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Forest Carbon Markets: Potential and Drawbacks

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July 3, 2008

Abstract. This report describes current markets for forest carbon sequestration, the potential for using forest to offset other sources of GHG emissions, and the drawbacks related to forest carbon sequestration efforts.

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Forest Carbon Markets: Potential and Drawbacks

Summary

Forests are major carbon sinks (storehouses), and activities that alter forests can release or sequester carbon dioxide (CO_2), the most common greenhouse gas (GHG). Some carbon markets have been formed under mandatory GHG reduction regimes, such as the Kyoto Protocol and various regional and state initiatives in the United States. Other markets have formed for voluntary efforts to reduce GHG emissions. Offsets, or credits for sequestering carbon or reducing emissions in unregulated sectors, are typically allowed in both mandatory and voluntary markets. Forestry activities are among the largest-volume and lowest-cost opportunities for generating offsets.

Various forestry activities may be feasible for carbon offsets. Afforestation (planting trees on open sites) and reforestation (planting trees on recently cleared sites) are the activities most commonly included for offsets. Some propose that the carbon stored in long-term wood products, such as lumber and plywood, could be credited as carbon offsets, and mill wastes often substitute for fossil fuels to produce energy; however, short-term products (e.g., paper) and the biomass left in the woods after timber harvesting release carbon, making the net carbon effects uncertain. Some forest management practices also might qualify for carbon offsets; certified sustainable forest practices provide a system of assured, long-term forests, while activities to increase tree growth face many of the same concerns as long-term wood products. Finally, deforestation is a major source of GHG emissions, accounting for as much as 20% of anthropogenic emissions. Thus, avoided deforestation, especially in the tropics, potentially provides an enormous opportunity to reduce GHG emissions. However, avoided deforestation is particularly prone to leakage (see below), as well as many of the concerns about forest carbon offsets generally.

Forestry projects may offer considerable market opportunities for carbon offsets, but several issues have generated concerns and controversy. One concern, especially for compliance markets, is whether the project is additional to business as usual. An activity that is common practice or industry standard, or a project that is required under current federal, state, or local laws, cannot be used as an offset. Functional carbon markets also require cost-effective practices to verify carbon sequestration. Current measurement and monitoring practices are costly and have several implementation challenges. Another concern is that, compared to other types of offsets, forestry projects present the greatest risk of leakage. Emission leakage can occur if carbon sequestered in one location (e.g., by avoided deforestation) leads to carbon release (e.g., from increased harvesting) in another location. Product leakage could occur if forest carbon sequestration encourages use of more carbon-intensive substitutes (e.g., cement or steel). Forest carbon projects are expected to generate offsets for decades. Some are concerned that the sequestration will subsequently be negated by human activity (e.g., change in land use) or a natural occurrence (e.g., forest fire or disease). Although there are legal and accounting mechanisms that can address this concern, implementing these options may present challenges, particularly for projects in developing nations. Finally, forward crediting to allow early credits for expected sequestration faces many of the same concerns about not fulfilling expectations.

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Forest Carbon Markets: Potential and Drawbacks

Forests are major carbon sinks — repositories of vast amounts of carbon. Activities that alter forests — create, enhance, or destroy them — significantly affect the amount of carbon dioxide (CO_2) in the atmosphere. Forests store about 45% of terrestrial carbon, and were estimated to sequester 2.6 billion metric tons (tonnes) of CO_2 per year in the 1990s, about a third of annual anthropogenic carbon emissions from fossil fuel and land use changes.[1]

Concerns about global climate change and its impacts on the environment and the economy are encouraging policy-makers and stakeholders to explore a range of opportunities that would reduce emissions of CO_2 and other greenhouse gases (GHGs).[2] Reducing deforestation and increasing the amount of carbon stored in forests are approaches that have generated considerable interest for their ability to support climate change mitigation.

Congress is considering climate change legislation that would, among other things, provide financial incentives for parties to reduce GHGs or sequester (store) CO_2.[3] The possible use of forests to sequester CO_2 is part of this larger debate over GHGs and climate change.

This report describes current markets for forest carbon sequestration, the potential for using forest to offset other sources of GHG emissions, and the drawbacks related to forest carbon sequestration efforts.

Forest Carbon Markets

The potential economic and environmental impacts of global climate change have led many to consider regulating GHG emissions from various sources, and to seek ways to ameliorate their own GHG emissions. Projects that sequester GHGs or reduce GHG emissions from unregulated economic sectors, such as forestry, can generate offsets, or credits, to sell to regulated entities or to those who wish to reduce their carbon footprints. In either case — for regulated entities or for voluntary

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[1] Gordon B. Bonan, "Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests," *Science*, v. 320 (2008): 1444-1449.

[2] Other greenhouse gases include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). In general, emissions of these gases are measured in carbon-equivalents or CO_2-equivalents.

[3] See CRS Report RL34436, *The Role of Offsets in a Greenhouse Gas Emissions Cap-and-Trade Program: Potential Benefits and Concerns*, by Jonathan L. Ramseur.

reductions — forestry activities (e.g., afforestation, reforestation, and avoided deforestation) present opportunities to offset GHG emissions.

Offsets are commonly project-based initiatives involving specific projects or activities whose primary purpose is to reduce, avoid, or sequester GHG emissions.[4] Parties can develop offsets from a wide variety of activities, such as renewable energy and agricultural projects,[5] but forestry-related projects offer the most potential, in terms of volume of GHGs avoided or sequestered.

Offsets, or credits earned by an offset project, would likely be the currency of most forest carbon markets. Offsets are the measurable avoidance, reduction, or sequestration of CO_2 or other GHG emissions. Forestry projects as offsets raise a number of concerns. To be credible, the emissions reduced, avoided, or sequestered must be *additional* to business as usual (i.e., what would have happened anyway), *verifiable*, and *permanent*. These concepts, and the problems that arise in assuring credible forestry, are discussed later in this report.

One concern for offset markets, in addition to the drawbacks discussed below, is the potential for double-counting the offsets — that is, that sellers might try to sell the same offset to multiple buyers. Thus, compliance markets, and some voluntary markets, require some type of reporting and registration for offsets. This has led to incentives for independent reporting and registry programs, as discussed below.

Compliance Offset Markets

A mandatory GHG reduction program, such as a cap-and-trade system, could allow covered entities (e.g., power plants) to use offsets to comply with their GHG emissions cap. For example, a regulated entity could purchase offsets, rather than reducing direct, onsite emissions, if the offsets are less expensive. Assuming that the tonne of CO_2 reduced, avoided, or sequestered through an offset project equates to a tonne reduced at a regulated source, the objective to reduce GHG emissions is met. For global climate change, it does not matter where or from what source the reduction or sequestration occurs: the effect on the atmospheric concentration of GHGs would be the same.

Although forestry-related projects are eligible as offsets in several existing or developing compliance markets, forest projects have, to date, played a negligible role. If the recent cap-and-trade proposals (discussed below) are any indication, however, interest in allowing forestry offsets in a compliance regime is growing.

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[4] Because offset projects can involve various GHGs, they are quantified and described with a standard form of measure, usually metric tons (tonnes) of CO_2-equivalents ($mtCO_2$-e).

[5] See CRS Report RL34436, *The Role of Offsets in a Greenhouse Gas Emissions Cap-and-Trade Program: Potential Benefits and Concerns*, by Jonathan L. Ramseur.

Kyoto Protocol.[6] The United Nations Framework Convention on Climate Change (UNFCCC) is the primary international agreement to mitigate climate change by reducing GHG emissions. The Kyoto Protocol established a framework for Annex I countries (developed countries, including the United States) for "reducing their overall emissions of such gases [GHGs] by at least 5% below 1990 levels in the commitment period 2008 to 2012." Although the United States originally signed the Kyoto Protocol, it later rejected participation, and thus is not bound by its goals. As of November 2007, 174 nations and the European Union were parties to the treaty, although major industrializing countries (notably China, India, and Brazil) were not signatories.

To increase flexibility, the protocol includes two mechanisms — the Clean Development Mechanism (CDM) and Joint Implementation (JI) — that allow certain forestry activities to generate offsets.

Clean Development Mechanism. The CDM is a project-based mechanism that permits Annex I countries under the Kyoto Protocol to earn credits for use in achieving their emission targets. It is the only mechanism that allows Annex I countries to earn credits for actions in non-Annex I countries (developing countries such as India or China). For forestry projects, the CDM includes only afforestation (planting trees where none were previously growing) and reforestation (replanting trees on recently cleared forest sites).[7] Further, project developers can only earn credits for additional projects — those that would not otherwise have occurred (if reforestation is required by a country's laws, for example, the reforestation project cannot earn credits under the CDM).

The CDM is the largest compliance offset market in the world. Both the trading volume and market value of the CDM have grown substantially in recent years. (See **Figure 1.**)

Although the forestry sector was initially expected to play a significant role in the CDM, that has not been the case. An IPCC report stated that although the forestry sector can make a "very significant contribution to a low-cost mitigation portfolio ... this opportunity is being lost in the current institutional context and lack of political will to implement and has resulted in only a small portion of this potential being realized at present."[8] Indeed, of the offsets issued under the CDM to date, afforestation and reforestation have accounted for a combined 0.3%.[9]

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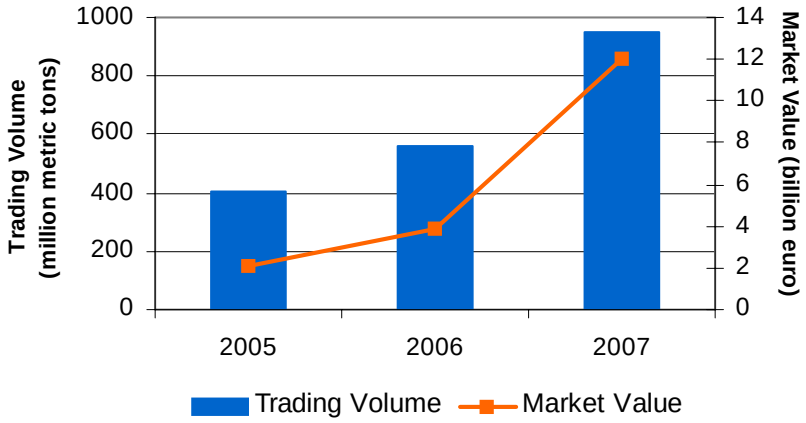
[6] See CRS Report RL33826, *Climate Change: The Kyoto Protocol, Bali "Action Plan," and International Actions*, by Larry Parker.

[7] See UNFCCC, Conference of the Parties, Seventh Session — "the Marrakesh Accords" — 2001, Decision 11.

[8] Intergovernmental Panel on Climate Change, *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report* (2007), p. 543.

[9] Put another way, of the 1,033 registered projects, only one is forestry-related. United Nations Environment Programme, *Capacity Development for the Clean Development Mechanism ("CDM Pipeline")*, at [http://cd4cdm.org/index.htm].

Figure 1. Trading Volume and Market Value of the Clean Development Mechanism (2005-2007)



Source: Prepared by Congressional Research Service with data from Point Carbon, *Carbon 2007*, and *Carbon 2008*, at [http://www.pointcarbon.com/].

Joint Implementation. JI is also a project-based approach for countries to earn credits toward their emission targets under the Kyoto Protocol. JI projects are conducted jointly between two Annex I countries. A broader array of forestry activities can earn credits than under CDM; in addition to afforestation and reforestation, avoided deforestation and forest management that enhances carbon sequestration can qualify as JI projects. As with CDM projects, credits are only earned on projects that otherwise would not have occurred. JI has a much smaller market than CDM, with about 13 million tonnes traded in 2007 (compared to more than 900 million tonnes for CDM).[10]

Ongoing Kyoto Developments. The concerns about tropical deforestation and Third World contributions to GHG emissions were among the issues discussed at the 13th Conference of the Parties to the UNFCCC (COP-13) and the 3rd Meeting of the Parties to the Kyoto Protocol (MOP-3) held in Bali, Indonesia, December 3-14,2007.[11] The United States participated in discussion at Bali, as a party to the UNFCCC and as an observer to the Kyoto Protocol. Among the outcomes of the Bali negotiations was an Action Plan that included:[12]

> Policy approaches and positive incentives ... [for] reducing emissions from deforestation and forest degradation [REDD] in developing countries; and [identifying] the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries ...

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[10] Point Carbon, *Carbon 2008*, at [http://www.pointcarbon.com/].

[11] See CRS Report RS22806, *The Bali Agreements and Forests*, by Ross W. Gorte and Pervaze A. Sheikh.

[12] UNFCCC, *Decision -/CP.13 — Bali Action Plan*, at [http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf].

The negotiations also led to a decision on forests and deforestation.[13] The decision encourages various efforts, including demonstration projects, to reduce GHG emissions from deforestation and forest degradation, financial and technical support for those efforts, and improved measurement and reporting of GHG reductions that result from such efforts. Some argue that the most important result of the Bali negotiations, however, is that avoided tropical deforestation will be included in any agreement on post-Kyoto (after 2012) actions on global climate change.

European Union's Emission Trading Scheme. Members of the European Union (EU) are implementing the requirements of the Kyoto Protocol through the EU's Emission Trading Scheme (ETS).[14] Private parties subject to the ETS cap cannot purchase forestry offsets. However, EU governments can purchase eligible forestry offsets, from afforestation or reforestation projects, to meet their Kyoto Protocol commitments, up to 1% annually of their country's base year (1990) emissions.[15] The World Bank has reported that global transactions of land use, land use change, and forestry offsets have only accounted for 6% of this allowable limit (i.e., 0.06% of EU carbon emission reductions).

Regional Initiatives in the United States. Even though the United States is not a signatory to the Kyoto Protocol, many states are participating in regional initiatives for mandatory reduction of GHG emissions. Twenty-three states have joined one of three regional partnerships that would require CO_2 (or GHG) emission reductions.

Set to take effect in 2009, the Regional Greenhouse Gas Initiative (RGGI) is a partnership of 10 Northeast and Mid-Atlantic states that creates a cap-and-trade system aimed at limiting carbon dioxide emissions from power plants.[16] RGGI allows for five types of offset projects to generate emission credits, including afforestation. RGGI participants agreed to continue to develop other offset projects, "including other types of forestry projects, and grassland revegetation projects."[17]

Seven western states (and three Canadian provinces) have formed the Western Climate Initiative (WCI), which set a regional economy-wide GHG emissions target

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[13] UNFCCC, *Decision -/CP.13 — Reducing Emissions From Deforestation in Developing Countries: Approaches to Stimulate Action*, at [http://unfccc.int/files/meetings/cop_13/application/pdf/cp_redd.pdf].

[14] See CRS Report RL34150, *Climate Change: The EU Emissions Trading Scheme (ETS) Enters Kyoto Compliance Phase*, by Larry Parker.

[15] See European Union Directive 2004/101/EC (Oct. 27, 2004); Kyoto Protocol, Decision 17/CP.7 (Nov. 2001).

[16] The 10 states are Connecticut, Delaware, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. Also participating are the District of Columbia, the Canadian province of New Brunswick, and "Eastern Canadian Provinces." See [http://www.rggi.org/about.htm].

[17] RGGI Memorandum of Understanding, at [http://www.rggi.org/].

of 15% below 2005 levels by 2020.[18] Although the WCI logistics are in the early stages, "in each of the opportunities for stakeholder engagement on the design of a cap-and-trade system for the Western Climate Initiative, there has been strong support for including an offset program."[19]

In addition, six states (and one Canadian province) signed the Midwestern Greenhouse Gas Reduction Accord, which would establish a multi-sector GHG cap-and-trade program in the Midwest.[20] As with the WCI, this program is still in the early development stages.

Mandatory U.S. State Requirements.[21] Several U.S. states have individual programs that currently or will soon mandate reductions in CO_2 or GHG emissions. For example, starting in 1997, Oregon has set standards for CO_2 emissions from new power plants; the plants can meet these standards by constraining emissions directly or by purchasing offsets from a nonprofit organization (the Oregon Climate Trust).[22] This organization has developed three forestry-related offset projects, which account for 21% of current offsets. To date, all of the new facilities have chosen to purchase offsets instead of constraining onsite emissions. Washington passed similar legislation in 2004. In addition to these current requirements, California, Hawaii, and New Jersey have passed legislation that would establish statewide reduction programs. These programs are still in development.

Proposals in the 110th Congress. Members have introduced several legislative proposals that would establish a GHG emissions reduction program, such as a cap-and-trade system.[23] Almost all of the cap-and-trade programs would allow for the use of offsets to varying degrees, thus creating a compliance offset market. Many of the proposals that allow offsets would include forestry-related activities as eligible offset projects.[24]

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[18] Participants are the states of Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington, and the Canadian provinces of British Columbia, Manitoba, and Quebec. Observers include the states of Alaska, Colorado, Idaho, Kansas, Nevada, and Wyoming, the Canadian province of Saskatchewan, and the Mexican border states of Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas. For the text of the agreement, see [http://www.westernclimateinitiative.org/].

[19] Western Climate Initiative, *Draft Design Recommendations on Elements of the Cap-and-Trade Program* (May 2008).

[20] Participants are the states of Illinois, Iowa, Kansas, Michigan, Minnesota, and Wisconsin, and the Canadian province of Manitoba. Observers include Indiana, Ohio, and South Dakota. The text of the accord is available at [http://www.midwesterngovernors.org/resolutions/GHGAccord.pdf.]

[21] For more information see CRS Report RL33812, *Climate Change: Action by States to Address Greenhouse Gas Emissions*, by Jonathan L. Ramseur.

[22] See [http://www.climatetrust.org].

[23] For more information on these bills, see CRS Report RL33846, *Greenhouse Gas Reduction: Cap-and-Trade Bills in the 110th Congress*, by Larry Parker, Brent D. Yacobucci, and Jonathan L. Ramseur.

[24] See CRS Report RL34436, *The Role of Offsets in a Greenhouse Gas Emissions*

(continued...)

Voluntary Offset Markets

Voluntary markets are exchanges of offsets by entities not subject to emissions caps. In contrast to compliance markets, forestry-related and other land use projects have played a much larger role in voluntary markets. A 2007 study found that, of the different offset categories in the voluntary market, forest sequestration accounted for the largest percentage (36%) of transaction volume.[25] The primary components of the voluntary market are "retail" offsets and offsets generated through the Chicago Climate Exchange, both of which include forestry projects.

In the United States and elsewhere, a growing number of organizations and individuals not subject to mandatory emission caps are buying or selling offsets. These exchanges are voluntary, because there is no requirement for these parties to curtail their GHG emissions.[26] Buyers may be interested in offsetting some or all of their GHG emissions from various activities, reducing their "carbon footprint," or becoming "carbon neutral." Buyers might also be preparing for future mandatory federal GHG emission reductions, getting into the market while prices are relatively low with the expectation that today's carbon offsets will be usable to achieve future federal emission ceilings or caps. Sellers are interested in receiving income for various activities, which, without the voluntary market, would likely not occur.

There is currently no registry or tracking system that follows all exchanges in the voluntary market. For this reason, the precise size or value of the voluntary offset market is unknown. However, a series of World Bank reports provides estimates for recent years indicating that the size of the market has increased rapidly every year since 2004.[27] In 2006, the market size was roughly 20 million metric tons of CO_2-equivalent ($mtCO_2$-e).[28] The World Bank report cites forecasts of increasing growth in coming years. One projection (described as "optimistic" by the World Bank) estimated that the volume of transactions in the international voluntary market would be 400 $mtCO_2$-e by 2010.[29] To put this figure in context, U.S. GHG emissions were approximately 7,054 $mtCO_2$-e in 2006.[30]

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[24] (...continued)
Cap-and-Trade Program: Potential Benefits and Concerns, by Jonathan L. Ramseur.

[25] Katherine Hamilton, Ricardo Bayon, Guy Turner, and Douglas Higgins, *State of the Voluntary Carbon Markets 2007: Picking Up Steam* (Washington, DC: Ecosystem Marketplace and New Carbon Finance, 2007).

[26] See CRS Report RL34241, *Voluntary Carbon Offsets: Overview and Assessment*, by Jonathan L. Ramseur.

[27] See, for example, The World Bank, *State and Trends of the Carbon Market 2007* (Washington, DC: May 2007), at [http://siteresources.worldbank.org/EXTCARFINASS/Resources/Carbon_Trends_2007-_FINAL_-_May_2.pdf].

[28] Another study estimated the size in 2006 at approximately 24 mtCO2-e. Katherine Hamilton et al., *State of the Voluntary Carbon Markets 2007*.

[29] The 2007 World Bank report (p. 41) cites ICF, *Voluntary Carbon Offsets Market: Outlook 2007* (2007).

[30] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005."

Retail Offsets. In general, the voluntary offset market refers to retail or "over-the-counter"[31] offsets that may be purchased by anyone. Purchasing a retail offset is as simple as online shopping. More than 170 organizations — private and nonprofit entities — develop, provide, or sell retail offsets to businesses and individuals in the voluntary market.[32] The quality of the retail offsets in the voluntary market varies considerably, largely because there are no commonly accepted standards. Some sellers offer offsets that comply with standards generally regarded as quite rigorous, such as the CDM or the Gold Standard.[33] Other sellers offer offsets that meet the seller's self-established guidelines, which may not be publicly available. These self-established protocols can vary considerably, raising questions of integrity.[34]

Chicago Climate Exchange. The Chicago Climate Exchange (CCX) was established in 2003 as a trading system for buyers and sellers of offset projects to reduce GHG emissions.[35] Buyers (i.e., GHG emitters) make voluntary but legally binding commitments to meet GHG emission reduction targets; those who emit more than their targets comply by purchasing CCX Carbon Financial Instrument (CFI) contracts, which can be generated by qualifying carbon offset projects (from sellers). CCX has standardized rules for CFI contracts, including forestry projects, and requires third-party verification for projects. Eligible forestry projects include afforestation, reforestation, reduced deforestation and forest degradation, forest management to increase stand-level and landscape-level carbon density, and long-term carbon storage in wood products.

CCX has guidelines and rules for determining eligible projects and their resulting carbon offsets. However, recent studies have been critical of the quality of the offsets generated by the CCX.[36]

Reporting and Registry Programs

In general, GHG reporting and registry programs allow facilities to submit and officially record emissions data. The primary incentive appears to be the opportunity for participants to create an official record of reduced or sequestered emissions,

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[31] Hamilton et al., *State of the Voluntary Carbon Markets 2007*.

[32] Environmental Data Services, *The ENDS Guide to Carbon Offsets* (London, 2008).

[33] The Gold Standard was developed by a group of nongovernmental organizations. The Gold Standard sets requirements beyond the CDM, but only applies to renewable and energy efficiency projects. See [http://www.cdmgoldstandard.org].

[34] Several studies have analyzed the offset sellers and provided recommendations; see, for example, *The ENDS Guide to Carbon Offsets*; Anja Kollmuss and Benjamin Bowell, *Voluntary Offsets For Air-Travel Carbon Emissions Evaluations and Recommendations of Voluntary Offset Companies*; Tufts Climate Initiative (revised Apr. 5, 2007); Clean Air-Cool Planet, *A Consumer's Guide to Retail Carbon Offset Providers* (Dec. 2006), prepared by Trexler Climate + Energy Services.

[35] See [http://www.chicagoclimatex.com/content.jsf?id=821].

[36] See *The ENDS Guide to Carbon Offsets*; Anja Kollmuss, Helge Zink, and Clifford Polycarp, *Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards* (Stockholm Environment Institute, Mar. 2008).

which the parties hope will count as emissions credits in future mandatory reduction programs. At a minimum, participants typically receive some public recognition for their efforts, which may help promote an organization's environmental stewardship profile.

1605(b) Reporting Program. Section 1605(b) of the Energy Policy Act of 1992 (P.L. 102-486; 42 U.S.C. §§ 13201, et seq.) created a program of voluntary reporting of GHG emissions, reductions, and sequestration. The U.S. Department of Energy, with assistance from other departments, established guidelines for reporting estimated emissions, reductions, and sequestration; the guidelines were revised and updated in 2006.

The program has been criticized, because facilities need only report reductions and/or sequestration, instead of reporting all emissions.[37] In other words, a company can submit a record of tons sequestered at one location, but continue to increase emissions at other sites. This may present a concern in subsequent years, if these companies are allowed to receive credit for these reductions or sequestration, and apply the credit towards compliance with an emissions cap.

California Registry. The California Climate Action Registry is a private, nonprofit organization for voluntary reporting of GHG emissions and reductions, initially formed by the State of California in 2001. Registry members (currently more than 300 corporations, government agencies, and other organizations) voluntarily measure, verify, and report emissions using registry standards and tools. The Climate Action Reserve is a division of the registry to establish standards for voluntary carbon reductions. The registry and reserve include forestry protocols for the forest sector (for organizations and landowners to account for entity-wide forest carbon stocks and emissions), for forest projects (for carbon sequestration projects by landowners), and for certification (for third-party verifiers to assess reported GHG data).[38]

The Climate Registry. The Climate Registry was launched on May 8, 2007. As of May 31, 2008, 39 states have joined the registry to support both voluntary and mandatory reporting schemes in the participating states. The Climate Registry is modeled on the California Climate Action Registry, with a goal of providing "an accurate, complete, consistent, transparent and verified set of greenhouse gas emissions data supported by a robust reporting and verification infrastructure."[39] Neither the California Registry nor the Climate Registry directly facilitate market transactions, but the information provided could provide a consistent basis for calculating carbon offsets.

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[37] See Pew Center on Climate Change, *Greenhouse Gas Reporting and Disclosure: Key Elements of a Prospective U.S. Program*, In Brief (Number 3), at [http://www.pewclimate.org/docUploads/policy_inbrief_ghg.pdf].

[38] See [http://www.climateregistry.org/tools/protocols/project-protocols/forests.html].

[39] See [http://www.theclimateregistry.org/principles.html].

USDA Guidelines.[40] The 2008 farm bill (the Food, Conservation, and Energy Act of 2008, P.L. 110-246) contains a new conservation provision to facilitate the development of markets in environmental services. It directs the U.S. Department of Agriculture to develop technical guidelines for measuring environmental services from farms and forests. The provision specifically includes carbon in environmental services, in recognition of the need for uniform standards and consistent measures of emissions reduction and carbon sequestration in the agricultural and forestry sectors. These technical guidelines are likely to provide a consistent basis for carbon reporting and for offset projects in both voluntary and compliance markets.

Forestry Projects for Offsets

Several types of forestry projects might qualify as offsets for compliance or voluntary carbon markets. The capacity of forestry projects to provide offsets is substantial, with higher carbon prices increasing the number of economically feasible projects. One study estimated that U.S. forestry projects could sequester more than 100 million $mtCO_2$-e at a carbon price of $5 per tonne or as much as 1,200 million $mtCO_2$-e at $50 per tonne, as shown in **Figure 2**.[41] Subsequent changes in law and policy, as well as changes in energy, carbon, and forestry markets and different assumptions, would lead to different conclusions. Still, this potential is significant when compared to the 7,054 $mtCO_2$-e of U.S. emissions in 2006.[42]

The inclusion of projects in other countries would affect the quantity and price of offsets. This is particularly significant for forestry, since tropical deforestation and forest degradation have been estimated to cause as much as 20% of anthropogenic carbon emissions. Whether to include international projects in compliance schemes has been subject of extensive debate. (See "Avoided Deforestation," below.) In addition, international forestry projects may face more significant problems than domestic projects, as discussed below.

Afforestation and Reforestation. Establishing stands of trees is one of the most basic objectives of forestry. *Afforestation* is planting tree seedlings or preparing an area for tree seeding on sites that have been without trees for several years (generally a decade or more), such as pastures or recently abandoned or retired cropland. *Reforestation* is similar, but applies to sites recently cleared of trees, due to timber harvesting or a natural disaster.

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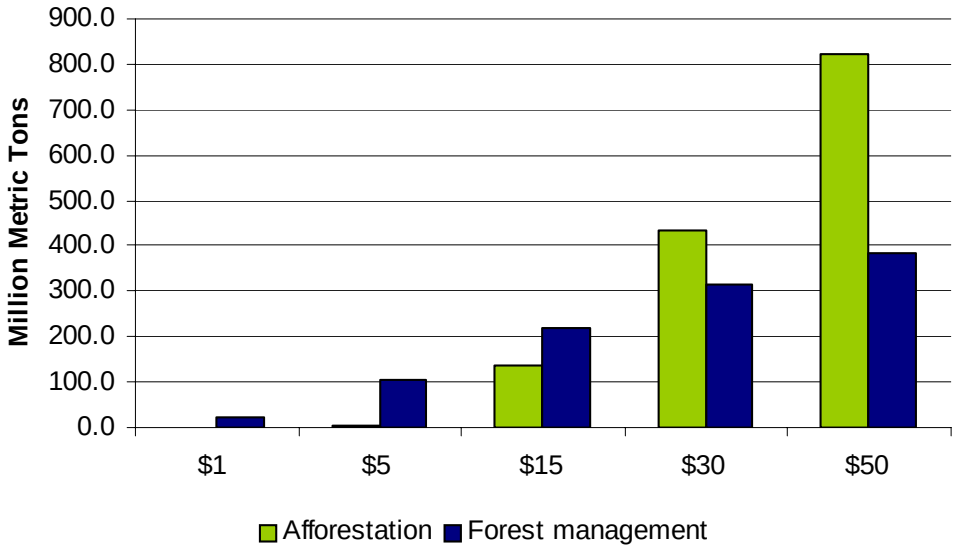
[40] See CRS Report RL34042, *Environmental Services Markets in the 2008 Farm Bill*, by Renée Johnson.

[41] U.S. Environmental Protection Agency, Office of Atmospheric Programs, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, EPA 430-R-05-006 (Washington, DC: Nov. 2005), p. 4-21.

[42] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005."

Figure 2. Estimated U.S. GHG Mitigation Totals by Activity: Annualized Averages, 2010-2110



Source: Prepared by Congressional Research Service with data from U.S. Environmental Protection Agency, Office of Atmospheric Programs, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture*, EPA 430-R-05-006 (Washington, DC: Nov. 2005), pp. 4-21.

Afforestation and reforestation are common forestry activities included in trading schemes for forest carbon sequestration offsets. Successful projects must result in established stands to qualify as an offset. Planting failures can result from disease or adverse ecosystem conditions. Forest stands generally sequester more carbon than sites without forest cover. Forest biomes store as much as 10 times more carbon in their vegetation than do non-forest biomes, usually at least for decades, and for centuries in some ecosystems. Afforestation will generally sequester more carbon than reforestation because of the carbon release from the site clearing prior to reforestation. (See "Long-Term Wood Products," below.) Afforestation can provide a broad array of other environmental benefits (e.g., improved water quality and habitat for native animal species), if the newly established tree stands restore a historically native mix of species. Plantations, including plantations of exotic species, probably provide less carbon storage than natural mixed forests, but can still be beneficial, especially if fast-growing species are used for products to displace harvests of natural forests (reducing deforestation).

The opportunities for afforestation are best in areas with long histories of land clearing for agriculture and other uses — Europe, North America, China, India, and the like. Some countries or regions with substantial open land may have limited opportunities for afforestation because of their arid conditions (e.g., central Asia, Sudan). In other areas (such as the United States), strong demand for corn and other agricultural products (e.g., soybeans or oil palms) to produce ethanol or biodiesel may also limit afforestation opportunities.

Long-Term Wood Products. Some have suggested that harvesting timber for long-term wood products should be included as possible carbon offsets. Lumber, plywood, and other solid wood products can store carbon for many years, ranging from 10 years for shipping pallets to 100 years or more for buildings.[43] Sawmill wastes are almost entirely used for paper or energy (burned as a substitute for fossil fuels). Paper products have a relatively brief duration, often releasing their carbon in less than a year, but paper often is recycled, reducing the carbon release as well as reducing the demand for wood from the forest.[44]

The wood left on the site after harvesting timber for wood products is more problematic. Some carbon may be added to the soil through decomposition, but much of the carbon left on the site returns to the atmosphere over time — a few minutes if the slash (tree tops and limbs) is burned; weeks, months, or even years if the slash rots.

Wood product harvests from natural tropical forests generally release more carbon than do harvests from plantations and temperate and boreal forests. Native tropical forests have much greater tree species diversity, and thus generally have a greater percentage of the biomass on a site remaining after a timber harvest. *Reduced impact logging* (RIL) is a collection of practices and techniques intended to reduce the environmental damage of logging, especially in the tropics, that can ameliorate the carbon release from tropical logging.[45] One source reported that RIL reduces wood waste by more than 60% and soil disturbance in roads, landings, and skid trails by almost 50%.[46] However, one barrier to increased use of RIL is illegal logging in the tropics.[47]

The net carbon consequences of timber harvesting for wood products have been debated extensively, with little resolution. Some argue that harvesting increases carbon sequestration by storing carbon in long-term products and sequestering large

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[43] Kenneth E. Skog and Geraldine A. Nicholson, "Carbon Sequestration in Wood and Paper Products," in *The Impact of Climate Change on America's Forests: A Technical Document Supporting the 2001 USDA Forest Service RPA Assessment* (Linda Joyce and Richard Birdsey, tech. eds.), Gen. Tech. Rept. RMRS-GTR-59 (Ft. Collins, CO: USDA Forest Service, 2000), pp. 79-88.

[44] Skog and Nicholson, "Carbon Sequestration in Wood and Paper Products."

[45] See Dennis P. Dykstra, *Reduced Impact Logging: Concepts and Issues*, FAO Corporate Document Repository, at [http://www.fao.org/docrep/005/ac805e/ac805e04.htm].

[46] Tropical Forest Foundation, "Reduced Impact Logging," at [http://www.tropicalforest foundation.org/ril.html].

[47] See CRS Report RL33932, *Illegal Logging: Background and Issues*, by Pervaze A. Sheikh. See also Patrick B. Durst and Thomas Enters, "Illegal Logging and the Adoption of Reduced Impact Logging," paper presented at *Forest Law Enforcement and Governance: East Asia Regional Ministerial Conference* (Denpasar, Indonesia: Sept. 11-13, 2001), at [http://wbla0018.worldbank.org/eap/eap.naf/Attachments/FLEG_S6-5/$File/6+5+Durst+ FAO.pdf].

amounts of carbon in reforestation.[48] Others have determined that the carbon released in harvesting operations substantially exceeds the additional carbon sequestered by reforestation.[49] Both conclusions may be valid in certain circumstances; the consequences probably depend on many factors, such as the products made and the amount and treatment of the carbon left on the site. Thus, whether timber harvesting for wood products could be a carbon offset is uncertain.

Forest Management. Forest management includes a variety of practices. Some are aimed at enhancing growth of the commercially desirable trees. Other plants compete for space, light, water, and nutrients. The undesirable vegetation can be killed chemically (with herbicides), mechanically (with machines or tools), or sometimes by fire (with prescribed burning). The net result, regardless of the tool, is that the carbon from the dead vegetation is released by burning or decomposition. One study found that mechanical thinning increased total carbon storage in dense, young stands, where competition had significantly reduced growth rates; elsewhere, it released carbon by reducing canopy cover and disturbing soils.[50] This is significant because many forest carbon models project carbon sequestration as a fixed percentage of commercial timber volume, not of total biomass on the site. In contrast, using fertilizers can enhance total vegetative growth without disturbing the soil, although many fertilizers are derived from fossil fuels and thus might not result in total net carbon storage. In sum, forestry practices to enhance growth apparently increase carbon sequestration in some circumstances, but not in others. This limits generalizations about potential of forestry practices to offset GHG emissions and raises questions about including growth enhancement for carbon offset projects.

Another significant practice is certified sustainable forestry. The sustainability of forests has long been an issue of environmental concern. In 1994, the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests was formed to develop internationally accepted measures of sustainable forestry.[51] The 12 member countries, representing 90% of the world's temperate and boreal forests, agreed in 1995 on a set of criteria and indicators to measure forest conservation and sustainable management; these are presented in the Santiago Declaration.[52]

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[48] John Perez-Garcia, Chadwick D. Oliver, and Bruce R. Lippke, "How Forests Can Help Reduce Carbon Dioxide Emissions to the Atmosphere," in U.S. House Resources Subcommittee on Forests and Forest Health, *Hearing on H.Con.Res. 151*, Sept. 18, 1997 (Washington, DC: GPO, 1998), Serial No. 105-61, pp. 46-68.

[49] Harmon et al., "Conversion of Old-Growth Forests," and Peter M. Vitousek, "Can Planted Forests Counteract Increasing Atmospheric Carbon Dioxide?" *Journal of Environmental Quality*, v. 20 (Apr.-June 1991): pp. 348-354.

[50] Paul Schroeder, "Can Intensive Management Increase Carbon Storage in Forests?" *Environmental Management*, v. 15, no. 4 (1991): pp. 475-481.

[51] See [http://www.rinya.maff.go.jp/mpci/].

[52] See [http://www.rinya.maff.go.jp/mpci/rep-pub/1995/santiago_e.html]. The Montreal Process excludes the forests of Europe (except for the Russian Federation), which have been addressed separately, under the Helsinki or Pan-European Process.

Several systems have been developed to certify that forests are being managed sustainably, consistent with the criteria and indicators developed through the Montreal Process and similar processes for other forested regions. The systems include programs from the Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI), and the Programme for the Endorsement of Forest Certification (PEFC). Although the programs differ in many details, they have many elements in common, such as using RIL, reforesting after harvests, protecting water quality, maintaining habitats for rare species, and preserving native peoples' rights. Furthermore, most require long-term planning for forested areas and independent, third-party monitoring to assure that implementation is consistent with the system's requirements. Most systems also require chain-of-custody reporting to assure that wood products claiming to be from sustainable forests actually come from certified forest lands.

Forest certification clearly provides a legally enforceable standard for forest management that could establish a permanent contract for sustainable production. It clearly produces environmental benefits and provides carbon sequestration when compared to unregulated timber harvesting. However, quantification of the carbon offsets that might result from forest certification, reflecting the variation in forest types and traditional forestry practices, poses a challenge.

Avoided Deforestation. As noted above, tropical deforestation is estimated to account for about 20% of global anthropogenic GHG emissions. Thus, avoiding tropical deforestation has great potential to reduce GHG emissions. Since tropical deforestation is currently external to carbon compliance requirements, it could be a substantial source of forest carbon offsets. At the project level, preventing deforestation is a relatively simple, straightforward action — contracts, easements, and other legal instruments can be created to assure that a site is not cleared of its timber. However, avoiding deforestation is particularly prone to leakage — deforestation of another site to provide the desired products or outcomes. This issue is discussed below.

Some of the leakage problem can be addressed by determining offsets for avoided deforestation at the national or regional level; this approach is used for some CDM and JI offsets. Proponents of including aggregate national total for avoided deforestation argue that (a) it lowers compliance costs, since avoiding deforestation can be substantially less expensive than active forestry or other emission reduction or sequestration efforts; and (b) it provides compensation to developing tropical Third World nations. Opponents argue that (a) it would be a disincentive to, and would raise eventual costs for, developing countries to participate in global GHG emission reduction efforts; (b) it would benefit the political elite of developing nations, while their indigenous peoples would be further disenfranchised; and (c) it would delay technological development and implementation to reduce GHG emissions in the industries that cause the emissions.[53]

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[53] See CRS Report RL34436, *The Role of Offsets in a Greenhouse Gas Emissions Cap-and-Trade Program: Potential Benefits and Concerns*, by Jonathan L. Ramseur.

Potential Drawbacks of Forestry-Related Projects

Although forestry-related projects may offer considerable opportunities to mitigate climate change, several issues with offsets and with forestry projects have generated controversy. The primary concern is the integrity and credibility of offsets generated by forestry activities. To be credible, a forestry offset should provide a net CO_2 reduction or sequestration equal to an emission reduction from a direct emission source, such as a smokestack or exhaust pipe. This issue is critical, particularly if the offsets are to be used in an emissions trading program.

Implementing this objective imposes challenges for all offset types, but forest offsets generally present more hurdles than other projects. To generate credible offsets, projects must be *additional* to what would have occurred without the incentive supplied by the carbon market; they must be *verifiable* (i.e., measurable and enforceable); they must control or adjust for *leakage*; and they must address the issue of *permanence*. *Forward crediting* is proposed by some to accommodate the long period of carbon accumulation in forests, but others are concerned about assuring payments only for actual carbon sequestration. These issues are discussed below.

Additionality

Additionality is a significant factor in determining offset integrity. Indeed, if a project is not *additional*, it cannot qualify as an offset in a compliance market. Additionality means that the offset project is an activity beyond what would have occurred under a business-as-usual scenario. In other words, in the case of a forestry project, would the sequestration have happened anyway?

A test of additionality would examine whether the offset project would have gone forward in the absence of the forest carbon market. For instance, does the activity represent a common practice or conform to an industry standard? Is the forestry project required under other federal, state, or local laws? Would the sequestration project generate financial gain (i.e., be profitable) due to revenues from outside the offset market?[54] For example, in the United States and Canada, reforestation following a timber harvest would generally not qualify as an offset, because most states and provinces require reforestation. Similarly, disposal of sawmill waste by burning to produce energy, and displace the use of fossil fuel, would not qualify as an offset, because all U.S. sawmills burn their waste (except for what is sold for paper production) for energy.

Additionality is at the crux of an offset's integrity, but applying the additionality criterion may present practical challenges. Assessing a project's additionality may involve some degree of subjectivity, which may lead to inconsistent additionality determinations. For instance, it may be impossible to accurately determine "what would have happened anyway" for some projects. Data on historic deforestation are sketchy, at best, making it difficult to assess whether an avoided deforestation program would be additional.

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[54] See World Resources Institute, *The Greenhouse Gas Protocol for Project Accounting* (Dec. 2005), at [http://www.ghgprotocol.org].

Verifiability

The forest carbon sequestration must be real and measurable. That is, the forestry project — afforestation, avoided deforestation, etc. — must actually occur and have a quantifiable amount of carbon sequestered. Meeting these objectives requires measurement, monitoring, and enforcement.

Measurement. Measuring forest carbon sequestration can be problematic. Various approaches have been taken, including tables, models, and protocols for estimating carbon sequestration by various practices in different locales. A common limitation is that many estimators use commercial timber volume as the basis for carbon stored, but the relationship between commercial volume and carbon sequestered may not be linear. For example, thinning is a forestry practice intended to increase commercial volume by concentrating the same total growth on fewer commercial stems.[55] Total growth also varies widely from site to site, depending on a host of localized physical and environmental factors. Thus, many observers recommend, and some existing carbon markets require, field measurements to adjust the estimated carbon storage to on-the-ground reality.[56] One problem is that field measurements are expensive and subject to sampling error.

Monitoring. To verify that sequestration projects are meeting their stated level of sequestration, some level of monitoring is required. For enforceable contracts, periodic monitoring is essential to assure that the contract is fulfilled. For agreements larger than projects, such as avoided deforestation for an entire landholding or country, periodic monitoring becomes more important and more difficult. Remote sensing (e.g., satellite imagery) and field sampling are common practices for monitoring large-scale changes, but both are expensive and both are subject to sampling error. The two practices are commonly used together, with field sampling to assure the on-the-ground accuracy of remotely sensed data.

Enforcement. Often, the reality of a project is assured through an enforceable contract, such as an easement attached to the forested property to require continued forest cover. Many existing forest carbon markets require third-party verification for forest carbon credits. For some markets and practices, assurance of sustainable forest management can be obtained through forest certification. A number of organizations, such as the Forest Stewardship Council (FSC), the Programme for the Endorsement of Forest Certification (PEFC), and the Sustainable Forestry Initiative (SFI), have set standards and rely on independent third parties for certification of sustainable forest management.

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[55] See David M. Smith, Bruce C. Larson, Matthew J. Kelty, and P. Mark S. Ashton, *The Practice of Silviculture: Applied Forest Ecology*, 9th ed. (New York, NY: John Wiley & Sons, Inc., 1997).

[56] See, for example, The Wilderness Society, Ecology and Economics Research Department, *Measuring Forest Carbon: Strengths and Weaknesses of Available Tools*, Science & Policy Brief, No. 1 (Washington, DC: April 2008).

Leakage

Leakage "occurs when economic activity is shifted as a result of the emission control regulation and, as a result, emission abatement achieved in one location that is subject to emission control regulation is [diminished] by increased emissions in unregulated locations."[57] In the context of forestry-related offsets, the opportunity for leakage exists on two fronts: emissions leakage and product leakage.

Emissions Leakage. Compared to other offset types, forestry projects, particularly those that sequester carbon by curbing logging, likely present the greatest risk of leakage.[58] For example, if large landowners or countries agree to preserve their forests, wood processors might simply shift their harvests to neighboring landowners or countries. As a result, the total harvest (total deforestation) might be unchanged, even though particular landowners or countries might have avoided deforestation of their forests. The only recognized solution is for a majority of landowners or countries to agree to participate in a program to reduce deforestation.[59]

Product Leakage. Forest products face another type of leakage: product leakage. Producing long-term wood products, such as lumber and plywood, uses much less energy — and thus emits fewer GHGs — than comparable quantities of alternative products used to build homes and other structures, such as concrete and masonry walls and steel and aluminum framing.[60] Thus, avoided deforestation might lead builders to replace wood with other more energy-intensive, GHG-emitting products. The net carbon consequences of such a shift are unclear.

Permanence

For forestry-related projects, one concern is that the projected sequestration will be halted or reversed. Forest offset projects are typically expected to generate offsets (via sequestration) for decades. Some are concerned that the emission offsets will be subsequently negated by human activity (e.g., change in land use) or a natural occurrence (e.g., forest fire, disease, or pestilence).

Permanence is especially problematic for forests, because forests are composed of living organisms — they are born (seeds germinate), they grow, and eventually

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[57] U.S. Environmental Protection Agency, Office of Air and Radiation, *Tools of the Trade: A Guide To Designing and Operating a Cap and Trade Program For Pollution Control*, EPA430-B-03-002 (June 2003), Glossary.

[58] Nicholas Institute for Environmental Policy Solutions, *Harnessing Farms and Forests in the Low-Carbon Economy: How to Create, Measure, and Verify Greenhouse Gas Offsets*, Zach Wiley and Bill Chameides, eds. (Durham, ND: Duke Univ. Press, 2007), pp. 18-19.

[59] Brian Murray and Lydia Olander, *A Core Participation Requirement for Creation of a REDD Market*, Nicholas Institute for Environmental Policy Solutions, Short Policy Brief (Durham, NC: Duke Univ. Press, May 2008).

[60] Jim Bowyer, Steve Bratkovich, Alison Lindberg, and Kathryn Fernholz, *Wood Products and Carbon Protocols: Carbon Storage and Low Energy Intensity Should Be Considered* (Dovetail Partners, Inc., April 28, 2008).

they die. This life cycle varies widely, depending on the tree species; for example, aspen and Southern yellow pines rarely grow older than 200 years, while Douglas-fir and many live oak species commonly grow for more than 1,000 years, and bristlecone pines can live for more than 4,000 years. Nevertheless, trees die eventually, and their carbon is converted to wood products, contributed to the soil, or sent into the atmosphere.

Permanence can be achieved for forest projects by providing for mitigation or a buffer against natural losses. An analysis of four particular carbon offset market standards found that one required a 10% buffer (i.e., only 90% of the estimated carbon offset could be sold); another required a 30% buffer, while the other two used variable buffers (from 5% to 60%) depending on an assessment of the risk of the project.[61] For landowners or countries, carbon sequestration permanence can be achieved through sustainable forestry practices, with reforestation following any and all carbon removals to assure stable or increasing carbon storage.

Forward Crediting

Many biological sequestration projects, such as afforestation or reforestation, present a unique challenge because of the significant time gap between the initial project activity (e.g., planting trees) and the actual carbon sequestration. Although the project may generate considerable offsets in aggregate, the offsets are produced gradually, over the course of many years or decades. Tree growth patterns follow a traditional S-shape, with slow growth in the early years, accelerating for many years to decades, before tapering off to an eventual maximum. The age at which growth has reached its maximum varies widely among species — as short as 200 years for short-lived species (e.g., aspen and Southern pines), and more than 1,000 years for long-lived species (e.g., western hemlock and Douglas-fir). However, even old-growth forests that have little or no additional tree growth apparently continue to sequester carbon in the soils.[62]

This aspect of sequestration projects raises the question of how sequestration offsets should be distributed. Should they be allotted as they are produced — on an annual basis — or should they be allotted up front in an aggregate sum, based on expected future sequestration? The latter option is referred to as forward crediting.

Forward crediting entails risk, because there is some uncertainty about whether the offsets will actually be realized. This risk can be addressed through discounting, much as the permanence risk is addressed through buffers: by retaining a percentage of the offsets that are expected over the course of the project to accommodate

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[61] Eduard Merger and Alwyn Williams, *Comparison of Carbon Offset Standards for Climate Forestation Projects Participating in the Voluntary Carbon Market: A Comparison of Climate, Community & Biodiversity Standard (CCBS), CarbonFix Standard (CFS), Plan Vivo Systems and Standard, and AFOLU Voluntary Carbon Standard (VCS)* (Christchurch, New Zealand: Univ. of Canterbury, May 2008).

[62] See, for example, Mark E. Harmon, William K. Ferrell, and Jerry F. Franklin, "Effects on Carbon Storage of Conversion of Old-Growth Forests to Young Forests," *Science*, v. 247 (Feb. 9, 1990): pp. 699-702.

unexpected events (e.g., slower vegetative growth than anticipated). Whether such discounting is necessary for forest carbon offsets, and if so how much the discount should be, are as yet undetermined.