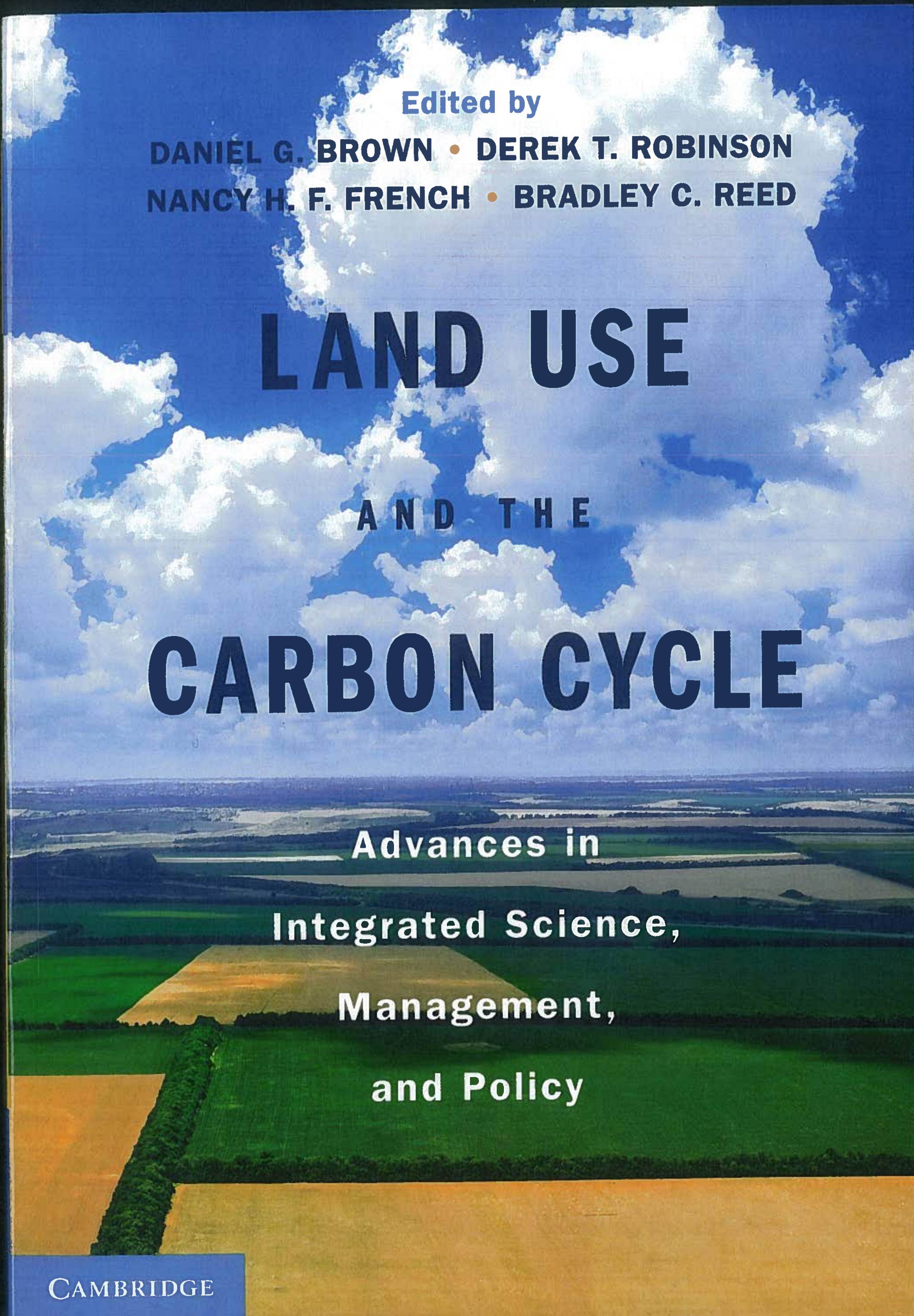

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17

Opportunities and Challenges for Offsetting Greenhouse Gas Emissions with Forests

TIMOTHY PEARSON AND SANDRA BROWN

1. Introduction

A strong consensus is building on the need to slow the rate of climate change. Emissions must be reduced, and where emission reductions are not financially feasible, mechanisms need to be in place to allow investment in reductions in neighboring areas, neighboring countries, and across the Earth. Forests have a large potential role to play in this system, and the environmental, social, and economic benefits of investing in forests are high. However, challenges exist if we are to maximize the potential of forests to affect climate change.

1.1. What Are Offsets?

Greenhouse gas (GHG) emissions regulations typically place a cap on permitted emissions. It is unrealistic to expect industries and companies to immediately and drastically decrease GHG emissions. As a result, a system exists that allows entities that cannot sufficiently reduce their own emissions to invest elsewhere to stimulate emission reductions or increases in sequestration. The financial instrument is typically known as an offset and is measured by Mg carbon dioxide (CO_2), or a carbon dioxide equivalent for non-CO_2 GHGs (Mg CO_2e), which have varying potentials to cause global warming.

1.2. What Is the Role of Forests in Offsetting?

Carbon (C) markets operate on the premise that a unit of CO_2e emitted anywhere in the world enters the atmosphere and has an equal impact on global warming. Forests function as large stores of C and can be sources or sinks of C depending on how they are managed (see Chapters 2, 3, 14, and 20). Thus investment in activities anywhere in the world that promote forest growth or prevent forest losses will have a direct impact on atmospheric GHG concentrations and, therefore, on climate change. Studies show that deforestation, mainly in the tropics, is responsible for as much as 12 to 20 percent of annual GHG emissions and as much as 35 percent of all GHGs in the atmosphere (Denman et al. 2007; Schrope 2009; Van der Werf et al. 2009).

The Intergovernmental Panel on Climate Change (IPCC), in its Fourth Assessment Report (Nabuurs et al. 2007), estimated that global mitigation activities in the forest sector have the economic potential (at C prices of up to $100 per ton of CO_2) to remove 2.7 Pg (range of 1.3 to 4.2 Pg) $CO_2e{\cdot}yr^{-1}$ from the atmosphere, which is approximately 11 percent of the global annual GHG emissions of 23.9 Pg $CO_2e{\cdot}yr^{-1}$ (by the Carbon Dioxide Information and Analysis Center).[1] As much as 1.6 Pg $CO_2e{\cdot}yr^{-1}$ could be removed from the atmosphere at a cost of less than $20 per ton (1 metric ton equals 1 megagram).

1.3. Why Are Forests Uniquely Valuable for Offsetting?

Forests, above all other offsetting categories, provide benefits that go beyond climate-change mitigation:

1. Forest offset projects have the unrealized potential to positively affect the poorest people in the poorest countries by providing an environment and ecosystem that gives livelihoods, jobs, and other services such as timber and nontimber products as well as shade, protection of watersheds, and protection against desertification. Some argue that C mitigation efforts such as the international offsetting scheme of the Kyoto Protocol, known as the Clean Development Mechanism (CDM), is largely missing the development aspect of C offsetting. For example, as of July 2011, 76 percent of all registered CDM projects (2,443 projects) were in just four countries (China, India, Brazil, and Mexico), whereas the whole of the continent of Africa accounted for only 2 percent (67 projects) of registered projects (with 28 percent of the African projects in South Africa). Linked to this statistic, the two largest CDM project categories, accounting for 81 percent of all projects, were Energy Industries and Waste Handling and Disposal projects. Forests accounted for just 0.7 percent of projects. Looking solely at forest C projects, the *State of the Forest Carbon Market 2009* recorded projects across forty countries with 11 percent of transactions being sourced from Africa (Hamilton, Chokkalingam, and Bendana 2010). Forest projects often occur in remote areas and provide amenities, resources, and livelihoods to the people of these areas. Forest projects predominantly do not need developed industries, sophisticated equipment, or highly educated workforces.
2. Forest projects are the source of other significant environmental services. They protect watersheds and maintain water quality and water supply, protect biodiversity, maintain soils, and function as a source of food and fuel for millions of people (Millennium Ecosystem Assessment 2005). The same cannot be said about any other offset project category.

[1] http://cdiac.esd.ornl.gov/ (accessed March 23, 2012).

1.4. What Is the Current Status of Forest Use in Carbon Offsets?

As described earlier, forests formed a small part of offsets generated to date under the CDM. This may be explained to a significant extent by the following: (1) limitation of the CDM to afforestation and reforestation (A/R), (2) lack of inclusion of CDM A/R in the European Trading Scheme (a compliance market), and (3) the use of temporary credits for CDM forestry. Temporary credits are not fungible with credits derived from any other sector; as a result, they were deemed to have low market value (Brown and Pearson 2009).

Indirectly, as a consequence of the limited scope of the CDM paired with the failure of the United States to ratify the Kyoto Protocol or enact independent legislation, a burgeoning voluntary market has developed for forest offset projects. The voluntary market encompasses both entities and individuals who will never be regulated as well as organizations focused on being prepared for future regulation (precompliance). The voluntary market offset project standards include avoided deforestation as well as changes in forest management alongside A/R.

Voluntary C markets grew by more than 1,800 percent between 2003 and 2008 and, according to Ecosystem Marketplace's State of the Voluntary Carbon Markets 2011, have since held steady despite the worldwide financial crisis (Peters-Stanley et al. 2011). Much of this growth was in anticipation of U.S. legislation to cap GHGs and the expectation that a broader, more encompassing international treaty will go into effect post-2012. Despite setbacks in terms of U.S. legislation, negotiations and drafts to date indicate that international legislation will prominently feature forest offsets. The driving factors behind the broader inclusion of forests are the points made in Section 1.3, plus the demand from buyers for forest-based credits that are seen to have higher public relations value for buyers than any other offset category.

Under international negotiations, the focus is on national-level participation for the generation of offsets from forestry in a system known as REDD (reducing emissions from deforestation and forest degradation in developing countries) and REDD+, which also includes sustainable management of forests, forest conservation, and enhancement of forest C stocks. Countries will likely agree to a reference level of emissions (based on historic emissions and national circumstances) from forests and then be credited for reductions in emissions or enhancements of removals of C relative to this reference level (Meridian Institute 2009, 2011). It is unclear how the system will operate. Crediting may only be to national governments, or at the other extreme, projects may be allowed to trade directly with markets with procedures in place to prevent double counting at the national level (O'Sullivan et al. 2010).

1.5. Challenges to Forest Offset Programs

The opportunity for forests to offset C emissions is clear. However, there are challenges that must be overcome before the potential impact of forests on climate-change mitigation can be realized together with the accompanying benefits. In particular, there is a perception that C stocks in forests cannot be measured and monitored with sufficient accuracy and precision, and that even if they can be monitored, the cost will be prohibitive. However, measurement and monitoring of forest C stocks is already routinely done. Accuracy is enhanced by correct application of forestry and ecological methods that have been in place for many decades (Brown 2002a, 2002b; Hardcastle, Baird, and Harden 2008; GOFC-GOLD 2009). Precision is refined through adequate sampling; with good planning and intelligent stratification (e.g., separating areas into zones with like stocks and variance), measurement costs can account for a limited fraction of project income (Pearson et al. 2010a; Pearson, Brown, and Sohngen 2010b). In the future, costs may be even lower when cost-effective remote methods of forest C assessment become available (e.g., Brown et al. 2005; Asner 2009; see Chapter 5).

In addition, changes in forest cover can be tracked with confidence at low cost using current technology (Achard et al. 2007; DeFries et al. 2007; Hansen, Stehman, and Potapov 2010). Satellite imagery is readily available for free or low cost at a resolution of 30 to 50 m. Regular interpretation of such imagery can accurately track areas being deforested or forested. Degradation is more challenging; however, several kinds of degradation may be monitored with a combination of fine- or medium-scale imagery and targeted ground measurements (Asner et al. 2005; Souza and Roberts 2005; see Chapter 5).

In our experience, the following represent the key technical challenges for projects and programs that use forests to offset GHG emissions (see Chapter 16 for additional discussion on these challenges):

1. *Standards and methodologies*: Approaches for accounting GHGs and GHG-emission reductions or increases in sequestration require both technical and regulatory or market definition to ensure consistent and effective application.
2. *Permanence or potential for reversal*: GHG mitigation activities on the land are inherently reversible, as trees and other vegetation can be removed, ploughed up, or burned and stocks emitted to the atmosphere.
3. *Leakage*: Activities to reduce emission or enhance sequestration in one area can lead to a displacement of activities and increases in emissions elsewhere.

These challenges are also identified in Chapter 16, which describes their influence on agricultural mitigation and offset programs. Additional challenges exist in the area of governance but are not the focus of this chapter. However, it should be clear that most governance issues are also faced by nonforest C offset projects, and these projects have not been limited in the same way as forest offsets under the CDM (see earlier discussion). Issues can, however, exist on a country-by-country basis with regard to land tenure and legal title to emission reduction benefits.

2. Project-Scale Emission Reductions

2.1. Standards and Methodologies

Offset standards are the basis for the development of methodologies that are used to determine how projects define their business-as-usual baseline scenario and to monitor and account for increases in sequestration or decreases in emissions. Continual improvement and innovation in the standards and methodologies is an important challenge, because atmospheric integrity has to be assured without setting the bar so high that it makes the offsetting system cost prohibitive. To date, significant delays and costs have been associated with the development of standards and methodologies. These delays have impeded the development of an offset market in the forest sector.

2.1.1. Development of Standards and Methodologies

Under the CDM – the dominant regulatory system – standards were developed through international agreement under the United Nations Framework Convention on Climate Change (UNFCCC). The standards are subject to ongoing interpretation and specification by the Clean Development Mechanism Executive Board (CDM EB), the Methodology Panel (Meth Panel), and for forestry, the Afforestation/Reforestation Working Group (A/R Working Group). Methodologies are submitted to the CDM EB and evaluated by the A/R Working Group and technical reviewers prior to approval, modification, or rejection.

Under the voluntary market, two approaches for the development of standards exist: a top-down and a bottom-up approach. The top-down approach includes three standards: the Climate Action Reserve (CAR),[2] the Regional Greenhouse Gas Initiative (RGGI),[3] and Carbon Fix.[4] These three standards have developed all the requirements for how projects should assign the baseline and measure and monitor project impacts (through establishing an expert panel and publishing output for public comment). Ultimately, CAR, RGGI, and Carbon Fix each have a single combined standard/methodology.[5]

The Verified Carbon Standard (VCS) and the American Carbon Registry (ACR) take a bottom-up approach.[6] This is akin to the approach of the CDM, whereby the standards provide guidelines but project developers create specific methodologies for baselines, leakage assessment, and monitoring according to the standards, and they must be submitted for approval. Another commonly referenced standard that uses the

[2] http://www.climateactionreserve.org (accessed March 23, 2012).
[3] http://www.rggi.org (accessed March 23, 2012).
[4] http://www.carbonfix.info (accessed March 23, 2012).
[5] Note that Carbon Fix allows ex-ante crediting, meaning that offsets are issued before sequestration or avoided emissions occur. This puts Carbon Fix in its own category with associated risks for integrity of the resulting offsets.
[6] Verified Carbon Standard: http://v-c-s.org/; American Carbon Registry: http://www.americancarbonregistry.org (accessed March 23, 2010).

bottom-up approach is the Climate, Community, and Biodiversity Alliance (CCBA); however, this standard is not included here because the CCBA is not a C accounting standard. The CCBA itself states: "It is important to note that the CCBA does not issue quantified emission reductions certificates and therefore encourages the use of a carbon accounting standard in combination with CCB Standards."[7]

The approval process is where the VCS and the ACR differ. The VCS has a double approval process, whereby two different verification organizations must review and approve each methodology. In contrast, the ACR appoints peer reviewers for the approval process, with at least two reviewers for each methodology and additional reviewers where the methodology includes unique expertise (such as modeling of econometrics, spatial patterns of land-use change, or agricultural emissions).

Another organization offering payments for ecosystem services, including C offsetting, is Plan Vivo,[8] which requires projects to develop project-specific implementation and accounting plans. Plan Vivo will not be discussed in depth because, after fourteen years, only five projects are in existence, and it is apparent that Plan Vivo has a predominant focus on reducing poverty, improving rural livelihoods, and food security (e.g., Peskett, Brown, and Schreckenberg 2010).

The progression of the C offset system under each of the standards is shown in Table 17.1. Under the CDM, no approved methodologies existed until late 2005. In July 2011, there were thirteen large-scale methodologies and seven small-scale methodologies (small-scale methodologies are limited to a maximum of 60,000 Mg CO_2 equivalent net emission reductions annually). The methodologies differ in minor but significant ways – for example, with regard to included pools and calculation of leakage. The first CDM methodologies formed a template for later methodologies developed under the VCS and ACR and have contributed to the entire process of methodology development under all registries and systems.

The VCS standard for Agriculture, Forestry, and Other Land Use (AFOLU) was released in November 2008, and the first methodology was approved in May 2010, with nine approved by July 2011. The first version of the ACR Forest Carbon Project Standard was released in March 2009. The ACR's Forest Carbon Project Standard Version 1 allowed project-specific protocols; methodologies applicable across multiple projects were only required under Version 2, released in March 2010. As of July 2011, there were four approved methodologies for forests under the ACR.

Some of the delay in availability of accounting methodologies was attributable to political uncertainty regarding future regulation (and therefore demand for offsets) in the United States and worldwide post-2012. However, some of the delay was attributable to complexities in the approval system. For example, whereas methodologies were in the review process for the VCS almost since the date of publication

[7] CCB Standard Version 2: http://climate-standards.org/standards/thestandards.html (accessed March 23, 2012).
[8] http://www.planvivo.org (accessed March 23, 2012).

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Table 17.1. *Progression of the development of standards, methodologies, and registration of projects under the CDM, the VCS, the ACR, the CAR, the RGGI, Carbon Fix, and Plan Vivo*

	1997	2004		2005				2006				2007				2008				2009				2010				2011	
		Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
CDM																													
First meeting of A/R Working Group																													
Methodologies approved							2	2	4	5	6	8	8	10	13	14	14	13	15	16	17	15	15	16	16	17	18	18	20
Projects registered											1	1	1	1	1	1	1	1	1	3	6	8	11	13	15	17	18	23	27
VCS																													
Release of AFOLU Standards																												v3	
Methodologies approved																									1	2	5	8	9
Projects registered																										1	2	4	12
ACR																													
Release of Forest Carbon Project Standard[a]																				v1					v2				
Methodologies approved																										1	2	2	4
Projects registered																								1	1	1	1	1	3
CAR																													
Release of protocols						Fv1								Fv2				Uv1				Fv3			Uv2				
Projects registered																		2	2	3	3	3	3	3	3	4	4	4	5
RGGI																													
Release of Model Rule																													
Projects registered																													0
Carbon Fix																													
Release of Standard																													
Projects registered																				1	1	1	2	2	2	3	3	4	4
Plan Vivo																													
Founded																													
Projects registered	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	3	4	4	4	5	5

v, version; F, forest protocol; U, urban forest protocol.
[a] Version 1 of the ACR standard allowed for project-specific protocols that are not included here as methodologies.

of the standard, the first methodology was approved only after eighteen months. The verification organizations (required by the VCS) are meticulous with regard to methodology review to avoid liabilities and ensure subsequent project validation and verification; at times, this meticulous approach has been paired with a lack of full expertise on the assessment topics. The result has been a slow and expensive process (Pearson et al. 2010a, 2010b).

The ACR's peer review process is quicker and less costly but leaves methodology development costs with project proponents. To ameliorate this process, the ACR is self-funding development of several methodologies (Nick Martin, ACR Chief Technical Officer, personal communication, 2010). The costs of methodology development are borne principally by project developers under the bottom-up approach, which adds a significant transaction cost to early actors. In comparison, the top-down approach has a low cost for developers; however, this hides the substantive costs and time that must be spent by the governing organizations themselves in developing the accounting approaches. In addition, the top-down approach that uses a single fixed accounting protocol offers little flexibility in terms of how accounting can occur and what choices projects can make.

2.1.2. Difference between Standards

Significant differences exist between the various existing standards. These differences have implications for the attractiveness and profitability of project development. Rather than examine the details of differences in accounting approaches, we focus on clear structural differences:

Project Lifetime. Under the CDM and RGGI, projects are limited to a maximum lifetime of 60 years. Under CAR, the lifetime is 200 years (with crediting only for the first 100 years). For both the VCS and the ACR, lifetimes are potentially infinite. The minimum project lifetime is 20 years under the CDM, VCS, and RGGI; 40 years under the ACR; and 200 years under CAR.

The differences are significant both in terms of the potential income that can be achieved by project investors and in the means and relative level of assurance that real emission reductions are achieved. A twenty-year project changing forest rotations will potentially impact just one rotation and would represent a very temporary increase in C stocks. In contrast, the CAR requirement to continue monitoring of a project for 200 years is a very high additional cost and a likely disincentive to landowners who would be ensuring restrictions in the decisions of future generations.

Landowner Agreements. The CAR requires that every landowner forming part of a registered C project has a legal agreement with the reserve. This requirement may add surety to the achieved offsets; however, it represents a significant transaction cost in terms of negotiation and creates a disincentive for landowner compliance. Equally, the requirement under the RGGI for permanent conservation easements on planted lands is a restriction on future land use that is untenable for many landowners.

2.2. Permanence

For any land-use project, the most high-profile issue is permanence. In any situation where atmospheric benefits result from C stored in plant material, in dead wood, or in the soil, the potential exists for reversal. Changes in management decisions or the impact of natural phenomena can lead to sequestered C being emitted or the realization of previously avoided emissions. The C offsetting standards have developed a range of potential approaches to the permanence issue with varied success.

2.2.1. Temporary Credits

The approach of the CDM was to view forest C as temporary and, therefore, to issue offsets that were themselves temporary and would expire within five to thirty years before being replaced with permanent offsets. The analogy can be made to renting instead of purchasing a car or house. However, the consequence of a temporary credit system was a labeling of CDM forest projects as "lower class" offset projects. Because the offsets were not fully fungible, they were less attractive for investment and subsequently forest projects represented only 1/200th of all registered projects (cf. Brown and Pearson 2009).

2.2.2. Long Project Terms and Legal Constraints

Voluntary systems in the United States and embryonic regulatory systems within the United States have often taken a legal approach to permanence. The RGGI Model Rule for afforestation offsets, as well as the first versions of the CAR Forest Protocol, required permanent conservation easements to restrict the ability of landowners and land managers to alter management and reverse C offsets. The most recent version of CAR's Forest Protocol (Version 3) requires all landowners to sign a legal agreement with the registry and to continue monitoring for 100 years after the last date of offset issuance. Such long-term legal constraints have proved unattractive for potential landowner participants.

2.2.3. Buffer Accounts

The approach of the VCS and the ACR is to have buffer accounts that may be drawn down in the event of a reversal. Projects must undergo a risk analysis to determine the relative risk of reversal, with more risky projects having a larger proportion of offsets withheld from sale. In addition, the buffer is not solely tied to a specific project but instead functions across the portfolio; thus, a catastrophic reversal that exceeds the available buffer of any one project would not undermine the system.

2.2.4. Insurance

Buffer accounts are a form of insurance. Ultimately, buffers are likely just a stopgap solution that is in place until a real insurance market exists for C offset projects. Such

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2.3. Leakage

…roject-scale emission reductions is leakage. If a forest is protected … an area is planted with trees, this may cause an increase in harvesting …ation elsewhere (e.g., because of reduced supply of land for some activity … steady demand), and the net effect on GHG emissions and removals could be zero. Furthermore, if offsets were issued without taking into account the increase in emissions elsewhere, then the net effect would be an increase in GHGs in the atmosphere over what would have been realized had the offsets not been issued. Several studies exist countering the argument that land-use C projects leak and that it is not possible to track the leakage (e.g., Chomitz 2002; Aukland, Moura Costa, and Brown 2003. Murray, McCarl, and Lee 2004; Sohngen and Brown 2004). Where the form of leakage is understood, leakage can be avoided, and where avoidance is not possible, methods exist that can be used to estimate the magnitude of the leakage.

Two forms of leakage are most applicable to land-use C projects: activity shifting and market effects. Activity shifting is the displacement of activities and their associated GHG emissions outside the project boundary. In this form of leakage, the activities that cause emissions are not permanently avoided but are instead displaced to an area outside the project boundaries (Aukland et al. 2003). For example, an afforestation project may displace slash-and-burn agriculturalists who instead move to and deforest an adjacent area to practice their livelihoods. Alternatively, a logging company prevented from harvesting in a specific concession may instead move to a neighboring concession and harvest there.

The second form of leakage involves market effects, whereby the countering of project emission reductions occurs by shifts in the supply and demand of the products and services affected by the project (Aukland et al. 2003). Market leakage is more challenging to assess than activity shifting because the impact can be felt at locations connected by nothing more than the market for the given product. For example, an improved forest management project may decrease the supply of timber, resulting in increases in timber prices and increases in logging activities by third parties elsewhere in response to the price-increase signal.

The two forms of leakage are illustrated in Figure 17.1. In this case, there is a fixed global supply of product X (e.g., timber) at the start of the project. Retiring the production of product X from the project area decreases the global supply. Activity shifting occurs when this decrease in supply is met by people displaced by the project,

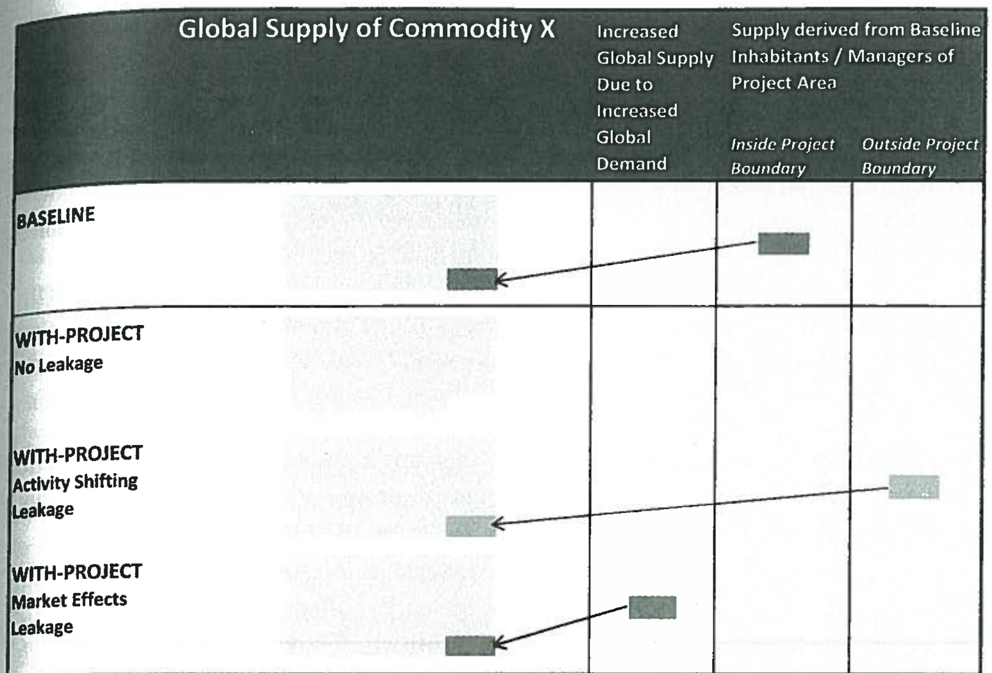

Figure 17.1. Illustration of the two forms of leakage to which land-use projects are most often exposed. Activity shifting occurs when the decrease in supplied products is met by those displaced by the project, whereas market-effects leakage is the result of inelastic global demand increasing market pressures and leading to emissions not directly connected to the project. (See color plates.)

whereas market effects involve market pressures leading to an increase in supply that is not directly connected to the project.

2.3.1. How Can Leakage Be Assessed?

Activity Shifting. Well-designed offset projects seek to prevent activity shifting from occurring at all. For example, it is possible to identify the people who convert or degrade the forests, referred to as baseline agents, and provide alternative livelihoods or other incentives that prevent leakage from occurring. Where activity shifting cannot be fully prevented, existing methodologies use one of four approaches to estimate activity-shifting impacts:

1. Tracking of baseline agents involves surveying people by using the project area in the baseline to determine their current practices and resource use. If the people move away from the area and can no longer be tracked or leakage is demonstrated, deductions are made to the project net emission reductions (e.g., CDM methodology AR-AM0004 or VCS methodology VM0007's approach for fuel wood).
2. Tracking livestock present in the baseline involves determining the forage needs of livestock and assessing how these needs would be met by the with-project case. If the project

cannot demonstrate that existing grasslands are available with sufficient forage resources, then leakage is assumed to occur (e.g., CDM methodology AR-AM0003 and derivative methodologies).

3. Leakage belts for avoided deforestation projects are used to assess a baseline deforestation rate for both the project area and an applicable area surrounding the project, referred to as a leakage belt. If deforestation in the project is no longer possible, then agents will move to the surrounding area. An increase in deforestation rate in the surrounding area is assumed to be leakage caused by displacement resulting from project implementation.
4. Default deductions are used in the CDM tool for the estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity.[9] Default levels of emissions caused by activity displacement are deducted from the project credits.

Application of any of these methodologies has costs associated with data collection and with deductions to the final offsets achieved; however, they also have the benefit of maintaining the atmospheric integrity of the associated land-use C projects.

Market Effects. There are two practical approaches to estimate the impacts of leakage of forest C offset projects attributable to market effects: econometric modeling and default deductions. Market effects are essentially an econometric issue. *Econometrics* is the unification of theoretical and factual studies through the application of quantitative and statistical approaches to elucidate economic principles (Frisch 1933). Implementing a C offset project can affect supply and demand of a specific product. The use of econometric models can determine this impact and the response in terms of increases in supply with associated emissions. Such an approach was used by Sohngen and Brown (2004), who estimated the market-effects leakage of a stop-logging project in Bolivia (the Noel Kempff Mercado project; Brown, Masera, and Sathaye 2000b).

Econometric modeling requires a high level of expertise with associated costs. As a consequence, there is a demand for default leakage deductions that projects can take. Deductions would be related to the decrease in the amount of production and the emissions associated with production in the project area relative to alternative production areas for the same product. Such deductions must be based on sound data and well-parameterized models (e.g., Sohngen and Brown 2004). Under the VCS, such default deductions are available to estimate market-effects leakage through the timber markets for projects that stop deforestation and projects that change forest management (stop logging or reduce timber output).

3. National-Scale Emission Reductions: REDD+

Since the early to mid-1990s, it has been recognized that reducing deforestation and forest degradation could serve as a significant GHG mitigation activity (Brown et al.

[9] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-15-v1.pdf/history view.

1996; Putz and Pinard 1993). During the mid- to late 1990s, pilot C offset projects that avoided deforestation or reduced degradation were initiated in several tropical countries in Asia and Latin America (Brown et al. 2000b). The largest pilot project was the Noel Kempff Climate Action Project in Bolivia that started in 1996 and was developed by the Nature Conservancy under the U.S. Activities Implemented Jointly (USAIJ) pilot phase. The project covered about 634,000 hectares and conserved natural forests that would otherwise have been subjected to continued logging and to future agricultural conversion (Brown et al. 2000a). This project has since been third-party verified by SGS (Société Générale de Surveillance, United Kingdom Ltd.) against UNFCCC criteria and principles of completeness, consistency, accuracy, transparency, and scientific integrity. Voluntary emission-reduction credits were issued for the period from 1997 to 2005.

The notion of scaling up such types of activities to the national scale was first introduced on the agenda at COP11 in Montreal by the Coalition of Rainforest Nations, led by Papua New Guinea and Costa Rica. Those discussions began with RED (i.e., limited to deforestation only) and expanded to REDD with consideration of forest degradation. By 2007, at the Conference of Parties in Bali, members confirmed their commitment to address global climate change through the Bali Action Plan (UNFCCC 2007, Decision 1/CP.13).

In essence, it is proposed that a REDD+ strategy will be a performance-based system, with compensation related to the successful implementation of policies and programs designed to reduce emissions and enhance C stocks compared to a baseline. Within the REDD+ context, the terms *forest reference emission level* (REL) or *reference level* (RL) are used as substitutes for the term *baseline*. In this chapter, we use the abbreviation RL as shorthand for both; however, reference level is generally used when referring to emissions from deforestation and forest degradation, as well as the amount of removals from sustainable management of forests and enhancement of forest C stocks, whereas reference emission level generally refers to emissions from deforestation and forest degradation only. Developing a credible RL and a monitoring system are two key technical challenges for successfully implementing a REDD+ mechanism. As part of the Copenhagen and Cancun agreements (UNFCCC 2009b, 2010), the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) was asked to do further work on methodological issues related to forest RLs and monitoring systems.

There is great interest by many developing countries in designing and implementing a REDD+ strategy as demonstrated, for example, by (1) the thirty-seven REDD country participants, (2) the twenty-four countries that have submitted Readiness-Preparation Proposals (R-PPs) to the World Bank's Forest Carbon Partnership Facility (FCPF),[10] and (3) the thirteen countries receiving support to develop

[10] As of July 2011.

and implement national REDD+ strategies from the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD). With the added resources provided by the international community and donors, progress is being made on many aspects of developing a national REDD+ strategy – for example, stakeholder consultation and analysis; assessment of forest laws, policy, and governance; identification and analyses of drivers of forest cover change; and analyses of social and environmental impacts. However, progress is slow in developing RLs and forest C monitoring systems, not because there is a lack of knowledge but rather a lack of resources and technical capabilities (UNFCCC 2009a, Herold 2009). A problem facing many developing countries that are investing resources to build capacity to participate in a REDD+ mechanism is the uncertainty about how such a global REDD+ system will work. The modalities and rules are still being decided, and it is expected that more years will pass before final decisions will be made.

Given the ongoing discussions on the modalities of REDD+ in the UNFCCC and the level of interest by many countries but recognizing their different stages of development, a generally accepted agreement is to use a three-phase approach to incorporate REDD+ into a future mechanism to mitigate climate change (Meridian Institute 2009). The timing and transitions of this phased approach will vary by country based on its level of capacity and funding. Funding sources are also expected to change in going from one phase to the next, starting with mostly international public funding sources such as FCPF, UN-REDD, and bilateral agreements and ending in a compliant offset market in the third phase.

To accomplish this phased approach will require the development of not only modalities and methodologies to address many of the technical aspects needed to implement a REDD+ strategy but also increased capacity building and knowledge transfer in developing countries (Baker et al. 2010; UNFCCC 2009a). Development of such technical tools and capacity is needed to provide confidence to the various donors and investors that the performance-based results have scientific integrity and a climate mitigation impact.

3.1. Technical Components for Implementing REDD+ Strategy

The technical components that will be required under a future REDD+ system are subject to significant political negotiation. However, certain consensus decisions have been reached (UNFCCC 2009b, p. 11–12):

- "To use the most recent Intergovernmental Panel on Climate Change guidance and guidelines . . . for estimating anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;

- ... developing country Parties in establishing forest reference emission levels and forest reference levels, should do so transparently taking into account historic data, and adjusting for national circumstances;
- To establish, according to national circumstances and capabilities, robust and transparent national forest monitoring systems and, if appropriate, sub-national systems as part of national monitoring systems:
  - Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks;
  - Provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities."

This approach sounds demanding but itself raises a range of additional challenges. For example, how will forests and REDD+ activities be defined? The definition of a forest lies at the core of what counts as deforestation; what counts as forest degradation; and alternatively, what counts as enhancement of stocks of existing forests and sustainable forest management. All or a subset of these practices may be included, and the definition of a forest will determine what can and cannot count.

Significant capacity development will be needed in many countries before the necessary data collection and analyses can be accomplished to develop an RL and a national monitoring system. Standards will need to be developed and agreed to by all parties. For example, decisions will be needed on acceptable levels of accuracy for remote sensing imagery used for national monitoring, how evolving technologies and new sensors will be harmonized over time to give consistent results; and what is an acceptable level of uncertainty for the estimation of C stocks of the forests (and deforested land uses) that will be used in combination with the remote sensing imagery.

3.1.1. Definition of a Forest and REDD+ Activities

Estimates of emission and removal of GHGs from REDD+ activities are determined by which lands are included in the accounting system, which in turn is determined by how forests are defined. It is likely that international agreements for REDD+ will allow for the definitions to be decided by a country under the same guidelines as those articulated in the Marrakesh Accords of the Kyoto Protocol. This includes three thresholds: a minimum forest area of 0.05 to 1 hectare, potential to reach a minimum height at maturity in situ of 2 to 5 m, and minimum tree crown cover (or equivalent stocking level) of 10 to 30 percent.

The selection of low thresholds for forest cover, height, and minimum area in defining forests ensure that practically all lands that contain trees could be eligible for REDD+ incentives; however, it would also mean that the RL would have to include these lands as well. Defining forests in a way that encompass more lands in the historic period can cost more in future monitoring. Given that the common cause of forest-cover change in many developing countries is a long-term and progressive degradation of forest to complete deforestation, it could make sense to use a 15 percent canopy cover as the definition for forests. The definition of forest at a low cover threshold (e.g., 15 percent) ensures that most lands containing tree cover will be classified as forest and will thus be eligible for REDD+ incentives either through reduced degradation, reduced deforestation, or enhancement of C stocks. On a technical level, it does not make sense to define forest with lower than a 15 percent threshold for canopy cover because as the cutoff gets lower, the accuracy of remote sensing also declines because of the large fraction of the variation in spectral properties of such land-cover classes.

The existing IPCC (2003) Good Practice Guidance for Land Use, Land-Use Change, and Forestry (GPG-LULUCF) framework provides approaches and methods for accounting for changes in C stocks from changes in the cover and use of all forestlands (Meridian Institute 2009). All of the REDD+ activities mentioned in the Bali Action Plan are covered by the three land-cover categories in the GPG-LULUCF framework of (1) forestland converted to other lands, which is equivalent to deforestation; (2) forest remaining as forest which includes degradation, forest conservation, sustainable management of forests, and enhancement (in existing degraded forests); and (3) other land converted to forest, which includes enhancement of C stocks through A/R of nonforestland. Thus it seems practical that this GPG-LULUCF framework be used for guiding the definition of all REDD+-related activities.

3.1.2. Reference Emission Level

Setting a country-specific RL has profound implications for the climate effectiveness, cost-efficiency, and distribution of REDD+ funds among countries and involves trade-offs between different interests and objectives. As such, establishing the RL is a critical step in moving forward on a REDD+ mechanism. At this time, there is no agreed-on methodology for how to set such a level and how it might be used to measure performance during the implementation phase of REDD+ interventions (Meridian Institute 2011).

The RL is critical because it is the standard against which the performance of REDD+ interventions will be monitored, reported, and verified. International discussions concerning REDD+ generally refer to an RL as originating with the historical emissions, starting at some year and going back several years; however, the specifics of both are still under discussion. The first step then is to estimate the historical emissions, the methods and guidance for which are in the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD, 2009) and the GPG-LULUCF. It is well known that the default factors in the IPCC (referred to as Tier 1) and Food and Agriculture Organization of the United Nations (FAO) estimates are highly uncertain, thus it is expected that countries will have to develop their own improved estimates of forest C stocks (target a high Tier 2, in IPCC parlance) and area change (on the basis of national interpretation of remote sensing imagery). This will likely require enhanced capacity; however, the capacity acquired in developing historic emission estimates will serve the countries well as they plan and design their national monitoring system.

The amount of quality remote sensing data available at little to no cost has increased since 2000 (e.g., the global and frequent coverage by the Moderate Resolution Imaging Spectroradiometer [MODIS] and freely available and more archival data of Landsat). However, the available satellite imagery is only useful for detecting deforestation with confidence; patterns and rates of forest degradation and forests undergoing C stock enhancement are difficult to detect without the use of additional data and new analytical techniques that are still in development (Asner et al. 2006; GOFC-GOLD 2009; Souza and Roberts 2005). Techniques have been developed for detecting logging activities both directly by using a combination of MODIS and Landsat satellite imagery and indirectly by observing logging infrastructure (e.g., logging roads, skid trails, and landing decks), although they have not been widely applied.

Data on forest C stocks for all key forest strata and relevant activities are also needed for establishing historic emission factors. Basic data may already exist within a country (e.g., an inventory of standing volume for some key forest types); however, new data will likely need to be acquired. The acquisition of new data on forest C stocks will be mostly used to characterize current forest conditions. Under this situation, the modalities and methodologies will need to include allowances for countries to assume that the conditions in current forests are the same as in the past. Forest stratification based on a variety of spatial data such as biogeographical factors (e.g., vegetation, elevations, soil, climate zones), transportation networks (e.g., roads and rivers), and forest management designations (e.g., production, protection, reserves) will be a key step in supporting such an assumption (Pearson et al. 2009). The new benchmark map of forest biomass C stocks in developing countries for the early 2000s (Saatchi et al. 2011) could also be used for stratifying national forests into similar C stock classes or even used to develop emission factors.

Another issue related to setting an RL is to identify which criteria should be used to legitimize "national circumstances." Some studies suggest that historical deforestation is the single most important factor to predict deforestation, because most of the underlying drivers of deforestation only change slowly over time, thus it may be appropriate to set the RL equal to the historic rate (Meridian Institute 2011). For some countries, the projected business-as-usual emissions may require an adjustment to the historic emissions on the basis of a variety of factors, such as the proportion of land area in forest cover, forest accessibility, economic development, agricultural commodity prices, and future development plans (Meridian Institute 2011). Some countries have proposed that the historical RLs take into account past development only and thus are arguing for adjustment factors to take into account future development plans, which may differ from the past. Griscom et al. (2009), in their analysis of the various approaches proposed for setting RLs, concluded that for payments to successfully function as incentives for implementation of REDD+ activities, the incentives should be (1) closely linked in quantity to actual emissions avoided against a credible, historically derived baseline and (2) closely linked in time and space to actions taken on the ground by local stakeholders that reduce emissions.

It is likely that a projected RL will ultimately be negotiated, and key questions then include the following: Should this then be fixed for some time period? What is a suitable length of time to be fixed? Should it be set for a fixed number of years (e.g., a ten- or five-year commitment period)? These critical issues remain to be clarified.

3.1.3. National Monitoring, Reporting, and Verification Systems

A key building block for a REDD+ mechanism is the need for a robust, transparent, sustainable, and cost-effective monitoring, reporting, and verification system based on good science and that quantifies C emissions and removals from REDD+ activities with low uncertainty (Meridian Institute 2009). The system must be able to confidently show change in emissions and removals measured against an RL cost-effectively; be able to access and use quality data with low uncertainty for rates of land-cover change and corresponding C stocks; use methodologies and techniques that can be implemented by in-country experts; report and verify performance to international standards; and comply with national and international policy frameworks.

Although there is a consensus that a common methodology based on remote sensing data and ground-based forest C inventory data should be used for monitoring, there are some monitoring issues for which there is little agreement. For instance, there is a question about whether all forest C pools out of the five recognized by the GPG-LULUCF (i.e., aboveground biomass, belowground biomass, dead wood, litter, and soil organic matter) should be included in the monitoring system or if a subset should be used. A precedent set under the CDM and for national GHG inventories allows countries to choose which pools to include and provide evidence of the conservativeness of their choice, which is a more cost-effective option. Another contentious issue is whether to create a complete national forest C inventory or sample only the subset of forests that are at risk for change. We argue that the scale of sampling must match the scale of the subject to be measured. In other words, the population of interest is likely the subsample of the forest area within a country that is under threat of change (e.g., close to roads or cleared areas, near population centers, on gentle slopes; cf. Harris et al. 2008). The problem with a national inventory is that the number of plots falling in some forest strata that are under high threat for change, based on past practices and patterns of change, may be insufficient to achieve stated precision standards (Pearson et al. 2009).

Detailed technical discussions on the elements of a monitoring system are described in the GOFC-GOLD *Sourcebook* (2009) and Baker et al. (2010). The sourcebook provides detailed methods on how to monitor changes in forest area and cover; how to monitor and estimate C stocks in forest vegetation and soils; how to estimate CO_2

emissions and removals; how to estimate uncertainties in estimates of emissions and removals; and the status of evolving technologies for monitoring area and C stocks. The remote sensing principles and technologies underlying some of these methods are described in Chapter 5.

Reporting and crediting of GHG emission reductions and enhancement of C stocks under REDD+ relies on the robustness of the science underpinning the methodologies, the associated credibility of the resulting estimates, and the way this information is compiled and presented (Grassi et al. 2008). Under the UNFCCC and elaborated by the IPCC, there are five general principles that guide the reporting of emissions and removals of GHGs: transparency, consistency, comparability, completeness, and accuracy. The principles of completeness and accuracy will likely be challenging for many developing countries (Grassi et al. 2008). A pragmatic approach for addressing the lack of completeness and uncertainties in emissions and removals from REDD+ activities is the principle of conservativeness and use of discount factors. This principle means that when completeness, accuracy, and precision cannot be achieved, the reported emission reductions or enhancements in C stocks should be underestimated, or at least the risk of overestimation should be minimized (Grassi et al. 2008).

The purpose of verification, defined as an independent third-party assessment of the expected or actual emission reductions of a particular mitigation activity (Angelsen 2008), is to assess that the information is well documented, based on UNFCCC modalities and methodologies, and transparent and consistent with the reporting requirements outlined in the UNFCCC guidelines. The UNFCCC uses a panel of experts to review national GHG inventories. For phase one and two of the phased approach for REDD+ implementation, this may suffice; however, more rigorous verification standards will likely be called for as REDD+ moves into the phase three market-based mechanisms (Meridian Institute 2009). This will likely include a formal development and acceptance of standards and methodologies using lessons learned from the market-based CDM and voluntary markets for subnational activities.

3.1.4. Capacity Development

Funding for REDD+ activities is increasingly available to developing countries. However, funding alone is not enough; resources must be used efficiently and effectively to provide detailed technical training in forest measuring and monitoring methods to those responsible for implementing their forest monitoring programs.

Recent studies (Hardcastle et al. 2008; Herold 2009; UNFCCC 2009a) assessed information on the state of data and capacity in ninety-nine tropical countries for measuring and monitoring forests as a requirement for REDD+ reporting under IPCC guidelines. Their approach was based on both country reporting to the UNFCCC and the FAO, as well as published sources, consultation with expert reviewers, and contacts with FAO country representatives. Although providing only a broad picture of each of the countries considered, results of the studies revealed that many countries have significant capacity in remote sensing, especially in Latin America, whereas capacity in methods to quantify forest C stocks is generally low, and very few countries have the capacity to develop national emission factors. In sum, most developing countries have limited capacity to fully participate in a REDD+ mechanism at present; however, given the proposed phased approach and the many sources of funding available for building capacity, it is likely that great advances in national capability will be made post-Kyoto.

3.2. Addressing REDD+ Leakage

A strong initial motivation for a national-level approach to REDD+ was that national reporting will capture leakage within each country. This is true particularly for activity shifting, as baseline deforestation agents will rarely shift their activities across national boundaries. National reporting will also capture market-effects leakage operating within national boundaries. For example, market pressures leading to increased timber harvest in a different region in the country will be captured. However, market impacts are not limited by national boundaries. Many products enter international markets (e.g., palm oil, soybeans, and timber), and when this is the case, it is possible that the price impact of reduced production in a given country will lead to increased emissions in a country not participating in REDD+. This risk is only faced where products are for international markets and where a given country significantly reduces output. However, international leakage is not considered in the other economic sectors under the Convention, thus the same principle should apply to the forest sector. Moreover, Annex I Parties are not required to consider international leakage in their national GHG reporting and accounting, therefore nor should developing-country Parties. The solution ultimately should be complete participation by all countries in REDD+ schemes so that increases in emissions anywhere will be captured.

The leakage issue becomes more problematic for REDD+ implementation at a subnational scale if no national monitoring system is in place. For project-scale activities, methodologies have been developed (e.g., the ACR and VCS; see Section 2.3) that call for monitoring a leakage belt around project areas. Therefore, for REDD implementation at the project to subnational scales, leakage would need to be monitored within the country to ensure that activities account only for real emission reductions. If a project or subnational jurisdiction does not implement and monitor leakage avoidance activities, then it should be required to accept a large leakage deduction.

3.3. Addressing REDD+ Permanence

How permanence will be handled under a future REDD+ regime is an open question. Potentially, the national-level reporting and commitment by host countries for ongoing national reporting will give confidence that any future reversals of avoided emissions will be captured. Alternatively, it is possible that buffer or even insurance approaches will be integrated into REDD+.

A system similar to those used in the voluntary market could be developed and applied at the subnational or national scales, where a portion of a country's benefits is withheld in a buffer depending on the risk of reversal (O'Sullivan et al. 2010). Thus, to engage in REDD+, there needs to be an assessment of the risk and the development of a plan to manage within-country risks associated with environmental, socioeconomic, legal, and political events. As countries develop their capacity in implementing and regulating a REDD+ system (e.g., at phase three), the size of their risk buffer could be reduced and more credits released for sale.

4. Conclusions

Activities to reduce emissions and enhance removals of forest C provide valid and important opportunities for mitigating global climate change while providing other benefits to the environment and to rural people worldwide. However, challenges exist that are preventing forests from fulfilling their potential role in mitigating climate change. Some of these challenges are political, in terms of national and international market development. Key technical challenges also impede mitigation opportunities that exist for forests. For example, increases in technical capabilities and knowledge in developing countries are needed to develop reference emissions levels and to create monitoring systems to track forest areas and associated stocks and emissions. Here, we have argued that many of the challenges, such as availability of standards and methods and dealing with permanence and leakage, are largely perceived rather than real and that the scientific knowledge already exists and is ready to be developed into practical tools.

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