and Indonesia account for approximately 50 percent of net deforestation (FAO 2006). The 15 countries with the highest LUCF CO_2 emissions, according to World Resources Institute's CAIT database (WRI/CAIT 2008), are shown in Table 2.2. These countries account for almost 90 percent of net global LUCF CO_2 emissions (Houghton 2003b; WRI/CAIT 2008). With the exception of Mexico, LUCF emissions make up the majority of these countries' GHG emissions. Further, for 10 of the top 15 countries, LUCF emissions account for more than 80 percent of their total CO_2 emissions.[2]

Figure 2.3 shows the proportion of LUCF emissions for the top CO_2 emitters according to the WRI/CAIT database. LUCF emissions account for a major portion of total emissions for some of the top CO_2-emitting countries. Indonesia, Brazil, and Malaysia are among the top 10 GHG emitters globally as a result of their high LUCF emissions.[3]

Table 2.2 CO_2 Emissions for Top 15 LUCF CO_2 Emitting Countries

	CO_2 EMISSIONS FROM LAND-USE CHANGE & FORESTRY (LUCF) IN 2000				TOTAL CO_2 EMISSIONS IN 2000			LUCF EMISSIONS AS A PERCENTAGE OF DOMESTIC EMISSIONS
COUNTRY	$MTCO_2$ FROM LUCF	RANK	PERCENT OF WORLD LUCF TOTAL	TONS LUCF CO_2/ PERSON	$MTCO_2$ FROM ALL SOURCES	RANK	PERCENT OF WORLD TOTAL	
Indonesia	2,563.10	(1)	33.64	12.4	2,859.10	(3)	9.01	89.65
Brazil	1,372.10	(2)	18.01	7.9	1,708.80	(4)	5.39	80.30
Malaysia	698.90	(3)	9.17	30.4	820.80	(9)	2.59	85.15
Myanmar	425.40	(4)	5.58	8.9	434.80	(15)	1.37	97.84
Congo, Dem. Rep.	317.30	(5)	4.16	6.3	318.90	(20)	1.01	99.50
Zambia	235.50	(6)	3.09	22.0	237.40	(28)	0.75	99.20
Nigeria	194.80	(7)	2.56	1.7	273.80	(26)	0.86	71.15
Peru	187.20	(8)	2.46	7.2	215.40	(31)	0.68	86.91
Papua New Guinea	146.00	(9)	1.92	27.6	148.40	(36)	0.47	98.38
Venezuela	144.10	(10)	1.89	5.9	283.30	(25)	0.89	50.86
Nepal	123.50	(11)	1.62	5.1	126.70	(40)	0.40	97.47
Colombia	106.10	(12)	1.39	2.5	169.50	(35)	0.53	62.60
Mexico	96.80	(13)	1.27	1.0	481.70	(12)	1.52	20.10
Philippines	94.90	(14)	1.25	1.3	170.20	(34)	0.54	55.76
Côte d'Ivoire	91.10	(15)	1.20	5.4	98.00	(44)	0.31	92.96
World total	**7,618.6**		**100.00**		**33,544.30**		**100.00**	**22.70**

Note: This table only considers CO_2 emissions and does not include emissions of other GHG.

Source: CAIT database (WRI 2008).

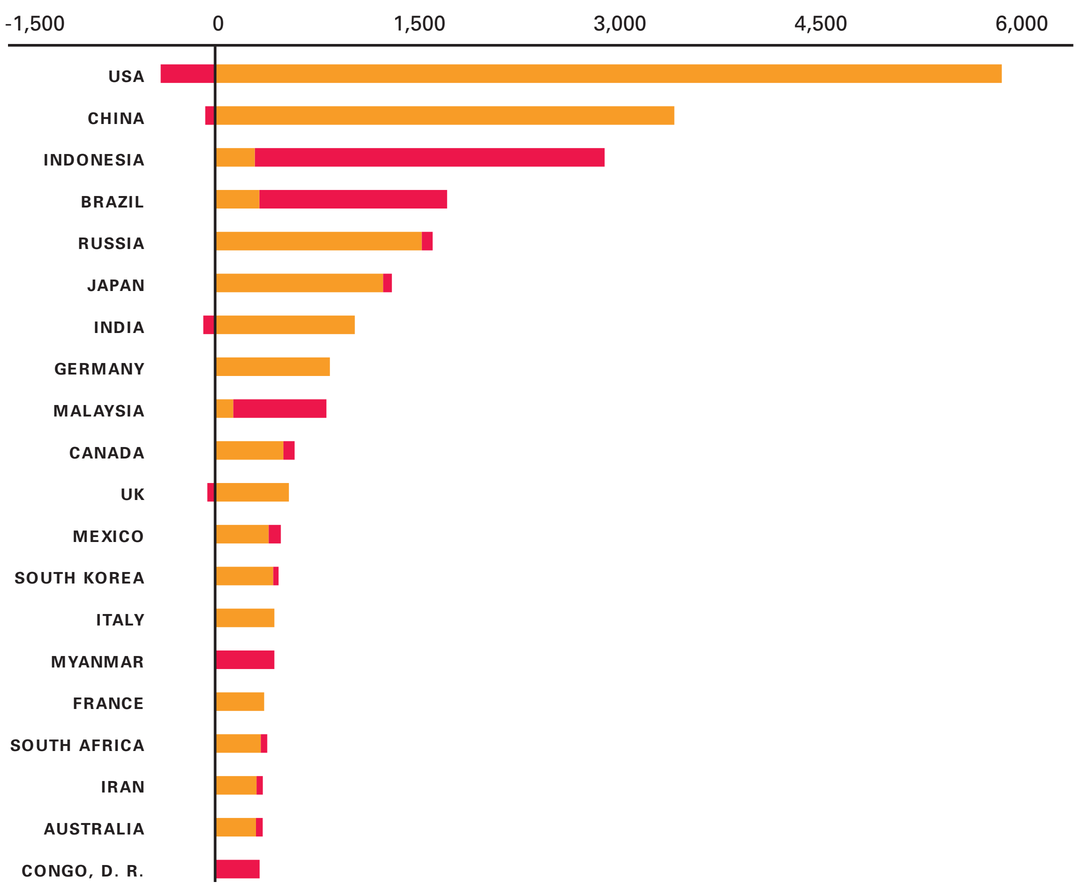


Figure 2.3 Total CO_2 Emissions in 2000 for Top 20 CO_2 Emitters

Source: WRI/CAIT 2008.

Deforestation versus Degradation

As the name REDD implies, deforestation and degradation are distinct activities. Although often lumped together, they have unique drivers and result in different forest conditions, and the processes of identifying and abating deforestation and degradation can be quite different. For these reasons, it is important to understand the differences.

Deforestation is defined by IPCC as the "permanent removal of forest cover and withdrawal of land from forest use, whether deliberately or circumstantially" (Watson et al. 2000). *Forest conversion* to pasture, cropland, or other managed uses is considered the same as *deforestation* unless noted otherwise. UNFCCC and IPCC employ a minimum crown cover criterion of 10 to 30 percent[4] to differentiate between forests and nonforests. If crown cover is reduced below this threshold, deforestation has occurred.

Deforestation is often driven by government-supported agricultural and timber policies, international markets for agricultural and forest products, population growth, and expansion of road networks. It is conducted by entities with sufficient capital to clear forests. Said another way, it generally takes money to pay for the equipment and labor necessary to clear forests. Whereas deforestation eliminates the forest canopy, degradation includes all actions resulting in carbon emissions that do not involve elimination of the canopy. Degradation can result from selective logging, grazing within forests, and understory fires as well as overcutting for fuelwood and subsistence agriculture. Degradation causes the gradual thinning of forests and can lead to deforestation, as seen in studies from the Brazilian Amazon (Asner et al. 2006). In the vicinity of roads and settlements, degradation may be at least as widespread as deforestation (Trines et al. 2006; Asner et al. 2007).

The potential carbon benefits of abating forest degradation are great; however, degradation is more difficult to identify and monitor than deforestation because of the sophisticated remote sensing program and ground-truthing required. Further, carbon fluxes associated with forest degradation are more uncertain. These challenges have created some concern about the practicality of including degradation in a policy to abate forestry emissions. Although this report refers to REDD policies, which implies the inclusion of forest degradation, the discussions and analyses are equally relevant to RED (reduced emissions from deforestation) policies.

Costs of REDD Activities

Early efforts to examine the costs and benefits of forest carbon focused on carbon sequestration in the forestry sector through activities such as AR, forest management, manipulation of rotation lengths, and the like (Sedjo and Solomon 1989; Richards and Stokes 2004). In some early studies that considered carbon benefits from avoided deforestation, costs and benefits were aggregated with sequestration activities, such that the effects of REDD activities could not be isolated from those of the other forestry activities (Kerr et al. 2001; Sedjo et al. 2001; Sohngen and Sedjo 2006; Benitez et al. 2007). Although these forestry sector studies report on the predicted forest carbon benefits at different carbon prices, one cannot tease out the specific contributions of REDD activities.

Recently, more analyses have focused specifically on the carbon benefits and costs of REDD activities (Osafo 2005; Osborne and Kiker 2005; Sathaye et al. 2005; Silva-Chavez 2005; Greig-Gran 2006; Kindermann et al. 2006; Sohngen and Beach 2006; Nepstad et al. 2007; Anger and Sathaye

Table 2.3 Cost and Supply of Avoided Deforestation from Ten Studies

Author	Geographic scope	Carbon price	Land benefit (M ha)		Carbon benefit (GtC)[1]	
Kindermann et al. (2006)	Global				Cumulative	
		$6/tC every 5 years ($1.6/tCO$_2$)			2050: 17 GtC (62 GtCO$_2$) 2100: 22 GtC (81 GtCO$_2$) (BAU[2] with no carbon price results in cumulative deforestation emissions by 2100 are 45 GtC. $6/ton results in a 49% reduction of projected carbon emissions)	
		$10/tC every 5 yrs ($2.7/tCO$_2$)			2100: 31 GtC (114 GtCO$_2$) (Compared to BAU, $10/ton results in a 69% reduction of projected carbon emissions)	
Sathaye et al. (2005)	Global	Carbon price per ton increasing at a given percentage	Cumulative		Cumulative	
			2050	2100	2050	2100
		$5/tC + 5% ($1.4/tCO$_2$)	122 M ha	499 M ha	8.0 GtC (29.3 GtCO$_2$)	37.1 GtC (136.0 GtCO$_2$)
		$10/tC + 5% ($2.7/tCO$_2$)	219 M ha	649 M ha	14.8 GtC (54.3 GtCO$_2$)	48.8 GtC (178.9 GtCO$_2$)
		$10/tC + 3% ($2.7/tCO$_2$)	160 M ha	478 M ha	10.7 GtC (39.2 GtCO$_2$)	34.5 GtC (126.5 GtCO$_2$)
Sohngen and Beach (2006)	Global	$5/tC ($1.4/tCO$_2$) ($23–$33/ha/yr varies per region)	8.4%–17.7% decrease in deforestation rates (varies per region)		Cumulative gain by 2055: 5.3 GtC (19.4 GtCO$_2$) (7% of total deforestation emissions)	
		$100/tC ($27.3/tCO$_2$) ($466–$659 /ha/yr varies per region)	94.7%–100% decrease in deforestation rates (varies per region)		Cumulative gain by 2055: 76.3 GtC (179.8 GtCO$_2$)	
Strassburg et al. (2008)	20 most-forested developing countries: Brazil, China, DR Congo, Indonesia, Peru, India, Sudan, Mexico, Colombia, Angola, Bolivia, Venezuela, Zambia, Tanzania, Argentina, Myanmar, Papua New Guinea, Central African Republic, Congo, Gabon	$20.67/tC ($5.63/tCO$_2$)	90% decrease in global emissions from deforestation		Annual carbon benefits: 0.9 to 1.7 Gt C (3.2 to 6.4 Gt CO$_2$)	
Greig-Gran (2006) (for the Stern Review)	Brazil, Indonesia, Papua New Guinea, Cameroon, Congo (cumulatively account for 46% global deforestation and 70% LUCF emissions)	$3.67–$7.33/tC ($1–$2 /tCO$_2$)	Annually: 6.2 M ha ($484–$1,048/ha depending on opportunity cost of land. Administration cost of REDD activities would add an additional $4–$15/ha/year)		Annual carbon benefits through 2050: 0.95–1.34 GtC/yr (3.5–4.9 GtCO$_2$/yr) Cumulative gain by 2050: 42–59 GtC/yr (154–216 GtCO$_2$/yr)	
McKinsey Report by Enkvist et al. (2007)	Africa and Latin America	$183.5/tC ($50/tCO$_2$ or 40€/tCO$_2$)	Reduce annual tropical deforestation in Africa by 50%. Reduce annual tropical deforestation in Latin America by 75%. Abatement in Asia would be more expensive.		Annual abatement of 0.8 GtC (3.0 GtCO$_2$)	
Nepstad et al. (2007)	Brazilian Amazon	$10/tC ($2.7/tCO$_2$) for a total of $115 billion	Reduce deforestation in Brazilian Amazon by 94%		Cumulative: 44 GtC (161 GtCO$_2$)	
Osafo (2005)	Ghana	$29.59/tC ($8.07/tCO$_2$) ($1,776/ha)	65,000 ha/yr		Cumulative: 3.9 MtC (14.2 MtCO$_2$)	
Osborne and Kiker (2005)	Guyana logging concession (single project)	$0.19–$0.23/tC ($0.70–$0.84/tCO$_2$) (12% discount rate)	1.5 M ha forest		Cumulative: 53.4 MtC (195.8 MtCO$_2$)	
Silva-Chavez (2005)	Bolivia	$4.43/tC (2005) rising to $9.50/tC by 2012 ($16.26 rising to $34.87/tCO$_2$)	150,000–168,000 ha/yr		Annual abatement: 30–33 MtC/year (110–121 MtCO$_2$/yr)	

1. Some studies focus on cumulative carbon benefits over a time period, whereas others focus on annual carbon benefits.

2. BAU is business-as-usual.

2008; Strassburg et al. 2008). The studies use different methodologies and underlying assumptions, making direct comparison difficult. Some studies focus on the one-time benefits of a specific forestry project (Osborne and Kiker 2005). Other studies use models based on local opportunity costs aggregated to a national or multinational level (Greig-Gran 2006, Nepstad et al. 2007; Strassburg et al. 2008). Other studies use global models that construct REDD carbon supply curves at different carbon prices (Sohngen and Beach 2006; Anger and Sathaye 2008; Sathaye et al. 2005; Kinderman et al. 2006). The results of these studies are summarized in Table 2.3. Although the results vary, all but one study support the conclusion that substantial carbon benefits can be realized through REDD activities at low initial carbon prices ($10/tC or less); the exception is the McKinsey report by Enkvist et al. (2007).

The McKinsey report found that reducing deforestation by 50 percent in Africa and 75 percent in Latin America could be achieved for about $183.50/tC ($50/tCO2) and abate 3 GtCO2 emissions (Enkvist et al. 2007). Enkvist et al. (2007) found that abating deforestation rates in Asia would be more expensive because of higher opportunity costs for forests. Additionally, they found that avoiding deforestation was more expensive than other forest mitigation measures.

Osafo (2005), Osborne and Kiker (2005), and Silva-Chavez (2005) calculate the break-even price for carbon based on the opportunity cost of forested land in the regions studied. Greig-Gran (2006) calculates the discounted return per hectare and not the price of land, explaining that land prices do not reflect avoided deforestation costs because of land tenure issues surrounding tropical forests. These studies draw on information about current drivers of deforestation, such as the percentage of land cleared for soy farming, cattle ranching, timber harvest, and the like to calculate the opportunity cost. Osafo (2005) accounts for revenues from agriculture but not the production costs and thus may overestimate the opportunity cost (Greig-Gran 2006). Greig-Gran (2006) includes transaction costs estimated from the administrative costs of payment-for-ecosystem-services (PES) programs in place in other countries. Specifically, Greig-Gran (2006) uses $4–$15/ha/year based on PES programs in place in Costa Rica, Mexico, and Ecuador. It is not clear how appropriate it is to extrapolate worldwide transaction costs based on these estimates. Greig-Gran (2006) does not include monitoring costs in her calculations. However, she estimates that monitoring costs would add $2 million/year for each of the eight countries studied. None of the other studies explicitly account for administrative and transaction costs. Osborne and Kiker (2005) note that costs for REDD pilot projects range from $0.10 to $15 per ton carbon worldwide and $1 to $6 per ton carbon in Latin America, though they do not include this in their cost calculations.

Sathaye et al. (2005) use a dynamic partial equilibrium model to examine the response of the forestry sector to carbon prices. Kindermann et al. (2006) use a spatially explicit integrated biophysical and socioeconomic land-use model. Sohngen and Beach (2006) use a global timber model to calculate the carbon supply curves for REDD activities at different carbon prices. Sohngen and Beach's (2006) results are broken out by region, as shown in Figures 2.4 and 2.5.

In regions where forests are relatively abundant, carbon stocks are high, and deforestation rates are high, avoiding deforestation may offer the highest potential for CO2 mitigation (Trines et al. 2006; Nabuurs et al. 2007; Stern 2007). Other forest mitigation measures include AR, forest management to increase the carbon stocks of a forest, and bioenergy as a substitute for fossil fuel use. Trines et al. (2006) identify reducing deforestation in the three tropical regions (Central and South America, Africa, and tropical Asia) as three of the four forest mitigation measures with "large" potential to mitigate CO2. The fourth is forest management in North America.

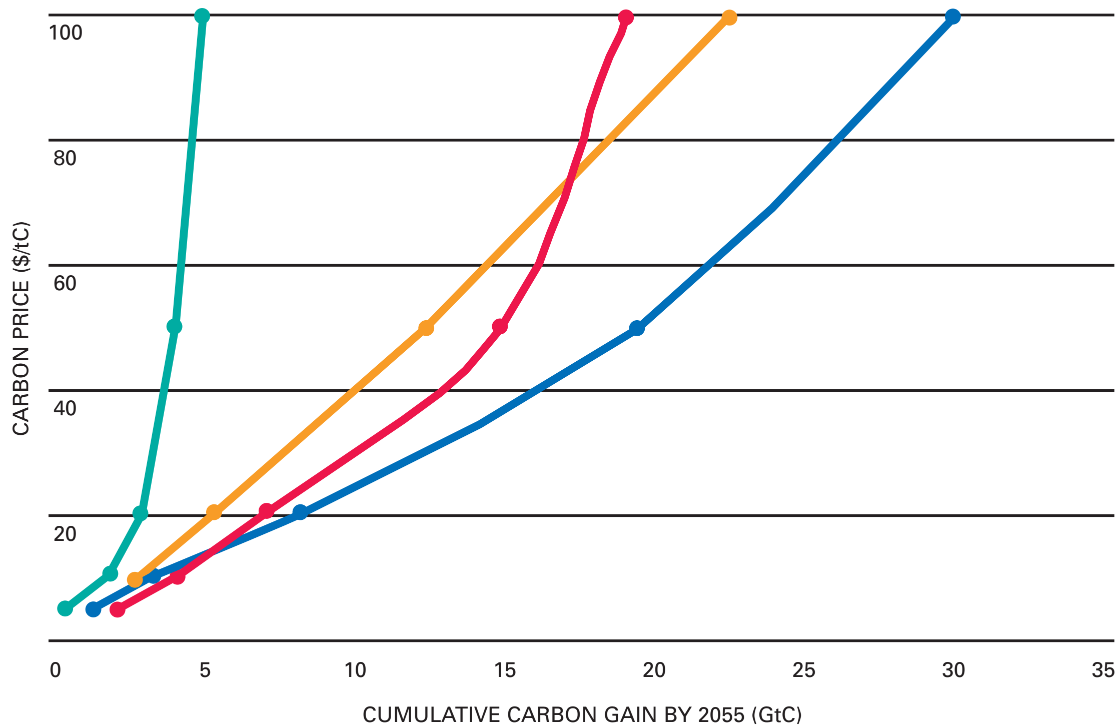


Figure 2.4
Cost Curves for Avoided Deforestation in Different Regions

Africa
Central America
South America
Southeast Asia

Source: Sohngen and Beach (2006)

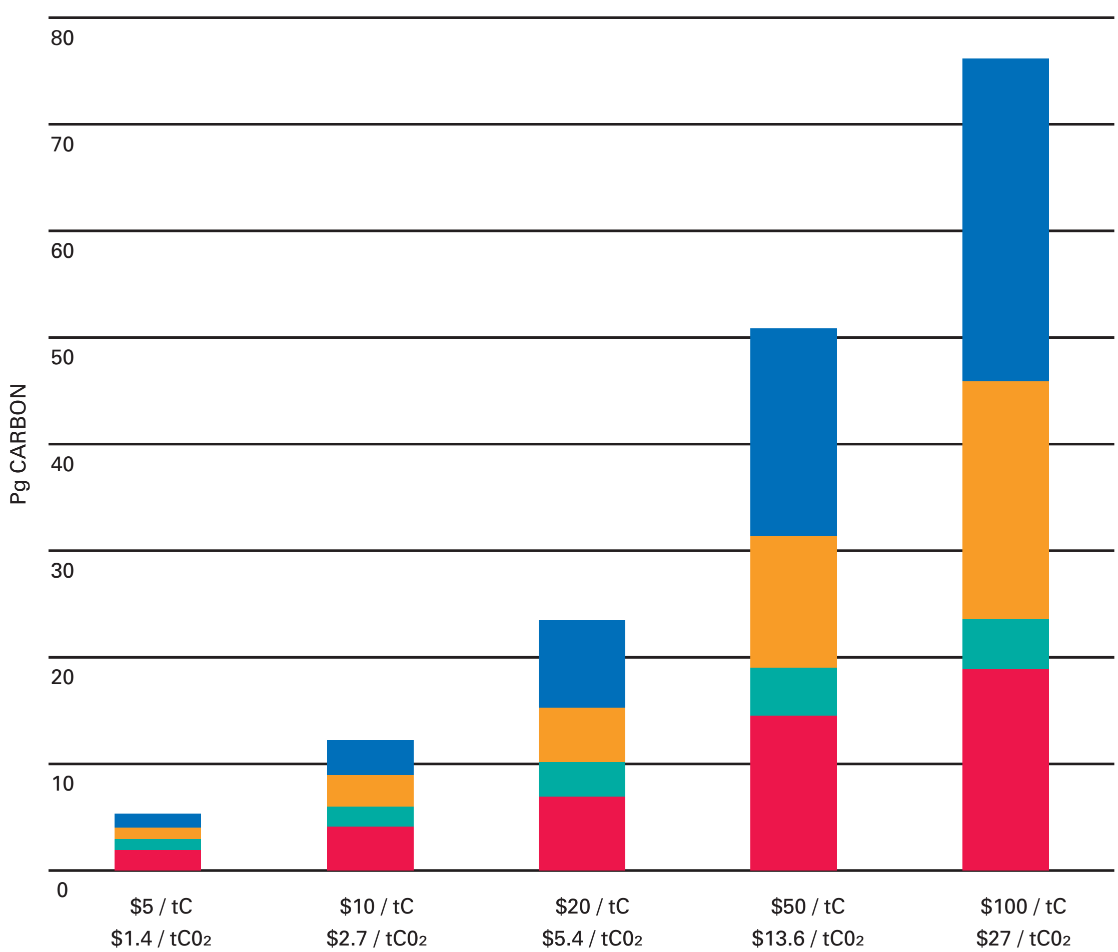


Figure 2.5
Cumulative Carbon Gains at Different Carbon Prices by 2055

Africa
Central America
South America
Southeast Asia

Source: Sohngen and Beach (2006)

Sathaye et al. (2005) analyzed the GHG mitigation potential of global forests at different carbon price scenarios. They considered long-rotation forestry, short-rotation forestry, and reduced deforestation. Their modeling found that reduced deforestation would account for 51 to 78 percent of carbon benefits gained by 2100, depending on the initial carbon price and rate of price increase. Although the scenario that began at $75/tC ($20.5/tCO2) yielded the greatest carbon benefits, half of the reduced deforestation benefits could be gained at carbon prices starting at $5 to $10/tC ($1.37 to $2.73/tCO2).

Given the magnitude of deforestation emissions and the predicted low abatement costs compared with both forestry and other mitigation measures, there is general agreement that emissions from deforestation and degradation should be addressed immediately (Nabuurs et al. 2007; Stern 2007). After an extensive analysis of the economics of climate change, the Stern Review concluded that "curbing deforestation is a highly cost-effective way of reducing greenhouse gas emissions and has the potential to offer significant reductions fairly quickly" (Stern 2007, 537).

In the context of forestry and land-use measures, both the Stern Review and the IPCC Working Group on Climate Change Mitigation (IPPC 2007) independently concluded that carbon mitigation efforts aimed at reducing deforestation rates offer the greatest benefits because of the size of the source and the cost-effectiveness of reducing emissions (Nabuurs et al. 2007; Stern 2007). In an analysis of the role of the forestry sector in mitigating climate change, IPCC (2007) concluded, "Reduced deforestation and degradation is the forest mitigation option with the largest and most immediate carbon stock impact in the short term per ha and per year globally … because large carbon stocks (about 350–900 tCO2/ha) are not emitted when deforestation is prevented" (Nabuurs et al. 2007, 14).

In addition to the carbon benefits of REDD activities, abating deforestation can have significant environmental and sustainable development co-benefits including biodiversity conservation; watershed protection; reduction of runoff, siltation, and flooding; protection of fisheries; and sustained incomes for local communities (Nabuurs et al. 2007). Despite agreement about the benefits of REDD activities, significant disagreement exists over how best to achieve them and what role market mechanisms should play in incentivizing REDD.

Deforestation and International Climate Policies

In 1997, the Kyoto Protocol of the UN Framework Convention on Climate Change laid out target emissions reductions and the different mechanisms by which countries could achieve those targets. To achieve the targets, countries had two options: either reduce their own domestic emissions, or pay someone else to reduce their emissions and thus offset the country's domestic emissions with reductions somewhere else.

The Kyoto Protocol established the rules and financing structures surrounding different types of offset mechanisms. At that time, the Parties to the Protocol excluded REDD from the offset mechanism because of uncertainties about the magnitude of deforestation emissions and the ability to monitor deforestation.

Although UNFCCC specifically notes the important role that forest sinks play in the sequestration of carbon, policy mechanisms to incentivize terrestrial carbon sequestering have been limited. The Kyoto Protocol does recognize credits from AR activities, which can be used to generate offsets under its clean development mechanism (CDM) and joint implementation (JI) mechanism.

AR credits are capped for use by Annex I parties (the industrialized nations) at 1 percent of base-year emissions or 5 percent of emissions during the entire five-year commitment period from 2008 to 2012 (Schlamadinger et al. 2005). At this time, avoided deforestation activities are excluded as a means to meet emissions targets.

Because of their exclusion from regulatory markets, REDD credits have been limited to the voluntary market, where a handful of projects are generating credits. These credits are sold at a fraction of the regulatory market price to buyers concerned about reducing their carbon footprint for reasons other than compliance with the law, such as improving their environmental image.

The outlook for REDD changed at the 2005 Conference of the Parties in Montreal. Costa Rica and Papua New Guinea, on behalf of the Coalition for Rainforest Nations, proposed to give developing countries access to the carbon market through credits generated from REDD activities. In response, UNFCCC launched a two-year initiative to examine the potential of REDD. Those two years culminated at the 13th UNFCCC Conference of the Parties (COP 13) in Bali, in December 2007.

Officially, the Bali decision was quite modest. The Bali Action Plan formally listed REDD among other mitigation activities as a potential means to achieve emissions targets and encouraged voluntary action on REDD. The decision of whether and how REDD would fit into the international climate mitigation strategy was put off until COP 15 in Copenhagen, in 2009.

And yet, Bali was a turning point because it put REDD on the broader COP agenda, signaling that the international climate change framework will address the problem of emissions from deforestation in some manner. The Bali decision encourages capacity building and the development of pilot projects. By reducing some of the uncertainty about the future of REDD, the Bali decision encourages developing countries and project developers to begin investing in REDD activities. Although the Bali decision put REDD on the roadmap, it did not include any language about the financing mechanism that might be used. Currently, several market-based and nonmarket-based initiatives are underway.

Nonmarket-based initiatives include Brazil's Amazon Fund, launched in August 2008 to support sustainable development and conservation in the region. Norway pledged $1 billion by 2015 to the fund and will begin payment immediately, but full payment is contingent upon a demonstrated reduction in deforestation (Mongabay.com 2008). The Amazon Fund follows the model of Brazil's proposed Voluntary RED Fund, which would reward countries that successfully reduced emissions from deforestation below reference rates. The fund would be supported by contributions from developed countries. Other nonmarket-based initiatives include increasing development assistance, barter transactions such as debt cancellation, taxing carbon-intensive activities to fund REDD activities, and cultivating private sponsorship.

Market-based REDD initiatives that build on the existing voluntary carbon market have gained a lot of support and are further discussed below. Some propose that REDD credits could be traded with other carbon credits without restriction. Others favor creating a separate market for REDD credits, distinct from the existing compliance market. Still others favor a combination of the two approaches.

The Current Market for Forestry Credits

Because REDD is excluded from the financing mechanisms of the Kyoto Protocol, demand for deforestation credits is relatively low and composed entirely of voluntary efforts. Demand for credits from AR activities is also low because the European Union's Emissions Trading Scheme (ETS), the largest such scheme in the world, currently excludes forestry credits, including those from AR activities. This is not to say that demand is nonexistent—in fact, forestry projects accounted for 15 percent of the voluntary carbon market in 2007 (Hamilton et al. 2008). However, this is still less than 0.2 percent of the $64 billion worldwide market for carbon-denominated assets.

Among voluntary programs, the World Bank dominates the current forestry credit market with its BioCarbon fund portfolio, which is expected to produce 6 million carbon credits. Taking into account the 5 percent cap on forestry CDM credits, Neef and Henders (2007) estimate the potential market volume to be 75 million carbon credits, much higher than the current market size.

With the encouragement of the Group of Eight, the World Bank announced a new, $250 million Forest Carbon Partnership Facility (FCPF) in Bali on December 11, 2007 (G8 2007). The FCPF is two funds within one facility with the dual objective of (a) building capacity for REDD in developing countries and (b) testing a program of performance-based payments in pilot countries to lay the foundation for a larger system of positive incentives and financing flows in the future. The general goal is to catalyze institutions and capacity-building for REDD such that the market will eventually take over much of the funding activities. Because REDD activities are outside the CDM protocol, credits generated by FCPF projects cannot be used for compliance as long as REDD activities are excluded from the regulatory market. In the meantime, REDD credits are expected to be traded on the voluntary market. The FCPF focuses on national-level participation and requires a country to make a nationwide commitment to reduce its deforestation rate. It will not support project-level activities without a national commitment to reduce deforestation.

In July 2008, the World Bank announced the first recipients of the readiness fund of the FCPF. The funding will support work to establish baseline emissions reference levels, adopt strategies to reduce deforestation, and design methodologies for monitoring progress. The selected 14 countries are in Africa (Democratic Republic of Congo, Gabon, Ghana, Kenya, Liberia, and Madagascar), Latin America (Bolivia, Costa Rica, Guyana, Mexico, and Panama), and Asia (Nepal, Lao PDR, and Vietnam).

In addition to the World Bank's efforts are a handful of planned and existing REDD projects, ranging from discrete forest conservation projects to provincial-level REDD commitments that involve a portfolio of sustainable forest management, forest conservation, and other activities. Credits from these projects are sold on the voluntary market and cannot be used by entities seeking to meet compliance obligations. Perhaps the most noteworthy of these subnational projects is the Ulu Masen project, which incorporates the entire province of Aceh, Indonesia. In February 2008, the project design was approved by the CCB Standards, a rigorous design standard that requires land-based carbon projects to simultaneously generate climate, biodiversity, and sustainable development benefits. The Ulu Masen project is projected to reduce emissions by 100 million tons over 30 years, equivalent to Mexico's annual emissions (Efstathiou 2008). Given its size and complexity, the Ulu Masen project is breaking new ground for REDD activities. It is expected to begin generating credits for sale on the voluntary market in late 2008.

REDD and the Future Carbon Market

Uncertainties regarding the magnitude of LUCF emissions and concerns over sovereignty[4] and methodological issues, such as leakage, additionality, and permanence, were at the source of the original reluctance to consider REDD activities as a means to generate carbon credits (Gullison et al. 2007). Some of these concerns have been assuaged. Further, consensus is growing that the global community is not going to solve the climate change problem without addressing emissions from forests, and confidence in monitoring methodologies for LUCF emissions is increasing. For many developing countries endowed with large tropical forests, the carbon market offers significant funding to support forest protection and sustainable development programs; thus, they are willing to consider engaging in the climate dialogue and taking on emissions reduction commitments, at least in the forestry sector.

Arguments for Incorporating REDD into the Carbon Market

Generally, arguments in favor of incorporating REDD into the carbon market are based on the amount of funding available and the potential to engage developing countries in climate change mitigation. Additional arguments include the following:

- LUCF emissions account for 20 percent of annual CO_2 emissions, which can be addressed, at least in part, through the carbon market.
- REDD is a cost-effective means to achieve emissions goals.
- Forestry projects can align with ecological and sustainable development goals.
- Credits generated from REDD create a means for developing countries to participate in carbon markets.
- Historically, official development assistance and nonmarket-based financing projects targeting tropical deforestation have suffered from limited funds and interest.[5]

Arguments against Incorporating REDD into the Carbon Market

Generally, the counterarguments fall into two categories: principled arguments against inclusion of REDD activities into mainstream market mechanisms, and practical concerns over the design and consequences of REDD credits. In summary, the principled arguments are as follows:

- REDD would distract attention from the problem of fossil-based energy production.
- It would reduce pressure on Annex I countries to increase their targets and implement in-country carbon mitigation programs.
- It may have adverse effects on sustainable development goals and local communities.
- It would provide incentives only for countries with high rates of deforestation and fails both to reward countries that have already reduced deforestation and to create incentives for countries that have never had high rates of deforestation (such as Democratic Republic of Congo).

The issues surrounding the design of REDD mechanisms at both the international and the national level are explored in detail in Chapter 3.

REDD and U.S. Domestic Climate Change Policy

International forestry projects and REDD-generated offsets provide a potentially cost-effective means for entities to meet their emissions obligations. In fact, one modeling study found that forest carbon (mostly from REDD) could cut the global cost of climate change policies in half (Tavoni et al. 2007). For the United States, this means that REDD-generated offsets could play a significant role in reducing the costs of any proposed market-based climate change policy. Further, investments in REDD credits may have sustainable development and environmental co-benefits that align with U.S. goals for development aid.

Because the United States is currently not a party to the Kyoto Protocol, Congress will not be constrained by the rules set by Kyoto if it passes a climate change bill. As a result, even though Kyoto does not recognize emissions reductions from REDD activities, U.S. climate policies could allow offsets from REDD activities, which is exactly what the Lieberman-Warner bill did. If passed, Lieberman-Warner would have regulated carbon emissions by establishing a cap-and-trade scheme for carbon credits, and it would have allowed offsets from international forest carbon activities (such as REDD) for up to 10 percent of the cap. The bill failed to overcome a filibuster in June 2008; however, if a bill with similar offset provisions is passed in the future, it would single-handedly create a large demand for REDD credits thus far unseen in existing carbon markets.

CHAPTER 3

Policy Design Issues

Scope

Currently, opinions differ significantly regarding the appropriate scope of REDD policies. In this report, scope refers to three distinct issues. First is the question of what types of activities qualify as REDD. Second and related is the question of whether policies should be project-based or national. Third is the question of whether REDD policies should encourage other forest carbon activities, such as AR activities and forest conservation in countries that are not experiencing deforestation.

Shades of REDD

Broadly speaking, all REDD activities can be categorized as projects, policies, or sector activities.

REDD projects would maintain carbon stocks in a localized area. Many of the current REDD projects focus on forest conservation and the creation of reserves and parks to protect threatened forests. These place-based REDD projects preserve the carbon stocks on a parcel of land that otherwise would be deforested.

REDD policies would reform land-use policies, such as agricultural and transportation policies, to reduce deforestation and associated emissions. Agricultural subsidies, for example, often create incentives to clear forests, and expanded road networks provide access to clear forests and remove timber. Reforming land-use policy could lead to significant reductions in forestry emissions, just as reforms in energy policy are expected to reduce emissions rates in the electricity sector.

Sectoral REDD activities would focus on reducing net deforestation rates over an entire country. A country or province could commit to a target emissions rate from forestry by setting an emissions cap in the forestry sector. For some developing countries, actively pursuing emissions targets in the forestry sector might be the most appealing and powerful way for them to participate in the global effort to mitigate climate change.

Those three shades of REDD—project, policy, and sector targets—capture the different scales at which REDD activities could be implemented, and each has its strengths and weaknesses.

REDD projects could be modeled after the forestry CDM, and some project developers are ready to begin investing in REDD projects. Because REDD projects would be geographically bound, they would be easier to implement than REDD policies or sector activities. There are, however, technical challenges that must be overcome—such as minimizing and accounting for leakage.[6] This is dealt with in more detail later in this chapter.

Further, emissions from deforestation account for 20 percent of global carbon emissions, and there is concern that REDD projects alone could not have a meaningful impact on the large magnitude of emissions from deforestation. Policies and sectoral caps that reduce emissions from deforestation may be better matched to the scale of the problem. Consequently, they would also require more coordination, but some countries lack a sufficiently strong central government or the proper governance institutions to monitor and enforce these programs.

In reality, countries currently have very different capacities on the ground to implement REDD activities. A climate change policy could allow a spectrum of REDD activities that create incentives for countries to take actions at the most appropriate scale for them. All three categories of REDD activities face technical and policy design challenges that must be addressed to ensure an environmentally robust mechanism. These challenges differ with each kind of activity. For example, projects that maintain carbon stocks on a hectare of land would require different accounting mechanisms than sectoral caps that reduce emissions rates over a country's entire forests. This topic is discussed further in the following section on national-based and project-based accounting.

National- versus Project-Based Policies

Whether REDD policies will be based on national participation or be designed for project-based activities will significantly affect other elements of REDD policies, such as the design of baselines, protection against leakage, and ensuring permanence. Further, the decision to make policies either national-based or project-based may influence the willingness of credit suppliers (forested developing countries), project investors, and credit buyers (private entities offsetting their emissions) to participate. For this reason, it is important to consider the comparative benefits of national- and project-based policies, keeping in mind the goals of REDD policies.

National-Based Policies

A purely national-based REDD policy would include national accounting of forestry emissions and national management of REDD projects. Participating countries would commit to reducing their emissions from deforestation, and credits would be generated based only on national-level forestry emissions accounting. National governments would manage a portfolio of REDD activities, credits would be awarded to countries, and national governments would then distribute credits and credit revenues appropriately. As a result, if an individual project reduced deforestation in its area but deforestation increased above the expected level elsewhere in the country, no credits might be issued to the country despite the success of the individual project.

If countries agreed to cap forestry emissions, the cap could be either binding or nonbinding. The often-discussed nonbinding cap would not penalize countries if they violate the cap; they simply would not receive any of the benefits. Another possibility is a binding cap that would make countries liable if forestry emissions went above the cap.

Advantages of national-based REDD policies. National-based policies would give countries flexibility to decide how to manage their forest resources collectively and adapt to shifting markets by changing their portfolio of REDD activities. Countries would simultaneously invest in national-level governance institutions and policy-based activities as well as place-based REDD projects. National-based REDD policies would account for in-country leakage. Because of the magnitude of

LUCF emissions, national-based REDD policies have the appropriate scale to incorporate large areas of forest and minimize forestry emissions.

Disadvantages of national-based REDD policies. National-based REDD policies might create bureaucratic procedures that could dissuade would-be investors in forestry projects from participating in the market. The hypothetical investors might be hesitant to tie the returns of their projects into the overall success of the country in reducing deforestation rates. To date, no analysis has been conducted regarding the degree to which national-based REDD policies would create negative incentives for would-be investors.

Further, national-based policies require strong central governments, whether to enforce forestry policies or to reform national agricultural and transportation programs. In some cases, it is the lack of strong central governing authority that has allowed the continued high rates of deforestation. Thus, national-based REDD policies might discourage participation by subnational groups that have the interest and ability to abate deforestation despite national-level disinterest or inability. For example, consider a hypothetical country that has a weak central government and is not able to control deforestation in its provinces. One province determines that the potential revenue from carbon credits makes it advantageous to participate in a REDD program. Although this province might have well-designed REDD projects that protect against leakage and impermanence, it has no control over forestry activities in the rest of the country. If deforestation rates increase in other provinces, its credit-generating projects would be diluted, and its incentive to invest in REDD projects would disappear. In this way, national-based REDD policies may discourage bottom-up participation.

Project-Based Policies

Project-based REDD policies could follow the model of the CDM, incorporating some of the lessons learned from forestry projects generating credits for the voluntary market. Project-based REDD policies could include both the project and the policy activities described earlier. Project developers could sell credits directly to the market or to third-party brokers. Protocols and methodologies, such as those developed by the Voluntary Carbon Standard, could ensure high-quality design to establish project baselines and minimize leakage (VCS 2007). Third-party entities could verify credit generation. Revenues would go to the project agents rather than being distributed by national entities, as in the national-based policies, above.

Advantages of project-based REDD policies: Project-based REDD policies would allow bottom-up participation by eco-entrepreneurs and progressive provinces that have invested in their capacity despite a lack of, organization, funding, and/or interest at the national level. Compared with national-based policies, project-based REDD policies more easily enable private sector involvement. Project-based REDD policies would initially be easier to implement, would accommodate different national circumstances, and would take advantage of within-country heterogeneity in capacity to implement REDD projects. A hypothetical investor in project development would maintain some control over the investment and might be more inclined to participate in the market.

Disadvantages of project-based REDD policies. Project-based REDD policies are smaller in scale than national-based policies, do not easily account for leakage, and do not clearly assign liability if emissions targets are not met. Given the magnitude of forestry emissions, project-based policies risk having a small impact. As is the case with the CDM, project-based REDD policies might not substantially engage developing countries in the climate change discourse and would not encourage developing countries to consider emissions commitments. Project-level REDD policies would have to address other shortcomings of the CDM, such as issues of additionality, the quality and robustness of credits, and whether sustainable development goals could be realized.

Hybrids

Numerous conceivable hybrid arrangements could enmesh the national- and project-based approaches described above. Below, two potential hybrid approaches are discussed. The first was proposed by Pedroni and Streck (2007) as the Nested Approach. The second is a variation of national-based approaches and pairs national-level commitments with project-level activities and payments.

Nested Approach. Immediate, project-based REDD activities would be paired with the eventual transition to a national-based REDD program. Such an approach would accommodate heterogeneity in the capacity to implement REDD programs by allowing subnational entities to generate credits through REDD projects. During the project phase, credits would be issued to project representatives. Hypothetically, the project phase would facilitate learning and capacity building and build momentum among country agents and among investors. After a given threshold—which could be based on forest area, as proposed by Pedroni and Streck (2007), or temporal—the country would transition to a national REDD policy in which accounting and credit generation would occur at the national level, and the national government would distribute credits appropriately.

The transition from project to national scope outlined in the Nested Approach takes advantage of existing capacity by subnational entities while maintaining focus on the magnitude of the issue, which can only be addressed by national-level commitments. Although this approach accommodates the real-world challenges to implementing effective national-based REDD policies, it is not clear that appropriate incentives exist to make the transition from project-level to national-level commitments. Additionally, once the transition is made to national accounting, investors may face disincentives to engage with national entities—similar to the disincentives they would have faced in outright national programs. Thus, there may be perverse incentives for the subnational entities and project investors to stall the transition to the national phase of the program. As a result, it may be more appropriate to have a temporal threshold: after **XX** years, a country must transition to national-based REDD program, barring extenuating circumstances.

National commitments with project-level investments. The success of REDD policies relies on the coordination between private interest in carbon credits and public interest in reduction of forestry emissions. Ideally, payments would be made to the landowner or user because it is this entity that must consider alternative uses for the land (Karousakis and Corfee-Morlot 2007). If potential payments for REDD activities are more than the potential returns from clearing the forest, landowners and users will find that conserving forests is in their best interest as well as the public interest. Because of investor reluctance to entwine investment returns with government performance, it is conceivable that project investors would prefer to work directly with the landowners and users. Given these interests, a REDD policy could pair project-level private investments with national guarantees of quality, additionality, permanence, and leakage management. The resulting credit revenues would be split between project agents and the government. In a hypothetical hybrid scenario, national governments would authorize private or public entities to develop and implement REDD activities and generate REDD credits. Private entities could invest in specific projects or portfolios of projects, free from government intervention. However, there would be a national reference rate of deforestation emissions to guarantee additionality. In payment for absorbing some of the risk, the government could charge a levy on the credits generated by the project. A question that needs to be addressed is how investors would be compensated if a project was successful but the host country missed its emissions target.

Consideration for Other Forest Carbon Activities

Much of the REDD debate focuses on countries with high deforestation rates. However, some argue that REDD activities must be included in a broad forest carbon policy that includes all activities that maintain or increase reserves of forest carbon (Terrestrial Carbon Group 2008). Such a policy would include reducing emissions in countries with high deforestation rates, increasing forest cover through AR activities, and maintaining forest carbon in countries that have low deforestation rates.

There are a cohort of countries with large forested areas that have low deforestation rates. If REDD policies focus only on countries with high deforestation rates, these countries might lack incentives to maintain low deforestation rates and may succumb to deforestation pressures that leak from countries with REDD policies in place (da Fonseca et al. 2007). One way to include these countries is to reward countries that have deforestation rates below the global mean or some other agreed-upon reference rate (Mollicone et al. 2007; da Fonseca et al. 2007). Da Fonseca et al. (2007) coined the phrase *preventive crediting* and estimate that such preventive credits would increase the potential supply of REDD credits by only 1.3 to 6.5 percent.[7] Although this begins to ameliorate concerns that preventive credits would swamp the REDD market, it assumes 100 percent reduction in forestry emissions. The da Fonseca et al. (2007) study provides a sense of the supply of preventive credits compared with the potential supply of REDD credits, but it raises questions about the impact of these credits on the REDD market at different carbon prices when deforestation is less than 100 percent.

One drawback of preventive crediting is that it may lead to "hot air." If countries that currently have low rates of deforestation are issued carbon credits as an incentive to keep deforestation rates low, they can sell their credits to Annex 1 countries to meet their obligations. In this way, preventive crediting may allow for *more* emissions than would be allowed otherwise. This effect would be more dramatic at low carbon prices: 100 percent of potential preventive credits can be issued at minimal carbon prices because there is initially no cost to continue the business-as-usual (BAU) practices that result in low deforestation rates. These are not additional emissions reductions; rather, they are emissions levels that would have occurred without incentives. At very low carbon prices, the total potential supply of preventive credits would be generated before the price rose high enough to fund a single REDD credit. This is not to say that preventive credits are not important or fair. As more countries enter into a REDD policy, preventive credits will deter transnational leakage[8] (discussed later in this chapter). As a result, restrictions on the supply of preventive credits may be necessary; otherwise it may not be appropriate to use the carbon market to create incentives to maintain current deforestation rates.

Given the limitations surrounding forestry credits under the CDM, activity in the forest credit market is small. Thus, there has been some discussion of including AR in a broader forest carbon policy with REDD activities. Internationally, the importance of biological sequestration through AR has been acknowledged. However, the current REDD debate has thus far deliberately excluded AR activities (UNFCCC 2007a, 2007b), presumably because of a reluctance to further complicate the already complex REDD debate. There may be more latitude in forthcoming U.S. climate change policies because in the current discussions, mention of biological sequestration does not distinguish among afforestation, reforestation, and avoided deforestation activities.

Scope Discussion

An international REDD policy does not necessarily have to limit itself to one of the three types of REDD activity—projects, policies, or sector activities—but could allow a spectrum of activities, acknowledging that countries differ in the pressures on their forests and their abilities to manage and monitor forests.

Whether it is of one type or a combination, a REDD policy could be built around either national commitments or project-based activities. Given the overarching objective to reduce carbon emissions, national commitments are better suited to reaching this goal. In reality, countries differ in their ability to implement REDD activities, and a purely national system might discourage participation by subnational entities that are able and interested in participating in a REDD market. Hybrid approaches that allow subnational participation can be designed to be inclusive, accommodating the differences among countries while also addressing the magnitude of the problem.

Forests are complex ecosystems that simultaneously sequester, store, and emit carbon. An umbrella forest carbon policy that included REDD activities, forest conservation activities, and AR activities would account for all of the carbon fluxes of forest ecosystems. However, it is complicated and time-consuming to design a policy for just one of these functions. Although ecosystem-based management is ideal, the realities of crafting environmental policies might impede the creation of ecosystem-based policies.

Monitoring

In recent years, the international climate change community has grown increasingly confident in the ability to measure deforestation. This is in contrast to a decade ago when concerns over the ability to monitor tropical deforestation and degradation drove some of the original reluctance to consider REDD as a measurable means of CO_2 mitigation. Since then, advances in monitoring methods and technologies have assuaged many of the initial concerns. At a 2006 workshop of the UNFCCC's Subsidiary Body for Scientific and Technological Advice, the convened experts concluded that the technology and methods currently exist to adequately measure deforestation, predominantly through remote sensing.

Nevertheless, cost-effectiveness remains an unresolved issue. The European Commission's Joint Research Centre notes that most remote sensing data are freely accessible on the Internet at a resolution of 20 to 30 m (Mollicone et al. 2007). Until now, much of the low-resolution data have been cheap because national governments have absorbed the cost of building and launching satellites, and the marginal cost of producing and processing images is low. The availability of cheap low-resolution imagery will continue as long as governments keep the current suite of low- to medium-resolution satellites updated; however, this is not guaranteed. High-resolution images are more expensive because of the technology needed for transmission, processing, and interpretation. Although the future cost of low-resolution imagery is uncertain, it appears that funds from the carbon market or some other source will be necessary to incorporate high-resolution imagery into a forest monitoring program.

The accuracy and cost-effectiveness of REDD monitoring relies on the intersection of three factors:

- the manner in which forest categories and carbon densities are defined, which affects the required resolution of remote sensing imagery, and thus the cost of monitoring;
- whether distinctions among forest categories can be monitored using remote sensing; and
- whether changes in carbon stocks can be calculated using a combination of remote sensing and carbon stock information.

Forest Categories and Carbon Density

A forest monitoring program begins with the definition of *forest*—essentially, what's in and what's out. Approaches that use simple, broad definitions and categorize land into a minimal number of forest categories (such as forest or nonforest) are easy and cost-effective but sacrifice accuracy in estimates of carbon stocks. With current technology, it is possible to have a more accurate monitoring program that incorporates multiple categories of forest, such as intact forest, nonforest, and levels of degraded and nonintact forest. However, such a scheme would require more high-resolution imagery and more ground-truthing, and thus would be more costly.

According to UNFCCC, a forest is defined by a minimum tree cover of 10 percent, though countries can choose more stringent crown cover criteria (DeFries et al. 2006). This binary, forest-nonforest classification makes monitoring through remote sensing relatively easy because determining whether a landscape has more or less than 10 percent forest cover is a fairly coarse estimate that can be measured with medium-resolution remote sensing imagery. However, this classification mechanism can also ignore forest degradation that might significantly deplete carbon stocks in what is categorized as a forest. For example, according to the UNFCCC definition, a forest with 100 percent tree cover could lose 70 percent of tree cover—and 70 percent of its carbon stocks—but still be categorized as a forest, with no acknowledgement that it is not a fully intact forest, or that carbon stocks have been degraded.

Forest degradation is important to consider in developing a monitoring program. Forest degradation is the reduction of canopy cover or biomass in a forest resulting from fire, logging, windfelling, or other such events. For all practical purposes, *degraded forest* is synonymous with *nonintact forest*. Forest degradation can account for a significant loss of carbon stocks and can be less costly to abate than deforestation (Trines et al. 2006). Although the inclusion of forest degradation in monitoring programs allows for more accurate measurements of carbon stocks, it also adds complexity and technical requirements. Forest degradation is more difficult to detect and has different driving forces than deforestation. It can be caused, for example, by gradual overuse by a large number of people in what is practically an open access arrangement. Studies have found that returns from this type of degradation activities are low, and that forest degradation can be abated with the establishment of a local governance institution (Trines et al. 2006). Degradation can also result from large-scale selective logging, which is more costly to abate.

Forest degradation can be defined by a tree cover criterion, a forest biomass criterion, or some combination thereof. The decision of how to define degradation and whether to monitor it will affect the cost and complexity of a monitoring program.

Mollicone et al. (2007) suggest a categorization scheme that divides land into *intact forest, non-intact forest, and nonforest,* based on a combination of canopy cover criteria and human impact criteria. This scheme accounts for the degradation of carbon stocks that can occur in forests. Although this scheme allows for more accurate accounting of carbon stocks, it is also more costly and more difficult to employ because of the higher-resolution imagery required to distinguish among forest categories.

Measurement of Distinctions Among Categories

A number of studies have concluded that current technology can accurately measure tropical deforestation (DeFries et al. 2005, 2006; UNFCCC 2006; Mollicone et al. 2007). However, continued monitoring capabilities rely on the successful launch of the latest Landsat sensor, scheduled for 2010, without which land cover monitoring will be compromised (DeFries et al. 2005). Existing data will allow for the establishment of baseline deforestation rates against which current rates can be compared (DeFries et al. 2005). Table 3.1 provides an overview of the technologies available to monitor deforestation.

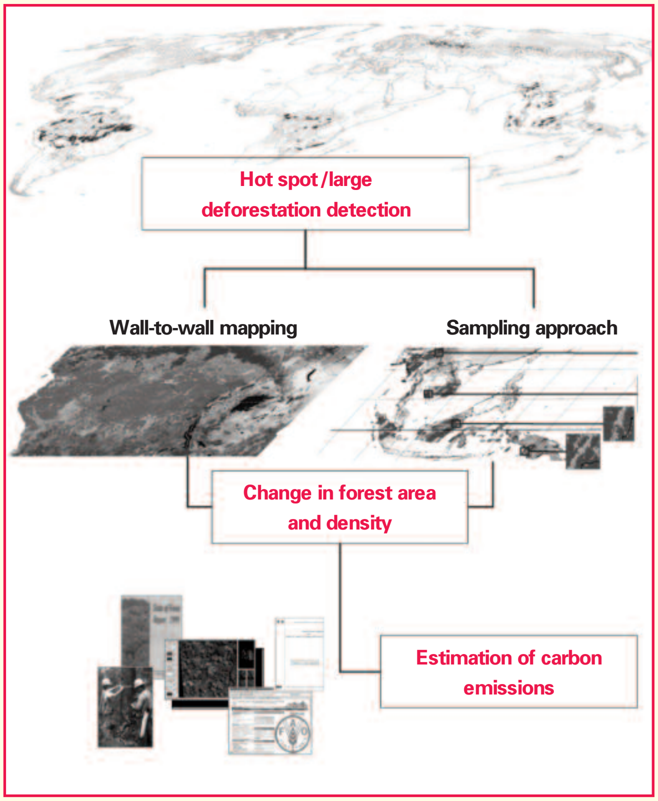
Geographic and ecological characteristics, such as seasonality of forests, slope, and cloud cover affect the choice of appropriate methodologies. For example, a deciduous forest in a temperate climate would have to be observed in the summer lest it appear not to meet a forest canopy criterion. Other types of forests would have to be monitored multiple times per year. Although no single methodology will be appropriate for all forest types, many suitable methods and protocols exist or can be developed through the adaptation of existing methodologies.

Table 3.1
Utility and Cost of Optical Sensors Currently Used to Monitor Deforestation

SENSOR RESOLUTION	EXAMPLES OF CURRENT SENSORS	UTILITY FOR MONITORING	COST
Very high (<5m)	IKONOS, Quickbird	Validation over small areas of results from coarser-resolution analysis	Very high
High (10–60m)	Landsat, SPOT HRV, AWiFs LISS III, CBERS	Primary tool to identify deforestation	Low/medium (historical) to medium/high (recent)
Medium (250–1000m)	MODIS, SPOT Vegetation	Consistent global annual monitoring to identify large clearings (>10–20 ha) and locate “hotspots” for further analysis with high resolution	Low or free

Source: reproduced from DeFries et al. (2006)

Figure 3.1 Conceptual Observation Framework for Monitoring Forest Changes and Related Carbon Emissions, Integrating Information from Different Data Sources



Global observations

- Global observations by medium-resolution sensors (250–1000 m) such as MODIS/ MERS
- Appropriate for the identification of hotspots of land-cover change: large fire and deforestation events (>10 ha)

Regional / national observations

Wall-to-wall mapping

- High-resolution sensors (10–60 m), such as Landsat, SPOT, CBERS, combined with ground-truthing and ancillary data
- Can identify areas of anthropogenic land-cover change (5–10 ha)
- Can be used to construct baseline

Sampling hotspots and forest degradation

- Very high-resolution sensors (<5 m), such as IKONOS and Quickbird; aerial photography; radar (SAR); LiDAR; visual/ digital interpretation of high-resolution images
- Can identify areas of anthro. land-cover change (<0.5–1 ha)
- Can identify carbon stocks

Fine-scale / in-situ observations

- Nat'l or regional forest inventories and FAO statistics
- Existing standard data from IPCC
- Plot-based sampling of carbon stocks (ground-truthing)
- Targeted remote surveys
- Models relating changes in forest biomass to changes in carbon stocks to carbon emissions

Notes: Due to practical limitations of monitoring, such as trained visual interpreters, algorithmic analysis by computers, and costs, methods exist to reduce the costs and time needed for analysis of remote sensing data. Routine "wall-to-wall" analysis that covers the entire forested area at high resolution allows for the identification of leakage; however, it may not be practical because of resource constraints. Alternatively, areas to be analyzed at high resolution can be identified through expert knowledge, "hot spot" identification by medium-resolution data and global observations, and/or statistical sampling. Information regarding carbon stocks in regional forests—which is available from FAO reports, forest inventories, and ground-truthing—informs estimates of carbon emissions.

Sources: image reproduced from DeFries et al. (2006); interpretation from DeFries et al. (2006) and Trines et al. (2006

Although the technological and methodological capabilities exist to monitor deforestation, high-resolution imagery and the associated analysis are often costly. To lower costs, different hotspot and statistical sampling methodologies have been developed to minimize the need for high-resolution images, outlined in Figure 3.1.

If forest degradation is defined by canopy cover, the methodologies to measure deforestation can be applied to forest degradation. However, forest degradation can be identified only with very high resolution imagery; thus, measurement of degradation is more costly and requires more visual image analysis than measurement of deforestation. If degradation is measured by other forest attributes, such as carbon stocks or ecological function, it will be less readily observable through remote sensing and will require ground-truthing or other measures.

Measurement of Changes in Carbon Stocks

A change in carbon stocks is a function of a change in the biomass of a forest. Changes in carbon stocks are not readily discernible with basic remote sensing methodologies and require a combination of ground-truthing and high-resolution remote sensing (Schlamadinger et al. 2005; Trines et al. 2006). Forest degradation and changes in carbon stocks become discernible when very high resolution sensors, aerial photography, RADAR, and visual interpretation of imagery are incorporated into the methodology. Moreover, measurement of changes in carbon stocks requires carbon data from national forest inventories, which are unavailable in many countries (Schlamadinger et al. 2005). These baseline inventories are generally costly to attain. There are also look-up tables that estimate the carbon content of a forest based on its region and type. Although inexpensive, these tables produce conservative estimates with high uncertainty.

Monitoring Discussion

Deforestation

The international climate change community now has confidence in the ability to monitor deforestation, predominantly through remote sensing technologies. Current technology and methodologies can be used to monitor deforestation at global, national, and subnational scales. Initial costs for national forest inventories and monitoring infrastructure (building and launching satellites) are high. Usually, infrastructure costs are absorbed by governments (and taxpayers) and marginal costs of production are low; thus, once these systems are in place, monitoring deforestation is satisfactorily cost-efficient. Currently, the United States, Europe, Canada, Japan, China, Brazil, Korea, Russia, Thailand and India have satellites that monitor changes in forest cover and land use. Private companies have different cost recovery and pricing schemes. Although remote sensing data from private companies are more expensive, it is conceivable that a company could negotiate a monitoring regime, with a consortium of nations contributing to the infrastructure cost.

Monitoring Infrastructure

The sensors and satellites currently used to monitor deforestation have a limited life expectancy. The continued ability to monitor deforestation using current methodologies relies on the successful launch of the Landsat sensor scheduled for 2010, and more generally the continued dedication to remote sensing programs. To date, there have been no cost-benefit analyses of remote sensing infrastructure in the context of climate change and the carbon market.

Forest Carbon Inventories

Measuring emissions from deforestation has three components. First, a forest inventory assesses the state and extent of a forest. A monitoring program must then monitor changes in that forest, ideally using a combination of remote sensing and field sampling on the ground. Information on changes in forest cover is not yet useful unless the carbon content of that forest is also known. Extensive field sampling is an accurate but costly way to get forest carbon information. A more cost-effective but less accurate alternative is to use look-up tables that estimate the carbon content for different types of forests. Estimates of carbon stocks for different types of intact forests are available in the literature (Houghton 2003a; Achard et al. 2004; FAO 2006; Mollicone et al. 2007). Although the methodologies for conducting forest inventories are established (the first step in monitoring forestry emissions), reliable forest inventories do not exist for some countries, and thus forest carbon inventories cannot be calculated.

Forest Degradation

Using a forest cover criterion to define forest degradation allows degradation to be monitored using remote sensing technologies, as illustrated in Figure 3.1. However, monitoring degradation is still more costly and more complex than monitoring deforestation. Although the challenges to monitoring forest degradation are great, degradation contributes significantly to forestry emissions, and the drivers of degradation may be easier to abate than the drivers of deforestation.

Additionally, information on the carbon stocks of degraded forests is poor. The lack of carbon data on degraded forests could be addressed by pairing very high resolution remote sensing with significant ground-truthing. Alternatively, rule-of-thumb assumptions could be made about the carbon stocks in a nonintact or degraded forest. For example, Mollicone et al. (2007) propose, for the sake of simplicity, an assumption that nonintact forests have half the carbon stocks of intact forests of the same type.

Baselines

For any type of REDD program to succeed, it must exhibit quantitative reductions of deforestation rates below baseline, or business-as-usual, scenarios. Thus, defining the baseline will significantly affect the "success" of a REDD program. To define baselines, one must address four questions.

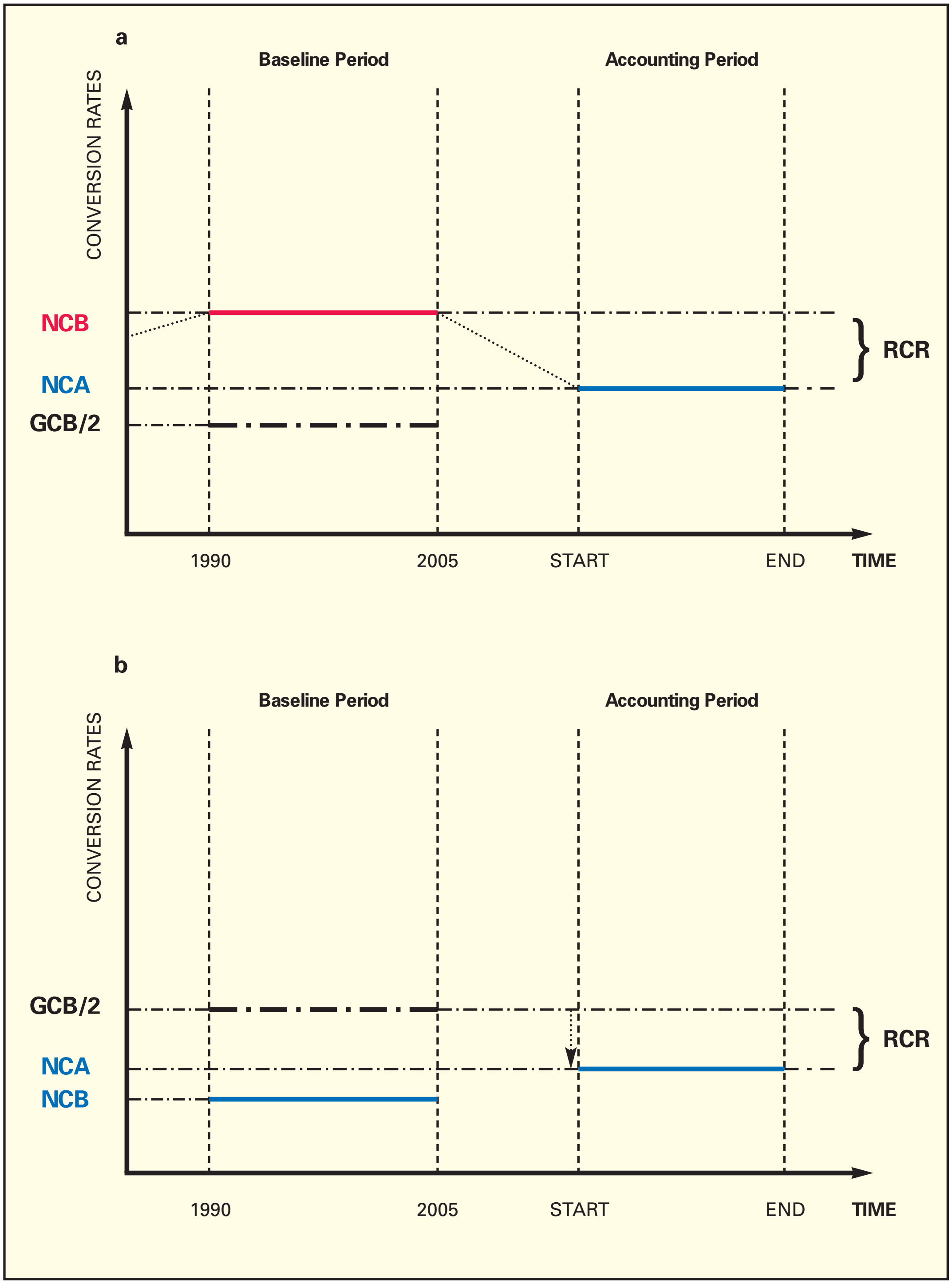
- Should baselines be at the project level or national level?
- Are the data sufficient to set a baseline deforestation rate?
- How should a baseline be set to maintain equity, encourage participation, and reduce the risk of hot air?
- Should baselines change over time?

Appropriate Geographic Scope for Baselines[9]

The choice of the appropriate geographic scope for setting baselines will be influenced by the fundamental decision of whether REDD policies will be project-based or national-based. If REDD policies are based on national emissions, national baselines would be appropriate. The host country would inevitably monitor the emissions of its portfolio of REDD projects, and thus would also establish project baselines. However, the national baseline would be the important one because the country would generate credits based on national deforestation rates compared with its national baseline. If REDD policies are project-based, baselines would have to incorporate areas that are at risk of leakage as well as the project area itself. Depending on the project size and the risk of leakage, a national baseline might be necessary. Project-based baselines would provide a BAU scenario

Figure 3.2
JRC Baseline and Crediting Scheme

Source: Figure courtesy Mollicone et al. (2007)



Notes: Examples of how credits could be generated for a country with a "high" forest conversion rate (a), and a country with a "low" conversion rate (b). GCB/2 (—·—·—) is the global reference rate against which national deforestation rates are compared.

In scenario (a), the country has a national baseline deforestation rate greater than the global reference rate. In the subsequent accounting period, they decrease their deforestation rate below their national baseline, and thus generate credits (RCR).

In scenario (b), the country has a national baseline rate less than the global reference rate. In the subsequent accounting period, they increase their deforestation rate. However, because the new deforestation rate is still less than the global reference rate, they generate credits proportional to the difference between the global reference rate and the new deforestation rate. Note that credits are generated as a function of the difference between the new deforestation rate and the global reference rate; the national baseline (NCB) serves simply to categorize this country into scenario (b).

against which to compare the actual deforestation rate. National baselines would also be necessary to determine if leakage occurred, meaning that reducing deforestation in the project site caused an increase in deforestation in other forests. The number of credits generated would have to be adjusted to account for that leakage.

Some proposed REDD policies require a global baseline against which national baselines could be compared (Mollicone et al. 2007). To create incentives for both (a) countries with high deforestation rates to reduce their rates of forest conversion and (b) countries with low conversion rates to maintain them, Mollicone et al. (2007) suggest a global reference rate.[10] In their scheme, for countries in category (a), credits are generated by decreases in national rates of deforestation; for countries in category (b), credits are based on the difference between the global reference rate and the national rate (Figure 3.2). Mollicone et al.'s (2007) global reference rate would be a component of a REDD policy based on national-level commitments.

Data for Setting Baseline Deforestation Rates

Remotely sensed data from aircraft and satellites dating back to the early 1990s are sufficient to measure changes in forest area with confidence (DeFries et al. 2006; Mollicone et al. 2007). Although data to set national and international forest cover baselines are available at relatively low cost, information on carbon stocks and forest inventories is not uniformly available. Degradation baselines are possible in some regions where information is available.

Maintaining Equity, Encouraging Participation, and Reducing Risks

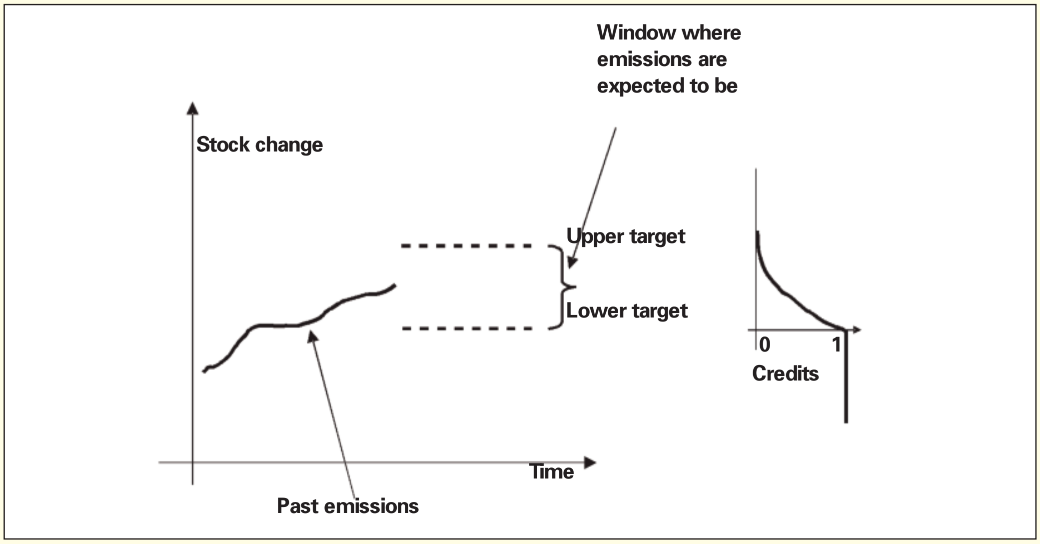
The baseline scenarios that will be advantageous, and thus politically preferable, to a country will depend on its historical and current patterns of deforestation. In all cases, deforestation is occurring within the context of natural cycles that affect forest cover. Therefore, any baseline that draws on historical rates must consider a large enough period to distinguish natural variation from anthropogenic forest change.

Using historical data from a defined period (such as 1990 to 2000) will avoid perverse incentives to increase short-term deforestation in anticipation of establishing baselines but might not capture current deforestation rates and trends. On the other hand, some countries may have faced historically low rates of deforestation because of political unrest (such as Democratic Republic of Congo and Colombia) but face deforestation pressure in the near future if the political situation stabilizes. However, using recent and projected rates of deforestation to create baselines would penalize countries that have successfully implemented forest conservation policies (such as Costa Rica) and reward those with weak governance institutions. This tension between helping the laggards and rewarding the leaders is a fundamental trade-off in all market policies. Although the inclination is to reward leaders for conserving their forests, doing so through the issuance of tradable carbon credits could lead to environmental harm because it would allow more carbon to be emitted than under BAU scenarios.

The capability exists to set objective baselines, but doing so might discourage participation. On the other hand, a negotiated liberal baseline that is more subjective might generate hot air and credits that are not the result of real reductions in emissions. Pfaff and Kerr (2007) argue that accurate baselines are essential to ensuring environmental integrity because both the seller and the

Figure 3.3
Target Band with Discounted Credits

Source: Image courtesy Schlamadinger et al. (2005)



Notes: Instead of a threshold baseline with a single emissions target, Schlamadinger et al. (2005) suggest a target spectrum that takes into account historic data and future projections. The graph on the right shows how credits would be discounted within the target spectrum based on their proximity to the bounds of the spectrum. Full credits would be generated only when emissions rates decreased below the lower bound of the spectrum.

Note that the baseline spectrum in this scheme is based on emissions and not deforestation rates or conversion rates, as seen in previously discussed proposals. However, hypothetically, this same model with a target spectrum, instead of a threshold, could be applied to overall emissions, forestry emissions, rates of forest change, and so on.

buyer would enjoy greater benefits from lax baselines and thus are incentivized to underestimate baselines to the detriment of emissions levels.

Schlamadinger et al. (2005) suggest an alternative involving a target band, or range, that captures a country's most likely emissions levels (Figure 3.3). Within this band, countries would generate discounted credits. The discount rate applied to the credit would change with proximity to the target bounds. Below the lower bound, countries could generate full-value credits for incremental emissions reductions. The upper bound would be set high enough that the probability of exceeding it would be low. The liberally set upper bound would ameliorate the risk of "run-away" noncompliance because a country would increasingly benefit from incremental decreases in emissions.

Baselines That Change over Time

Although baselines must remain constant for multiple compliance periods, there are some drawbacks to making baselines permanent. For example, after successfully implementing REDD programs over a period of time, a country will enter a new BAU scenario, and it might be appropriate to reevaluate the baseline. At the other end of the spectrum, if a country decides to participate in REDD programs but is not initially able to abate deforestation, its deforestation rate may move so far above its baseline that subsequent reductions in deforestation rates would not yield credits. Again, in such situations it might be appropriate to reevaluate the baseline. In sum, baselines that are adjusted over time would create the flexibility to adapt to new deforestation patterns and to correct any inaccuracies in the original baseline estimates and negotiations.

Baselines Discussion

Historic, remotely sensed data can be used to set baselines. However, because of heterogeneity in countries' recent patterns of deforestation and in the availability of forest carbon inventories, it will be difficult to find a single baseline methodology that is appropriate for all would-be participants.

Target Band

Employing a target band instead of a threshold baseline appears to accommodate the greatest range of forest change histories. However, a target band will make it difficult to generate full-value credits and identify leakage. A target band might not be accurate enough to ensure environmental integrity.

Threshold Baselines

Threshold baselines will facilitate the generation of full-value credits. When constructing threshold baselines, it is important to balance universal methodological principles with the circumstances of individual countries. Additionally, it is important to consider the effect on individual countries and the effect on the environment.

Leakage

IPCC's *Special Report on Land Use, Land-Use Change and Forestry* defines leakage as "the unanticipated decrease or increase in GHG benefits outside of the project's accounting boundary … as a result of project activities" (Watson et al. 2000, 5.3.3). In the context of the REDD debate, there is much concern over "negative leakage," in which reducing deforestation in one area would simply shift the deforestation activity to another area. If leakage occurs, benefits from a REDD project would be diluted by increased deforestation and increased emissions elsewhere such that there would be little or no net decrease in emissions at the national or global scale. Although leakage is a concern when considering REDD, leakage can occur in any sector affected by GHG mitigation. For example, in France, the cost of production for carbon-intensive products has increased because regulations in Europe limit carbon emissions. As a result, prices of some exports such as cement and steel have increased. Construction companies in Singapore may choose to purchase materials from China rather than France because China currently has no regulations limiting carbon emissions, making these products cheaper. As a result, the benefits from reduced carbon emissions in France would be diluted by increased carbon emissions in China. As with leakage in other sectors, leakage in the forest sector can be eliminated only by developing a global policy framework that applies everywhere.

The specific characteristics of the forestry project and the market driving deforestation will affect whether the risk of leakage is large or small. Generally, stopping deforestation driven by subsistence activities will risk smaller leakage than stopping deforestation driven by commercial markets. In the latter example, supposing the forest would be cleared for timber, decreasing deforestation may cause the market price for timber to increase just enough to make it cost-effective for others to cut down forests that they had previously conserved. This is called *market leakage* and is hard to manage because the price on the international market changes as supply and demand shifts. *Activity shifting leakage* occurs when the actual agents of deforestation go somewhere else. Activity-shifting leakage is easier to manage because the agents of deforestation are geographically bound. Activity-shifting leakage and market leakage are discussed in further detail in the following sections.

Chomitz (2006) argues that even where leakage is large, it is probably less than 100 percent. For example, for every 20 ha of forest protected from agricultural clearing, forest elsewhere may be cleared, but the area cleared will likely be less than 20 ha. Note that if leakage was greater than 100 percent, the project would be creating more harm than good by increasing the concentration of environmental carbon. It is possible that leakage can be minimized through project design and measures that encourage agricultural intensification in nonforested areas that can soak up the labor, commodity supply, and capital diverted by forest protections (Sohngen and Brown 2004; Chomitz 2006).

Activity-Shifting Leakage

Activity-shifting leakage occurs when the activity that caused the deforestation in a project area is displaced to a location outside the project boundaries. For example, farmers inside a conservation project area might shift operations and clear forests outside the project area. Activity-shifting leakage can be largely controlled at the project level through project selection and project design measures that address both the proximate causes of deforestation (land-use change and forest conversion) and the underlying drivers (e.g., poverty, agricultural policies, and land tenure) (Schwarze et al. 2002; Sohngen and Brown 2004).

The risk of activity-shifting leakage is a function of the physical mobility of the activity (including labor and capital) as well as the physical availability of forested land. For example, if capital is not available to invest in new deforestation activities, or if additional forest is not available to cut down, activity-shifting leakage will be less likely than if these circumstances were reversed.

Project design measures to minimize activity-shifting leakage would integrate forest conservation with sustainable development activities that would address the socioeconomic drivers of deforestation. For example, the Noel Kempff Mercado forest conservation project in Bolivia controlled activity-shifting leakage by pairing equipment retirement schemes (addressing the proximate causes of deforestation) with sustainable sources of firewood and local employment (addressing the underlying drivers) (Schwarze et al. 2002; Sohngen and Brown 2004). Thus it is possible to develop design standards and protocols to minimize the risk of activity-shifting leakage for a REDD project.

The Voluntary Carbon Standard (VCS)—a standard under which REDD projects selling credits in the voluntary market receive accreditation if they have met certain stringent criteria—outlines methodologies for calculating and accounting for leakage (VCS 2007). Under the VCS, predicted leakage must be calculated in the "leakage belt" and then subtracted from the potential number of credits generated (VCS 2007). The VCS requires that projects account for activity-shifting leakage, any increases in emissions due to measures implemented to prevent leakage, and increases in emissions due to the increased consumption of fossil fuels for implementing forest protection, monitoring, and surveillance tasks within the leakage belt (VCS 2007). Areas subject to leakage must be monitored throughout the duration of the project.

Market Leakage

Market leakage occurs when a project or policy changes the supply-and-demand equilibrium, causing market actors to shift. That is, if a project decreases timber supply, prices will rise, which will be met by increased supply (and increased deforestation) from outside the project area. The magnitude of market leakage is affected by the elasticity of demand and supply of forest and forest products.

If drivers of deforestation are commercial, such as timber production, supply is probably elastic, and a small increase in timber prices will increase timber harvests outside the REDD project area to meet timber demand on the world market. This will be especially true if perfect substitutes exist for the timber taken off the market and the timber was traded on a small, niche market where reduced supply in one locale will cause prices on the international market to increase. For example, if Bolivian mahogany is a substitute for Brazilian mahogany, and REDD policies in Brazil decrease the harvest of mahogany trees, harvest of Bolivian mahogany trees will be expected to increase to meet international demand. If supply is elastic, the risk of market leakage will be high. Leakage will be lessened if other operators respond to unmet demand by intensifying production without using increased land (Chomitz 2006, 2007). The risk of market leakage also depends on the size of the market and whether REDD policies affect global prices.

On the other hand, if drivers of deforestation involve subsistence, such as fuelwood harvesting and subsistence agricultural practices, the consumers of forest products are not part of an international market. With subsistence-driven deforestation, forests are often open access, and costs for forest resources are limited to the cost of effort to harvest wood or clear land. Activity-shifting leakage is a greater risk here but may be ameliorated through careful front-end project design. Although the market leakage risk is low for subsistence activities, REDD policies risk endangering individuals who rely on forests for their survival. Therefore REDD policies may need to provide subsistence forest users with substitute products and activities, such as solar cookers to replace fuelwood and intensive agricultural production on already cleared land to replace subsistence agriculture (Chomitz 2006).

Risk of market leakage will depend on the drivers of deforestation, demand elasticity, availability of substitutes, and the ability of other operators to intensify their production. Market leakage is not easily controlled but can be measured, modeled, and accounted for through discounting credits according to the estimated leakage (Sohngen and Brown 2004). However, modeling requires information on markets, which is unavailable in some developing countries.

At least two studies have attempted to estimate LUCF leakage in specific markets.

- Murray et al. (2002) estimated carbon leakage from afforestation, reforestation, and avoided deforestation projects in the United States to range from 10 percent in the Pacific Northwest to 90 percent in the Lakes States. Regional differences resulted from differences in forest and market characteristics.
- Sohngen and Brown (2004) found that potential in-country leakage from the Noel Kempff Mercado forest conservation project in Bolivia ranged from 5 to 42 percent without discounting carbon and 2 to 38 percent with discounting. Sensitivity analysis revealed that demand elasticity and wood decomposition rates have the largest effects on leakage calculations, with more elastic demand and higher rates of biomass decomposition leading to lower leakage.

Results from such case studies are not necessarily transferable because of the different scale of forestry projects, carbon characteristics of forests, drivers of forestry activities, mobility of capital in Annex I countries, and lack of mobility in non-Annex I countries. The examples do illustrate that leakage can be estimated based on the characteristics of the REDD project. It follows that projects could be selected based on leakage risks, and discount rates could be applied to the project credits to account for leakage. These discount rates could be adjusted as the project matures and actual leakage rates are measured.

Leakage and Scope

The decision of whether REDD policies will be project-based or national-based will affect how leakage is accounted for and mitigated.

- Under a project-based REDD policy, the risks of within-country leakage would have to be accounted for when issuing credits. Project leakage can be modeled and accounted for; however, the implementation of some REDD projects suggests that it is better to focus on the prevention and minimization of sources of leakage through understanding the drivers and agents of deforestation (Brown 2002). International leakage would also be an issue.
- Under a national-based REDD policy, within-country leakage is incorporated into the national accounting and credit generation (Schwarze et al. 2002; Santilli et al. 2005). International leakage to nonparticipating countries would still be an issue; however, it may be impractical to account for international leakage because a participating country cannot be penalized for the capacity of another country to resist deforestation pressure. In general, higher levels of participation internationally would reduce leakage, since there would be fewer recipient countries that would allow deforestation to leak across their borders.

Leakage Discussion

Leakage is a risk for REDD projects, as it is for any GHG-mitigating project. The magnitude of the risk depends on the project design, the market forces driving deforestation, the policies and market pressures affecting surrounding land, and the level of international participation in REDD programs.

Project leakage can be minimized through project selection, project design, and complementary measures that increase agricultural production intensity in other operations in nonforested areas. It may be possible to control most activity-shifting leakage through design measures that address the unique drivers of deforestation in each project area. Market leakage at the national level can be estimated using models that incorporate forest and market characteristics; however, data are lacking for some developing country forestry markets. In the Noel Kempff case, Brown (2002) found that it was better to prevent and minimize leakage from the outset than to quantify and account for it once it had taken place. For this reason, she recommends focusing on specific groups of people and dynamics rather than broader issues and geographic statistics.

Leakage can be incorporated into REDD accounting measures. The Voluntary Carbon Standard suggests that leakage be estimated and deducted from the number of credits available for sale. At the national level, leakage is incorporated into national accounting. Within-country leakage is not an issue for accounting. Although international leakage is a risk, it is not easily distinguishable from a recipient country's poor forestry practices and might not be able to be reasonably accounted for.

Stakeholder Interests in Credit Design

In designing REDD credits, it is important to consider how design elements such as fungibility, liability, and permanence will encourage or discourage market participation by project developers, potential suppliers (such as developing countries), and investors (such as investment banks, firms subject to emissions caps, and Annex I countries). Design elements must be carefully considered to avoid dampening the mitigation potential of REDD policies. Thus, it is important to understand the different and sometimes conflicting concerns of suppliers, investors, and society.

Project Developers' Interests

Project developers invest in REDD activities in developing countries. They may sell credits directly to firms or to a credit broker. Developers, and the firms that invest in them, are generally concerned about the ease of doing business in the countries where projects are located. Their concerns include the ease of starting a business, freedom from burdensome regulations and taxes, and any bureaucratic procedures or taxes that might affect their business. Project developers are unlikely to want to link investment returns to the performance of a central government in a developing country. Therefore, they are expected to prefer project-based REDD accounting and direct payments to the project agent rather than relying on the government to distribute benefits from credit revenues.

It is likely that many of the initial REDD projects will be developed, at least in part, by individuals and organizations from countries other than the host country. As a result, these project developers will also prefer countries that are open to foreign investment and do not penalize foreign companies operating in their countries. Further, project developers are concerned about the clarity of land tenure, since the success of their projects will rely on establishing a chain of custody for carbon credits.

Suppliers' Interests

Suppliers are the individuals, businesses, and governments implementing REDD activities that generate credits. Whether REDD crediting is national-based or project-based, suppliers are concerned with whether the potential credit revenues are sufficient to fund REDD activities. This is obviously a function of the credit price and the opportunity costs for alternative land uses, but it is also affected by any taxes or transaction costs that would reduce the funds actually available for the on-the-ground implementation and management of REDD projects.

In the case of national-level accounting, host countries also have specific concerns about national-level REDD policies:

- REDD credits may be at odds with domestic forests and land-use policies. Host countries are concerned about maintaining their ability to shift land-use strategies and priorities to take advantage of changing markets (Chomitz 1999). Some countries are concerned that REDD policies would detract from national economic development goals and even constrain their sovereignty to make domestic land-use decisions.

- Host countries do not want land-use decisions in their countries to be made by Annex-1 countries and the international community.
- In addition to generating sufficient revenues to fund REDD activities, REDD credits should allow revenues to be used for projects that include other co-benefits, such as sustainable development and biodiversity conservation.
- Host countries are concerned that binding emissions commitments in any sector may hamper economic development goals and are unjust, given Annex 1 countries' historical fossil fuel emissions.
- The initial transition from deforestation activities to REDD activities is likely to be capital intensive and will require initial financing before any credits can be generated.
- Host countries are concerned with how REDD policies align with existing in-country institutional capacity that might affect how REDD activities are implemented and benefits are distributed among stakeholders.

Some of these concerns may be overstated and reflect current uncertainty surrounding how REDD policies would be implemented. Although these concerns might be ameliorated with careful design of REDD policies, other concerns are more difficult to address.

Buyers' Interests

In a carbon market where REDD credits can be used to meet firms' regulatory obligations, buyers are the firms whose carbon emissions are regulated by a climate change policy. Whereas suppliers' interests are broad and encompass financing, sovereignty, and sustainable development issues that stretch from the national to the local scale, buyers' interests are much more focused on the credit's cost, its fungibility in global markets, and the management of risk that might result either from investing in foreign forestry policies or from a lack of integrity in the credit system. Buyers will be cautious about investing in REDD credits if the accounting or credit design casts doubt on the integrity of the credits. Some argue that buyers may prefer permanent credits to offset permanent emissions. Others contend that buyers would prefer temporary credits to bridge the transition to low-carbon technologies if future credit prices are expected to be lower than present prices.

Society's Interests

Ultimately, society as a whole is interested in the large-scale reduction of carbon emissions at low cost. At the global level, a ton of carbon that is emitted from a car's tailpipe is the same as a ton of carbon that is emitted from a burning forest. Generally, society is interested in attaining reductions in carbon emissions at a low cost and/or with the delivery of other co-benefits that it cares about. Whereas suppliers, buyers, and project developers would benefit from unreasonably high baselines so that many credits could be generated and sold, society's interest in environmental integrity demands strict baselines. High baselines would create hot air: credits for emissions reductions would be generated and traded, but these emissions reductions would have occurred in the absence of incentives from credits. Thus, the credits are not really additional to a BAU scenario, and the credits allow the emissions levels to exceed what they would have been without a crediting system. Given this potential for market failure, third-party entities must be involved in establishing baselines and verifying credit generation.

High-Quality Credits

Ex post, third-party-verified REDD carbon credits would ensure the environmental integrity of REDD credits and avoid hot air. Although ex post, third-party accounting ensures integrity, it will have higher transaction costs because of the required monitoring and accounting. Ex post accounting is necessary to verify and quantify changes in the deforestation rate. However, ex post accounting creates a challenge with generating initial funding. Financing REDD activities is discussed in greater depth in chapter 4.

A few front-end design standards and methodologies, such as the Climate, Community & Biodiversity Standards[11] and Social Carbon system,[12] require that REDD projects be audited by a third party to certify that they meet the criteria of the design standard. Certification under a design standard provides projects with a milestone that they can use to generate financing before any credits are generated.

Stakeholder Interest Discussion

Suppliers', buyers', and project developers' interests differ. Project developers are generally interested in the ease of doing business in the host country as well as securing financing before the project begins generating credits. As suppliers, host countries want to maintain sovereignty over land-use decisions, achieve sustainable development and ecosystem service co-benefits, have financing for the initial capacity building needed to implement REDD, and ensure equitable distribution of benefits among stakeholders. Buyers are interested in managing risk, reducing costs, and credit fungibility.

Society as a whole is interested in environmental integrity. Ex post, third-party-verified REDD carbon credits ensure that the environmental integrity of the system is maintained. Front-end design standards may also contribute to the delivery of high-quality credits.

Permanence and Liability

Questions of whether reduced emissions from deforestation can be considered permanent are part of the current debate about REDD. Concerns over permanence are rooted in the idea that emissions reductions are potentially reversible because of forests' vulnerability to fires, pest outbreaks, changes in management, and other natural and anthropogenic disturbances. Thus the gain from lower emissions in one year might be undone by exceptionally high emissions in a later year.

Currently, consensus is lacking as to whether this characteristic of forest carbon makes REDD inherently different from avoided fossil fuel emissions. On one hand, forest carbon is considered to carry a greater risk of impermanence, and the benefits of carbon storage in one time period risk being undone in a future time period (Chomitz 1999; Sedjo and Marland 2003; Watson et al. 2000). On the other hand, all emissions reductions carry some risk of impermanence that is, lowered emissions in one year somehow lead to higher emission rates in a future year. It can be argued that the permanence risks associated with forest carbon can be managed such that a reduction in forestry emissions is no different from a reduction in other emissions.

One reason for the uncertainty regarding permanence is that it is difficult to decouple issues of permanence from issues of scope – that is, whether REDD accounting will be project- or national-based. In a world of project-based REDD accounting and policies, focus would be on the carbon stocks within the confines of the project area. A project area would have discrete boundaries within which carbon stocks would be monitored. In this context, it is easy to imagine that an accidental fire or a deliberate decision to change land use could release carbon that had already been used to issue credits.

In a world of national-based REDD accounting and policies, focus would be on national emissions rates from deforestation and degradation. A country would manage a portfolio of land-use policies to reduce its rates of deforestation. Therefore, the focus would be not on preserving a specific unit of carbon within a specific stand of trees, but rather on the net change in forest cover. Although this REDD portfolio might contain some discrete projects, such as reserves, crediting would be based on changes in the national rate of deforestation and degradation, and nations could experiment with different combinations of land-use policies to attain the desired emissions rate. For example, reforming agricultural and transportation policies might not explicitly target specific forests for conservation (as would happen with geographically bound projects) but would nonetheless result in less deforestation. At the national level, many of the risks to project-level permanence would seem to average out, making it less of an issue. In other words, lower national emissions in one period would seem less likely to result in higher national emissions rates in the future.

What is a Permanent Emissions Reduction?

In the debate over permanence, the underlying question is whether lower emissions rates in one year are likely to result in raised emissions rates in a future year (suggesting an impermanent reduction), or whether the reduction will lead to permanently lower levels of carbon in the atmosphere. Permanence here does not mean that a specific atom of carbon will remain in a forest or oil reserve forever. "To the extent that the emission displacement propagates forward until the end of the time horizon, the result is a 'permanent' savings" (Watson et al. 2000, 2.3.6.2). To borrow an example from the IPCC's *Special Report on Land Use, Land-Use Change and Forestry,* suppose an individual replaced his traditional incandescent bulbs with compact fluorescents and avoided one ton of emissions over the life of the compact fluorescent bulbs. This benefit is permanent; there is no risk that the fossil fuel emissions will be accidentally released in subsequent years. The benefit will persist even if traditional incandescent bulbs are installed after the compact fluorescents burn out (Watson et al. 2000).

The light bulb scenario is illustrated in Figure 3.3A, which shows the impact of a one-time use of a compact fluorescent on the stock of fossil fuels, and Figure 3.4, which shows the impact on the rate of emissions. In Figure 3.3A, note that the reduction in emissions in the first time step causes the time path of consumption to shift out. After this first time step, the initial rate of depletion could resume, and stock levels would continue to decrease as oil is burned and CO_2 continues to be emitted. Although the reduction in fossil fuel consumption (and thus emissions rate) is temporary, the fossil fuel *stocks* in the ground are greater in every time step than they would have been without the one-time use of the compact fluorescent (the difference between the baseline stocks and the alternative stocks in Figure 3.3A). Thus, the overall reduction in the amount of CO_2 in the atmosphere is permanently less than it would have been without the use of the compact fluorescent bulb.[13]

Do Emissions Reductions from Deforestation Differ from Fossil Fuel Emissions Reductions?

Figures 3.3A and 3.4 clearly show how a one-time reduction in emissions rate can result in a permanent reduction in atmospheric CO_2. It is not a far stretch to substitute the light bulbs in the above example with tropical forests to understand how a one-time reduction in deforestation rates could lead to a greater area of standing forest in any given time period, and thus a permanent reduction in atmospheric CO_2. Reductions would be permanent as long as the baseline deforestation rate was not exceeded. It is important to note that as in the light bulb example, the emissions in the atmosphere are lower than the baseline, even though the forest is not permanently conserved.

Thus, whether a reduction in deforestation emissions has different permanence characteristics than a reduction in fossil fuel emissions depends on whether future deforestation rate are more likely than fossil fuel consumption rates to spike above the baseline after the reduction. This possible spike in deforestation rates is shown by Series C and D in Figures 3.5 and 3.6. Note that with a spike in deforestation rates, the forest carbon stocks may be greater or less than what they would have been in the baseline scenario depending on the timing, duration, and magnitude of the spike.

In a world of project-based REDD programs, one can imagine that the carbon benefits of one forestry project could be reversed if the carbon previously stored in the forest were released through burning, forest conversions, or other activities. One such incident could produce a deforestation spike of such great magnitude that it would nullify all previous benefits, and forest stocks would return to the baseline scenario. Thus, in the project-based world, it is easy to envision how emissions reductions could turn out to be impermanent.

However, in a world of national-based REDD activities or reforming land-use policies, a spike in deforestation rates is, theoretically, less likely because a national government would manage and monitor a portfolio of REDD policies and projects. Even if REDD activities are implemented flawlessly, it is possible that one activity might fail; however, it is less likely that all REDD activities within a country would fail simultaneously. The effect of an unexpectedly high rate of deforestation in one area could be moderated by successful REDD activities in another area, resulting in net decreases in deforestation emissions. To create a spike in emissions and undo a previous period of low deforestation, routine events occurring under the baseline—which likely include burning, forest conversion, and other activities—would have to occur at rates *higher* than the baseline rate, and it is not apparent why these rates would spike above the baseline rates.

Further, reducing deforestation within national-based REDD programs will require investments in new governance institutions and forestry management systems, just as reducing fossil fuel emissions requires capital investments in new technologies and information distribution. Although the costs of initial capacity building may be high because of the need to integrate REDD policies with sectors outside forestry, maintenance of these new forestry management policies may be easier and less costly than their initial implementation. Once these processes are in place, there may be some institutional lock-in or institutional inertia that would also maintain deforestation rates con-

Figure 3.3A

Effect of Light Bulb Use on Fossil Fuel Stocks

A: Baseline Stock (continued use of incandescent bulb)

B: Stock with one-time use of compact fluorescent

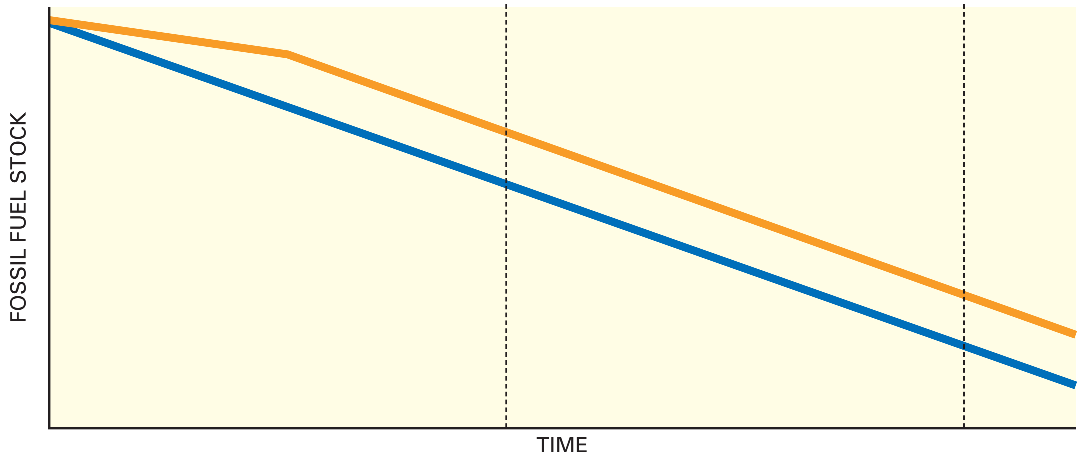
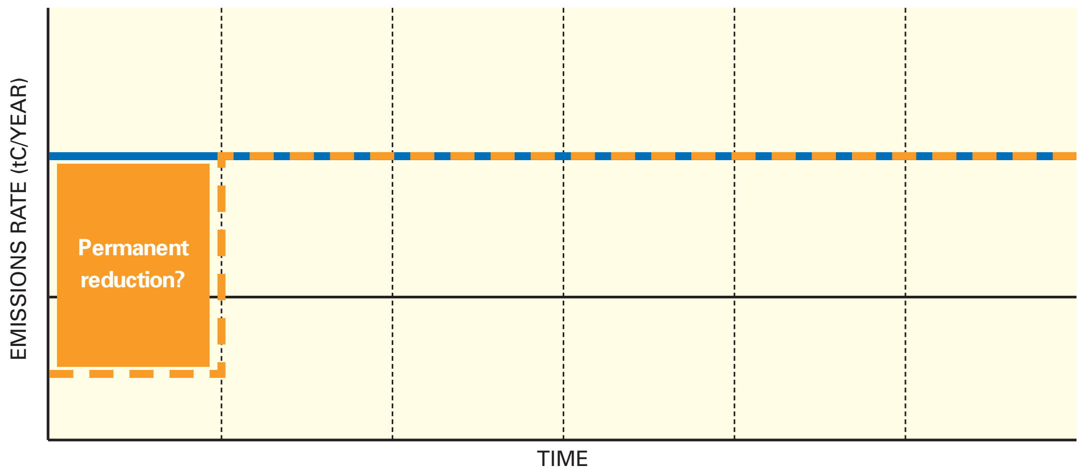


Figure 3.4
Effect of Light Bulb Use on Emissions Rates

A: Baseline Emissions Rate

B: Emissions Rate with one-time reduction



Notes: Series A in Figure 3.3A represents the time path to consumption of a fossil fuel stock using traditional incandescent bulbs, which results in a baseline emissions rate, shown in Figure 3.4.

Series B illustrates a temporary reduction in emissions rates caused by the one-time use of compact fluorescent bulbs, followed by replacement with incandescent bulbs and a return to the original emissions rates. Even though the reduction in emissions rate is temporary, the savings experienced in the initial year are carried through to the end of the time period, and the atmosphere has less carbon in every time step than it would without the reduction in the initial time period. Thus, there is a permanent increase in the fossil fuel stocks in every time step and a permanent decrease in the carbon in the atmosphere.

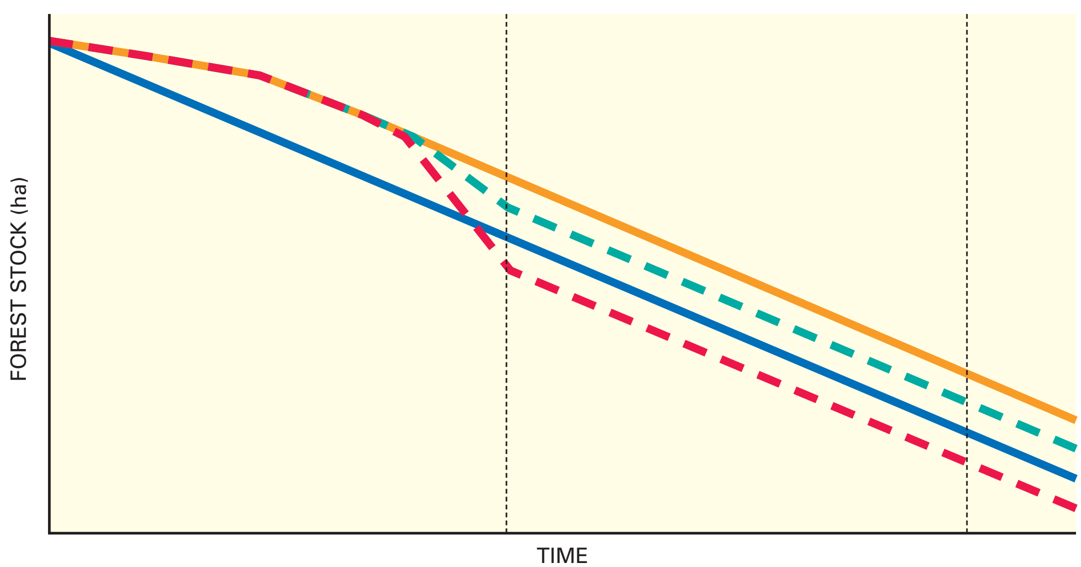
Figure 3.5
Forest Stocks under Different Deforestation Scenarios

A: Baseline Forest Stock

B: Stock with one-time reductions in deforestation

C: Spike in deforestation rate (alternate A)

D: Spike in deforestation rate (alternate B)



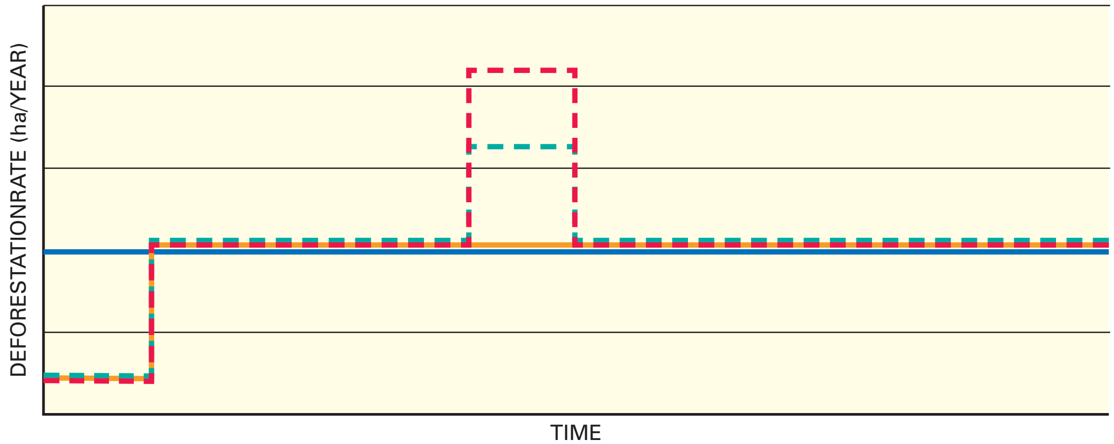


Figure 3.6
Deforestation Rates under Different Scenarios

A: Baseline Forest Stock
B: Stock with one-time reductions in deforestation
C: Spike in deforestation rate (alternate A)
D: Spike in deforestation rate (alternate B)

Notes: Series A is the baseline rate of deforestation – that is, what would occur if no mitigation action is taken.

Series B illustrates the effect of reducing the rate of deforestation for one year. Even though the deforestation rate returned to the baseline rate the following year, the savings experienced in the initial year are carried through to the end of the time period, and the atmosphere has less carbon in every time step than it would without the reduction in the initial year. As long as the deforestation rate does not go above the baseline, the benefit of one year's reduced emissions will be permanent.

Series C and Series D illustrate a spike in emissions rates followed by a return to baseline deforestation rates. Note that the magnitude of the spike determines whether some or all of the carbon benefits are lost. The extent to which carbon benefits would be reversed by a spike in deforestation rates depends on the timing, duration, and magnitude of the spike compared with the size of the stocks and the previous success in lowering deforestation rates.

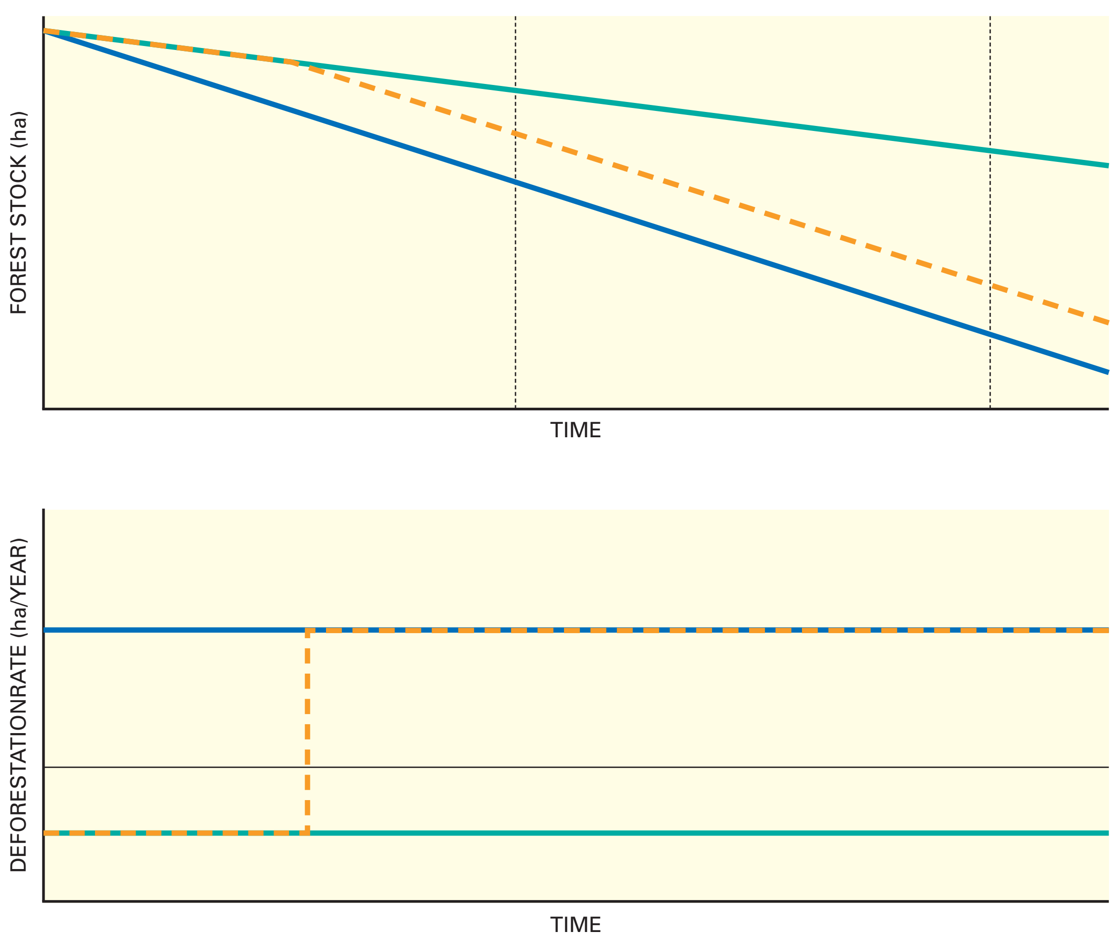


Figure 3.7
Forest Stocks and Deforestation Rates with Perpetual Reduction in Deforestation

A: Baseline Forest Stock
B: Stock with one-time reductions in deforestation
C: Stock with perpetual reduction of deforestation

sistently below their baseline and lessen the probability of future spikes in deforestation. In this way, there would be not only a shift in the rate of forest depletion, as portrayed in Figure 3.5, but also a flattening of the trajectory such that the forest is actually growing relative to the baseline,[14] illustrated in Figure 3.7.

One can argue that emissions rates from deforestation have greater uncertainty and variability than fossil fuel emissions rates. However, the uncertainty in deforestation rates may not be entirely different from the uncertainty present in predicting seasonal weather trends, which significantly affect energy use and fossil fuel burning. For example, an exceptionally cold winter followed by a hotter-than-normal summer might cause fossil fuel consumption to spike above baseline expectations, analogous to the potential spike that could be seen in deforestation rates. Further, some of the risks of uncertainty can be managed by requiring REDD countries to maintain reserve accounts, explained below.

Permanent Emissions Crediting

Permanent crediting could be appropriate in a national-based REDD policy scenario in which credits are issued based on national deforestation rates. A host country would commit to not exceeding a baseline rate of deforestation in exchange for access to the carbon market and the ability to sell credits for emissions, even with national-level crediting, the risk of exceeding the baseline deforestation rate remains. Thus, it is important to consider how to minimize the risk of impermanence and who bears the liability if emissions reductions turn out to be impermanent.

Buffers, Credit Banking, and Reserve Accounts

Because not all deforestation is controllable, buffering and banking mechanisms could be incorporated into REDD policies to ensure that credits are indeed permanent. *Buffers, credit banking,* and *reserve accounts* all refer to a similar arrangement in which a percentage of the credits that could be generated are held in reserve by a host country to counter the risk that deforestation will increase in the future. For example, if ex post verification determined that deforestation rates below the baseline had prevented the emission of 100 tons of carbon, 70 permanent credits could be traded on the carbon market, and 30 would be deposited in the reserve account. The percentage of REDD credits that could be deposited into the reserve account, or buffer, would be determined by the risk of the project and the number of years after the project's initiation. For example, a project occurring within a protected area that had adequate enforcement would have less risk and require a smaller reserve than a project outside a protected area. If deforestation rates increased above the baseline, the country could dip into its reserve account. Reserve accounts could be designed to be proportional to the number of credits a country generates. Thus, the quantity of required deposits into the reserve account would diminish as the reserve account grows. Reserve accounts, buffers, and credit banking are fundamentally the same as discounting REDD credits; however, they allow full-value credits to be issued.

Although most proposals envision a reserve account for each country, a pooled account may also be appropriate. An example of such a pooled account is the U.S. nuclear insurance fund, established by the Price-Anderson Nuclear Industries Indemnity Act, in which individual operators have limited liability up to a ceiling amount above which the Price-Anderson fund makes up the difference. The Price-Anderson fund is financed by obligatory contributions by the nuclear reactor companies themselves. Similarly, REDD projects could generate buffer credits that are deposited in national reserve accounts as well as an international pooled fund.

Permanent Credits with Host Country Liability

Some proposed REDD policies suggest that the host country accept liability if baseline deforestation is exceeded in any current or future time period: a country that exceeds its baseline deforestation rate would have to buy emissions reductions. However, with the reserve account arrangement, countries would draw upon their reserve in the case of impermanence, and then would replenish the reserve account during the next period when credits were generated. In the absence of host country liability, if REDD credits became impermanent, emissions reductions would be reversed and carbon in excess of target levels would be emitted into the atmosphere; essentially, the environment would be liable.

Permanent Credits with Nonbinding Commitments

Some of the resistance to permanent credits comes from developing countries that are opposed to taking caps on emissions; they argue that emissions caps will stifle needed economic development and that Annex 1 countries are responsible for the current pool of carbon in the atmosphere. However, it is possible to design a system with national-level accounting and crediting without binding emissions commitments (Philibert 2000; Philibert and Pershing 2001).

Instead of a national cap on deforestation emissions, one can imagine a nonbinding target rate of deforestation emissions. If deforestation emissions were below this reference rate, permanent credits could be issued and sold. If deforestation emissions exceeded this reference rate, no credits would be issued. No penalties would be imposed on the buyer or seller of the credits; however, no new credits could be issued until deforestation emissions returned to the reference rate.

This system of nonbinding commitments risks the introduction of hot air—and an increase in global emissions. This risk might be ameliorated by combining credits generated from nonbinding commitments with set-asides.[15] In this case, if the reductions turned out to lack permanence, they would have only a small effect on the overall emissions level because the credits would have been limited to the amount of the set-aside. The downside to set-asides is that they limit the number of REDD credits that can be used to meet emissions commitments.

Philibert (2000) and Philibert and Pershing (2001) propose another option for maintaining the integrity of a system using nonbinding commitments that could be employed with a REDD crediting system. A country could have two targets: one nonbinding, and one binding. The binding emissions target would be the higher one; it would be set high enough not to constrain economic growth. The nonbinding target would be set low enough that it would eliminate or greatly reduce the risk of hot air. The lower, nonbinding target would be the selling target, below which a country would sell credits. The higher, binding target would be the buying target, above which a country would have to purchase credits. If actual emissions were between the two targets, no trading could occur in either direction. A drawback of the two-target system is that parties would have little incentive to make any change in their deforestation practices unless they were close to one of the targets. If a country were between the targets, it would tend toward inaction. This drawback could potentially be remedied by allowing countries between targets to generate gradually discounted credits, as illustrated in Figure 3.2. Thus, incremental changes in deforestation rates would affect the number of credits issued.

The concept of a nonbinding target is attractive because it allows for national accounting, it allows developing countries to fully engage in the carbon market, and it can result in more ambitious targets than could be negotiated with binding commitments. On the other hand, because targets are not binding, certainty regarding the expected amount of the emissions reduction is low. A solution is to pair nonbinding commitments with reserve accounts so that integrity of the credits sold is not jeopardized if the country fails to meet its target emissions in the future.

Advantages and Disadvantages of Permanent Credits

The greatest advantage of permanent credits is their higher price compared with temporary credits or partial credits. Because of their higher price, permanent credits would be in greater supply; more forests would be protected from conversion to nonforests; the potential for co-benefits, such as biodiversity and sustainable development co-benefits would be greater; and the mitigating effect on this large source of emissions would potentially be much larger. Additionally, permanent credits could be fully fungible in the carbon market.

However, issues of liability and constraints on host country sovereignty must be seriously considered. Many potential host countries are opposed to making emissions commitments. Further, some countries argue that permanent credits will constrain their ability to take advantage of emerging high-end land uses (Chomitz 1999). However, in a world of national-based REDD policies, countries would constantly balance land-use policies to achieve target deforestation rates. Therefore, countries would still have flexibility to respond to changing international markets as long as they achieved overall deforestation goals.

REDD Credits in a Project-Based World

In a project-based REDD scenario, risks of impermanence are more difficult to manage, causing some to question the appropriateness of permanent credits (Marland 2001; Sedjo 2003). Three accounting mechanisms have been proposed to address the impermanent nature of reduced emissions from forestry projects. The tCER approach, or rental credit approach, employs a similar methodology to the short-term credit approach for forestry credits under the CDM. In the ton-year approach, credit would be given for the number of tons of carbon held out of the atmosphere for a given number of years, and an equivalency factor would be used to determine the climate effect of this temporary reduction compared with a permanent reduction. The third approach, suggested by the Voluntary Carbon Standard, uses reserve accounts, such as those described in the previous section.

tCERs, or the Rental Credit Approach

Even though reductions in deforestation rates may not be permanent, temporary reductions may still be valuable for all entities involved. Delaying the release of carbon delays radiative forcing and delays damages associated with climate change (Chomitz 2000; Watson et al. 2000). Temporary emissions reductions shift down the time path of temperature increases. Thus, every year, damages would be less than they would have been otherwise. If society has a positive discount rate, cumulative damages would be less (Chomitz 1999).

Because of a perceived lack of permanence and the potential reversibility of forestry projects (Neef and Henders 2007), CDM credits generated by AR activities are temporary: either short-term certified emissions reductions (tCERs) or long-term certified emissions reductions (lCERs). Both tCER and lCER projects must be reverified every five years, at which time additional credits may be generated.

Forestry tCERs are valid for one five-year interval, after which they expire and new tCER are issued upon reverification (Locatelli and Pedroni 2004; Neef and Henders 2007). lCERs are valid for the duration of the project (usually 30 to 60 years), at which point they expire and the buyer must replace them with permanent credits. lCERs are virtually nonexistent in the CDM market.

In a world of project-based activities, REDD credits could follow the tCER approach employed in the forestry CDM. REDD tCERs would be valid for one or more commitment periods, after which they would expire and new tCERs would be issued if reverification showed that deforestation rates had stayed below the baseline rate. Increases in deforestation rates would be met with decreases in the number of credits issued. If fewer credits were issued, the buyer would be responsible for finding a new source of emissions reductions, which is sometimes called buyer liability.

Marland et al. (2001) and Sedjo and Marland (2003) explain a tCER or rental credit in terms of a credit-debit system. An emissions credit is leased for a finite time period, at the end of which the renter will incur a debit unless the carbon remains sequestered and the lease is renewed. Marland et al. (2001) use the analogy of renting a parking space in a garage: at the end of the lease contract, the renter can either renew the lease and continue to park her car there, or she must find another arrangement as long as she is in possession of the car. "At the end of the rental period the renter would incur an emissions debit and the host would be released from further liability. If the carbon remained sequestered, the host could: (a) renew the lease at newly re-negotiated terms, (b) lease the credit to another Annex B party, (c) retain the credit for its own use, or (d) set free the sequestered carbon if it had a higher [value] use" (Marland et al. 2001, 265).

Temporary credits represent an attractive approach for investors who have a temporary need for credits until permanent credit-generating projects come online. It can be financially burdensome for firms to switch all technologies to low-carbon alternatives before the end of their natural life-cycle, especially while substitute technologies are still expensive. Temporary credits allow old technologies to run their course and do not necessitate premature replacement, thus creating a bridge to a low-carbon future by buying time for technological advancements and allowing for the gradual adoption of low-carbon technologies.

However, temporary credits are not attractive to investors looking for permanent offsets. Further, prices for temporary credits would be lower than for permanent credits and thus might not generate sufficient funds to finance activities to reduce deforestation. In fact, it is possible that temporary credits would be worth nothing in the current carbon market.

Temporary Credit—Does the tCER Have Enough Value?

The method for calculating the value of a REDD tCER is adapted from the method to calculate AR CDM credits explained in the *Guidebook to Markets and Commercialization of Forestry CDM Projects* (Neef and Henders 2007).

An investor will consider buying a REDD tCER if the price of a tCER today plus the present value price of a permanent credit (CER) upon the expiry of the tCER is equivalent to the cost of buying a permanent credit today:

$$p_{CER_0} = p_{tCER_0} + \frac{p_{CER_T}}{(1+d)^T}$$

Therefore, if the current and future prices of a CER are known, one can calculate the maximum price of a REDD tCER. The price of a tCER is affected by the discount rate (d), the expected future price of a permanent credit (PCERT), and the lifespan of the tCER (T). However, if the price of a permanent credit rises at the discount rate, a temporary credit would have no value:

$$P_{CER_T} = P_{CER_0} \times (1 + r)^T$$
$$r = annual \ \ increase \ \ in \ \ value \ \ of \ \ CER$$
$$if \ \ r = d$$
$$P_{tCER0} = P_{CER_0} - \frac{P_{CER_0} \times (1 + d)^T}{(1 + d)^T} = 0$$

Table 3.2 shows how a temporary credit could have zero value using a plausible credit price scenario. Although the future of U.S. climate policy is unknown, if a cap-and-trade system is put in place, the price for a carbon credit will equilibrate at some value. We use a permanent credit price at T=0 of $12. Table 3.2 shows the price at which a buyer would be willing to purchase tCER's based on three different expected future prices for a permanent credit. If a buyer believes that the price of a permanent credit will rise at a rate less than the discount rate—perhaps because of improvements in cost-effective monitoring or decreases in enforcement costs—she will be willing to buy a tCER. If a buyer believes that the price of a permanent credit will rise at a rate greater than the discount rate—perhaps because of increased demand due to more aggressive caps on emissions levels—she will not be willing to buy a tCER. And if the price of a permanent credit was expected to rise at the discount rate (five percent in this scenario) a temporary credit would be worth $0.

Ton-Year Approach

The ton-year approach is based on the premise that one ton of carbon released into the atmosphere decays over time until it is absorbed into the ocean or biosphere. The turnover time of carbon in the atmosphere essentially becomes the defining factor in determining a "permanent" reduction. This is the equivalency factor that relates a ton-year to a permanent reduction. For example, if a one-ton emissions reduction must persist for 100 years to be permanent, a one-ton emissions reduction for a one-year duration would be worth 1/100th of a permanent ton.

The ton-year approach raises a number of challenges. First, consensus has not been achieved regarding the appropriate equivalency factor. Values ranging from 42 to 150 have been suggested with logical reasoning for each (Marland et al. 2001). Second, ton-years are low-value compared with permanent tons and take a long time to accrue.

Table 3.2. Price of REDD tCER Given Different Future Prices of Permanent Credits

Permanent credit price at T=0 (P_{CER_0})	$12.00		
Permanent credit price at end of commitment period (P_{CER_T})	$13.91 (3% annual rise)	***$15.32 (5% annual rise)***	$18.46 (9% annual rise)
Discount rate	5%		
Length of commitment period or length of tCER (yrs) (T)	5		
Price at which buyer would be willing to purchase tCER (p_{tCER})	$1.10	***$0.00***	-$2.47

VCS and Reserve Accounts

To mitigate the risks of nonpermanence for project-based REDD activities and still generate permanent credits, the VCS employs reserve accounts, such as those described in the previous section. First, a project receives a risk rating based on seven types of risk factors. After determining the overall risk class of the project, the VCS provides a look-up table that suggests the percentage of a project's credits that should be held in a reserve account based on the risk class, shown in Table 3.3. Credits in the reserve account would be canceled if deforestation increased above the baseline.

Table 3.3 Reserve Account Size Based on Risk Class

RISK CLASS	BUFFER RANGE
High	20–30%
Medium	10–20%
Low	5–10%

Permanence and Liability Discussion

In a world of national-based REDD policies, impermanence risks are not inherently different from those of fossil fuel emissions reductions. These risks can be managed by balancing the national portfolio of REDD programs and through reserve accounts. In contrast, project-based REDD policies carry a greater risk of accidental reversal of carbon benefits than do national-based policies, and thus temporary or partial crediting may be appropriate. It is difficult to decouple issues of permanence from issues of scope, and it may be appropriate to consider the two simultaneously.

Temporary credits may have zero value. In a cap-and-trade system, it is likely that carbon prices will rise at the discount rate, at least for the foreseeable future. If carbon prices rise at the discount rate, temporary credits will have no present value ($0). Therefore, partial crediting, such as the ton-year approach and the VCS reserve accounts, might be a more appropriate means to account for temporary reductions in deforestation emissions than temporary credits.

Effect on the Carbon Market

From some perspectives, REDD-generated credits are envisioned as the low-hanging fruit of the carbon market, offering large quantities of cheap credits. It is posited that REDD-generated credits would increase the supply of carbon credits and thus reduce the price of carbon. If realized, this could reduce the cost of CO_2 mitigation. However, it could also reduce incentives to invest in clean-energy technologies, and thus delay the transformation to a low-carbon economy.

Recent optimization modeling research by Tavoni et al. (2007) shows that forestry credits, largely from REDD activities, could have a profound effect on the global cost of implementing climate change policy. Within the context of a 550 ppmv CO_2 stabilization target, forest sinks could contribute to one-third of the total abatement measures taken to achieve this target. Their model predicts that using forest sinks to meet emissions targets would decrease the price of carbon by 40 percent by 2050 and decreases the cumulative global cost of climate change policy by 50 percent, from 0.2 to 0.1 percent of global income (for the year 2070). By lowering the carbon price and the total cost of implementing target climate change policies, forestry displaces some abatement in the energy sector for the first 10–20 years, namely the deployment of low-carbon technologies in the energy sector such as carbon capture and sequestration and nuclear power (Tavoni et al. 2007).

Other studies find that forestry credits will have a more moderate effect on carbon prices and the deployment of low-carbon technology. Cabezas and Keohane (2008) analyzed the potential impacts of REDD credits on the carbon market using a spreadsheet-based tool developed by Environmental Defense. They found that allowing REDD credits to be used for compliance would lower the carbon price by 13 percent, and that a more expansive policy including all forestry activities could reduce the price by 33 percent. Despite these price impacts, Cabezas and Kepoane found that the carbon price would still be high enough to create incentives for low-carbon technologies. Under the expansive policy scenario, they found that carbon prices would be $16/tCO2 in 2012, $24/tCO2 in 2020, and $40/tCO2 in 2030. One of the crucial factors in their analysis was the ability to bank emissions reductions—meaning the "ability of regulated entities, in any given year, to save surplus allowances and credits for use in future years" (Cabezas and Keohane 2008, 4). Because they did not set any limits on the number of forest carbon credits allowed in the market, Cabezas and Keohane may overstate the price impact of REDD credits.

Credits from REDD could play a major role in achieving these emissions goals while keeping carbon prices relatively low. However, reducing compliance costs may not align with other social goals for the development of clean-energy technologies. Studies have shown that REDD credits are likely to displace some investments in low-carbon energy technologies that are more costly and would not be incentivized unless carbon prices were higher. In reality, many countries do not currently have the capacity to implement REDD activities. For this reason, forestry credits will likely have a much more moderate impact on carbon prices and abatement costs, at least initially.

It can be argued that emissions targets have three objectives: to reduce GHG emissions, to encourage other parties to achieve emissions targets, and to incentivize the development of low-carbon technology. The inclusion of REDD credits into the existing compliance carbon market helps achieve the first goal. REDD policies would shift the emissions abatement cost curve down resulting in an increase in the efficient quantity of emissions reductions. In other words, including REDD credits in the carbon market changes the "optimal" level of emissions reductions. By lowering the total cost of achieving emission reductions, it becomes better for society as a whole to set more aggressive emissions reduction targets. Coupling REDD credits with deeper emissions reduction commitments by Annex-1 countries would have little impact on the carbon price, and meet all three objectives of emissions targets.

Another potential means to address negative impacts that forestry credits might have on the carbon market is to create a price floor for carbon credits. This would ensure that the price of carbon would not sink below a given threshold, protecting the carbon market and also facilitating the conservation of more forests than would otherwise be conserved.

In the case of temporary credits, the potential exists for supply-side volatility. If it is uncertain whether temporary credits will be renewed, whether due to a host country's decision not to renew or the degradation of forest carbon, the sudden evaporation of the temporary credit supply could create a surge in demand for permanent allowances, causing price volatility. This risk is exacerbated with REDD credits because a small number of suppliers could have significant market power given the distribution of deforestation emissions. It is conceivable that such price volatility could be tempered with price ceilings or safety valves. Supply-side uncertainty could be addressed by scheduling renewal negotiations or verification measurements before the end of the current credit term so that buyers would have sufficient time to arrange for other allowances before their temporary credits expired.

Effect on the Carbon Market Discussion

REDD credits will probably decrease the overall cost of achieving emissions targets. Although this is generally a good thing, it may also result in the delayed development and implementation of low-carbon technologies in the energy sector. The displacement of low-carbon technologies could be ameliorated by tighter emissions targets and/or price floors. The potential impact of REDD credits predicted by models will be dampened by delays in host country readiness to implement REDD projects.

Temporary REDD credits could cause supply-side volatility due to the limited number of suppliers and Annex-1 countries' liability for permanent emissions. Such potential volatility could be addressed with price ceilings, safety valves, and strategic scheduling of emissions verifications and expirations.

Comparison of Current Proposals

Countries that are parties to Kyoto, countries that are not parties to Kyoto, and NGOs have all proposed REDD policies and mechanisms. Below is a discussion of five proposals that take different approaches to baselines, leakage, permanence, fungibility and capacity building. The discussion (summarized in Table 3.4) describes the basics of how REDD would be incorporated into the regulatory market under each scheme. This discussion is not meant to be an exhaustive examination of existing proposals, but rather to illustrate different approaches to address the issues facing REDD. All of the proposals discussed here are market-based REDD policies and use ex post verification of emissions reductions.

Compensated Reduction

The Compensated Reduction proposal was brought forward by Papua New Guinea and Costa Rica on behalf of the Coalition for Rainforest Nations[16] (Santilli et al. 2005). Under this approach, developing countries that reduce deforestation rates below a baseline rate generate credits that can be traded on the carbon market. REDD credits would be fully fungible with other types of emissions allowances. Verification of emissions reductions would be ex post, and no credits would be generated if deforestation rates were not reduced below the baseline.

Table 3.4 Five Proposed REDD Policies

Proposal	*Scope*	*Target*	*Quality assurance and risk management*
Compensated Reduction	National	Tropical deforestation	Permanent credits with reserve accounts
Joint Research Centre	National, global	Deforestation and forest conservation	Temporary credits
Nested Approach	Project, national	Tropical deforestation; unclear whether degradation is covered	Temporary or permanent credits at project level; permanent credits with reserve accounts at national level
Dual Markets Approach	National	Tropical deforestation and degradation	Separate market for REDD credits
Terrestrial Carbon Group System	National	All terrestrial carbon activities including deforestation, degradation, AR, and activities on peatlands	Required recategorization to protected terrestrial carbon when credits are generated; possible use of reserve accounts

Because Compensated Reduction is based on national participation and uses national deforestation rates to determine the number of credits generated, any within-country leakage is accounted for in the calculation of credits. The baseline could be constructed based on historical deforestation rates or on deforestation during a given period. Although initial participation would be voluntary, countries that generated REDD credits would agree to maintain or further improve reduced deforestation rates into the future. Thus, credits would be permanent and participating countries would be bound to maintain deforestation rates. The approach could incorporate reserve accounts to ameliorate the risk that a country's deforestation rate might increase; otherwise, participating countries would have to purchase credits abroad.

Verification of deforestation rates would rely on remote sensing augmented by ground-truthing. Emissions reductions would be calculated from a combination of forest change and biomass change. Using this methodology, carbon loss through forest degradation could also be calculated, though with more difficulty and cost.

Analytical support for Compensated Reduction comes from economic analyses published by Environmental Defense and the Amazon Institute for Environmental Research in *Tropical Deforestation and Climate Change* (2005) (Moutinho and Schwartzman 2005). These analyses indicate that in some countries with high rates of deforestation, forest protection could become economically competitive with alternative land uses at relatively low carbon prices (on the order of $5/ton). The analyses look at the breakeven price for carbon and do not consider transaction costs associated with implementing REDD policies.

Joint Research Centre Proposal

The European Commission's Joint Research Centre (JRC) proposal shares the basic elements of Compensated Reduction with three modifications. First, the JRC proposal incorporates forest degradation, measured using satellite-based methodologies, through three categories of forest change: intact forest to nonintact (i.e., degraded) forest, nonintact forest to nonforest, and intact forest to nonforest.[17] The changes in carbon stocks associated with these forest conversions would be calculated using figures for total carbon stocks for different types[18] of intact forests, which are available in the literature (Mollicone et al. 2007).

Second, the JRC proposal suggests that participating country baselines be relative to an average annual global forest conversion rate (in percentages); the intent is to incentivize countries with high conversion rates to reduce them and to incentivize countries with low conversion rates to maintain them. A global reference rate would be set at one-half of the global mean deforestation rate. Countries with conversion rates above the global reference rate would generate credits for reductions in conversion rates. Countries with conversion rates below the global reference rate would also generate credits as long as conversion rates remained below the global reference rate (see Figure 3.1). Thus this mechanism tries to reward countries that have already taken steps to reduce deforestation and to create incentives for forested countries to combat pressures to deforest. The advantages and disadvantages of including countries with low deforestation rates and issues facing the implementation of baselines are discussed in chapter 3.

Finally, the JRC proposal suggests the use of temporary credits, such as TCERs, which would shift liability to the buyer country and avoid the issues of permanence and sovereignty (Trines et al. 2006).

Nested Approach

The Nested Approach proposed by Lucio Pedroni of Centro Agronómico Tropical de Investigación y Enseñanza and Charlotte Streck of Climate Focus (Pedroni and Streck 2007) incorporates a national REDD policy with an initial project-based CDM-like mechanism, which, the authors argue, would allow countries to build capacity and transition to the national policy. The Nested Approach was designed to incentivize immediate action while accommodating differences in countries' current capacities to implement REDD activities.

Within the project phase, subnational, local, or project groups could implement REDD activities and generate credits. This approach includes project baselines and accounting for leakage. The project phase would allow either temporary or permanent credits. In the case of permanent credits, the project and government would share the credits, and the national government would maintain a reserve account to buffer against impermanence. Arguably, these subnational projects would simultaneously build in-country and investor momentum and learning to facilitate the eventual transition to national-level baselines and accounting.

Once the total project area of a participating country reached a certain level, the country would transition to the national REDD policies. The national phase of the Nested Approach is similar to the basic structure of the Compensated Reduction proposal. The national REDD policies would involve a national baseline and national target emissions rate. Credits generated during the national phase would be permanent and fungible with any other emissions allowance. Countries could allocate the credits to private entities and authorize them to trade the issued credits. A buffer in the form of a reserve account of REDD credits would be required to guarantee the permanence of emissions reductions. If a participating country exceeded its target emissions from deforestation and degradation after credits were generated, it could do one of the following:

- transfer credits from its reserve account;
- acquire credits from other countries;
- overcomply in a subsequent verification period; or
- request adjustment of the target level.

The Nested Approach acknowledges that many of the countries with the greatest need for international funding to support REDD activities do not have the capacity to implement these activities. Due to weak central governments, would-be investors are generally unwilling to link investment revenues to government performance. Therefore, private entities are more interested in investing in project-based activities that avoid some of the political and legal risks of a national program.

Dual Markets Approach

The Center for Clean Air Policy (CCAP) proposed the Dual Markets Approach, which creates a separate market for REDD credits outside the existing carbon market. Because of uncertainty in both the environmental integrity of REDD credits and the effect of REDD credits on the existing carbon market, the Dual Markets Approach protects the carbon market from any potentially adverse effects. In this approach, Annex I countries could allocate a portion of their overall cap to be met by REDD credits. REDD credits would not be fungible with other credits or allowances traded on the carbon market. In the example used by CCAP, Europe might commit to reducing emissions by 25 percent below 1990 levels through domestic reductions and the carbon market, and an additional 5 percent through the REDD market, for a total emissions reduction of 30 percent. The Conference of Parties would decide the maximum amount of REDD credits that an Annex I country could use to meet its obligations (Ogonowski et al. 2007).

It is expected to be costly for many developing countries to build the capacity to implement REDD activities. To send a clear signal to developing countries that the demand for REDD credits justifies the investment in capacity-building activities, Annex I countries will specify at the outset the developing countries from which they will buy REDD credits.

The theory behind the Dual Markets Approach is that market-based mechanisms provide the large sums of money necessary to support widespread REDD activities but may disrupt the existing carbon market. The approach allows the REDD market to develop without threatening the stability of the existing carbon market. Eventually, COP could decide to link the REDD market to the general carbon market, making REDD credits fully fungible. If an Annex I country does not have enough REDD credits to meet its REDD market commitment (5 percent in the example above), the country can buy credits on the general carbon market or borrow from future commitment periods. The major drawback of the Dual Markets Approach is that it would unnecessarily limit the amount of REDD activities that would be undertaken and thus limit Annex I countries' flexibility in meeting their emissions obligations.

Terrestrial Carbon Group System

Unlike the preceding four examples, the Terrestrial Carbon Group System is not a specific market-based proposal but is a way of accounting for REDD activities and other terrestrial carbon that could be incorporated into market-based and nonmarket-based proposals. *Terrestrial carbon* refers to all carbon that is stored in the terrestrial system, including but not limited to forests. The Terrestrial Carbon Group System focuses on maintaining existing terrestrial carbon and creating new terrestrial carbon and includes all terrestrial carbon activities that both sequester carbon and reduce emissions. As such, it creates incentives for AR activities, REDD activities, forest conservation, and other activities in forests and peatlands.

The system is based on national accounting of terrestrial carbon. It categorizes a country's total terrestrial carbon as either protected or tradable terrestrial carbon. Protected terrestrial carbon is "effectively protected from being emitted by law or by being inaccessible because of biophysical or economic constraints" (Terrestrial Carbon Group 2008, 9). It assumes that in a BAU scenario, all the tradable terrestrial carbon would be emitted over an extended time horizon (e.g., 50 years). Using the total amount of tradable terrestrial carbon and the expected time horizon, an annual terrestrial carbon budget can be calculated. The accounting system is relatively straightforward:

- All the protected terrestrial carbon must be retained.
- The annual terrestrial carbon budget can be emitted without penalty. If a country emits less than its annual terrestrial carbon budget, it can sell the difference as terrestrial carbon credits.
- To manage the risk of nonpermanence, the protected terrestrial carbon must be increased by the amount of credits sold. For example, a country that sold 50 terrestrial carbon credits in a year would have to permanently protect 50 additional tons of carbon. Note that the actual terrestrial carbon used to generate credits does not have to be recategorized as protected terrestrial carbon.

Rather, an amount equivalent to the number of credits must be protected, giving a country flexibility in where it allows deforestation and where it protects forests.

- If a country's emissions of terrestrial carbon exceed its budget, the country is in noncompliance. It can then purchase credits on the carbon market to stay in compliance, draw upon credits in its reserve account (if it has one), or withdraw from the system and stop generating terrestrial carbon credits. If a country withdraws from the system, it must make up the deficit before rejoining the system and generating carbon credits again.

CHAPTER 4

Host Country Issues

Much of this report has focused on the many design issues that must be resolved before deciding whether and how to incorporate REDD-generated credits into mainstream market-based climate change policies. It is equally important to understand the host country issues that must be addressed to successfully implement REDD activities. In this chapter, I summarize some important host country issues.

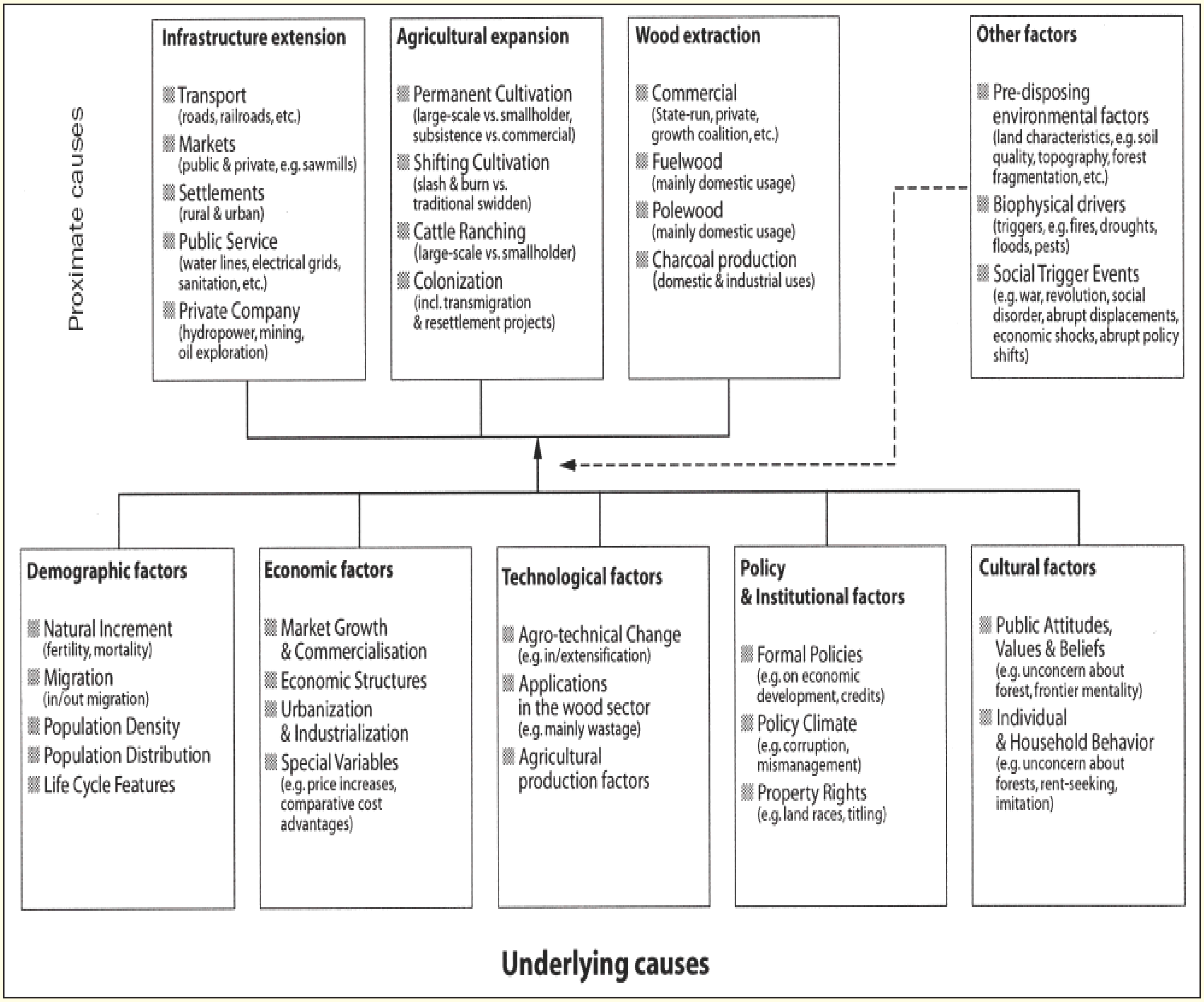
Drivers of Deforestation

For any REDD policy to succeed, the factors driving deforestation must be well understood. These factors and their interactions vary among deforestation cases, making generalizations difficult. In fact, the factors that drive deforestation in some circumstances do not play a role in others. Understanding the case-specific factors influencing deforestation is as important as securing the necessary funding to implement REDD activities. As previous projects in the forestry sector have shown, investing in forest conservation projects without understanding the causes of deforestation can waste resources and fail to slow deforestation rates (Chomitz 2007).

The driving forces behind tropical deforestation have been examined extensively in the literature. Two comprehensive reviews of existing studies on drivers of deforestation include the background document for the UNFCCC's Subsidiary Body for Scientific and Technological Advice workshop on the reduction of emissions from deforestation in developing countxries (UNFCCC 2006), and a thorough meta-analysis by Geist and Lambin (2001) that examines the proximate and underlying causes of tropical deforestation. A review of the major studies reveals that deforestation is driven by a number of direct and indirect factors that stretch beyond the forestry sector. Only a few drivers are globally universal. These drivers and other factors interact differently among regions and even among cases. In many cases factors related to economic development and the expansion of agriculture interact with other factors to drive deforestation.

In their analysis, Geist and Lambin (2002) offer a helpful chart (reproduced in Figure 4.1) for understanding how proximate factors and underlying drivers interact to cause deforestation. Proximate causes are human activities that directly affect the environment at the local level. Underlying drivers are social, economic, political, and/or cultural processes that indirectly cause deforestation. "Other factors" or predisposing conditions, such as soil quality and topography, also affect the likelihood of deforestation. The following discussion of the causes of deforestation follows Geist and Lambin's (2002) structure.

Figure 4.1 Causes of Deforestation



Notes: Five broad clusters of underlying driving forces (or fundamental social processes) underpin the proximate causes of tropical deforestation, which are immediate human actions directly affecting forest cover.

Source: reproduced from Geist and Lambin 2002, 144.

Proximate Causes

Proximate causes are the direct, immediate causes of the removal of forest cover and are often influenced by a combination of underlying drivers.

Agriculture

In the tropics, fertile land can be scarce, and the forest frontier offers untapped agricultural potential. The forest frontier is populated by poor and displaced people (UNFCCC 2006), and increasing population pressure on the forest frontier—from urban unemployment, for example—increases the pressure for agricultural expansion and deforestation. Agricultural expansion is a leading cause of tropical deforestation around the world and was a cause in 96 percent of the 152 cases of deforestation examined by Geist and Lambin (2002) (Geist and Lambin 2002; UNFCCC 2006). Agricultural expansion includes establishing permanent crops, cattle ranching, shifting cultivation, and colonization and resettlement on the forest frontiers. Although shifting cultivation is often identified as a major cause of deforestation, Tomich et al. (2005) found that permanent cropping and cattle ranching are equally influential. Cultivation of subsistence food crops dominates the forest clearing that is done for permanent agriculture (Geist and Lambin 2002).

Wood Extraction

Generally, logging alone does not lead directly to deforestation, yet when in concert with other factors it can cause forest conversion (UNFCCC 2006). Selective logging of trees with high commercial value contributes to forest degradation. Degraded forests may ultimately become deforested land; additionally, degraded forests are more susceptible to fire than intact forests. Although the effect of selective logging is less than that of clear cutting, it nevertheless requires roads and infrastructure, which are highly associated with deforestation. One-time logging is also used to clear land for agriculture. In Africa, frontier forests are cleared through harvesting for fuelwood and poles (Geist and Lambin 2001).

Transport Expansion

Road construction provides access to forests and is linked to deforestation. The absence of roads is a barrier to entry to forests. Without roads, timber operations, commercial agricultural businesses, and individual settlers would not be able to access and exploit forest resources beyond the forest frontier. The construction of roads opens up the forest interiors to exploitative activities. Other infrastructure, such as dams and market infrastructure, are not closely associated with deforestation.

Underlying Drivers

Underlying drivers of deforestation are the broader economic, political, technological, cultural, and demographic factors and the fundamental social processes that underpin the proximate factors of deforestation. Often the underlying drivers act in concert with one another to enable the proximate causes.

Economic Factors

Global and national economic factors play a prominent role in deforestation. Increased prices and expansion of agricultural markets increase deforestation pressure (Geist and Lambin 2001; Chomitz 2007). Commercialization of timber and other forest products also drives deforestation (Geist and Lambin 2001; UNFCCC 2006). Increased gross domestic product (GDP) may have a positive or negative effect on deforestation (Trines et al. 2006; Chomitz 2007). Market structures and market variables can also have varying effects, depending on how they affect the profitability of forest uses. Poverty and lack of employment may encourage deforestation via forest clearing for subsistence agriculture. On the other hand, payments for ecosystem services such as carbon and biodiversity may encourage forest conservation if they offset the benefits of deforestation and are directed to the appropriate parties.

Policy and Institutional Factors

Policy and institutional factors play a significant role in deforestation. In some cases, policies encourage deforestation through agricultural incentives, transportation and infrastructure development, urban expansion, and timber subsidies (Geist and Lambin 2001; Trines et al. 2006; UNFCCC 2006; Chomitz 2007). Weak governance institutions and corruption are associated with illegal logging in parts of Asia and with agricultural expansion in Latin America. Not only do weak institutions and corruption lead to deforestation, they also impede the development of local capacity to implement REDD projects. Poorly defined property rights and land tenure issues can result in open-access forests that are overexploited. However, establishing property rights may further encourage deforestation, depending on how property rights are assigned and how resources were historically used by the stakeholders. Chomitz (2007) suggests that land tenure issues be addressed while a forest is still intact—before it becomes a frontier forest subject to competing interests.

Technological Factors

Technological factors affecting deforestation include technologies to increase agricultural intensification and inferior technologies in the logging sector that lead to wasteful practices (Geist and Lambin 2001). Technologies that increase the profitability of agriculture can promote the expansion of agriculture into forested land that is less suitable for agriculture and would otherwise have resulted in marginal agricultural returns (Angelson and Kaimowitz 2001; Geist and Lambin 2001). Hypothetically, technologies that encourage the intensification of agriculture can decrease deforestation pressure by increasing productivity and employment on a given plot (Chomitz 2006). However, there is little evidence indicating that this trend is taking place, and if technologies cause more in-migration to the forest frontier, such technologies may encourage further deforestation (Tomich et al. 2005).

Cultural Factors

Geist and Lambin (2001) found that cultural factors contribute to the economic and institutional drivers that underpin deforestation. Cultural factors include attitudes and lack of public concern for forest conservation, as well as the willingness to continue historical forest practices such as burning.

Demographic Factors

Natural population growth alone has a minimal impact on deforestation. However, in-migration and colonization of the forest frontier increase deforestation pressures (Geist and Lambin 2002; Chomitz 2007).

Other Factors

Among the other factors affecting deforestation, predisposing environmental conditions can affect whether a section of forest will be selected for deforestation. Areas that are easy to access, have suitable topography for agriculture, and have high soil quality are more susceptible to deforestation pressure.

Regional Differences

Although the causes of deforestation vary around the world, some regional trends result from similar social, economic, and environmental conditions within a region (UNFCCC 2006). In Africa, population pressure drives agricultural expansion, which causes deforestation (Kaimowitz et al. 1998). Land rights are also a factor in Africa, where uncertain land tenure drives a shift from communally owned land to privately held land and results in deforestation caused by shifting agriculture (Geist and Lambin 2002).

In Latin America, land-use policies tend to favor agricultural expansion by medium and large operations (Kaimowitz et al. 1998; Geist and Lambin 2002; UNFCCC 2006). Cattle ranching is a main factor contributing to deforestation (Kaimowitz et al. 1998; UNFCCC 2006; Chomitz 2007).

In Asia, policies favoring logging and agriculture drive deforestation (Geist and Lambin 2002; UNFCCC 2006). Logging operations are carried out by larger entities, whereas agricultural expansion is carried out by small farmers (UNFCCC 2006).

Interacting Factors

Deforestation cannot be pinned down to one simple cause; rather, it is caused by a combination of proximate and underlying factors. The dynamics of these interactions are often location specific, and lessons gleaned from one locale do not necessarily translate to others. Although this makes generalizations about deforestation difficult, Geist and Lambin (2001) identified some trends in their analysis of 152 studies of deforestation. They found that deforestation was often associated with the interaction of three or four underlying drivers relating to two or three proximate causes:

- agriculture–wood–road proximate causes driven by economic, policy, institutional and cultural underlying drivers;
- agriculture–wood proximate causes driven by technological underlying drivers; and
- agriculture proximate causes driven by population expansion.

The agriculture–wood interaction was especially prevalent in Asian cases, and the agriculture–road interaction was especially prevalent in Latin American cases.

Despite those trends, each case exhibited unique interlinkages. Further, some factors were present in multiple cases but interacted differently according to local circumstances, making it difficult to distill an overarching theory of deforestation. In sum, deforestation results from the complex interaction of a number of factors. These interactions are influenced by local conditions such that drivers of deforestation must be examined on a case-by-case basis to design an appropriate REDD program.

Funding and Financing REDD Activities

Host countries face two challenges in financing REDD activities. First, many countries are neither ready nor able to implement REDD projects, even if funding were available. Before REDD projects can be designed and implemented, these countries must develop the capacity to assess forest carbon stocks, monitor deforestation, and enforce forestry policies. Additionally, because markets for REDD credits do not yet exist, host countries and investing entities will likely need some assistance as they proceed into uncharted territory and inevitably encounter unforeseen challenges.

Second, ex post third-party-verified credits are preferred in the forestry sector to ensure the environmental integrity of credits. However, host countries will frequently need up-front capital investments to implement the REDD projects that will eventually produce credits. At the time for verification, there is the risk that emissions will not have been reduced and credits will not be issued. Therefore, host countries must work with investors to create financing mechanisms that will provide the necessary initial capital and will manage the risk of project default.

A small number of forest carbon funds have recently been developed to address the first challenge and help countries build capacity and implement REDD projects. These funds are described below. Possible solutions to the second challenge come from the financial sector. I also explores two financing mechanisms that have been envisioned for REDD projects.

Forest Carbon Funds

BioCarbon Fund (World Bank)[19]

The BioCarbon Fund (World Bank 2007a) provides carbon finance for projects that sequester or conserve GHGs in forests, agro-ecosystems, and other ecosystems. The BioCarbon Fund tests and demonstrates how land use, land-use change and forestry (LULUCF) activities can generate high-quality emissions reductions with environmental and livelihood benefits that can be measured, monitored, and certified and will stand the test of time. Through its focus on biocarbon, or sinks, this fund finances the generation of credits in developing countries that comply with the CDM or JI, giving these countries access to the carbon market. Because of this objective, the BioCarbon Fund has focused mainly on AR projects and temporary credits. However, the BioCarbon Fund has been involved in some REDD projects.

The BioCarbon Fund is administered by the World Bank. It is composed of two tranches. The first tranche opened in May 2004 and raised $54 million; the second tranche opened in 2007.

Forest Carbon Partnership Facility (World Bank)[20]

The Forest Carbon Partnership Facility (FCPF) (World Bank 2007b) was launched in December 2007 at the Bali COP. It focuses specifically on assisting developing countries to reduce emissions from deforestation and degradation. The FCPF has two separate mechanisms with the objectives of (a) building capacity for REDD in developing countries, and (b) testing a program of performance-based incentive payments in some pilot countries—on a relatively small scale—to set the stage for a much larger system of incentives and financing flows in the future, which would presumably be funded by the market rather than the facility.

The Readiness Mechanism is expected to be $50 million and will fund capacity building in 20 countries. It will offer these countries technical assistance in developing baseline emissions rates, estimating forest carbon stocks, calculating opportunity costs of possible REDD interventions, and designing an adapted REDD strategy that takes into account country priorities and constraints. In July 2008, FCPF's steering committee selected 14 developing counties to receive funding through the readiness mechanism. The countries are in Africa (Democratic Republic of Congo, Gabon, Ghana, Kenya, Liberia, and Madagascar), Latin America (Bolivia, Costa Rica, Guyana, Mexico, and Panama), and Asia (Nepal, Lao PDR, and Vietnam).

The Carbon Finance Mechanism is expected to be $200 million and will fund the implementation and evaluation of pilot incentives for REDD. Countries would receive payments for reducing emissions below a reference scenario, and payments would be made only to countries that achieve measurable and verifiable emissions reductions.

The FCPF aims to create an enabling environment for REDD and amass a body of knowledge and experiences that can facilitate the development of a much larger global program of incentives for REDD over the medium term (5–10 years). If successful, the FCPF will catalyze institutional development and capacity building for a global REDD market. It will draw on methodologies from the BioCarbon Fund.

Global Initiative on Forests and Climate (Australia)[21]

The Global Initiative on Forests and Climate (GIFC) (Australian Greenhouse Office 2007) supports forestry projects in selected developing countries (particularly but not exclusively in the Southeast Asia and Pacific regions). This fund focuses on reducing deforestation, encouraging reforestation, promoting sustainable forest use, and developing monitoring and forest assessment technology and methodologies. The fund expects to explore financial incentives for REDD through pilot projects. The GIFC is based in Australia and expects to collaborate with other nations as well as the World Bank. This $200 million fund was launched on March 29, 2007.

Financing REDD Activities

Forest-secured escrow accounts and the sale of options for REDD credits are two financing mechanisms that have been proposed for REDD activities. Conceivably, a host of other financing mechanisms could be designed to provide initial capital and manage the risk for REDD activities.

Forest-Secured Escrow Accounts

The forest-secured escrow account scheme is based on a host country–investor partnership in which investment is in advance of credit generation, but full payment to the host country is ex post. Principal investments would go into an escrow account, and interest could be accessed by the host country as it accrues, with payout of principal and credits occurring at the end of the contract period (Schwarze and Niles 2000). Alternatively, frequent verification could facilitate the incremental issuance of credits and payments (consisting of principal and interest) for reduced emissions. Although the forest-secured escrow account addresses issues of permanence and liability, it will likely be unattractive to investors because it requires advance payment by investors in exchange for delayed returns in the form of credits, the quantity of which is not guaranteed.

Sale of Options for REDD Credits

In this financing mechanism, the host country would sell options to REDD-generated credits at a fixed price to generate up-front financing to fund REDD activities (Schlamadinger et al. 2005). Upon successful completion of the project and verification of emissions reductions, investors could choose to buy the credits at the guaranteed strike price. To maintain environmental integrity, the sale of options by the host country would be limited to a fraction of the project's expected emissions reduction (Schlamadinger et al. 2005).

Readiness to Implement REDD Policies

Although a significant focus at the international level is on policy and credit design, the success of REDD ultimately lies in the hands of host countries and their abilities to reduce deforestation. Therefore, it is important to consider the priorities and historical forest uses of stakeholders in the targeted forested regions. Further, policies must align with existing governance institutions, and institutional linkages must ensure that benefits from the generation of carbon credits reach local communities and stakeholders.

Some of the greatest challenges facing REDD are the varying national circumstances and capacities of would-be host countries. Many of these countries have been unable to stop deforestation in the past because of weak institutions and governance mechanisms that are not effective, transparent, or equitable. Even if sufficient funding is made available, these countries will be unable to successfully implement REDD activities unless they are able to strengthen forest management practices, align other land-use policies (such as agriculture) with forestry policies, and engage local stakeholders in the project design process.

Sustainable development and poverty alleviation are frequently cited as co-benefits of REDD activities. However, these benefits are unlikely to be realized unless REDD project design specifically incorporates them as goals and unless local stakeholders are incorporated into the design and planning processes.

The FCPF and the GIFC include specific goals to build capacity and improve host country readiness for REDD. Additionally, NGOs, such as the Center for International Forestry Research, are engaged in assessing and strengthening institutional readiness for REDD. Despite the paucity of pilot projects, lessons can be gleaned from previous efforts to abate deforestation; many of these efforts were driven by other environmental goals, such as biodiversity conservation and watershed maintenance.

CHAPTER 5

Conclusion

The integration of REDD into international market-based climate change policies faces challenges in international design as well as with on-the-ground readiness. This report has explored some of the issues that must be systematically addressed if an economically and environmentally sound REDD crediting scheme is to be developed. In the international policy and design realm, some of the issues, such as monitoring, have received greater consideration and attracted more consensus than others. Two issues that call for more attention and analysis are permanence and liability.

Although the integrity of REDD credit schemes depends on their design, the success of REDD policies ultimately will depend on host countries' abilities to reduce deforestation. For this reason, it is imperative that attention and research into host country readiness parallels efforts on the international design issues. Further, communities in forested regions in developing countries are some of the most important stakeholders because REDD policies will affect their livelihoods, and these stakeholders will likely be directly involved in the implementation and maintenance of REDD activities. Without stakeholder buy-in it will be impossible to achieve the environmental and sustainable development goals that are targeted by REDD activities. Therefore, efforts to link on-the-ground forest communities with REDD negotiations and planning at the international level will improve the chances for success.

ACRONYMS AND CONVERSIONS

AR	afforestation and reforestation
BAU	business as usual
CAIT	climate analysis indicators tool
CER	carbon emissions reduction
lCER	long-term carbon emissions reduction
tCER	temporary carbon emissions reduction
COP	Conference of the Parties (Kyoto Protocol)
CDM	clean development mechanism
CR	compensated reductions
FAO	Food and Agriculture Organization (United Nations)
FCPF	Forest Carbon Partnership Facility (World Bank)
GHG	greenhouse gas
GIFC	Global Initiative on Forests and Climate (Australia)
IPCC	Intergovernmental Panel on Climate Change
JI	joint implementation
JRC	European Commission Joint Research Centre
LUCF	land-use change and forestry
LULUCF	land use, land-use change and forestry
REDD	reduced emissions from deforestation and degradation
UNFCCC	United Nations Framework Convention on Climate Change

ha	hectare
Mt	megatonne
1 GtC	1 gigatonne = 1 Pg (petragramme) = 1000 Mt = 109 tonnes = 1015 grammes
1 tC	3.67 tCO_2
$10/tC	$2.72/$tCO_2$

NOTES

1 CAIT is the Climate Analysis Indicators Tool, an online database of GHG emissions data developed by the World Resources Institute (WRI). CAIT data come from the UNFCCC, Carbon Dioxide Information Analysis Center (CDIAC), Energy Information Administration (EIA), International Energy Agency (IEA), Earthtrends (WRI), the U.S. Environmental Protection Agency (non-CO_2 and carbon sequestration), Emission Database for Global Atmospheric Research (EDGAR), Special Report on Emission Scenarios (SRES), World Development Indicators (WDI) online (World Bank), Human Development Indicators online (United Nations Development Programme, UNDP), GEO Data Portal (United Nations Environment Programme, UNEP), and Central Intelligence Agency World Factbook. Estimates of CO_2 emissions from land-use change and forestry were developed by Houghton (Houghton 2003b) and based on the product of change in forest area and change in average forest biomass.

2 The ranking of LUCF CO_2 emitters differs significantly from a ranking of countries with the highest rates of deforestation because forest carbon density in forests varies in different countries and regions. For example, burning a hectare of forest in Southeast Asia will release more carbon than burning a hectare of forest in Africa.

3 The data in Figure 2.3 differ from data on GHG emissions published by UNFCCC. Although UNFCCC reports "official" emissions, the LUCF data are self-reported by individual countries, frequently contain outdated information, do not reflect uniform accounting methodologies, and are acknowledged to be imprecise; they serve as a default in the absence of more rigorous analyses. The CAIT data shown in Figure 2.3 incorporate Houghton's (2003a) "bookkeeping" analyses of LUCF emissions, which he employed systematically for all countries. Houghton's (2003a) methodology incorporates the self-reported deforestation data with other measurements of forest change and carbon stock.

4 Although UNFCCC and IPCC use a minimum crown cover of 10 percent to differentiate between forest and nonforest, individual countries can employ higher minimum standards. Many countries opt for a minimum crown cover standard of 30 percent.

5 Potential host countries were concerned that by undertaking REDD projects, they would commit themselves to certain land uses into perpetuity, and countries would lose the right to make future land-use decisions if, for example, the comparative returns on agriculture and REDD activities were to change in the future.

6 However, there has been a surge of interest in nonmarket-based financing, including Norway's $1 billion commitment to the Brazilian Amazon Fund.

7 According to IPCC's *Special Report on Land Use, Land-Use Change and Forestry,* leakage is defined as "the unanticipated decrease or increase in GHG benefits outside of the project's accounting boundary … as a result of project activities" (Watson et al. 2000, 5.3.3). Leakage is discussed further in chapter 3.

8 The potential supply of LUCF credits without preventive crediting is the amount of credits that would be generated if all deforestation emissions in developing countries were reduced to a target baseline.

9 Transnational leakage or international leakage means that reductions in deforestation in one country cause deforestation rates in another country to increase.

10 In some cases, subnational yet supraproject baselines might be appropriate, such as a baseline for the state of Amazonas in Brazil or for different islands in Indonesia.

11 A global reference rate is based on a global baseline (the average global rate of deforestation) but could be lower if it is decided that countries must perform significantly better than the global average to generate credits.

12 The Climate, Community & Biodiversity Standards evaluate land-based carbon mitigation projects and identify high-quality projects that will generate credible and robust carbon offsets while also achieving community and biodiversity goals; www.climate-standards.org/.

13 Social Carbon is a methodology that assess the social, environmental, and economic merits of carbon projects, developed by the Ecológica Institute in Brazil; www.socialcarbon.com.

14 This would not be the case if, for example, the lowered energy consumption from the compact fluorescent created market leakage by reducing energy prices so that demand for energy increased, and more energy was consumed somewhere else. This might arguably happen if, for example, significant increases in vehicle fuel economy lead to dramatically lower oil prices.

15 Note that the forest is growing in relation to the baseline; however, the forest will still be smaller than it was at the beginning of the REDD activities.

16 Set-asides are sometimes used for high-risk projects. With set-asides, a portion of the cap is earmarked for specific types of reductions or offsets, thus limiting the risk. For example, if a climate change policy defined a 2 percent set-aside for REDD projects, the risk of impermanence would be limited to 2 percent of the total cap.

17 Member countries in the Coalition for Rainforest Nations are Bolivia, Central African Republic, Chile, Congo, Costa Rica, DR Congo, Dominican Republic, Fiji, Gabon, Guatemala, Nicaragua, Panama, Papua New Guinea, Solomon Islands, and Vanuatu. The following countries participate in activities with the Coalition for Rainforest Nations but are not members: Bangladesh, Cameroon, Colombia, Ecuador, El Salvador, Ghana, Honduras, Indonesia, Kenya, Lesotho, Malaysia, Nigeria, Paraguay, Peru, Samoa, Thailand, Uruguay, and Uganda.

18 In *intact* forests, tree cover can range between 10 and 100 percent but must be undisturbed. There can be no timber extraction. In nonintact forests, tree cover must be greater than 10 percent, but there are signs of some timber extraction. *Nonforest* has less than 10 percent tree cover (Mollicone et al. 2007).

19 Types of forest are categorized by species and region.

20 http://carbonfinance.org/Router.cfm?Page=BioCF&ItemID=9708&FID=9708.

21 http://carbonfinance.org/Router.cfm?Page=FCPF&ItemID=34267&FID=34267.

22 www.greenhouse.gov.au/international/forests/index.html.

REFERENCES

Achard, F., et al. 2004. Improved Estimates of Net Carbon Emissions from Land Cover Change in the Tropics for the 1990s. *Global Biogeochemical Cycles* 18: 12.

Angelson, A., and D. Kaimowitz, eds. 2001. *Agricultural Technologies and Tropical Deforestation*. New York: CABI Publishing.

Anger and Sathaye. 2008. Reducing Deforestation and Trading Emissions: Economic Implications for the post-Kyoto Carbon Market. ZEW– Centre for European Economic Research Discussion Paper No. 08-016.

Asner, G. P., et al. 2006. Condition and Fate of Logged Forests in the Brazilian Amazon. *Proceedings of the National Academy of Sciences* 103(34): 12947–50.

Australian Greenhouse Office. 2007. Department of the Environment and Water Resources. Global Initiative on Forests and Climate.

Baumert, K. A., et al. 2005. *Navigating the Numbers: Greenhouse Gas Data and International Climate Policy.* Washington, D.C.: World Resources Institute.

Benitez, P. C., et al. 2007. Global Potential for Carbon Sequestration: Geographical Distribution, Country Risk and Policy Implications. *Ecological Economics* 60: 572–83.

Brown, S. 2002. Report of Leakage Analysis for the Noel Kempff Averted Deforestation Component. In *Land Use and Forest, Carbon Monitoring, and Global Change.* Arlington, VA: Winrock International and Ecosecurities Ltd.

Butler, R. A. 2007. A World Imperiled: Forces behind Forest Loss. *Tropical Rainforests: Imperiled Riches—Threatened Rainforests.* http://rainforests.mongabay.com. Retrieved July 12, 2007.

Cabezas and Keohane. 2008.Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD): Implications for the Carbon Market. Washington D.C.: Environmental Defense.

Chomitz, K. 1999. Evaluating Carbon Offsets from Forestry and Energy Projects: How Do They Compare? Policy Research Working Paper. Washington, D.C.: World Bank.

Chomitz, K. 2006. Policies for National-Level Avoided Deforestation Programs: A Proposal for Discussion. Washington, D.C.: World Bank.

Chomitz, K. 2007. *At Loggerheads? Agricultural Expansion, Poverty Reduction, and Environment in the Tropical Forests.* Washington, D.C.: World Bank.

da Fonseca, G. A. B., et al. 2007. No Forest Left Behind. *PLoS Biology* 5: 8.

DeFries, R. S. et al. 2002. Carbon Emissions from Tropical Deforestation and Regrowth Based on Satellite Observations for the 1980s and 1990s. *Proceedings of the National Academy of Sciences* 99(22): 14256–61.

DeFries, R., et al. 2005. Monitoring Tropical Deforestation for Emerging Carbon Markets. In *Tropical Deforestation and Climate Change,* edited by P. Moutinho and S. Schwartzman. Washington, D.C.: Amazon Institute for Environmental Research and Environmental Defense.

DeFries, R., et al. 2006. *Reducing Greenhouse Gas Emissions from Deforestation in Developing Countries: Considerations for Monitoring and Measuring.* Rome: Global Terrestrial Observing System (GOTS).

Denman, K., et al. 2007. Couplings between Changes in the Climate System and Biogeochemistry. *In Climate Change 2007: The Physical Basis. Contribu-*

tion of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel of Climate Change, edited by K. Boonpragob, M. Heimann, and M. Molina. New York: Cambridge University Press.

Enkvist, P.-A., et al. 2007. A Cost Curve for Greenhouse Gas Reduction: A Global Study of the Size and Cost of Measures to Reduce Greenhouse Gas Emissions Yields Important Insights for Businesses and Policy Makers. *The McKinsey Quarterly* 2007: 1.

Efstathiou Jr., J. 2008. Carbon Trading May Reward Indonesians for Saving Rainforest. Bloom berg.com, February 7. www.bloomberg.com/apps/news?pid=20601085&sid=aD1Vb_5uDGlA&refer=europe. Retrieved October 10.

FAO. 2006. Global Forest Resources Assessment 2005: Progress towards sustainable forest management. Forestry Paper. Rome: Food and Agriculture Organization of the United Nations.

G8. 2007. G8 Summit Declaration: Growth and Responsibility in the World Economy.

Geist, H. J., and E. F. Lambin 2001. *What Drives Tropical Deforestation: A Meta-Analysis of Proximate and Underlying Causes of Deforestation Based on Subnational Case Study Evidence.* LUCC Report Series. Louvain-la-Neuve: LUCC International Project Office.

Geist, H. J., and E. F. Lambin 2002. Proximate Causes and Underlying Driving Forces of Tropical Deforestation. *BioScience* 52(2): 143-150.

Greig-Gran, M. 2006. *The Cost of Avoiding Deforestation.* Report Prepared for Stern Review of the Economics of Climate Change. London: International Institute for Environment and Development.

Gullison, R. E., et al. 2007. Environment: Tropical Forests and Climate Policy. *Science* 316(5827): 2.

Hamilton et al. 2008. *Forging a Frontier: State of the Voluntary Carbon Markets 2008*. Washington D.C.: Ecosystem Marketplace and New Carbon Finance. May 8.

Houghton, R. A. 2003a. Revised estimates of the annual net flux of carbon to the atmosphere from changes in land use and land management 1850–2000. *Tellus* 55B(2): 378–90.

Houghton, R. A. 2003b. *Emissions (and Sinks) of Carbon from Land-Use Change.* Report to the World Resources Institute from the Woods Hole Research Center. Falmouth, MA: Woods Hole Research Center.

IPCC. 2000. *Land Use, Land-Use Change, and Forestry.* Special Report of the IPCC, edited by R. Watson, I. Noble, B. Bolin, et al. Cambridge, UK: Intergovernmental Panel on Climate Change.

IPCC. 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by S. Solomon, D. Qin, M. Manning, et al. New York: Intergovernmental Panel on Climate Change.

Kaimowitz, D., et al. 1998. Public Policies to Reduce Inappropriate Deforestation. In *Agriculture and the Environment: Perspectives on Sustainable Rural Development,* edited by E. Lutz. Washington, D.C.: World Bank, 303–22.

Karousakis, K., and J. Corfee-Morlot. 2007. Financing Mechanisms to Reduce Emissions from Deforestation: Issues in Design and Implementation. Organization for Economic Co-operation and Development. COM/ENV/EPOC/IEA/SLT(2007)7.

Kerr, S., et al. 2001. The Dynamics of Deforestation and the Supply of Carbon Sequestration: Illustrative Results from Costa Rica. *In Central America Project, Environment: Conservation and Competitiveness,* edited by T. Panayotou. Cambridge, MA: Harvard University Press.

Kindermann, G. E., et al. 2006. Predicting the Deforestation-Trend under Different Carbon-Prices. *Carbon Balance and Management* 17.

Locatelli, B., and L. Pedroni 2004. Accounting Methods for Carbon Credits: Impacts on the Minimum Area of Forestry Projects under the Clean Development Mechanism. *Climate Policy* 4: 193–204.

Marland, G., et al. 2001. Accounting for Sequestered Carbon: The Question of Permanence. *Environmental Science & Policy* 4: 259–68.

Mollicone, D., et al. 2007. An Incentive Mechanism for Reducing Emissions from Conversion of Intact and Non-intact Forests. *Climate Change* 83: 17.

Mongabay.com. 2008. Norway offers $1 billion towards saving the Amazon rainforest. September 17. Retrieved from http://news.mongabay.com/2008/0917-brazil.html.

Moutinho, P., and S. Schwartzman. 2005. *Tropical Deforestation and Climate Change.* Washington, D.C.: Environmental Defense and IPAM.

Murray et al. 2002. Estimating Leakage From Forest Carbon Sequestration Programs. RTI International Working Paper 02_06. Research Triangle Park, NC: RTI International.

Nabuurs, G. J., et al. 2007. Forestry. In *Climate Change 2007: Mitigation of Climate Change. Contributions of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* edited by M. Apps and E. Calvo. New York: Cambridge University Press.

Neef, T., and S. Henders. 2007. *Guidebook to Markets and Commercialization of Forestry CDM Projects*. Turrialba, Costa Rica: Centro Agronomico Tropical de Investigacion (CATIE).

Nepstad et al. 2007. The Costs and Benefits of Reducing Carbon Emissions from Deforestation and Forest Degradation in the Brazilian Amazon. Falmouth, MA: Woods Hole Research Center.

Ogonowski et al. 2007. Reducing Emissions from Deforestation and Degradation: The Dual Markets Approach. The Dialogue on Future International Actions to Address Global Climate Change (Future Actions Dialogue) Working Papers. Washington D.C.: Center for Clean Air Policy.

Osafo, Y. B. 2005. Reducing Emissions from Tropical Forest Deforestation: Applying Compensated Reduction in Ghana. In *Tropical Deforestation and Climate Change,* edited by P. Moutinho and S. Schwartzman. Washington, D.C.: Environmental Defense, 63–72.

Osborne, T., and C. Kiker. 2005. Carbon Offsets as an Economic Alternative to Large-Scale Logging: A Case Study in Guyana. *Ecological Economics* 52: 481–96.

Pedroni, L., and C. Streck. 2007. Mobilizing Public and Private Resources for the Protection of Tropical Rainforests: The Need to Create Incentives for Immediate Investments in the Reduction of Emissions from Deforestation within the International Climate Change Regime. Rotterdam, Netherlands: Climate FOcus and Centro Agronomico Tropical de Investigacion (CATIE).

Pfaff, A., and S. Kerr. 2007. What Would Have Happened: Reviewing and Improving Estimated Baselines for Tropical Forests and Sequestered Carbon. Unpublished manuscript.

Philibert, C. 2000. How Could Emissions Trading Benefit Developing Countries? *Energy Policy* 28: 947–56.

Philibert, C., and J. Pershing. 2001. Considering the Options: Climate Targets for All Countries. *Climate Policy* 1: 211–27.

Richards, K. R., and C. Stokes. 2004. A Review of Forest Carbon Sequestration Cost Studies: A Dozen Years of Research. *Climate Change* 63: 48.

Santilli, M., et al. 2005. Tropical Deforestation and the Kyoto Protocol: An Editorial Essay. *Climate Change* 71: 10.

Sathaye, J., et al. 2005. GHG Mitigation Potential, Costs and Benefits in Global Forests: A Dynamic Partial Equilibrium Approach. Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory.

Schlamadinger, B., et al. 2005. Should We Include Avoidance of Deforestation in the International Response to Climate Change? In *Tropical Deforestation and Climate Change,* edited by P. Moutinho and S. Schwartzman. Washington, D.C.: Amazon Institute for Environmental Research and Environmental Defense.

Schwarze, R., and J. O. Niles. 2000. The Long-Term Requirement for Clean Development Mechanism Forestry and Economic Liability. *Journal of Environment & Development* 9(4): 21.

Schwarze, R., et al. 2002. Understanding and Managing Leakage in Forest-Based Greenhouse-Gas-Mitigation Projects. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences* 360(1797): 19.

Sedjo, R., and G. Marland. 2003. Inter-trading Permanent Emissions Credits and Rented Temporary Carbon Emissions Offsets: Some Issues and Alternatives. *Climate Policy* 3: 435–44.

Sedjo, R., and A. Solomon 1989. Climate and Forests. In *Greenhouse Warming: Abatement and Adaptation,* edited by N. Rosenberg, W. Easterling, P. Crosson, and J. Darmstadter. Washington, D.C.: RFF Press: 105–19.

Sedjo, R., et al. 2001. Estimating Carbon Supply Curves for Global Forests and Other Land Uses. RFF Discussion Paper. Washington, D.C.: Resources for the Future.

Sierra, C. A., et al. 2007. Spatial and Temporal Variability of Net Ecosystem Production in a Tropical Forest: Testing the Hypothesis of a Significant Carbon Sink. *Global Change Biology* 13(4): 838–53

Silva-Chavez, G. 2005. Reducing Greenhouse Gas Emissions from Tropical Deforestation by Applying Compensated Reduction to Bolivia. In *Tropical Deforestation and Climate Change,* edited by P. Moutinho and S. Schwartzman. Washington, D.C.: Environmental Defense, 73–86.

Sohngen, B., and R. H. Beach. 2006. Avoided Deforestation as a Greenhouse Gas Mitigation Tool: Economic Issues for Consideration. Unpublished manuscript.

Sohngen, B., and S. Brown. 2004. Measuring Leakage from Carbon Projects in Open Economies: A Stop Timber Harvesting Project in Bolivia as a Case Study. *Canadian Journal of Forestry Research* 34: 11.

Sohngen, B., and R. Sedjo. 2006. Carbon Sequestration in Global Forests under Different Carbon Price Regimes. *The Energy Journal* (Multi-Greenhouse Gas Mitigation and Climate Policy Special Issue): 109–26.

Stern, N. 2007. *The Economics of Climate Change: The Stern Review. Cambridge,* UK: Cambridge University Press.

Strassburg et al. 2008. An Empirically-Derived Mechanism of Combined Incentives to Reduce Emissions from Deforestation. CSERGE Working Paper ECM 08-01.Norwich, UK: Centre for Social and Economic Research on the Global Environment.

Tavoni, M., et al. 2007. Forestry and the Carbon Market Response to Stabilize Climate. Climate Change Modeling and Policy Working Papers, Fondazione Eni Enrico Mattei (FEEM): 17.

Terrestrial Carbon Group. 2008. How to Include Terrestrial Carbon in Developing Nations in the Overall Climate Change Solution.

Tomich, T., et al. 2005. Balancing Agricultural Development and Environmental Objectives: Assessing Tradeoffs in the Humid Tropics. In

Slash-and-Burn Agriculture: The Search for Alternatives, edited by C. A. Palm, S. A. Vosti, P. A. Sanchez, and P. J. Ericksen. New York: Columbia University Press, 415–40.

Trines, E., et al. 2006. Climate Change Scientific Assessment and Policy Analysis: Integrating Agriculture, Forestry and Other Land Use in Future Climate Regimes. Bilthoven: Netherlands Environmental Assessment Agency.

UNFCCC. 2006. Background Paper for the Workshop on Reducing Emissions from Deforestation in Developing Countries: Scientific, Socio-Economic, Technical and Methodological Issues Related to Deforestation in Developing Countries.

UNFCCC. 2007a. Reducing Emissions from Deforestation in Developing Countries: Draft Conclusions Proposed by the Chair. SBSTA. FCCC/SBSTA/2007/L.10: 4.

UNFCCC. 2007b. Report on the Second Workshop on Reducing Emissions from Deforestation in Developing Countries. SBSTA. FCCC/SBSTA/2007/3: 18.

Voluntary Carbon Standard (VCS). 2007. Voluntary Carbon Standard Guidance for Agriculture, Forestry and Other Land Use Projects.

Watson, R., I. R. Noble, B. Bolin, et al. 2000. *IPCC Special Report on Land Use, Land-Use Change and Forestry.* Cambridge, UK: IPCC.

World Bank. 2007a. BioCarbon Fund. Washington, D.C.: World Bank Carbon Finance Unit.

World Bank. 2007b. Forest Carbon Partnership Facility. Washington, D.C.: World Bank Carbon Finance Unit.

WRI. 2008. CAIT: Climate Analysis Indicators Tool. Washington, D.C.: World Resources Institute.