Key Design Issues Relating to Greenhouse Gas Abatement and Sequestration Projects in Agriculture and Forestry[1]

Background Paper for the EPRI Greenhouse Gas Emissions Offset Policy Dialogue Workshop #4

February 2009

I. Background

This paper has been prepared for a workshop that will be held by the Electric Power Research Institute (EPRI) on February 19, 2009 in Washington D.C. It is the fourth in a series of workshops to be held by EPRI in 2008 and 2009 on the subject of greenhouse gas (GHG) emissions offsets.

The purpose of this paper is to provide background for workshop discussions on topics relating to GHG abatement and sequestration projects in the agriculture and forestry sectors. Topics addressed in this background paper include:

- The importance of GHG abatement and sequestration projects in the agriculture and forestry sectors in the context of emission reduction efforts in the U.S. and any future national GHG cap-and-trade program;
- Definitions and descriptions of several categories of GHG abatement and sequestration projects in the agriculture and forestry sectors that may be eligible to create offsets under a future U.S. offset system;
- Definition and discussion of the issue of permanence in the context of carbon sequestration projects in the agriculture and forestry sectors. Topics relating to permanence, including:
    - Accounting for the impermanence of carbon sequestered from agriculture and forestry projects in GHG registries;
    - Temporary crediting for sequestration reductions;
    - Options for addressing liability for ensuring the permanence of sequestration reductions; and
    - Experience with liability in the Clean Development Mechanism (CDM).
- Definition and discussion of the issue of leakage in the context of agriculture and forestry carbon sequestration projects. Topics relating to leakage, including:
    - Quantifying leakage; and
    - Compensating for leakage
- Allowance set-asides; and
- Current approaches in offset programs for addressing impermanence.

[1] Prepared by Natsource Advisory and Research Services and the Electric Power Research Institute.

II. Importance of GHG Abatement and Sequestration Projects in the Agricultural and Forestry Sectors

Globally, agriculture is responsible for more than 20% of anthropic GHG emissions. The United Nations' Intergovernmental Panel on Climate Change estimates that agricultural activities emit 21–25% of all anthropic CO_2 fluxes, 55–60% of total CH_4 emissions, and 65–80% of total N_2O fluxes. [2] CO_2 emissions are derived from deforestation and fossil fuel use; CH_4 emanates from enteric fermentation, rice cultivation, biomass burning, and animal wastes; and N_2O emissions come from cultivated soils, animal wastes, and biomass burning. The magnitude of these fluxes and their sensitivity to management makes agriculture an attractive target for many GHG stabilization schemes. Also, because most of these fluxes are interdependent, there are numerous opportunities to exploit synergies.[3]

Many believe that the U.S. agriculture and forestry sectors have the potential to create a significant volume of cost-effective GHG emission reductions. While the agriculture sector accounts for approximately 7.4% of annual U.S. GHG emissions, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Agriculture (USDA) estimate that agricultural soils potentially could sequester enough carbon to offset 10–15 percent of annual U.S. GHG emissions.[4]

In its March 2008 analysis of climate change legislation introduced by Senators Lieberman and Warner (S. 2191), EPA estimated that the agriculture and forestry sector would supply approximately 400 million metric tons (Mt) CO_2e in 2015 and approximately 500 Mt in 2020—the largest volumes contributed by any sector likely to participate in an offset system.[5]

According to the EPA analysis, the activities with the potential to create the largest volumes of GHG offsets within the sector are, from largest to smallest, afforestation, agricultural soil sequestration, forest management, and agricultural nitrous oxide (N_20) and methane (CH_4) emission reductions.[6] (Note that avoided deforestation was not evaluated because it would not be eligible to generate offset credits under the proposed Lieberman-Warner legislation.).

EPA estimates that in 2010, afforestation, agricultural soil sequestration and forest management activities will be able to supply approximately 100 Mt at a marginal abatement cost of $20 per ton CO_2e (tCO_2 or "tonne").[7] In 2020, the estimate for afforestation supply at $20/tonne increases significantly to approximately 350 $MtCO_2e$, while agricultural soil sequestration would

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[2] IPCC. 2001. Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK.

[3] Developing Greenhouse Gas Emissions Offsets by Reducing Nitrous Oxide (N_2O) Emissions in Agricultural Crop Production, Project Overview and Early Preliminary Results from Year 1. EPRI, Palo Alto, CA: 2007. 1015463., p 2-1.

[4] "21st Century Agriculture Project: The Role of Agriculture in Reducing Greenhouse Gas Emissions: Recommendations for a National Cap-and-Trade Program," Senator Bob Dole and Senator Tom Daschle, April 2008, p.12.

[5] "EPA Analysis of the Lieberman-Warner Climate Security Act of 2008, S. 2191 in 110th Congress," U.S. EPA, March 14, 2008 (figures are rough estimates for EPA's ADAGE model, based on graph on p. 29).

[6] Ibid. Based on graph of results from EPA's IGEM model, p. 89.

[7] "Offsets in EPA Analyses of S. 2191, S. 1766, and S. 280," presentation by Allen Fawcett, U.S. EPA, at EPRI GHG Emissions Offsets Workshop, June 26, 2008 (based on graph on p. 22).

remain near 100 $MtCO_2e$ and forest management would decrease to approximately 50 $MtCO_2e$.[8] Based on these volumes and marginal costs, these categories of projects (together with landfill gas projects) are expected to be the most cost-effective available, and could account for a very large portion of overall U.S. emission reductions.

III. Definitions and Descriptions of Sequestration and Emission Reduction Activities in Agriculture and Forestry

Provisions incorporated in federal legislation to establish a GHG cap-and-trade program authorize several types of projects in the agriculture and forestry sectors to create offsets. In addition, regional U.S. cap-and-trade programs authorize the creation of offsets from various types of agriculture and forestry projects.

The Regional Greenhouse Gas Initiative (RGGI), which entered into operation at the beginning of 2009, authorizes the use of offsets created by afforestation and manure management projects. The Western Climate Initiative (WCI) will consider authorizing the use of offsets created by a broad range of activities in the agriculture and forestry sectors.

Table 1 summarizes the GHG offset project types included in the "positive lists" incorporated in RGGI, WCI, the version of the Lieberman-Warner legislation considered by the Senate in June 2008 (S. 3036), and draft legislation introduced in late 2008 by the former Chairman of the House Energy and Commerce Committee, Rep. John Dingell (D-MI), and Rep. Rick Boucher (D-VA), the former Chairman of the Subcommittee on Energy and Air Quality.[9]

Table 1: Eligible Offset Project Categories under Proposed Federal Cap-and-Trade Legislation and Regional Cap-and-Trade Legislation[10]

	RGGI	WCI[11]	Lieberman-Warner	Dingell-Boucher
Agriculture and Forestry				
Agricultural Soil Sequestration		✓	✓	Maybe
Afforestation	✓	✓	✓	✓
Reforestation		✓	✓	✓
Agricultural Soil Management		✓	✓	Maybe
Land Use Change				Maybe
Forest Management		✓	✓	Maybe
Forest products		✓		
Manure Management	✓	✓	✓	✓
Avoided Deforestation		✓	Maybe via international offsets	Maybe

[8] Ibid. Based on graph on p. 23.
[9] This subcommittee has been renamed the Energy and Environment Subcommittee. Its new Chairman is Rep. Edward Markey (D-MA).
[10] Project types listed as "maybe" in Table 1 are those listed for further consideration in the Dingell-Boucher draft legislation.
[11] The WCI has identified these categories of offsets as priority areas for further consideration, but has not yet approved their use in the WCI program.

	RGGI	WCI	Lieberman-Warner	Dingell-Boucher
Other Economic Sectors				
Landfill Methane	✓	✓		✓
Coal Mine Methane				✓
Wastewater Management		✓		Maybe
SF_6 Emission Reductions	✓			
End-Use Efficiency	✓			

This section of the paper defines and describes offset project types in the agriculture and forestry sectors that are included in the programs shown in Table 1. The discussion below does not include the project category of manure management (e.g., animal waste digesters) because methane destruction in livestock production does not raise concerns relating to permanence and leakage and there are well-established measurement, monitoring and verification methodologies that have been established for this project type.

Also, the discussion below provides relatively little detail on generating offsets from avoided deforestation or Reduced Emissions from Deforestation and Destruction (REDD), because these kinds of offsets largely would be generated in tropical regions and nations abroad. Emissions offsets generated through REDD will be the topic of a future EPRI GHG offsets workshop.

A. Afforestation and Reforestation

Afforestation is "the establishment of trees on lands that were not previously forested," while reforestation is the establishment of "trees on lands that are not currently forested, but were forested at some point in the past."[12] Growing new trees increases biomass within project boundaries and sequesters carbon in live and dead wood.[13] Carbon is retained in stands of trees unless there is a timber harvest, at which time a substantial amount of the carbon returns to the atmosphere through decomposition of logging wastes and releases of soil carbon. However, when wood is harvested for use in wood products, much of the carbon remains stored in the wood products over long periods of time.

In the U.S., a portion of forest land over time has been converted to agricultural land. This historic conversion creates opportunities to increase sequestration on certain agricultural lands through tree planting.[14] The rate of carbon uptake and total carbon storage capacity of forests depends on such factors as tree species, geographic region, and the age of the forest.[15] From a technical standpoint, most forest planting projects may be considered reforestation projects, as most sites that are physically suitable and cost-effective for growing trees have had tree stands at some point in the past.[16] However, some offset project protocols require reforestation project

[12] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, Palo Alto, CA: 2006, 1012576, p. 6-1.
[13] Ibid
[14] "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 13
[15] Ibid.
[16] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 6-1.

lands to have been in non-forest use for a period of time to qualify to create offsets. For example, the California Climate Action Registry (CCAR) defines reforestation as:

> *The establishment and subsequent maintenance of native tree cover on lands that were previously forested but have had less than 10% tree canopy cover for a minimum time of ten years, or have been subject to a significant disturbance within the last ten years [involving the loss of at least 20% of the project area's forest carbon stocks] that is not the result of intentional or grossly negligent acts of the landowner*.[17]

To maximize revenue from project lands, land owners may seek to benefit from carbon sequestration in young trees (when carbon uptake is rapid) and harvesting and sale of a portion of older trees.[18] The ability to implement such hybrid management approaches depends on contractual arrangements between the buyer and seller of sequestered carbon and the underlying requirements of the offset program that may stipulate which specific future land uses are consistent with maintenance of issued offsets. In some cases, project protocols may require project owners to purchase land easements that prohibit logging or require the maintenance of a specified volume of standing timber over long periods of time. Easement prices can approach the land purchase price in practice.[19] If easements are not required, then ongoing monitoring to ensure continued maintenance of forest stands and sequestration of carbon becomes critical to ensuring the permanence of sequestered tons. (Permanence is discussed in more detail below in Section IV.A.)

B. Agricultural Soil Sequestration

Agricultural soil sequestration activities are land management practices that increase the rate of carbon input or reduce the rate of carbon removals in soil, thereby increasing the amount of carbon stored.[20] Such activities include decreasing soil disturbance in annual cropping through conservation tillage – the preparation of the seedbed using methods that reduce erosion and leave 15–30% of the surface covered with crop residue after planting.[21] Conservation tillage requires fewer passes of equipment than conventional tillage, in which soil is completely inverted before planting, resulting in significant releases of CO_2 to the atmosphere.[22] In addition to reducing CO_2 releases, conservation tillage and other soil sequestration activities can provide such benefits as air and water quality improvements, improved soil tilth (i.e., suitability for planting or growing a crop), enhanced crop productivity and reduced nutrient leaching and run-off.[23]

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[17] "Revised Forest Project Protocol," California Climate Action Registry, draft, December 2008, p. 7.
[18] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 9-5.
[19] Ibid, p. 3-3.
[20] "Harnessing Farms and Forests in the Low-Carbon Economy: How to Create, Measure and Verify Greenhouse Gas Offsets," The Nicholas Institute for Environmental Policy Solutions, Zach Willey and Bill Chameides, Editors, Duke University Press, 2007, p. 25.
[21] Ibid, p. 26.
[22] Ibid.
[23] "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 13.

Conservation tillage methods include reduced-till and no-till cropping.[24] Reduced-till cropping involves plowing only narrow strips of soil. Types of reduced-till cropping include ridge tilling and chisel plowing. Ridge tilling involves creating a series of ridges for growing rows of crops every 2-3 years, and leaving the soil undisturbed between harvest and planting. In chisel plowing, vertical shafts are used to rip the soil, which is partially covered with crop residue and "disked" or smoothed. No-till cropping eliminates soil disturbance entirely, apart from carving slots in the ground for seed.

The rate and level of carbon sequestration in soils depends on such factors as soil type, management practice, location and climate.[25] In addition, soils that historically have lost carbon due to land conversion or management practices have a greater capacity to sequester carbon and can do so at higher rates than soils that are closer to **"saturation"** – i.e., their limit for carbon absorption. Thus, greater amounts of sequestration and faster absorption rates can be achieved on lands that have engaged in traditional tillage practices than those that have already undertaken no-till or low-till cropping. The initial rate of carbon absorption is higher when a sequestration practice is first adopted, and then slows over time as the ecosystem approaches saturation, an equilibrium point at which the rates of carbon inputs and outputs are equal. Sequestration practices have the impact of increasing the level of equilibrium and saturation. Many sites suitable for soil sequestration activities are expected to reach CO_2 saturation within approximately 2 decades or so from the beginning of no-till farming practices.

C. Agricultural Soil Management to Reduce Emissions of Nitrous Oxide (N_2O)

Nitrous Oxide (N_2O) is a significant GHG that contributes to global climate change. Each ton of N_2O emitted into the atmosphere is equivalent to emitting 296 tons of CO_2 in terms of its Global Warming Potential (GWP). Therefore, GHG emission offset projects that reduce even relatively small amounts of N_2O emitted into the atmosphere can have a proportionately larger effect on reducing radiative forcing associated with climate change than similar changes in CO_2 emissions. This sensitivity to small changes provides a strong impetus for including N_2O and other non-CO_2 GHGs in the development of effective GHG mitigation strategies.[26]

Emission sources of nitrous oxide from agricultural lands include N_2O emissions from soils, the incorporation of crop residue into soil, and the use of fertilizers and manure on croplands.[27] N_2O

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[24] Information in this paragraph was derived from "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., p. 26.

[25] Information in this paragraph was derived from "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 13 and "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, Editor G.A. Smith, a book developed by Environmental Defense, 2006, p. 20 of book chapter.

[26] Ibid.

[27] "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 12.

[27] Information in this paragraph was derived from "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., and "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit.

emissions from agricultural soils accounts for more than 50% of the global anthropic N_2O flux, as shown in Figure 1. N_2O is formed during nitrification and denitrification.[28]

Measures to reduce N_2O emissions include reducing fertilizer and manure use on croplands, reducing the frequency and duration of flooding, and increasing the uptake of nitrogen by plants.[29] Nitrogen uptake by soils and nitrogen use efficiency can be enhanced through the use of nitrogen tests to reduce and adjust fertilizer applications, timing applications to better coincide with crop demand for nitrogen, elimination of fallow periods and the use of cover crops.

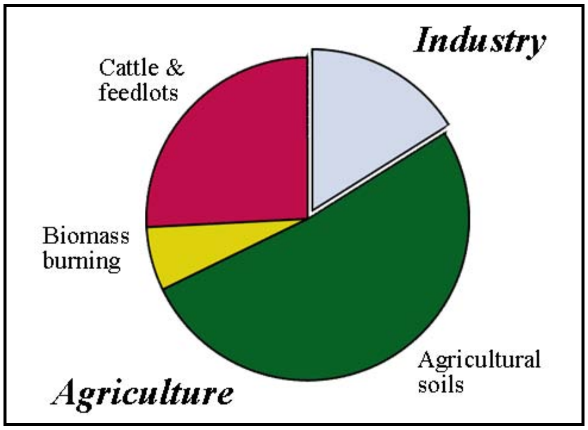

Figure 1. Anthropic sources of N_2O globally; Total anthropic flux is 1 Pg C-equivalent y^{-1}.
Source: IPCC 2001, Robertson 2004.

N_2O emissions reductions related to changes in crop production methods may offer an approach that can generate large-scale and potentially cost-effective GHG emissions offsets that could be implemented across broad geographic areas of the U.S. and internationally.

To understand the potential scope of this approach and its scientific efficacy, in 2006 EPRI launched a three-year long project in conjunction with Michigan State University (MSU) and eight EPRI-member electric companies to investigate the potential to reduce nitrogen fertilizer use and concomitant N_2O emissions on agricultural lands planted in corn in the Midwest.

Based on results to date, EPRI and MSU estimate that N_2O emissions could be reduced on average approximately 0.5 tonnes CO_2e per acre annually – an avoided emissions rate similar to the rate of carbon sequestration based on no-till agricultural practices. However, in contrast to enhanced carbon sequestration via conservation tillage, N_2O emissions are permanent and are not expected to cause large-scale leakage, N_2O emissions can be reduced without substantially reducing expected overall crop yields.

[28] Nitrification refers to the microbial oxidation of NH_4^+ to NO_3^-, and denitrification refers to the microbial reduction of NO_3^- to N_2O and then N_2.
[29] Information in this paragraph was derived from “Harnessing Farms and Forests in the Low-Carbon Economy,” The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., p. 30.

D. Forest Management

Forest management in the context of sequestration projects consists of management practices that result in increased carbon stocks on or from a given parcel of land.[30] One approach to increase carbon stocks is to lengthen rotations – i.e., delaying harvests of trees until they are older and larger, when they contain more carbon than smaller trees harvested on shorter rotations. The cost-effectiveness of this approach would depend on the price of offsets and the price of timber harvests foregone (i.e., delayed).

Another forest management approach is switching from even-age management (in which all trees that dominate a forest stand are approximately the same age; the non-technical term for such management is "clear cutting") to uneven-age management, in which trees vary in age and are harvested periodically and selectively, in order to make room for new trees. This approach allows for a denser forest and more biomass and sequestration because even-age management requires more space between trees to allow them to reach mature levels at the same time, while uneven-age management can take advantage of the smaller space requirements of younger trees and timing harvesting to efficiently create room for growing trees over time.

Increasing utilization – i.e., increasing the amount of wood products obtained from each tree, thereby reducing harvesting without reducing product output – is another management approach that increases carbon stocks. Increasing the proportion of harvested wood that is used for wood products also increases carbon stocks, but regulations would need to determine which entity (tree grower, wood product manufacturer, the purchaser of the product), if any, would be able to claim credit for sequestered carbon.

E. Avoided Deforestation

Avoided deforestation projects implement "specific conservation actions to prevent the site-specific clearing and conversion of native forests to a non-forest use, such as agriculture or other commercial development."[31] On a global basis, deforestation and degradation of forests from 1850 to 1990 resulted in GHG emissions equal to approximately one-half the emissions associated with burning of fossil fuels.[32]

In addition to reducing emissions, avoiding deforestation would provide other ecological benefits associated with maintaining forests. In the U.S., forests are cleared mainly for residential development.[33] Challenges in the U.S. for avoiding deforestation include obstacles to clustered development and high transaction costs for projects undertaken on small parcels. The Western

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[30] Information in this section was derived from "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., pp. 6-4, 6-5, and "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., pp. 23-24.

[31] "Revised Forest Project Protocol," California Climate Action Registry, draft, December 2008, p. 3.

[32] "The annual net flux of carbon to the atmosphere from changes in land use 1850-1990," R.A. Houghton, 1999, *Tellus*, 51B: 298-313, cited in "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 6-6.

[33] Information in the remainder of this section was derived from "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 6-6, and "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., p. 25.

Climate Initiative (WCI) will consider including avoided deforestation as an eligible offset category, and the California Climate Action Registry (CCAR) includes "avoided conversion" projects.

If a project reduces the amount of wood supplied to a market, other suppliers can be expected to make up most of the lost supply.[34] This displacement of harvesting also typically displaces GHG emissions, thereby diminishing the project's impact on *net GHG emissions*. As discussed in Section IV.B, the displacement of emissions to another location by a project is a phenomenon known as "leakage." In the case of avoided deforestation projects, leakage may occur when a project decreases the amount of marketable wood supplied to the market, resulting in an increase in timber harvesting elsewhere to compensate for the lost supply. Leakage may be avoided, for example, by establishing a new forest plantation on land not previously forested, thereby maintaining the supply of timber to the market.

In some developing countries where forests typically are cleared for conversion to agricultural use, efforts to avoid deforestation and forest degradation face a number of challenges. These include gaining acceptance and recognition of methods for quantifying GHG emission reductions, as well as methodologies to reduce forest clearing without displacing emissions to other locations.

Avoided deforestation is currently not eligible to generate emission reduction credits under the Kyoto Protocol's Clean Development Mechanism (CDM), nor can these kinds of offsets projects be used to achieve compliance with the EU Emissions Trading Scheme (EU ETS). However, international climate negotiators are considering approaches for crediting emission reductions from Reduced Emissions from Deforestation and Forest Degradation (REDD) after 2012, when the Protocol expires. Discussions on REDD have centered on methodological issues relating to reference emission levels for deforestation and degradation, and the role and contribution of conservation, sustainable management of forests, among other topics.

IV. Permanence, Leakage and Related Issues

A. Permanence

Emission reductions resulting from such actions as fuel switching or using more efficient technologies represent permanent reductions. Once those actions are taken, GHG emissions are avoided, and no subsequent action is required to ensure the permanence of the emission reductions.

In contrast, the removal of GHGs from the atmosphere – through sequestration of carbon in forests or agricultural soil, for example – is impermanent. Once carbon is sequestered, it must be maintained (i.e., stored) through time, in order to have continued atmospheric benefits.[35] Unlike

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[34] "Estimating leakage from forest carbon sequestration programs," B.C. Murray, B.A. McCarl, and H-C Lee, *Land Economics*, 80(1): 109-124, 2004 (cited in "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 6-7)

[35] A distinction is made between sequestration and storage of carbon. As noted in EPRI, 2006, "Removal of CO_2 from the atmosphere (sequestration) can be a GHG emission offset. Keeping that carbon out of the atmosphere by

permanent emission reductions, the impact of a sequestered ton of CO_2 on the atmosphere is contingent on actions and events subsequent to the actual sequestration period. If the ton is ultimately released to the atmosphere, the benefits of the project are negated.[36] Such releases are termed "**reversals**." The topic of "permanence" (or as some prefer, "impermanence") relates to the risk that emission reductions from sequestration projects will not be permanent, and actions to address this risk.

Different offsets project types in the agricultural and forestry sectors face different permanence risks. On one hand, soil carbon sequestration projects face relatively high permanence risk because the use of conventional tillage practices just one time can reverse most of the soil sequestration benefits obtained through many years of no-till agriculture. At the other extreme, N_2O emissions reductions in agricultural crop production are permanent as this approach avoids the "business-as-usual" emissions of N_2O.

Table 2 shows which offsets types in the agriculture and forestry sector may be affected by permanence and leakage risks that are described below.

Table 2: Potential Permanence and Leakage Risks for Agriculture and Forestry Offset Project Categories

Agriculture and Forestry Offset Types	Permanence Risk	Leakage Risk
Agricultural Soil Sequestration	Yes	Yes
Afforestation	Yes	Yes
Reforestation	Yes	Yes
Agricultural Soil Management	No	No
Land Use Change	Yes	Yes
Forest Management	Yes	Yes

Reversals in agriculture and forestry sequestration projects may be unintentional or intentional. **Unintentional reversals** result from natural and unpredictable events. Agricultural soil sequestration can be reversed due to flooding and pest infestation. Sequestration from afforestation, reforestation and forest management projects can be reversed due to fire, pests, disease and storm damage.[37] Such reversals may be catastrophic and are generally beyond the control of a project developer – e.g., a wildfire can completely release all of the carbon sequestered in a stand of trees.

In contrast, **intentional reversals** result from decisions by project owners, and are avoidable. For example, after implementing reduced-till cropping to sequester carbon and receive offset

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storing the carbon in wood maintains the offset through time, but *does not create a new offset*." "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 5-2.

[36] "Addressing Impermanence Risk and Liability in Agriculture, Land Use Change, and Forest Carbon Projects," Policy Brief, B.C. Murray and L.P. Olander, The Nicholas Institute for Environmental Policy Solutions, Duke University, October 2008, p. 2.

[37] Ibid, p. 3.

credits, a farmer may switch back to conventional tilling practices. Similarly, an owner of forest land who undertakes an afforestation, reforestation or forest management project to receive offset credits later may opt to harvest timber, or revert to conventional rotation lengths and harvesting practices.[38]

While long-term contracts such as easements could prevent some types of intentional reversals by "locking-in" specific activities, landowners may not be willing to enter into contracts that create restrictions on how land will be used over the longer term. If contracts are not long-term, there remains a need for monitoring to continue over time, and for such monitoring to be paid for, even after the contract has expired. The limited duration of contracts, the costs of monitoring, the opportunity costs of continuing to store carbon, and the reversibility of sequestered tons raise a number of questions and challenges, such as:

- How should sequestration tons be accounted for in a registry or other emissions accounting system (given their impermanence and potential for subsequent release)?
- Who should be held liable for reversals, and how can they be held liable (i.e., the buyer, the seller, or the system as a whole through such approaches as buffer reserves)?
- How can project requirements be established to best ensure that the necessary monitoring of projects is maintained over time, even after a project stops generating additional offset credits?

These questions are considered in the discussions on emissions accounting, temporary crediting, and liability that follow.

1. Emissions accounting

From an emissions accounting perspective (i.e., accounting for an actual physical emission or avoided emission, as distinct from accounting for an issued offset credit), it is necessary to provide ongoing monitoring of agriculture and forestry sequestration projects, and adjustments in a registry or other emissions accounting system to accurately reflect environmental performance. A standard approach is described in Murray and Olander, 2008:

> *[T]ake carbon stock measurements at regular time intervals, ideally based on field or aerial measurements, and compute the net credit (or debit) quantities as the change in stock between periods, adjusted for leakage and possibly other factors… [C]arbon that was sequestered, measured, and credited in a previous period but is subsequently released through natural and management disturbance will contribute negatively to the carbon stock change measure during the next measurement period… The more challenging situation is when the carbon reversals outweigh the gains, causing a net decline in carbon stocks and a system debit. This raises the specter that some sort of adjustment may be necessary to resolve the net loss in previously credited carbon that has since circulated through the offset market.*[39]

[38] Ibid.
[39] "Addressing Impermanence Risk and Liability in Agriculture, Land Use Change, and Forest Carbon Projects," B.C. Murray and L.P. Olander, The Nicholas Institute for Environmental Policy Solutions, 2008, op. cit., p. 4.

2. Temporary crediting

One approach for ensuring that reversible offsets are not lost is to identify them as temporary or "rented" in the registry account and have them expire in the registry after a defined period.[40] At the time of expiration, the buyer (or current holder of the temporary offset) must buy new offsets to replace the expired offsets. (As discussed below, the CDM program uses this approach for afforestation and reforestation projects.) For accounting purposes, reversed offsets could be counted as emissions and added to the offset buyer's/holder's GHG emission inventory in the year in which the reversal occurs.[41] Instead of being required to purchase permanent offsets to replace the expiring offsets, the buyer/holder could be given the opportunity to renew the expiring temporary offsets by ensuring that the sequestered carbon is still being stored. For example, the buyer might be required to buy a permanent easement, or to provide maintenance payments to the project to allow for ongoing maintenance of the sequestered tons to ensure their continuing validity. This flexibility effectively would allow some temporary offsets to become renewable, and therefore more similar to permanent offsets.

This approach effectively allows buyers to postpone the purchase of permanent offsets. Temporary offsets typically would be priced at a discount to permanent offsets, taking into account the present value of replacing the temporary offsets at the end of the rental term, and assuming that the real price of offsets increases over time.[42] The duration of the contract plays an important role in the size of the discount; longer contracts will have smaller discounts than shorter contracts, since longer contracts postpone the purchase of replacement credits for a longer period. However, the discount also depends on the expected rate of increase in offset prices. If prices are expected to increase significantly (i.e., more than the interest rate) over time, it will be costly (in present value terms) to replace temporary offsets; as a result, they may have little value.[43] Low prices for temporary offsets could discourage landowners from undertaking sequestration projects, particularly if transaction costs are significant.[44] On the other hand, if the price of offsets is expected to increase at rates lower than the interest rate, rentals would become attractive because the present value of a postponed purchase of a permanent offset is lower than the current price of a permanent offset. The present value of future offset prices could be lower than current offset prices if breakthrough technologies are developed that achieve substantial GHG emissions reductions cost-effectively.[45] Finally there is a concern that temporary carbon

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[40] Unless otherwise noted, information in this paragraph derived from "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., pp. 16, 20, 21, and "Permanence Discounting for Land-Based Carbon Sequestration," M-K Kim, B.A. McCarl, B.C. Murray, *Ecological Economics*, vol. 64, pp. 763-769, 2007.

[41] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 5-5.

[42] Derivations of formulas for permanence discounts are provided in "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., pp. 24-32 of book chapter, and "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., pp. 125-127, and "Permanence Discounting for Land-Based Carbon Sequestration," M-K Kim, B.A. McCarl, B.C. Murray, 2007, op. cit., pp. 763-769.

[43] "Addressing Impermanence Risk and Liability in Agriculture, Land Use Change, and Forest Carbon Projects," B.C. Murray and L.P. Olander, The Nicholas Institute for Environmental Policy Solutions, 2008, op. cit., p. 11.

[44] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 9-8.

[45] Ibid,, p. 3-6.

offset credits will not really be fungible with other carbon assets and instruments that are being traded in the world's evolving global carbon markets.

As noted above, buyers may be given the opportunity to provide maintenance payments to farmers/forest managers to ensure continued storage of sequestered carbon for which offsets have already been issued. If this option is provided, there is a risk that farmers/forest managers will not comply with ongoing project monitoring and reporting requirements – i.e., they may abandon the project or simply stop reporting. In addition, if there is seller liability (see discussion on liability in the next section), farmers/forest managers may be unwilling to compensate for reversals occurring long after the last revenue from offset sales.

As also noted above, one potential solution might be to require buyers/holders of expiring temporary offsets who wish to renew those offsets to buy an easement from the farmer/forest manager, thus ensuring continued storage of carbon. Alternatively, buyers/holders of expiring temporary offsets could be required to purchase the land, take credit for only a fixed percentage of likely carbon sequestration, and then give the land to the government or a land trust for perpetual holding.[46] The latter approach would address both the risk of intentional reversals and – through partial crediting – the risk of unintentional reversals.

The CDM has adopted a temporary crediting approach for afforestation and reforestation projects.[47] Project participants may choose to be issued tCERs (temporary Certified Emissions Reductions) or lCERs (long-term CERs). Temporary CERs expire at the end of the commitment period in which they were issued, and lCERs expire at the end of the crediting period for the project.

In contrast to the approach described above, there is no option for avoiding expiration in the CDM. When retired tCERs and lCERs expire, they must be replaced by other Kyoto Protocol compliance units. For this purpose, national emissions registries must have tCER and lCER replacement accounts in which valid Kyoto units are canceled to replace expiring tCERs and lCERs. It should be noted that only one afforestation/reforestation project has been registered to date under the CDM, perhaps because of the significant discount assigned to temporary credits.

As discussed in detail in Section V, RGGI, CCAR and the Voluntary Carbon Standard (VCS) have devised approaches for addressing impermanence that effectively treat sequestration offsets as permanent (mainly through the use of buffer reserves), thereby avoiding some of the challenges associated with temporary crediting.

[46] Personal correspondence with Gordon Smith, EcoFor.
[47] Information in this paragraph derived from "CDM Rulebook" entries for tCERs and lCERs, Baker & McKensie, http://cdmrulebook.org/PageId/332

3. Liability

Responsibility for compensating for reversals may be assigned to different entities involved in carbon market transactions. Each approach has its advantages and disadvantages, as described in detail by Murray and Olander, 2008, and briefly summarized below.[48]

Offset producer (seller) liability

In the case of reversals, the seller (i.e., the farmer or the forest landowner) must replace defaulted tons with valid, verified offset credits.[49] This approach provides strong incentives to the seller to reduce reversal risk and maintain sequestration practices. However, exposure to catastrophic risk (e.g., fire or flood) could create disincentives for project development by landowners and agricultural/forest producers, who are typically small entities. In addition, these entities could be bankrupted by massive unintentional reversal, leaving the reversal unremedied (unless the government addressed the problem by setting aside tons out of an emissions cap to compensate for such reversals). Insurance products potentially could emerge to address catastrophic risk, but such insurance would need to be affordable for project developers.

Buyer liability

Under this approach, the buyer/holder of offsets that have been reversed would be required to replace them. In addition, offsets that already have been used for compliance would need to be replaced. Buyers would have a strong financial interest in buying high-quality offsets, and would be likely to price sequestration projects differentially based on risk assessments. However, they would be exposed to the risk of unintentional reversals, which generally cannot be prevented. Insurance products potentially could emerge to address this risk. Risk exposure to unintentional reversals would reduce the fungibility of agricultural/forestry offsets with other compliance instruments, could discourage buyers from purchasing these offsets, or could result in significant price discounting, potentially discouraging project development.

Murray and Olander, 2008 note that existing carbon markets incorporate price differentiation to account for risk – i.e., the risk that purchased CDM offset credits (of any technology type) will not ultimately be convertible into CERs that can be used for compliance. However, buyer liability for agriculture and forestry sequestration projects would introduce a different kind of uncertainty to the market – that even approved and issued credits for these projects may later be subject to reversal.

Liability negotiated between buyers and sellers

This approach – in which liability is not determined by policy but is instead addressed in contracts (i.e., the choice of buyer or seller liability is left to the market) – is likely to be more flexible and allows for hybrid solutions. For example, a buyer could agree to bear the risk of unintentional reversals, and the seller could accept responsibility for any intentional reversals. To the extent that contracts call for buyer liability, this non-uniform approach would have some of the disadvantages of a buyer liability approach with respect to fungibility. It also could create

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[48] The discussion on liability options derives from "Addressing Impermanence Risk and Liability in Agriculture, Land Use Change, and Forest Carbon Projects," B.C. Murray and L.P. Olander, The Nicholas Institute for Environmental Policy Solutions, 2008, op. cit., pp. 5-9.

[49] Given that the farmer/producer is often not the landowner, contracts would need to determine how liability risks would be assigned.

obstacles to correct price discovery, as different contract terms would introduce more variables into pricing and contract details may not be readily available to the market.

System liability

This approach would shift liability from the project to the system level, such that reversals would be compensated by the offset system as a whole. Such compensation or mitigation could be provided through different approaches, such as adjusting the aggregate cap in a cap-and-trade system over time (i.e., canceling allowances out of the cap) to compensate for reversals associated with offsets that already have been issued.

Mitigation also could be provided through the use of set-asides or buffer reserves, in which agriculture and forestry project developers must contribute a portion of their offsets to a pool that would be drawn down to cover reversals. The buffer or pool could be applied on an individual basis – i.e., a project's set-asides would be used only to address reversals from that project.

Alternatively, the buffer could be implemented system-wide – i.e., pooled across all parties and drawn upon for all cases of reversals. Under this approach, reversals would be monitored and compensated for at the system level, and reserve requirements could be adjusted over time to account for system over- or under-performance. Necessary reserve requirements could be set conservatively initially to avoid under-performance by the system. Surplus buffer credits could be released into the market, given back to project owners to incentivize certain risk-minimizing activities, or rolled over from one period to the next. To avoid the "moral hazard" of project developers not taking necessary actions to mitigate risk, due diligence standards could be established and responsibility for intentional reversals could be assigned to project owners. System liability approaches have been adopted in project protocols for CCAR and the Voluntary Carbon Standard.

Table 3 summarizes the liability options described by Murray and Olander, 2008.

Table 3: Summary of Offset Liability Options

Liable Party	Description	Advantages	Disadvantages
Seller	Originator responsible for replacing reversed credits	Strongest reversal prevention incentive	Small sellers may not be able to bear risk
Buyer	Liability travels with the credit holder – like default risk	Natural extension of compliance performance – easier to monitor	Complicates transaction by keeping unresolved liability on books for buyers
Negotiated between seller and buyer	Liability specified explicitly in contract between seller and buyer	Flexible. Can be assigned more efficiently	Adds transaction and monitoring costs, though can be minimized if standard contract terms used
System	Liability shifts from transactions to system, possibly absorbed/ignored	Risk-pooling, reduces transaction costs	Moral hazard potential, inefficient cost-shifting

Source: Murray and Olander, 2008.

Experience with liability in the CDM program

Under the CDM, liability questions arise in the context of whether an emission reduction sold from a project developer to a buyer (i.e., a primary Certified Emission Reduction (CER)) will be approved by the CDM Executive Board (EB) and converted into an issued CER.

In the current CDM market, buyers and sellers agree on contract provisions that determine the terms of delivery of emission reductions. These contracts vary in terms of how liability is shared between buyer and seller. On one end of the spectrum, some contracts have provided that seller provides no guarantee to deliver emission reductions, regardless of whether they are eventually approved by the EB. On the other end, some contracts have provided that the seller guarantees to deliver a fixed volume of Kyoto-compliant or EU Emissions Trading Scheme-compliant CERs and accepts all delivery risks. These include the risk that the EB will not convert the primary CERs to issued CERs, and the risk (that existed until recently) that international registry connections would be postponed such that issued CERs could not be delivered in a timely manner.

In recent years, an active secondary CER market has emerged to provide an alternative for buyers that seek a lower level of delivery risk than the primary CER market can provide. Secondary CERs are typically sold by highly creditworthy sellers (typically institutions that have purchased primary CERs from project developers), are backed by guarantees that the seller will delivery CERs (or if not, an equivalent instrument valid for Phase 2 EU ETS compliance), and assign virtually most if not all delivery risk to the seller.

Under this approach to liability, a market has emerged in which primary CERs are priced based on a combination of delivery risk (including project performance risk, regulatory risk, country risk, counterparty risk, and other risks), contract terms regarding liability, and maturity (i.e., the stage of the project in the approval process at the time of sale).

This approach has facilitated the growth of the CDM market by avoiding the automatic imposition of all delivery risks on sellers. On the other hand, it has created risks for buyers and imposes costs in terms of due diligence. Delivery risks can be managed by buyers using a number of approaches. These options include developing the internal capacity and expertise to assess delivery risk and purchase a diversified portfolio of primary CERs, purchasing delivery risk analysis from external providers, purchasing primary CERs from market intermediaries, participating in compliance funds that purchase primary CERs in large volumes on behalf of participants, and purchasing secondary CERs.

B. Leakage

Leakage is defined as "a GHG effect occurring outside the boundary of what is being reported or accounted for a project or activity that, however, is caused by the project or activity and reduces its environmental benefit."[50] It usually occurs when a project has the effect of reducing the

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[50] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. B-2.

supply of a good (e.g., crops, timber), thereby displacing production and associated GHG emissions to another location.[51]

As noted in EPRI 2006, markets for both wood and land are relatively efficient, and if wood production or land development is reduced in one location, it is likely it will be replaced by suppliers in another location.[52] Examples of leakage that could result from agriculture and forestry sequestration projects are described below.

- If the existence of an offset program in the U.S. led to a widespread shift in agricultural land use from crop production to forests, this would reduce crop production, potentially leading to an increase in crop and food prices. It also could increase timber production, thereby lowering forest product prices. The higher crop prices and lower forest product prices in turn may lead to conversion of forest land to agricultural land (i.e., deforestation) in developing countries, thereby increasing GHG emissions and diminishing or negating the GHG impact of forest sequestration projects in the U.S.[53]
- If a landowner reduces timber harvests to gain sequestration credits, and demand for forest products remains the same, harvests likely would increase in another forest stand, thereby reducing or negating the GHG sequestration impact of the project.[54] An example of such leakage occurred in the 1990s in the U.S. Pacific Northwest where reductions in harvests on public lands (which likely were undertaken for conservation purposes but not expressly for carbon sequestration) triggered a nearly matching increase in harvests on other U.S. and Canadian lands, with estimated leakage rates of approximately 85%.[55] This high leakage rate likely was due in part to the fact that the lands being preserved in the Pacific Northwest previously had been highly-productive forestlands providing lumber to the world's construction markets.
- Conversion of cropland into grassland for purposes of increasing sequestration would lower crop production and raise prices, stimulating increased crop production elsewhere – potentially brought about through conversion of grassland into cropland. For example, in the U.S. Conservation Reserve Program, about 20% of acres converted from cropland to other uses consistent with carbon sequestration were replaced by additional acreage that was converted to cropland.[56]

In order to account for project-related leakage and accurately determine a sequestration project's net GHG impact, estimated leakage resulting from a project needs to be deducted from the

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[51] "Harnessing Farms and Forests in the Low-Carbon Economy," The Nicholas Institute for Environmental Policy Solutions, 2007, op. cit., p. 91.
[52] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 8-5.
[53] Example provided in "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., p. 7 of book chapter.
[54] Example provided in "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 19.
[55] Example provided in "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., p. 71.
[56] Example provided in "Estimating Leakage from Forest Carbon Sequestration Programs," B.C. Murray, B.A. McCarl, H-C Lee, RTI International, working paper 02_06, May 2002, p. 5.

project's estimated GHG emission benefit.[57] Thus, a leakage analysis must estimate the amount of leakage (in terms of the production of goods or conversion and use of land) that can be attributed to the project, and the amount of GHG emissions associated with that leakage, which would then be subtracted from the estimated sequestration from the project in order to determine the level of offsets that should be credited. Quantifying leakage is quite difficult and existing estimates and expert opinions related to leakage rates for forestry and agricultural offset projects vary widely.

1. Quantifying leakage

Leakage is difficult to measure on a project basis because it generally can never be observed and can occur almost anywhere in the world.[58] [59] Approaches for calculating leakage combine theoretical economic analysis, empirical modeling (e.g., sector wide models for the forest sector) and "adaptive approaches."[60]

Estimating leakage is complex, as projects can have multiple effects on different goods over 20-30 years or longer, particularly if the project leads to deforestation and replacement of forest lands with other crops.[61] Even small projects can cause leakage. When a project's market share is small, production usually can be replaced easily, leading to enhanced leakage.[62] Empirical estimates of leakage from sequestration projects in the U.S. range from less than 10 percent to over 90 percent, depending on the activity and region.[63] Significant work has been done in this technical field. Examples of these modeling approaches are provided in Murray, McCarl and Lee, 2002, and The Nicholas Institute, 2007, and McCarl, 2006.[64]

In some cases, it may be argued that an agricultural GHG emission reduction project does not affect commodity production, and therefore does not involve leakage. For example, recovery of methane emissions from intensive livestock manure lagoons likely does not impact commodity (dairy) production.[65] Also, N_2O emissions offsets derived from reduced fertilizer use do not dramatically affect crop yields but generate substantial permanent GHG emission reductions.

[57] "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 5-3.
[58] "Revised Forest Project Protocol," California Climate Action Registry, draft, December 2008, p. 10.
[59] "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., p. 74.
[60] Ibid.
[61] Ibid, p. 92.
[62] Ibid.
[63] Estimating Leakage from Forest Carbon Sequestration Programs," B.C. Murray, B.A. McCarl, H-C Lee, RTI International, working paper 02_06, May 2002, p. 2.
[64] Ibid, pp. 91-98; and "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., pp. 71-91.
[65] "Permanence, Leakage, Uncertainty and Additionality in GHG Projects," McCarl, B.A., in *Terrestrial GHG Quantification and Accounting*, 2006, op. cit., p. 83.

2. Compensating for leakage

Projects can compensate for leakage – which may in some cases be significant – through efforts to maintain the supply of final products in the marketplace.[66] For example, a forest conservation project that would have the effect of reducing timber supply could establish an intensively managed timber plantation simultaneously to offset the reduction in timber supply.

Leakage also can be avoided in cases where the land use that is being displaced is declining overall. For example, a project that converts pasture land to forest land would not displace demand for pasture if total pasture use is declining more quickly than offset projects are reforesting land. This same process may be occurring in the Lower Mississippi River bottom land area of the Southern U.S. where large-scale reforestation projects now are being undertaken by electric companies, conservation organizations and others to restore native forests on land that was converted to what has now become marginal cropland that is falling further out of production.

C. Allowance Set-Asides

An alternative approach for addressing permanence and leakage issues in agriculture and forestry sequestration projects – as well as early action, as discussed below – might be to "carve out" or "set aside" a portion of a cap-and-trade program's overall cap of allowances. Under this approach, allowances would be set aside and be provided exclusively to qualifying agriculture and forestry projects.

This approach is incorporated in S. 1766, the "Low Carbon Economy Act of 2007," introduced by Senators Bingaman and Specter, and S. 3036, "America's Climate Security Act of 2007," the version of legislation introduced by Senators Lieberman and Warner that was considered on the Senate floor in 2008 (S. 3036). These bills proposed to set aside 4-5 percent of total allowances for agriculture and forestry projects.[67] The two bills also would allow for agriculture and forestry projects to create offsets, if they can meet the various monitoring, reporting, additionality and other requirements incorporated in the offset program, but would not allow a project to receive both allowances and offsets. This approach, in which projects are given a choice between getting certified to receive offsets or allowances, has been referred to as a "hybrid" approach.[68] Under this approach, it may be expected that projects would prefer to be certified to receive allowances, as allowances may be priced higher than offsets if quantitative limits are imposed on offset use, and as requirements under the allowance "track" may be less stringent, as discussed below.

A set aside for agriculture and forestry projects would mitigate concerns regarding impermanence risks and leakage for these projects because the "credits" assigned to such projects would not be additional to the cap, as in the case of an offset program. The credits – in this case, allowances – would be taken out of the overall cap. Therefore, even in an extreme hypothetical scenario in which all of the agriculture and forestry projects receiving allowances

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[66] Information in this paragraph was derived from "Guidance for Electric Companies on the Use of Forest Carbon Sequestration Projects to Offset Greenhouse Gas Emissions," EPRI, 2006, op. cit., p. 8-5.

[67] The Bingaman-Specter bill set aside 5% of allowances for this purpose, and the Lieberman-Warner bill set aside 4.25% in the period through 2030, and 4.5% from 2031 through 2050.

[68] "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 19.

achieved no net emission reductions – due to such issues as impermanence risks, leakage and additionality – the program's overall emissions cap would be maintained. Conversely, any net emission reductions achieved by agriculture and forestry projects would represent emission reductions in excess of those required under the program's overall cap. Under this approach, the regulator could consider imposing less stringent monitoring and verification requirements under the set aside in order to streamline project approval processes and facilitate project development.

Some observers also have noted that a set-aside could be particularly helpful to reward "early actors" that already are implementing emission reduction activities that create environmental benefits but would not meet additionality requirements.[69] For example, some farmers are currently employing no-till farming despite the absence of requirements or a federal offset system that rewards such activity. A set-aside could be used as a mechanism to continue to provide an incentive for such activities. This would mitigate concerns about the additionality of these activities, and ensure that the program's cap is not jeopardized. It also could prevent farmers currently undertaking no-till and other beneficial practices from abandoning them in favor of new activities that could earn offset credits.[70]

Although a set-aside provides benefits, it also can increase costs by reducing the amount of allowances available to entities that are required to limit their emissions. In contrast, an approach in which the agriculture and forestry sectors could only receive offsets would reduce allowance costs by increasing the supply of cost-effective offsets.[71]

Some observers have suggested pursuing a targeted hybrid approach – i.e., with the set-aside used primarily to reward early action, while most projects would have to earn offset credits – which may create several public benefits. However, the onus would remain on the offset system to maintain system integrity without creating unnecessary barriers to the development of good offset projects.

V. Current Approaches Used to Address Impermanence

Several existing offset systems and various proposals incorporate approaches for addressing the impermanence of carbon sequestration from agricultural and forestry projects. These provisions provide useful examples and potential models that might be used to address impermanence in any future federal GHG offset program.

To date there appears to be a growing preference for the use of buffer pools to mitigate against permanence risk and allow emission reductions and offset credits from sequestration projects to be considered permanent. One important exception is the CDM, which treats CERs created by afforestation and reforestation projects as temporary and requires that they be replaced at the end of the project (see discussion in Section IV.A under "temporary crediting"). As noted in that discussion, only one afforestation/reforestation CDM project has been registered to date.

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[69] This discussion was derived from "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., pp. 19-22.

[70] "Agriculture's Role in Addressing Climate Change," Pew Center on Global Climate Change, "In Brief" number 2, p. 5.

[71] "21st Century Agriculture Project," Senator Bob Dole and Senator Tom Daschle, 2008, op. cit., p. 21.

A. RGGI

Under the RGGI Model Rule, which establishes the requirements of the program, offsets may be created from afforestation projects. Sequestration (carbon in live and dead wood and soil, but not in material removed from the project area such as harvested wood) may be credited only during the first 60 years of a project, in three 20-year allocation periods that each can be renewed following a "consistency determination."

In each period, credited sequestration is limited to the amount of net additional carbon sequestered. Project land must have a permanent, enforceable conservation easement that requires the land to be maintained in a forested state in perpetuity. The amount of carbon sequestered is measured as the net increase in carbon relative to the baseline, minus 10% to account for potential losses of sequestered carbon. The 10% discount is not required if the project sponsor retains eligible long-term insurance that guarantees replacement of any lost sequestered carbon for which offsets were awarded.

In effect, the RGGI program addresses impermanence by requiring permanent conservation easements and imposing a 10% discount as an individual buffer reserve. Under this approach, offsets generated by afforestation projects would be considered permanent RGGI offsets. The benefit of the approach is that it avoids the complexity imposed by differential pricing and qualifications for temporary offsets. In addition, the 10% discount provides market certainty. However, it remains to be seen whether it is sufficiently conservative to cover all reversals. Ideally, the discount might be adjustable over time to take experience into account.

B. California Climate Action Registry

CCAR allows for the consideration of projects in three forest project categories:

1) **Reforestation** (defined above in Section III.A);
2) **Improved forest management** ("the management of either private or public lands for commercial or noncommercial harvest and regeneration of native trees when employing natural forest management practices" (practices that promote and maintain native forests comprised of multiple ages and mixed native species at multiple scales[72])); and
3) **Avoided conversion** (projects "consisting of specific conservation actions to prevent the site-specific clearing and conversion of native forests to a non-forest use, such as agriculture or other commercial development").[73]

CCAR addresses permanence through several provisions and requirements which are briefly summarized below and will be discussed in the upcoming EPRI workshop:

- Projects must ensure that credited sequestration tons are stored for at least 100 years (which is commonly considered to represent permanent storage[74]). Each project must enter into a Project Implementation Agreement with CCAR establishing the obligation of the landowner and its "successors and assigns" to comply with the forest project protocol

[72] "Revised Forest Project Protocol," California Climate Action Registry, December 2008, op. cit., p. 3.
[73] Ibid.
[74] "Permanence Discounting for Land-Based Carbon Sequestration," M-K Kim, B.A. McCarl, B.C. Murray, 2007, op. cit., p. 766.

for 100 years, and rights and remedies in cases of noncompliance. A conservation easement may be used in addition to the agreement.

- Each project is required to contribute offsets into a buffer pool account based on the project's risk rating, which is assessed by project proponents and verifiers.
- Risk rating is based on an assessment of several categories of risk, including the risk of:
  - illegal logging;
  - conversion of forestland to other uses in light of economic incentives for development;
  - overharvesting (e.g., if timber prices increase);
  - natural disturbance (e.g., wildfire, disease or insect outbreak, and other episodic catastrophic events); and
  - government changing climate policy or regulations on GHG accounting, thereby changing incentives to continue project activities.
- If insurance products to insure against reversals are developed in the future and approved by CCAR, these may be used to reduce the calculated reserves required for a project.
- Changes in carbon stocks (broadly defined to include all net GHG removals, reductions and avoided emissions relative to project baseline levels) are monitored, calculated and reported annually to test earlier estimations of project performance. Leakage adjustments are made for any offsite harvesting caused by the project.
- If a project experiences a reversal, the project's own buffer pool offsets are used to compensate for the reversal. If the reversal exceeds the project's buffer pool, other projects' buffer pools are drawn upon proportionally to fully compensate for the reversal.

For avoided conversion (i.e., deforestation) projects, project proponents must provide proof of site-specific threats to conversion (e.g., impending development). Annual deforestation rates can be calculated based on CCAR's estimates of deforestation rates by county.

C. Voluntary Carbon Standard

The following project types in the category of agriculture, forestry and other land use projects are eligible to create offsets under the Voluntary Carbon Standard (VCS):

1) **Afforestation, reforestation and revegetation**;

2) **Agricultural land management** (i.e., land use and management activities on cropland or grassland that increase carbon stocks and/or decrease CO_2, N_2O or methane emissions from soils);

3) **Improved forest management**; and

4) **Reduced emissions from deforestation and** degradation (REDD).[75]

[75] Information in this section was derived from "Voluntary Carbon Standard: Guidance for Agriculture and Other Land Use Projects," November 18, 2008, pp. 32-38

VCS addresses impermanence through the use of a buffer pool and other design elements, as summarized below.

- Projects must maintain adequate buffer reserves to cover unforeseen losses in carbon stocks. Buffer reserves from all projects are held in a single pooled buffer account.
- Projects must conduct a risk assessment to assess transient and permanent potential losses in carbon stocks in order to determine the appropriate buffer reserve. The risk assessment occurs every time a project seeks VCS verification. The risk assessment and estimate of the buffer withholding percentage must be confirmed by an approved verifier. Projects will be rejected if the verifier calls for a buffer in excess of the largest withholding percentage available for the project type. A second approved verifier also must review the risk assessment and buffer determination and either approve it or work with the first verifier to determine an appropriate buffer.
- Projects may lower their rating and reduce their buffer requirement over time by enhancing their risk mitigation strategies. In addition, if a project's overall risk rating remains the same or decreases from one verification event to the next, then every five years upon verification 15% of its total buffer reserve will be released to the project.
- Periodically all VCS verification reports will be reviewed to determine appropriate adjustments for buffer values and risk criteria to ensure there is always a net surplus in the overall buffer after taking losses into account.
- The most significant risk factors are fire potential, timber values, illegal logging potential, and unemployment potential (i.e., the risk that those who lose their employment due to implementation of a project will resort to such illegal activities as logging). Another major factor in calculating risk is project length. Shorter-term projects are considered to have a much higher risk of impermanence than longer-term projects. (Unlike RGGI and CCAR, it does not appear that VCS requires that project proponents enter into a long-term legal agreement or easement.) Projects that involve wood harvesting also are assigned higher non-permanence risk. For agricultural land management projects, which are less vulnerable to natural disturbances than forestry projects, the primary risk is discontinuation of practices arising from a change in ownership or a change in potential net financial returns (e.g., due to a change in the cost, or opportunity cost, of maintaining the management practice).
- Like CCAR, VCS notes the possibility for projects to manage non-permanence risk in the future through approved insurance.
- If a project has not reduced emissions or increased sequestration relative to the project baseline, no future offset credits are issued to the project until the deficit is remedied. If offsets were already issued for the project, an amount of offsets equal to the issued offsets is automatically cancelled from the pooled buffer. Given the conservative buffer values assigned to each project type, CCAR expects that the pool is unlikely to have a negative balance.
- If a project does not submit a verification report within five years from its latest verification, 50% of the credits in its buffer will automatically be cancelled. After ten years, all of its remaining buffer credits will be cancelled. After 15 years, if the crediting period of the project has not yet expired, the pooled buffer account will cancel credits

equal to the total number of offsets issued to the project. Projects may claim the cancelled credits in the future by submitting a new verification prior to the expiration of their crediting period. At the end of the crediting period, any remaining credit balance in each project's buffer is automatically cancelled.

- Offsets already issued to projects that subsequently fail are not canceled. Such situations are remedied through cancellation of credits in the pool. This approach, and the top-down approach of conservatively managing reversals through a pooled buffer, is intended to allow VCS projects to increase market confidence and produce permanent offsets that are fully fungible with other permanent offset types.

D. Other Proposals

Other proposals relating to impermanence have been offered in discussions and presentations made at the three GHG Emissions Offset Policy Dialogue workshops held in 2008. The following discussion briefly touches on these proposals, which – with the Australian Government's approach -- are similar to the CCAR and VCS approaches.

1. Nicholas Institute

The Nicholas Institute for Environmental Policy Solutions at Duke University has proposed that all sequestration projects should have a set-aside of offset allowances withdrawn from their account to guarantee that all offset project reversals are fully compensated.[76] The set-aside would be proportional to risk, calculated in the monitoring and quantification plan for sequestration projects based on certified methods, and adjustable over time.

2. Coalition for Emission Reduction Projects

In a presentation at the third Offset Policy Dialogue workshop, Kyle Danish of the Coalition for Emission Reduction Projects (CERP) proposed to address reversal risks inherent in forestry projects by creating a buffer reserve. Under CERP's proposed approach, reversal risk would be calculated for each project, and corresponding credits would be withheld from each project and transferred to a buffer reserve. In cases of unintentional reversals, credits in the reserve would be cancelled. In contrast, project representative would be held liable for intentional reversals. Project reporting would be required for the duration of the crediting period plus five years after the end of the period. The reserve would be subject to regular review and auditing by the responsible government agency. In addition, all projects would be subject to agency auditing.

3. Offset Quality Initiative (OQI)

The Offset Quality Initiative (OQI) is an initiative of six non-governmental organizations (NGOs).[77] In July 2008, OQI published a "white paper" designed provide guidance to U.S.

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[76] "Designing Offset Policy for the U.S.," .Nicholas Institute for Environmental Policy Solutions, Duke University, Lydia Olander, T. Profeta, C. Galik, B. Murray and M. Dawson, May 2008, NI R 08-01, pp. 42-45.
[77]These NGOs include: The Climate Trust, Pew Center on Global Climate Change, California Climate Action Registry, Environmental Resources Trust, Greenhouse Gas Management Institute and The Climate Group.

policymakers on the design of offset policies.[78] Several of OQI's "key offset quality criteria" cover the issues of permanence and leakage.

From OQI's perspective, quality offsets clearly need to address potential leakage. OQI suggests that "Offset program design should include monitoring/ verification plans and protocols that provide the necessary mechanisms to properly account for potential leakage over the life of an offset project."[79]

And, with regards to permanence, OQI states that "There is a risk that emission reductions generated by certain offset project types can be reversed, and thus are not permanent." As such, OQI suggests "Regulatory regimes should address permanence through policy mechanisms that ensure the minimization of loss in the case of project reversal. Such mechanisms include reserve pools, buffer accounts, and insurance, among others."[80]

OQI further states that "While some advocate a special "temporary offset" category for certain types of potentially non-permanent emission reductions, OQI recommends against this approach due to its barriers to inter-market fungibility, additional administrative requirements, and movement towards a globally tradable and credible commodity. OQI believes that if sufficient assurances and measures are in place to ensure replacement of offset credits in the event of project reversal, offset credits sourced from projects that face permanence issues should be treated as any other reduction that meets the applicable offset eligibility requirements.[81]

4. Australian approach (issue permits to participating forestry projects)

During the third Offset Dialogue workshop, it was noted that the Australian Government had adopted an approach in its GHG cap and trade program for addressing impermanence that differed from those of CCAR and VCS. Australia's federal cap and trade program is scheduled to begin on July 1, 2010.[82]

Under Australia's proposed approach, accounting for carbon sequestration from reforestation projects will be directly linked to and consistent with carbon sinks and GHG emissions

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[78] "Ensuring Offset Quality: Integrating High Quality Greenhouse Gas Offsets into North American Cap-and-Trade Policy," Offset Quality Initiative, July 2008, http://www.pewclimate.org/docUploads/OQI-Ensuring-Offset-Quality-white-paper.pdf.
[79] Ibid., p 3.
[80] Ibid., p 3.
[81] Ibid., p. 19.
[82] The discussion in this section focuses on the Australian federal government's approach to addressing impermanence because it represents a departure from the offset-based approach adopted in most afforestation and reforestation programs and proposals to date. The federal cap-and-trade program is to be distinguished from the New South Wales Greenhouse Gas Abatement Scheme (GGAS), which has been in operation since 2003. Like the federal cap and trade program, GGAS also allows for Kyoto Protocol-compliant afforestation and reforestation projects to generate offsets. GGAS's provisions to address impermanence are in some ways similar to those of CCAR and VCS. For example, project proponents must demonstrate that sequestered carbon will be maintained for 100 years in order to receive offsets (Greenhouse Gas Benchmark Rule (Carbon Sequestration) No. 5 of 2003, Government of Australia, http://www.greenhousegas.nsw.gov.au/documents/syn66.asp).

accounting at the national level under the Kyoto Protocol.[83] Forest owners can voluntarily opt-in to the trading program, and would be given permits (e.g.,, sinks credits under the Kyoto Protocol – so-called Removal Units or "RMUs" or alternatively, allowances from the cap-and-trade program) when carbon stocks increase. If forest owners' carbon stocks decline (e.g., if they convert forested land to non-forest land use, or harvest without updating their emissions estimation plan), they would be required to surrender permits to cover the associated carbon emissions, but would not be required to surrender more permits than had been issued for the project. The Government would enforce obligations for approximately 70 years following the issue of the last permit for a project.

Forest owners would be required to demonstrate that the project conforms to the rules of the Kyoto Protocol, and may be required to place a restriction on use on the land title to ensure compliance. Permits (e.g., RMUs or allowances) would be issued on an average crediting basis, in which permits are issued for the projected net GHG removals (sinks less sources) for the project, based on the forest owner's initial emissions estimation plan and updated as necessary. Permits will be issued "in arrears," only after trees have grown. To avoid perverse incentives to clear existing forests, permits for existing forests would only be issued for net removals starting in 2010 once carbon stocks are greater than in 2008.

To address the risk of unintentional reversals, the permit issuance limit for each project would be reduced by that project's estimated "buffer reduction" (i.e., buffer reserve amount). The buffer reduction would take into account project-level risk factors, such as the number of permits issued, the location of the forest and the entity's management record, and could be amended over time to reflect changed circumstances.

As noted by one workshop participant, this approach would eliminate the need to demonstrate additionality, and would assign impermanence risk to the government, consistent with the government's international emissions limitation obligations.

[83] Information in this section was derived from "Carbon Pollution Reduction Scheme: Australia's Low Pollution Future," White Paper, Volume 1, Australian Government, December 2008, http://www.climatechange.gov.au/whitepaper/report/index.html, pp. 6-46 to 6-59.

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