CREDIT CHECK: A Comparative Evaluation of Tree-Planting and Fossil -Fuel Emission Reduction Offsets

A David Suzuki Foundation Technical Paper

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Acknowledgements:
The following individuals gave generously of their time in providing information and commenting on drafts of this technical paper: Stewart Elgie, Werner Kurz, Peter Salonius, Taumey Mahendrappa, Graham Stinson, Martin von Mirbach, and Johanne Whitmore.

This report was made possible by the generous support of the Bullitt Foundation and the Stephen R. Bronfman Foundation.

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Introduction

Although many countries have large regulatory markets for emission credits, Canada and the United States do not have legal requirements for most businesses to reduce their greenhouse gas emissions. But as awareness and concern about climate change enter the mainstream, more and more individuals and companies are voluntarily turning to "carbon offsets" as a way to reduce their carbon footprint, creating a rapidly growing voluntary market.

Buying a carbon offset allows the purchaser to claim "credit" for a reduction in the amount of greenhouse gases in the atmosphere that was achieved through activities elsewhere. These carbon offsets can then be counted against the emissions resulting from the purchaser's own activities. Because it is often impractical or expensive to directly reduce one's own emissions of greenhouse gases to zero, the purchase of offsets is often a critical component of plans by businesses, organizations, and individuals seeking to go "carbon neutral".

Most activities funded through the purchase of carbon credits on the voluntary market can be divided into two primary types: 1) activities that reduce fossil-fuel use and, 2) tree-planting projects, as trees remove carbon dioxide from the atmosphere and store it as biomass (e.g., trunks, limbs, roots, bark, leaves, and seeds, etc).

Both of these types of activities can claim benefits for the climate, but the fundamental differences between them must be understood in order to make informed decisions about purchasing carbon credits. This report will explore the implications of these differences for the voluntary carbon market and examine whether a tonne of carbon sequestered and stored in plant biomass can be treated as equivalent to a tonne of carbon that remains locked up underground in the form of fossil fuels (i.e., as oil, natural gas, or coal deposits), and whether carbon stored in plant biomass can truly offset carbon from fossil fuels that is taken out of the ground and released into the atmosphere.

This report compares the effectiveness of these two main types of carbon offsets based on the following performance criteria:

1. Permanence: Will the gains achieved from the offset project last for the many centuries required?

2. Quantification: Can the emission reductions achieved by offset projects be accurately and transparently calculated?
3. Sustainability: Do the offset projects advance, rather than conflict with, other sustainability goals?
4. Additionality: Does the purchase of the offsets result in reduced greenhouse gases in the atmosphere (either through reduced emissions or increased removals) than would have happened otherwise, or would these results have happened anyway?
5. Leakage: Will the gains achieved by the offset project simply result in emissions increasing or carbon storage decreasing in another location, so that the overall net gain is reduced or eliminated?

Why Carbon Offsets?

The most effective means by which businesses, organizations, and individuals can reduce their contribution to the greenhouse gases (GHGs) that cause global warming is by reducing their reliance on fossil fuels for energy. This is because burning fossil fuels (e.g., oil, natural gas, and coal) for transportation, heating, and other energy purposes releases most of the greenhouse gases that cause global warming. A direct reduction in greenhouse gas emissions can be best achieved through greater energy conservation, increased energy efficiency, or switching to renewable sources of energy (e.g., solar or wind power) that produce much fewer or no greenhouse gases at all. However, even with such efforts, many individuals, organizations, and businesses can find themselves with some remaining emissions that are difficult or next to impossible to reduce.

One way to take responsibility for these unavoidable emissions is to offset them by purchasing carbon credits or offsets. Carbon offsets are simply reductions in greenhouse gas emissions claimed by one party that are achieved by another party located elsewhere. The purchaser of an offset does not participate directly in the GHG reduction efforts. Rather, the reductions achieved are quantified as credits, assigned a monetary value, and sold to purchasers, who thereby receive both the exclusive right to count these offsets against their own GHG emissions, and a confirmation that the reductions purchased actually occurred.

Trading in greenhouse gas offsets makes sense both in terms of fighting global warming and economics. Greenhouse gases quickly diffuse around the globe once they enter the atmosphere, thus the specific place on Earth in which GHG reductions or removals

The Kyoto Protocol

One hundred and seventy-one countries have ratified the Kyoto Protocol, which sets country-specific greenhouse gas emission-reduction targets for developed countries[2] for the 2008-2012 period[3] and creates a number of mechanisms for meeting those targets (so-called "flexible mechanisms"). The Clean Development Mechanism (CDM) allows countries with national reduction targets to invest in emission-reduction projects in developing countries and obtain reduction credits that can be applied to their own national targets. These credits are called "Certified Emission Reductions" (CER). Beginning in 2008, credits will also be available from so-called Joint Implementation projects, which are projects undertaken in a country with national targets by another party with national targets. Credits from these projects are called "Emission Reduction Units" (ERU).

CERs are allowed within the European Union Emission Trading Scheme (EU-ETS). The United Kingdom recently proposed that CERs and ERUs be recognized under its new standard for voluntary offsets.

While the Kyoto Protocol has included afforestation and reforestation projects[4] (i.e., planting new forests in areas that have been non-forested since 1990) in its eligible CDM projects, the Certified Emission Reductions obtained from forestry projects are not regular CERs but are designed as special temporary credits (tCERs and lCERs), which must be renewed or replaced with new offsets once they expire.[5]

have occurred is irrelevant to their effectiveness in addressing global warming. Moreover, the costs involved in reducing greenhouse gas emissions vary across economic sectors and activities, so that some reductions are more cost-effective than others. Offsets trading provides an incentive to maximize emission reduction efforts where they are most cost effective, thereby minimizing the overall cost of action.[1]

It must be stressed that carbon offsets, in themselves, are not a sufficient solution to global warming, because they are unlikely to produce the overall deep GHG reductions required to avert dangerous climate change (see: Long-term emission-reduction targets). Nevertheless, purchasing offsets can be an effective interim strategy to assist with mitigation that can be implemented immediately. Purchasing offsets educates purchasers about their own greenhouse gas emissions, assigns a cost to personal emissions, and can help to catalyze the development of mitigation projects that would not otherwise be profitable. Moreover, offset trading can extend carbon reduction incentives to sectors of the economy not yet covered by domestic reduction requirements, and to developing countries that are not yet subject to mandatory targets under the Kyoto Protocol.

As noted above, this report is aimed at the voluntary carbon market. However, regulated or "compliance" emission reductions markets, driven by mandatory emissions-reduction targets under the Kyoto Protocol and the European Greenhouse Gas Emissions Trading Scheme (ETS), are a separate – and much larger – type of carbon market. Within these markets, companies and countries can purchase carbon credits to achieve compliance with their mandatory targets. While many of the issues are similar under both the voluntary and compliance markets, some differences exist that could not be explored in this report. In particular, this report should not be taken as an endorsement of offsets mechanisms under any and all circumstances. Depending on the design and objectives of different regulatory approaches, such as cap-and-trade systems, offsets mechanisms may or may not be necessary or advisable as part of such systems.

Long-term emission-reduction targets

Scientists believe that much faster and deeper cuts in greenhouse gases are necessary than currently mandated by the Kyoto Protocol if we are to stabilize atmospheric concentrations of GHGs "at a level that would prevent dangerous anthropogenic interference with the climate system."[6] A 2005 report by the David Suzuki Foundation and the Pembina Institute[7] concludes that, to achieve this more ambitious goal, Canada must adopt the following emission-reduction targets:

- A reduction in Canada's GHG emissions to 25 per cent below the 1990 level by 2020.
- A reduction in Canada's GHG emissions to 80 per cent below the 1990 level by 2050.

Types of Carbon Offsets

In 2007, approximately 65 million tonnes of carbon dioxide (Mt CO_2e)[8] were traded as carbon offsets within voluntary markets around the world. Most of these offsets were derived from emission-reduction efforts (energy efficiency and reduction projects) or carbon sequestration projects, mostly achieved through tree-planting.[9] Other types of carbon offsets also exist or have been proposed, such as credits for protecting existing forests (i.e., avoided deforestation and forest degradation offsets), sequestration through carbon-conservative agricultural management practices (e.g., low-till farming), credits for the artificial sequestration and storage of carbon dioxide in geological or deep ocean reservoirs (carbon capture and storage offsets), and offsets generated from preventing higher potency greenhouse gases from entering the atmosphere.[10] The latter includes methane gas capture from landfills or from agricultural wastes[11], and the destruction of HFCs and N2O produced by industrial processes. These types of offsets are not examined in this paper (but see text box on "Avoided deforestation and degradation").

Forest Carbon Offsets

Forestry offsets are derived from biological carbon sequestration and storage. Trees and other types of vegetation remove carbon dioxide from the atmosphere and metabolize it into biomass (trunks, limbs and roots, bark, leaves, and seeds, etc.) through the process of photosynthesis. Some of the carbon dioxide absorbed from the atmosphere and incorporated into the living tissue of trees and other vegetation will remain sequestered long after the plant itself has died, stored in dead wood on the forest floor, humus within forest soils[12], or within harvested wood products.[13]

Ecological and economic value of trees and forests

There are many compelling reasons to support the conservation of standing forests as well as the reforestation of previously cleared lands through tree-planting. Trees provide a broad range of benefits to both natural ecosystems and human-dominated environments, such as cities. Trees are indispensable for oxygen production, as wildlife habitat, and are beneficial for stormwater control and slope stabilization. A recent study that assessed the economic value of Canada's boreal region determined that it provides $14.9 billion in market values to the nation's GDP, in addition to a further $10.5 billion in non-market values, excluding any value from carbon sequestration services.[14] Within urban areas, trees are extremely effective in reducing the urban heat island effect (not to be confused with global warming),[15] removing pollutants like ozone and particulate matter from the air,[16] and in increasing property values.[17]

Tree-planting projects involve the establishment of new trees and/or forests,[18] whereas forest restoration or forest management projects increase the level of carbon storage in existing forests (see text box on "Forest management and Kyoto Protocol, Article 3.4). To date, tree-planting projects are the most common type of forestry offset. Some tree-planting projects involve a mix of native species, while others are monoculture plantations of fast-growing exotic species.

As with any valid offsets, tree-planting offsets must only be issued for the amount of sequestration achieved over and above business-as-usual practices (e.g., government legal requirements and incentive programs) and must result from projects that would not have occurred if offset credits were not available (see section on "additionality"). The amount of greenhouse gases sequestered by tree-planting offsets can vary considerably, depending on the species planted, the local site conditions of the project, and the amount of fossil-fuel greenhouse gases emitted in the course of establishing and maintaining the project.[19]

Emission Reduction Offsets

Emission-reduction offsets are produced in two ways. Implementation of energy efficiency measures (e.g., improved building insulation) can reduce overall demand for energy, while the installation of renewable energy technologies (e.g., a wind-power or solar-energy project) produces additional energy supply with little or no greenhouse gas emissions. These projects result in less carbon being removed from geologically stable fossil-fuel reservoirs (e.g., coal beds or oil-and-gas fields) and released into the atmosphere when the fuel is burned. These "avoided" emissions mean that, at any given time, the total amount of fossil fuels consumed will be less than had the project not been implemented.[20] Emission-reduction offsets are created equivalent to the amount of the avoided carbon dioxide emissions, net of any emissions associated with creating the project.

Many emission-reduction projects, such as a wind-power project or a building energy-efficiency upgrade, will only operate for a limited period, generating offsets during this time with each unit of power generated or saved. Since the effect of a project is to reduce the amount of greenhouse gases emitted into the atmosphere below what would otherwise have happened at any given time, this net gain remains after the project itself is completed or ceases to operate. Many infrastructure-based efficiency or renewable energy projects (e.g., an office-lighting retrofit) will operate at full capacity right away. Other projects, such as energy-efficiency outreach programs that retrofit a given number of buildings each month, will produce increasing amounts of offset each year, as the number of operating emission-reduction installations increases over time.

Evaluating the Performance of Offset Types

Additionality

Carbon offsets in the voluntary sector entail a purchaser paying another business or organization to make GHG emission reductions on its behalf. Because of this, it is critical that the reductions achieved or emissions sequestered by an offset project are "additional" to business-as-usual activities; i.e., they would not have occurred in the absence of the offset. For example, an organization may be compelled by regulations to implement actions that directly or indirectly result in carbon sequestration or emission reductions. Carbon sequestration or emission reductions achieved in this way are not "additional" because reductions would occur regardless of the sale of the offset. Similarly, a business that upgrades itself with new technology that is also more energy efficient (e.g., a new furnace) would not likely be able to claim offsets unless the extra money received from the sale of offsets (rather than operational cost savings, or a need to replace old equipment) was a decisive factor in the decision to upgrade. Additionality must be demonstrated in the case of both tree-planting and reduction of emissions from fossil fuels.

Unfortunately, it is often difficult for a prospective offset purchaser to know if an offset is additional or not without access to detailed information about the project. Some offset projects on the market are accredited by third parties, like the CDM and the Gold Standard, which screen for additionality. The basic threshold is that the reductions must be additional to what is required by existing regulations. Beyond this, there are a number of factors that are usually considered in any robust analysis of additionality. These include:

- Whether the technology used in the project and the related expertise are readily available in the area where the project is being developed.
- Whether income from the offsets is important to make the project financially viable (i.e., "financial additionality").
- Whether other barriers exist to implementation of the project, such as a perception of risk, resistance by regulators because of an unfamiliar technology, or a lack of trained project operators.
- Timing can also be an indicator: if the decision to undertake the project, including the reductions, was made before the sale of offsets was contemplated, the project is clearly not additional.[21]

Double counting

To ensure the quality of offsets, double counting must be avoided. Double counting of emissions reductions can occur in a number of ways. The simplest case would be when an unscrupulous offset retailer sells credits for the same activity to two or more buyers. Such fraudulent activities are a potential problem on the voluntary market, where there are no controls such as a central registry of all transactions and carbon credits. Clearly this type of double counting is unacceptable. Other potential types of double counting raise more complex policy issues, such as whether emissions reductions purchased on the voluntary markets should count toward regulated provincial, national, or international reduction targets, or whether they should be additional to such targets. Another issue is how to deal with the different environmental attributes of a given activity beyond GHG emission reductions. For example, a wind-energy project may be eligible for Renewable Energy Credits (RECs), or be required under Renewable Portfolio Standards, which obligate utilities to supply a certain amount of renewable energy to their customers. Since the emissions reduction from these activities would happen anyway, these emissions reductions would fail the additionality test. Double-counting concerns would apply to tree-planting projects in cases where offsets from a project were sold, but the project was also counted against local, provincial, or national targets.

Most of these double-counting issues can be addressed easily. In particular, companies producing offsets – and the organizations that verify them – can do so by registering these offsets and retiring them once they have been sold so that the same offsets can only be purchased once. Moreover, project proponents must ensure that the climate change attributes of their projects are not sold again as a separate product such as a "renewable energy credit" or counted toward the fulfillment of government targets, such as quotas for renewable-energy production or for carbon sequestration.

Leakage

"Leakage" occurs when activities that reduce greenhouse gas emissions in one location cause emissions to increase somewhere else. This can reduce or eliminate the net benefit of an offset project. Leakage can be a problem both for tree-planting and for reduction of emissions from fossil fuels. For example, if a carbon sequestration project plants trees on farmland to convert it to a new forest, leakage might occur if this resulted in the clearing of forests elsewhere to compensate for the loss in arable land.[22] Likewise, projects that assist consumers to reduce their energy consumption – by providing energy-efficient products such as compact fluorescent bulbs – may suffer from leakage if the money saved through reduced energy use is invested in a new energy-consuming item for the home, such as a big-screen TV.[23] By contrast, renewable-energy projects are much less likely to result in leakage because they simply replace energy created by burning fossil fuels without requiring any reduction in energy consumption. The average amount of leakage from industrial plantation forests "established for carbon purposes" has been estimated at 40 per cent compared with an estimated leakage of five to 20 per cent for energy-sector projects.[24] Considerations of leakage are important at the project-design stage, and recognized standards like the CDM and the Gold Standard require that project developers illustrate how potential leakage problems have been addressed.

Permanence

Most emission-reduction projects can be characterized as fixed-term initiatives that deliver a virtual guarantee of permanent reductions. Most projects are financed on the assumption of a limited operational lifetime: an energy-efficiency upgrade to a building will only last as long as the building, while individual wind turbines have an operational life span of 25 to 30 years. Despite this, the emission-reduction benefits they produce are permanent. These projects all result in less carbon being removed from geologically stable fossil-fuel reservoirs (e.g., coal beds or oil-and-gas fields) and released into the atmosphere when the fuel is burned. Once an emission-reduction project becomes operational, the cumulative total of fossil fuels consumed will always be less than it would have been otherwise had the project not been implemented. This difference grows throughout the operational lifetime of the project.[25] By contrast, tree-planting projects involve a long-term commitment of land and investments in order to produce what are naturally volatile and impermanent offsets. Tree-planting projects can create permanent forest carbon offsets only if an area of land is dedicated in perpetuity for this purpose through a legal mechanism such as a conservation easement in order to protect the site from future human-caused land-use change.[26] Even with legal protection of the land in place, long-term management of the planted forest is required to ensure that it is maintained for many centuries.

Given the importance of permanence when sequestering carbon in forests, it is remarkable that many tree-planting offset projects call for the trees under care to be logged off at regular intervals and replanted.[27] This is because the economics of tree-planting projects encourage the planting of relatively quick-growing but smaller or short-lived tree species.[28] Since the present value of an offset depends on how far into the future it is produced, prospective project proponents have a strong fiscal incentive to maximize carbon sequestration within the short-term.[29] And while some species of trees are very long-lived and can sequester additional carbon over the course of many decades or centuries, they do not produce the rapid gains required within the short term to make a carbon-sequestration project financially additional: that is, a project in which income from offsets is crucial to implementation of the project. As a result, a significant number of tree-planting projects rely on fast-growing, short-lived trees such as hybrid poplar or eucalyptus that are intended to be harvested at regular intervals.

A potential alternative solution, that of selling the offsets long before they have been achieved, greatly increases the risk of loss on the part of the offset purchaser and is disallowed under many offset-validation systems (see: "Forward sales of offsets").

In addition to the planned impermanence of many carbon-sequestration projects due to harvesting, there is also the risk of unplanned or accidental "emission reversals", which can negate some or all the gains achieved by the tree-planting project. Storing carbon in the form of plant and soil biomass is inherently risky, since these are flammable or digestible by insects or pathogens. As such, forest-sequestration projects face considerable risks from fire,

Avoided deforestation and degradation

The United Nations Framework Convention on Climate Change's (UNFCCC) objective of stabilizing greenhouse gas emissions concentrations at a level that will avert dangerous climate change can only be achieved by reducing *all* major sources of emissions.[30] While much of the debate has focused on the emissions from fossil-fuel combustion, nearly a quarter of all annual emissions – an amount equivalent to the entire fossil-fuel emissions of the U.S. – is caused by the degradation and clearing of forests, principally deforestation in the tropics (e.g., the Amazon).[31] In some countries, more than 80 per cent of their respective GHG emissions are caused by forest destruction as opposed to industrial processes.[32] When forest soils are disturbed or trees are cut down with logging and other types of land clearance, much of the stored carbon in the ecosystem is released back into the atmosphere as heat-trapping greenhouse gases. The emissions resulting from such land use are additional to those from the burning of fossil fuels for energy production or transportation, such as coal, oil, and natural gas. For this reason, forest conservation in the tropics and the northern boreal region (which is believed to store more carbon than the world's combined tropical and temperate forests[33]) is receiving increasing attention as a complementary strategy of climate change mitigation. Most recently, a coalition of tropical countries, led by Papua New Guinea and Costa Rica, has proposed that avoided deforestation and degradation be included in a future international climate change agreement to follow the Kyoto Protocol after 2012.[34] The current UN agreements (both the UNFCCC and the Kyoto Protocol) do not provide concrete mechanisms or targets for reducing emissions from this major sector.

disease, and insect infestations unless considerable effort is made to prevent such disturbances during the operational lifetime of the project (e.g., through ongoing fire-suppression efforts).[35] Furthermore, in some parts of Canada, natural forest disturbances are likely to become much more prevalent as a result of global warming itself (e.g., more forest-fires in the western boreal forest due to warmer temperatures and reduced precipitation).[36] A study from 2006 has suggested that the stress of climate change is already causing existing forests to break down as temperatures rise and precipitation regimes shift, making forests worldwide more likely to become net sources of greenhouse gases.[37] This has been amply demonstrated in the forests of British Columbia, where mountain pine beetle populations have exploded, in part due to warmer temperatures, resulting in an unprecedented die-off of the province's mature pine trees.[38] By the end of 2006, the infestation covered 13 million hectares of land[39] – an area two-and-a-half times the size of Nova Scotia[40] – and is expected to kill more than three-quarters of B.C.'s marketable pine forests by 2015.[41] Modellers from the Canadian Forest Service (CFS) estimate that the beetle outbreak in the affected region will help convert Canada's much larger 2.1 million-square-kilometre "managed forest" area from a net carbon sink to an emission source contributing between 30 and 245 Mt CO_2e per year between 2008 and 2012.[42] Between 2000 and 2020 the CFS estimates that the cumulative impact of the mountain pine beetle infestation will be emissions of 270 million tonnes (Mt) of carbon – or 990 Mt CO2e – from 37 million hectares of forest.[43]

Tree-planting is commonly thought to increase the total amount of carbon stored over the long-term within the reservoirs of ground litter and forest soils, and within long-lived wood products and undecomposed waste within landfills.[44] Unfortunately, findings to date for the most relevant of these secondary reservoirs – tree plantation soils and landfills – indicate that managed forests like these have a severely limited capacity for carbon storage.

For example, a Quebec survey of 57 plantations found that soil carbon declined sharply in the first quarter-century after the land-use change, before restabilizing at a level 30 per cent below the original carbon content.[45] Another study from Michigan found no gain in soil carbon for a plantation established on agricultural lands with lower initial carbon content over a period of 10 years, although a (non-additional) naturally regenerated forest did achieve gains in soil carbon during this time.[46]

Risks to the permanency of carbon offsets could be accounted for and accommodated at the project level by increasing spending on insurance and/or reducing the number of offsets sold from the project in order to add a contingency buffer. The costs of providing this insurance against loss would be much greater for a single project within a single area than it would be for a large number of projects taking place over a wide area where the risk could be more effectively distributed, and the margins required for any particular project could be reduced.[50] Perhaps the best example of pooled risk within the voluntary market is the Chicago Climate Exchange, which requires that 20 per cent of the forest carbon-sequestration offsets generated through CCX-eligible sequestration practices be placed into a "reserve pool", for retirement in the event of any carbon-storage reversal from any of the projects sold through the exchange. This requirement is restricted to carbon-sequestration projects, putting the offsets they produce at a competitive disadvantage with emission-reduction offsets.[51] In the absence of a shared risk mechanism, project developers are forced to choose between an even greater increase in project overhead costs, or passing the elevated risk of losing generated offsets to fire, infestation, or unplanned logging along to the purchasers of the offsets.

Forest management and Kyoto Protocol, Article 3.4

Under Article 3.4 of the Kyoto Protocol, countries with emission-reduction targets can decide to include greenhouse gas emissions by sources, together with removals by sinks within a range of agricultural soils and land-use change and forestry categories, including "forest management" if they so decide.[47] Carbon-sequestration processes within a country's self-defined "managed forest" area can consistently exceed carbon emissions from the forest (including those that occur from natural disturbances such as wildfire and insect infestation). In these cases, inclusion of the managed forest in the inventory would reduce the total emission reductions a party would otherwise be required to achieve in order to meet its emission-reduction target. Parties were required to decide which categories, if any, they would include for the first commitment period prior to the end of 2006. The decision is irrevocable and commits the party to include this category in its emission inventory for commitment periods negotiated under the Protocol.[48] Canada negotiated hard for the inclusion of this provision within the Kyoto Protocol, largely on the expectation that it would receive a large net carbon credit though the inclusion of managed forestry. When it finally released its decision in 2007, however, it turned out that the government of Canada had decided to include only emission sources and sinks from cropland management, indicating that the national government has little confidence that Canada's managed forests will be a net carbon sink in the future.[49]

An alternative approach to addressing the impermanence of forest carbon offsets would be to sell them as "temporary offsets". Under this approach, a forest-sequestration project would effectively sell offsets as "tonne-years", guaranteeing a specific quantity of offsets only for a specific length of time. At the end of one period, the validity of the temporary credits could be extended to additional fixed periods, after proper inspection and monitoring. Alternatively, the purchaser would be obliged to purchase a new set of offsets to replace those that had expired.[52]

Despite its real advantages, characterizing carbon sequestration gains as "temporary offsets" has profound implications for the viability of projects.[53] While this solution provides environmental integrity, the use of a temporary-credits framework makes it clear that forest-sequestration offsets are distinct from, and much less valuable than, "permanent" offsets. [54] The sharply reduced income provided by a project selling temporary offsets makes it much harder for a project to achieve financial viability, let alone demonstrate financial additionality (i.e., establish that it is the income from the sale of offsets in particular that makes the project economically attractive). The designation of offsets as "temporary" may undermine the purchaser's confidence in the project, and creates uncertainty regarding the cost of future expenditures, since buyers are obliged to repurchase the same quantity of credits all over again as each set of temporary forest offsets expires. [55] To get around this issue, those proposing temporary offsets suggest that the purchaser could always buy permanent emission-reduction offsets at a later date, but this further reduces the role of carbon-sequestration offsets to that of short-term expediency. [56]

In sum, the impermanence of forest carbon offsets is a major shortcoming relative to emission-reduction offsets that cannot be overlooked. While there are means of responsibly addressing these permanence issues, such as designating forest sequestration offsets as "temporary offsets," implementation of these approaches reduces the competitiveness of forest carbon offsets sold on the voluntary market relative to offsets from the reduction of fossil-fuel emissions.

Timeliness

Proponents often argue that tree-planting projects can be implemented quickly, and thus can "buy time" for society to make the crucial changes in our energy and industrial systems needed to avoid dangerous climate change. In practice, however, tree-planting projects may have only just started to produce net benefits by the time a wind-farm plant proposed at the same time has been built, operated for a full term of 25 years, and then decommissioned.

In theory, implementation of a tree-planting project can often be done within a matter of days or weeks, although full implementation of a project may take considerably longer in practice. As one example, Reckitt Benckiser[57] invested in the "Trees for Change" project in order to offset all of the GHGs emitted by the company through its product-manufacturing processes (2006 manufacturing emissions = 276,000 tonnes). This project was initiated in 2006, with the planting of 45,000 trees on deforested land in British Columbia within just six days in 2006. However, this pilot planting accounted for only two per cent of the entire project and was intended to provide information "to prepare and carry out the main project planting in 2007 and 2008." [58] As such, the project was planned for implementation over a two-year period, a timeline similar to that for a renewable-energy facility or an energy-efficiency retrofit.

The pronounced S-shaped growth rate of trees over time means that seedlings sequester only modest amounts of carbon during their first years. At the same time, high soil decomposition rates from the exposed soils exceed the modest annual increases in biomass achieved by the small saplings. As a result, "net carbon uptake is generally low or negative (i.e., net carbon release) in forests less than 20 years old." [59] Even after this point, the amount of stored carbon in a new forest can be "much less than the avoided emissions from a protected forest of equal area" as long as 50 years after the trees were planted. [60] Beyond this, the process of planting and tending new forests typically involves a number of activities that result in emissions of greenhouse gases, including the use of machinery, fertilization, and brush control or thinning. [61] This combination of low initial sequestration rates and significant project-related emissions at the start of the project means that it may take many more years before the project delivers a true net benefit in terms of carbon offsets.

By comparison, most fossil-fuel emission-reduction projects produce net gains within the short term. Once installed, many infrastructure-based efficiency or renewable energy projects (e.g., an office-lighting retrofit, a wind farm, or a purchase of transit vehicles) will operate at full capacity right away. [62] Real net

Forward sales of offsets

Income from the sale of offsets is often critical during the initial financing of the project. It is not just a matter of raising money for implementation of the project; in order to satisfy financial additionality requirements, revenue from the sale of offsets must constitute the difference between a financially attractive investment and a nonviable project. As a result, project developers have a powerful motivation to "borrow from the future" and sell many or all of the offsets that the project is forecast to generate right at the beginning of the project, well before these reductions have actually been achieved.[64] However, it is possible to sell an exclusive right to verified offsets that will be generated at some point in the future, rather than the yet-to-be generated offsets themselves. This is the approach adopted by the Gold Standard. [65]

One significant concern with the forward sale of offsets is the prospect of applying promised "offsets" that have yet to be achieved against very real emissions that have already occurred. In order to be credible, offsets need to have been achieved and verified within the same general time period as the emissions they are applied against. [66]

A second concern is that the practice of forward selling generates significant risk, since the failure of the project at any point during this period will prevent some or all of the projected reductions from being achieved. [67] As with any speculative investment, however, there are ways to reduce the risk of an offset failure. One obvious solution for the purchaser is to obtain a guarantee from the vendor that any shortfall in promised offsets will be made good with offsets of similar quality from another source.

reductions are typically achieved within the space of a few months or years, even when emissions associated with the manufacture and installation of project machinery are included, and we assume that all "overhead" emissions must be made good before the project can generate net offsets.[63] In cases such as an upgrade or addition to energy-generating capacity that would have happened anyway, installing a more energy-efficient option than the business-as-usual choice results in little if any emissions additional to what would have occurred under the default option. In these cases, net reductions may be produced almost as soon as the new facility becomes operational.

Quantification

No system of trading can work effectively if the precise amounts of the goods and services being traded are unknown or subject to significant error. When it comes to carbon offsets, it is crucial to have accurate, verifiable, and cost-effective methods of quantifying the amount of emission reductions achieved by the project. Thus, projects that are more amenable to simple and accurate monitoring are desirable.

Methodologies for calculating emission reductions derived from renewable-energy projects are well advanced and are conceptually simple. A good example can be found in the baseline methodology adopted by the Clean Development Mechanism Executive Board. Offsets from energy-efficiency projects (e.g., a retrofit of a commercial building) are usually calculated against a baseline of energy consumption prior to implementation of the project.[68] Additional emissions resulting from "leakage" can be significant for both emission reduction and forest carbon-offset projects and must be factored in when quantifying offsets generated (see: "Leakage").

It is inherently more difficult and more costly to quantify a project's forest-sequestration offsets to a level of accuracy equal to that of emission-reduction offsets. Carbon is stored not just in wood, but in a variety of plant components (e.g., the foliage, roots, and bark of trees) as well as the soil the trees grow in. All of these disparate carbon stores within a single project require accurate accounting. Moreover, different species of trees grow at different rates, and differences in soils and microclimates within a project area – let alone forest-management practices – can produce significant variations in carbon sequestration within a small area even between individuals of the same species.[69] Estimating the amount of carbon sequestered in soils is even more difficult. The inherent complexity of quantifying carbon sequestration in forests is reflected in the numerous procedures and formulas of the 49-page "baseline and monitoring methodology" for CDM afforestation and reforestation projects on degraded land.[70]

While the CDM methodology reflects current best practice, even this level of effort does not produce truly accurate results; the document itself notes that the methodology's "targeted precision level for biomass estimation within each stratum is +/- 10% of the mean at a 95% confidence level." [71] As such, the 2001 assessment of Britain's Royal Society remains valid today; while "accurate measure techniques are vital … for quantification and verification of land carbon sinks under the Kyoto Protocol … the uncertainties associated with all current measurement techniques mean that they do not appear to be accurate enough for this task." [72] Potential purchasers of voluntary offsets may also conclude that the inherent inaccuracy in measuring carbon sequestered by tree-planting projects makes them a poor alternative to offsets from emission-reduction projects.

Impacts on Other Sustainability Objectives

Most offset projects will have some impact on the local economy and environment where they are established. These effects can be either positive or negative, depending on the type of the offset, as well as the particular design of each project. Offset purchasers should seek assurance that the offsets they choose are not inherently harmful to broader sustainability or social efforts, but rather preserve or improve local environments and communities.

Although some large-scale emission-reduction projects such as reservoir-based hydroelectric power dams and nuclear plants do reduce the net flow of greenhouse gases to the atmosphere, they also create major social and environmental problems (e.g., large dams cause extensive flooding and disrupt downstream river flows). [73] Similarly, many forest sequestration projects conflict with broader sustainability goals. For example, some forest plantations consist of exotic (i.e., non-native) species that negatively impact native biodiversity. Many tree plantations have very low biodiversity, provide few local jobs, and often require both fertilizer and pesticides to maintain their productivity, which can detrimentally affect the ecology of the surrounding land and waters. [74] In fact, the prospect of large-scale carbon-sequestration projects in the developing world has led to a broader critique of them as "CO_2lonialism": a system by which large parts of the developing world are at risk of being planted with fast-growing forests for the benefit of offsetting emissions in the developed world, but which are of marginal benefit to local peoples as a source of food, fibres, medicines, building-materials, and fuel sources. [75]

At their best, forest offset projects are capable of delivering true sustainability benefits. Ideally, projects would create new or rehabilitated permanent forests of indigenous species, strengthen local ecodiversity, provide additional ecosystem services such as increased slope stability, and provide economic benefits to local residents in the form of non-timber forest products (e.g., mushrooms, nuts, or fruits). One identified type of high-value project would be to provide Clean Development Mechanism financing for "forest conservation and restoration" projects in degraded watersheds within developing countries. A study of two such areas in Latin America found that the benefits of reduced erosion alone – avoiding the need for expensive drinking water infrastructure upgrades – would make the projects economically viable, even without harvesting the forest. Added to this were other benefits, such as those from increased biodiversity.[76] Another study that modelled external benefits such as wildlife diversity, soil stability, and fish and deer abundance for managed forests in the U.S. Pacific Northwest found that specific types of carbon-sequestration management regimes could provide additional benefits compared with a "profit maximizing" timber-supply regime.[77]

Most emission-reduction measures can produce significant positive overall benefits in addition to reduced greenhouse gas emissions. Properly sized and managed to ensure critical water flows are maintained, and sited in locations that minimize or avoid impacts on aquatic ecosystems, run-of-river small hydro projects can result in minimal environmental impacts.[78] Similarly, properly sited wind farms can have a relatively benign impact on the environment.[79] These small-scale renewable energy projects are also notable for producing permanent, highly skilled operations and maintenance jobs in rural areas, and for providing a stable new stream of revenue to local government and landowners through land-lease payments and property taxes.[80] Based on recent data from the U.S., even a new, large wind farm with considerable efficiencies of scale will produce more than twice as many operations-phase jobs per MW of installed capacity than a combined-cycle natural-gas plant.[81] Energy-efficiency projects are also generally associated with little or no direct environmental impacts; indeed, reduced demand for energy may indirectly reduce the environmental impacts associated with energy generation. Energy-efficiency retrofit projects are even more labour-intensive than renewable-energy projects and provide the largest number of new jobs per kilowatt of energy saved.[82]

Conclusion

Given the urgent need to prevent the buildup of greenhouse gases in the atmosphere, further delay in transforming our energy and industrial systems, and especially reducing emissions from fossil-fuel use, is unacceptable. This report has shown that tree-planting projects are in crucial respects fundamentally different from projects that reduce fossil-fuel use and resulting GHG emissions. A tonne of carbon sequestered and stored in living plant biomass cannot be considered equivalent to a tonne of carbon left in the ground in the form of fossil deposits. Carbon-sequestration projects that transfer carbon from the atmosphere to biomass are vulnerable to the risk in perpetuity of that carbon returning to the atmosphere, and this risk will likely be increased in a warming world. Certainly, tree-planting, when properly planned and carried out, can have a range of climatic, ecological, and economic benefits, but they cannot be considered as effective as projects that reduce fossil-fuel use in reducing the net buildup of greenhouse gases in the global atmosphere.

If individuals or companies are unable to reduce their own fossil-fuel-related emissions, the best alternative is to reduce the consumption of fossil fuels elsewhere. Energy efficiency and renewable energy offsets decrease the use of fossil fuels and resulting emissions. As such, they help to transform our society with its over-reliance on inefficient, nonrenewable, and polluting sources of energy to sustainable, clean, and zero-emission energy sources.

The Gold Standard for voluntary emission reductions

The Gold Standard for voluntary offsets[83] is currently the only standard in the voluntary market that builds on the safeguards of the Kyoto CDM system and thus significantly reduces the due diligence and investigation required by an offset purchaser. The Gold Standard was developed by WWF-International, Helio International, and South South North and is now an independent organization based in Switzerland that is supported internationally by a broad group of stakeholders, including over 50 NGOs. Registration with the Gold Standard requires 1) third-party verification by accredited inspectors according to recognized methodologies, 2) additionality screening, and 3) evaluation against sustainable-development criteria. Gold Standard projects are located in developing countries that do not have targets under the Kyoto Protocol. In addition to generating emissions reductions, these projects can help communities achieve the benefits of more developed countries without relying on fossil fuels. To protect against double counting of reductions (once by Canada's national inventory and once by the offset purchaser), offset projects within Canada, a country with reduction targets under the Kyoto Protocol, cannot be registered to the Gold Standard; however, Canadian purchasers can buy Gold Standard offsets from projects in developing countries.[84] Some high-profile events that have purchased Gold Standard offsets include the 2006 FIFA World Cup in Germany and the 2005 United Nations Climate Change Conference in Montreal.[85]

All offset projects, including energy-efficiency and renewable projects, must be designed, managed, and accounted for in accordance with certain criteria for the climate gains to be real. They must:

- **Ensure additionality.** Offsets should only be issued to projects that result in actual reductions in GHG emissions or higher GHG removals than would be the case if offset credits were not available, and must be surplus to legal requirements and government incentives. It is usually difficult for a purchaser to determine if offsets are additional without recourse to a verifier using a recognized formal additionality-assessment tool, such as that used by the CDM and the Gold Standard.
- **Prevent double counting.** Transparent, verifiable procedures for registering and retiring the offsets should be in place so that benefits resulting from an offset project are only counted once.
- **Account for leakage.** The emissions reductions achieved by a project should not result in emissions in another location, and if such emissions occur they must be deducted from the credited amount.
- **Insist on permanence.** To be effective in addressing climate change, offsets must ensure that carbon is removed from the atmosphere for a period of many centuries. This issue is of particular concern to offset projects that involve capturing and storing carbon such as tree-planting projects.

A Gold Standard project: the biomass power plant at Malavalli, India

The Malavalli biomass project is a Gold Standard renewable-energy offset that uses existing crop residues and other biomass fuels to generate electricity for the local power grid. As with other renewable-energy projects, offsets are created through the generation of low-emission electricity, thus reducing demand for electricity from fossil fuel sources. Local farmers, who previously burned cane trash and coconut fronds in their fields, now supply this biomass as fuel for the power plant. The project thus transforms a former waste product into a valuable new “crop,” and helps alleviate poverty in the region through employment. The biomass burnt in the 4.5 MW power plant produces a nutrient-rich ash, which is processed and distributed back to the farmers as fertilizer, thereby reducing their need for petrochemical fertilizers.[86] The Malavalli plant has overcome a number of financial and technological barriers: it is an unusually small plant burning unusually low-density wastes, with an integrated 100 per cent ash-recovery and fertilizer-distribution component. Third-party project verifiers have concluded that the project “demonstrates additionality”, since these financial barriers would regularly prevent the project from recovering its costs unless income from offsets are factored in.[82] The Malavalli project is designed to produce 22,000 tonnes of CO_2e offsets per year, and issued its first CERs (Certified Emission Reductions) on March 19, 2007.[88]

- **Be mindful of timeliness.** Beware of purchasing offsets that will not be realized in the same time period as the emissions they are applied against, and ensure that the vendor will replace any shortfall in any pre-sold offsets with credits of similar quality.
- **Ensure reliable quantification of offsets.** Purchasers should have confidence that they are actually receiving the quantity of goods they have paid for. While it is inherently more difficult (and expensive) to quantify forest carbon sequestration offsets, accredited third-party verifiers and accepted transparent methodologies deliver good results.
- **Promote sustainable development.** It is important that offset projects provide net positive benefits for the environment and communities where they are established, meet local needs, and have stakeholder and community support.

Voluntary carbon offsets can be an effective way to reduce our carbon footprint, as a complement to other measures we take in our own lives and as a society to reduce our greenhouse gas emissions to sustainable levels. However, a few poorly managed projects, unsubstantiated and suspect claims, and unprofessional practices can undermine support for all offsets. Especially at this early stage of the development of the voluntary carbon market, where there is little accountability or effective governance of the wide range of actors involved in the carbon market, buyers of carbon credits face a daunting task of separating the wheat from the chaff. Fortunately, some credible and well-founded certification schemes are emerging, such as the Gold Standard (see box). The information in this report is intended to provide further guidance and support in this task.

Endnotes

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[1] Emission trading systems have previously been used against forms of pollution, most notably by the United States to reduce sulphur oxide emissions from industry, which cause acid rain. See Haites, E. [G. Bird (ed.)] (2002). *An emerging market for the environment: a guide to emissions trading*. Oxford, UK, Commissioned by United Nations Environment Program (UNEP), UNEP Collaborating Centre on Energy and the Environment (UCCEE), and the UNCTAD/Earth Council Carbon Marketing Programme. Available at www.unep.fr/energy/publications/pdfs/EmissionsTrading-Feb03.pdf
[2] Referred to as "Annex I parties" within the Kyoto Protocol. UNFCCC (1997). *Kyoto Protocol*. Available at http://unfccc.int/kyoto_protocol/items/2830.php. For more details, see http://unfccc.int/parties_and_observers/items/2704.php
[3] The five years from 2008 to 2012 are referred to as the "first commitment period" of the Kyoto Protocol. Negotiations on the post-2012 "second commitment period" are currently underway. For more information on the Kyoto Protocol, see http://unfccc.int/kyoto_protocol/items/2830.php
[4] See endnote 16 below for the UNFCCC definitions of "afforestation" and "reforestation."
[5] UNFCCC (2005). *Modalities and procedures for afforestation and reforestation project activities under the clean development mechanism in the first commitment period of the Kyoto Protocol*. Decision 5/CMP.1. Document FCCC/KP/CMP/2005/8/Add.1. Available at http://unfccc.int/resource/docs/2005/cmp1/eng/08a01.pdf
[6] UNFCCC (1993). *Framework Convention on Climate Change: Articles*. New York, United Nations. Available at http://unfccc.int/essential_background/convention/background/items/2853.php
[7] Bramley, M. (2005). *The Case for Deep Reductions: Canada's Role In Preventing Dangerous Climate Change*. Vancouver, David Suzuki Foundation and the Pembina Institute for Appropriate Development. Available at www.davidsuzuki.org/Publications/case_for_deep_reductions.asp
[8] By comparison, fully 2,918 million tonnes CO_2e of offsets were traded within the world's regulatory markets in 2007. Hamilton, M., Sjardin, M. *et. al.* (2008). *Forging a Frontier: State of the Voluntary Carbon Markets 2008*. Washington, DC, and New York, Ecosystem Marketplace and New Carbon Finance. Available at www.newcarbonfinance.
[9] *Ibid*. Forest and agricultural land offsets constituted 18 per cent of the voluntary market, while offsets from renewable energy and energy efficiency projects accounted for 31 per cent and 18 per cent of the total respectively, or 67% in all. The conversion of methane into CO_2 accounted for a further 16% of the market. Offsets from the destruction of industrial gases with high global warming potentials (GWP), including N_2O and HFC, accounted for 2 per cent of all transactions, while fuel switching, geological sequestration and "mixed" types of offsets accounted for the remaining 15 per cent of the market.
[10] Banuri, T., T. Barker *et. al.* (2007). Technical Summary. In *Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, [B. Metz, O. Davidson *et. al.* (eds.)]. Cambridge and New York, Cambridge University Press.
[11] The subsequent use of captured methane as a fuel in place of fossil fuels is an emission reduction measure and is included within the scope of this report.
[12] Undisturbed boreal and temperate forests can store large amounts of carbon within forest soils, but there is relatively little carbon storage within tropical forest soils. Dixon, R.., A. Solomon, *et al.* (1994). Carbon pools and flux of global forest ecosystems, *Science* **263** (5144): 185 - 190.
[13] Stinson, G. and B. Freedman (2001). Potential for carbon sequestration in Canadian forests and agroecosystems, *Mitigation and Adaptation Strategies for Global Change* **6**: 1-23.
[14] The non-market figure monetizes valuable ecosystem services such as pest control from resident birds, wilderness recreation activities, the provision of subsistence products for aboriginal peoples, other non-timber forest products, and includes minor contributions for services to municipal watersheds and

citizens' explicit valuation of the boreal forest for its own sake. Anielski, M. and S. Wilson (2005). *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems*. Ottawa, Canadian Boreal Initiative. Available at www.borealcanada.ca

[15] Akbari, H., M. Pomerantz, *et al.* (2001). Cool surfaces and shade trees to reduce energy use and improve air quality in urban areas, *Solar Energy* **70** (3): 295-310.

[16] Nowak, D., D. Crane, *et al.* (2002). *Understanding and Quantifying Urban Forest Structure, Functions, and Value*. 5th Canadian Urban Forest Conference, Region of York, Ontario.

[17] Anderson, L. and H. Cordell (1988). Residential Property Values Improved by Landscaping with Trees, *Southern Journal of Applied Forestry* **9** (162-166). See also Bolund, P. and S. Hunhammar (1999). Ecosystem services in urban areas, *Ecological Economics* **29**: 293–301.

[18] This should not be confused with replanting a forest that has recently been harvested, since this activity is not additional, but merely replaces what was recently lost. The Kyoto Protocol states that project lands must have been deforested prior to 1990 in order for tree-planting projects to be additional. The UNFCCC's definitions for deforestation, reforestation and afforestation are set out in UNFCCC (2001). *Definitions, modalities, rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol: Annex to UNFCCC Decision 11/CP.7 (Land use, land-use change and forestry)*. FCCC/CP/2001/13/Add.1: p 58. Available at http://unfccc.int/resource/docs/cop7/13a01.pdf

[19] As with many other studies, Stinson and Freedman do not include "fossil fuel use associated with forest management and timber harvesting" in their carbon sequestration model, but acknowledge that these emissions should be included in a full accounting of net carbon sequestration from forest offset projects. Stinson, G. and B. Freedman (2001). Potential for carbon sequestration in Canadian forests and agroecosystems. *Mitigation and Adaptation Strategies for Global Change* **6**: 1-23.

[20] See discussion on p. 85 of Watson, R., I. Noble, *et al.* (eds.) (2000). *Land use, land-use change, and forestry: a special report of the IPCC.* New York, Cambridge University Press. Published for the Intergovernmental Panel on Climate Change. Available at www.grida.no/Climate/ipcc/land_use/index.htm.

[21] Clean Development Mechanism Executive Board. (2005). *Tool for the demonstration and assessment of additionality* (version 02). Available at http://cdm.unfccc.int/EB/index.html

[22] Kauppi, P. and R. A. Sedjo (2001). Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geo-Engineering. In *Mitigation: Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, Cambridge University Press: 301-344. Available at www.grida.no/climate/IPCC_tar/wg3/155.htm

[23] Chomitz, K. M. (2002). Baseline, leakage and measurement issues: how do forestry and energy projects compare? *Climate Policy* **2**(1): 35-49.

[24] Kauppi, P. and R. A. Sedjo (2001). Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geo-Engineering. In *Mitigation: Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, Cambridge University Press: 301-344. Available at www.grida.no/climate/IPCC_tar/wg3/155.htm

[25] In this sense, emission reduction projects are similar to forest sequestration projects in that their offsets also represent sequestered carbon. Like offsets from avoided deforestation, these offsets are generated by protecting existing stores from depletion, rather than creating new stockpiles. Unlike avoided deforestation offsets, however, the carbon is sequestered in a highly stable underground reservoir, almost completely protected from threats of "reversal."

[26] Theoretically, the offsets gained from forest carbon projects could be maintained at a succession of different locations, so long as the net amount of additional carbon stored was maintained in perpetuity.

[27] Graph 4.6 of the chapter on carbon sinks in the IPCC Third Assessment Report illustrates "cumulative carbon changes for a scenario involving afforestation and harvest." Kauppi, P., R. Sedjo *et. al.* (2001). Technical and economic potential of options to enhance, maintain and manage biological carbon reservoirs and geoengineering. In In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, [Metz, B., O. Davidson, *et. al.* (eds.)]. Cambridge, Cambridge University Press. Other types of forest carbon sequestion projects, such as those implementing lengthened rotation periods, or replanting forests with faster-growing tree species also require tree harvesting as part of the project plan.

[28] Van Kooten, C. and A. Eagle. Forest carbon sinks: a temporary and costly alternative to reducing emissions for climate change mitigation. In *Sustainability, institutions, and natural resources: institutions for sustainable forest management* [Kant, S. and A. Berry (eds.)]. Dordrecht, Netherlands, Springer. pp. 233-255

[29] Boyland, M. (2006). The economics of using forests to increase carbon storage, *Canadian Journal of Forest Research* **36**: 2223-2234. Available at http://pubs.nrc-cnrc.gc.ca

[30] Environmental Defense (2007). *Reducing Emissions from Deforestation in Developing Countries: Policy Approaches to Stimulate Action, Environmental Defense and Instituto de Pesquisa Ambiental da Amazonia*. Submission to the XXVI SBSTA of the UNFCCC, 23 February 2007. Available at www.climaedesmatamento.org.br/files/general/ED_IPAM_et_al._submission_UNFCCC.pdf

[31] Silva-Chavez, G. and A. Petsonk (2006). Rainforest credits, *Carbon Finance* 6:18.

[32] Indonesia has the highest rate of deforestation on Earth. Indonesian greenhouse gas emissions resulting from deforestation and forest fires account for five times the emissions from non-forestry sources. USAID / Indonesia Program Office (2007*). Addressing climate change in Indonesia*. United States Embassy – Indonesia. Available at: http://jakarta.usembassy.gov/Climate_Change_Page/Climate%20Fact%20Sheet%2012_1_7%20Bali%20COP_2_srb%20_2_.pdf

[33] (2007) Petition to Canadian government leaders from 1500 scientists, dated May 14, 2007. International Boreal Forest Campaign, Canadian Boreal Initiative and Boreal Songbird Initiative. See endnote iii. Available at: http://www.borealbirds.org/scienceletter.shtml

[34] FAO (2007). *Reducing emissions from deforestation in developing countries: recent developments in UNFCCC: item 7*. FAO Advisory Committee on Paper and Wood Products. Available at: http://www.fao.org/forestry/media/12785/1/0/. See also: Coalition for Rainforest Nations website at: http://www.rainforestcoalition.org/eng/ Accessed June 18, 2008.

[35] Some carbon sequestration models [e.g., Kurz, W. A., S. J. Beukema, *et al.* (1998). Carbon budget implications of the transition from natural to managed disturbance regimes in forest landscapes, *Mitigation and Adaptation Strategies for Global Change* **2**: 405-421], include the assumption that fire and disease are completely eliminated in the managed forest. Kurz et. al. maintain that factoring fire and disease into the managed forest regime would not affect their results so long as each year's harvesting rate was adjusted to fully compensate for these natural losses. This might be difficult to achieve in practice: for example, in B.C. during the 1980s, the number of forest hectares lost to fire and pests was three times the total forest area harvested. British Columbia Forest Service (1996). *1994 forest, range and recreation resource analysis.* Victoria, British Columbia Forest Service. Available at www.for.gov.bc.ca/hfd/library/frra/1994/

[36] Westerling, A., H. Hidalgo, *et al.* (2006). Warming and earlier spring increases western U.S. forest wildfire activity, *Science xpress* 10.1126/science.1128834. Available at www.sciencemag.org/cgi/content/full/313/5789/940. FAO (2007). See also: FAO (2007*) State of the World's Forests 2007*. Rome, Food and Agriculture Organization of the United Nations. Available at www.fao.org/docrep/009/a0773e/a0773e00.htm. The 2001 IPCC report on LULUCF notes three ways in

which the effectiveness of forest carbon sequestration measures may "diminish in the medium term." Firstly, "the capacity of some ecosystems to sequester carbon may be approached. Secondly, "photosynthesis will no longer increase as CO_2 concentrations continues to rise, whereas respiration is expected to continue to increase with the rise in temperature. A third reason is that trees may begin to die as a result of climate change." Watson, R., I. Noble, *et al.* (eds.) (2000). *Land use, land-use change, and forestry: a special report of the IPCC.* New York, Cambridge University Press. Published for the Intergovernmental Panel on Climate Change. p.26 Available at www.grida.no/Climate/ipcc/land_use/index.htm

[37] Scholze, M., W. Knorr *et. al.* (2006). A climate-change risk analysis for world ecosystems, *Proceedings of the National Academy of Sciences.* **103** (35): 13116-13120. Available at www.pnas.org/cgi/reprint/0601816103v

[38] Kurz, W., C. Dymond *et. al.* (2008). Mountain pine beetle and forest carbon feedback to climate change, *Nature* **452**: 987-990 (24 April 2008). Available at www.nature.com/nature/journal/v452/n7190/abs/nature06777.html

[39] *Ibid*.

[40] The Nova Scotia Land Services Branch, states that the province covers 12 million acres (4.85 million hectares) See http://www.gov.ns.ca/natr/landservices.asp

[41] Forest Analysis and Inventory Branch (2007). *Timber supply and the mountain pine beetle infestation in British Columbia: 2007 Update*. Victoria, BC: B.C. Ministry of Forests and Range. Available at www.for.gov.bc.ca/hfp/mountain_pine_beetle/Pine_Beetle_Update20070917.pdf

[42] Kurz, W., Stinson, G. *et. al.* (2008). Risk of natural disturbances makes future contribution of Canada's forests to the global carbon cycle highly uncertain, *Proceedings of the National Academy of Sciences*, **105** (5): 1551-1555 (February 5, 2008).

[43] Kurz, W., Dymond C. et. al. (2008). Mountain pine beetle and forest carbon feedback to climate change, *Nature*, 452, 987-990 (24 April 2008). Available at www.nature.com/nature/journal/v452/n7190/abs/nature06777.html

[44] Figure 4.6 in Kauppi, P., R. Sedjo *et. al.* (2001). Technical and economic potential of options to enhance, maintain and manage biological carbon reservoirs and geoengineering. In *Mitigaton 2001: The IPCC Third Assessment Report*, [B. Metz, O. Davidson *et. al.* (eds.)]. Cambridge, Cambridge University Press, provides a visual argument for carbon sequestration in a new forest with periodic harvests. In addition to showing generous lifetimes for manufactured products, the diagram neglects to include any loss of soil carbon at the start of the first rotation, or after each harvest.

[45] Tremblay, S., S. Perie, *et. al.* (2006). Changes in organic carbon storage in a 50 year white spruce plantation chronsequence established on fallow land in Quebec, *Canadian Journal of Forestry Research*. **36**: 2713-2723. Availble at http://pubs.nrc-cnrc.gc.ca/rp-ps/articleOptions.jsp?jcode=cjfr&ftl=x06-076&lang=eng

[46] Degryze, S., J. Six, *et. al.* (2004). Soil organic pool changes following land-use conversions, *Global Change Biology* **10**: 1120-1132. Available at www.blackwell-synergy.com/doi/abs/doi%3A+10.1111/j.1529-8817.2003.00786.x?cookieSet=1&journalCode=gcb

[47] Categories under Article 3.4 include "cropland management" and "rangeland management" in addition to "forest management." UNFCCC (1997). *Kyoto Protocol*. Available at http://unfccc.int/kyoto_protocol/items/2830.php.

[48] *Ibid.*

[49] Government of Canada. (2007). *Canada's Initial Report Under the Kyoto Protocol: Facilitating the calculation of Canada's assigned amount and demonstrating its capacity to account for its emissions and assigned amount under the Kyoto Protocol, pursuant to Article 7, paragraph 4 of the Kyoto Protocol.* Ottawa, Government of Canada.

Available at http://www.ec.gc.ca/climate/initial_Kyoto_Rep_e.pdf
[50] Pooling resources against risks of reversal is stressed in: . Climate Change Policy Partnership (n.d.). Harnessing farms and forests: domestic greenhouse gas offsets for a federal cap and trade policy FAQs. Durham, NC, Climate Change Policy Partnership. Accessed on June 18, 2008. Available at http://www.env.duke.edu/ccpp/convenientguide/PDFs/harnessingfaqs.pdf
[51] Chicago Climate Exchange (2007). *Forest Carbon Emission Offsets*. Chicago, IL, Chicago Climate Exchange. Available at http://www.sicirec.org/media/CCX_Forest_Carbon_Offsets.pdf
[52] See the following sources for more information and analysis of temporary offsets: Chomitz, K. M. (n.d.) *Evaluating carbon offsets from forestry and energy projects: how do they compare?* World Bank Development Research Group. Available at http://wbln0018.worldbank.org/Research/workpapers.nsf/0/d92de72e3c60be77852568; van Kooten, C. and A. Eagle. Forest carbon sinks: a temporary and costly alternative to reducing emissions for climate change mitigation. In *Sustainability, institutions, and natural resources: institutions for sustainable forest management* [Kant, S. and A. Berry (eds.)]. Dordrecht, Netherlands, Springer. pp. 233-255; Government of Canada (2005). *Offset System for Greenhouse Gases. Papers for Consultation: Overview Paper and Technical Background*. Available at http://www.ec.gc.ca/publications/index.cfm?screen=PubDetail&PubID=751&CategoryID=24&lang=e
[53] If a price difference were to accurately reflect the true relative value of forest carbon and emission reduction offsets, it follows that forest carbon offsets – particularly those that have not explicitly accounted for impermanence risks – are currently overpriced.
[54] The estimated value of a temporary 5-year offset within the CDM system has estimated as being only 14 – 35% of a permanent offset. Nabuurs, G., O. Masera *et. al.* (2007). Forestry. In *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, [B. Metz, O. Davidson *et. al.* (eds.)]. Cambridge University Press, Cambridge UK and New York.
[55] *Ibid*.
[56] The purchase of temporary offsets has been justified as a means of enabling a company to achieve emission reductions in the short term, before it would be economic for them to replace high-emissions sources within their operations. Under this scenario, the company would continue to purchase temporary credits until such time as they were able to realize a greater amount of reductions within their own operations, by replacing old equipment with new low-emission units. Others have noted that bad-faith purchasers might also be attracted to temporary offsets if they were gambling on a future collapse of the carbon market, where offsets would be very inexpensive or no longer required at all. It seems unlikely that many voluntary purchasers of offsets would want to be associated with the second line of thinking. See: Chomitz, K., and F. Lecocq (2003). *Temporary sequestration credits: an instrument for carbon bears*. World Bank Policy Research Working Paper. World Bank. Available at http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2004/01/16/000160016_20040116163806/Rendered/PDF/WPS3181.pdf
[57] UK-based Reckitt Benckiser is the manufacturer of numerous household products including Clearasil™ face cleaner, Airwick™ air fresheners and French's™ mustard.
[58] Reckitt Benckiser (2006). Trees for Change – Pilot Planting – April 2006. Webpage: http://www.reckittbenckiser.com/Sites/treesforchange/latest_update.htm. Accessed June 12, 2008. As of June 12, 2008, no information about subsequent plantings was available on the Reckitt Benckiser website.
[59] Wilson, S. and R. Hebda (2008). *Mitigating and adapting to climate change through the conservation of nature*. Land Trust Alliance of British Columbia. Available at http://landtrustalliance.bc.ca/research.html
[60] *Ibid*.

[61] The CDM methodologies for carbon sequestration projects require projects to consider project-related greenhouse gas emissions from combusting fossil fuels, using fertilizers, and burning biomass. See CDM Executive Board (2008). *Consolidated afforestation and reforestation baseline and monitoring methodology*. AR-ACM0001. Adopted 14 March 2008. Available at http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

[62] Other projects, such as energy-efficiency outreach programs that retrofit a given number of buildings each month, will produce accumulating results over time.

[63] The Pembina Institute conducted a life cycle analysis of a 600 kW turbine with a low 20% capacity located in Alberta, Canada (annual production: 1150 MWh/year). The report calculated that GHG emissions from the mining and processing of raw materials, and the manufacture and transport of the turbine were 13 kg per MWh of electricity, based on an operational lifetime of 25 years, or 475 t CO_2e in total. The same study calculated that the life-cycle emissions for a natural gas plant (including emissions from extracting, refining, and transporting the natural gas) were 786 kg per MWh. As such, the wind turbine would have to produce 604 MWh of electricity, equivalent to 6-7 months of average operation, before the emissions associated with the wind turbine were entirely offset. McCulloch, M., M. Reynolds *et. al.* (2000). *Life-cycle value assessment of a wind turbine*. Calgary, Pembina Institute for Appropriate Development, Available at www.pembina.org/pub/15.

[64] "Forward sales" of offsets are also referred to as "forward contracts" per Lecocq, F. and K. Capoor (2005). *State and trends of carbon market: 2005*. Washington, International Emissions Trading Association / World Bank, and as "ex ante accounting" in Taiyab, N. (2006). *Exploring the market for voluntary carbon offsets*. London, International Institute for Environment and Development (IIED). See also Trexler Climate and Energy Services (2006). *A consumers' guide to retail offset providers*. Prepared for Clean Air – Cool Planet. Available at http://www.cleanair-coolplanet.org/ConsumersGuidetoCarbonOffsets.pdf

[65] (2006) *The Gold Standard voluntary emission reductions (VERs) manual for project developers*. Version 5. The Gold Standard-IETA-Climate Group. p.50. Accessed June 18, 2008. Available at: http://www.cdmgoldstandard.org/uploads/file/GS-VER_Proj_Dev_manual_final%20.pdf

[66] See discussion in: Gössling, S., J. Broderick *et. al*. Voluntary carbon offsetting schemes for aviation: efficiency, credibility and sustainable tourism, *Journal of sustainable tourism* (**15**) 3: 223-258.

[67] Trexler Climate and Energy Services (2006). *A consumers' guide to retail offset providers*. Prepared for Clean Air – Cool Planet. Available at: http://www.cleanair-coolplanet.org/ConsumersGuidetoCarbonOffsets.pdf. In the case of tree-planting projects, there is a real risk of retroactive reversals; see the section on permanence.

[68] All CDM methodologies (including approved methodologies and those still under development) can be accessed at http://cdm.unfccc.int/methodologies/index.html

[69] Garcia-Oliva, F., O. Masera (2004) Assessment and measurement issues related to soil carbon sequestration in land-use, land-use change, and forestry (LULUCF) projects under the Kyoto Protocol, *Climatic change*. (**65**) 3: 347-364. Available at: http://cat.inist.fr/?aModele=afficheN&cpsidt=16165676; and personal communication with Peter Salonius, Canadian Forest Service, on July 3, 2007 regarding soil carbon trends for afforested lands, and the effect of different forest management techniques.

[70] CDM Executive Board (2008). *Consolidated afforestation and reforestation baseline and monitoring methodology*. AR-ACM0001. Adopted 14 March 2008. Available at http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

[71] *Ibid.*

[72] Royal Society (2001). *The role of land carbon sinks in mitigating global climate change*. London, Royal Society. p.17. Available athttp://royalsociety.org/document.asp?id=1421

[73] For a critique of large dams see Imhof, A. S. Wong *et. al.* (2002). *Citizen's Guide to the World Commission on Dams*. Berekeley, CA, International Rivers Network. Available at http://www.internationalrivers.org/en/node/1453
For an assessment of nuclear power, see UK Sustainable Development Commission (2006). *The role of nuclear power in a low carbon economy. DSC position paper*. London, Sustainable Development Commission. Available at http://www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf. See also Winfield, M. A. Jamieson, *et. al.* (2006). *Nuclear power in Canada: an examination of risks, impacts and sustainability.* Calgary, Pembina Institute for Appropriate Development. Available at www.pembina.org/pub/1346
[74] Several high-profile tree plantation projects in the developing world, such as the Plantar eucalyptus plantation in Minas Gerais, Brazil, have become notorious for their negative impacts on local communities. See: Forests and the European Union Resource Network (FERN) (2001). *Sinks in the Kyoto Protocol: a dirty deal for forests, forest peoples and the climate*. Available at www.fern.org/pubs/briefs/sinks2.pdf ; See also David Suzuki Foundation (2003). *Risky business: how Canada is avoiding Kyoto action with controversial projects in developing countries*. Available at http://www.davidsuzuki.org/Publications/Risky_Business.asp
[75] Forests and the European Union Resource Network (FERN) (2001). *Sinks in the Kyoto Protocol: a dirty deal for forests, forest peoples and the climate*. Available at www.fern.org/pubs/briefs/sinks2.pdf
[76] Hardner, J., P. Frumhoff and D. Goetze (2000). Prospects for mitigating carbon, conserving biodiversity, and promoting socioeconomic development objectives through the Clean Development Mechanism, *Mitigation and Adaptation Strategies for Global Change*. (**5**)1:61-80. Available at www.springerlink.com/content/g006tk4015714q7t/ While the study included the option to purchase private lands and convert them to forest lands, it did not calculate the economic cost of land use change for tenants or workers on these lands.
[77] Englin, J. and J. Callaway (1995). Environmental impacts of sequestering carbon through forestation, *Climatic* Change (**31**) 1: 67-78. Available at www.springerlink.com/content/g006tk4015714q7t/
[78] A checklist of possible impacts and best practices for small hydro facilities can be found at: Natural Resources Canada (2004). Hydroelectric energy: environmental Impacts and preventable measures. Webpage: http://www.canren.gc.ca/tech_appl/index.asp?CaId=4&PgId=43. Last accessed June 23, 2008. See also Habitat and Enhancement Branch (1999). *Guidelines for the Protection of Fish and Fish Habitat at Small Hydro Developments in British Columbia*. Vancouver, Fisheries and Oceans Canada. Available at http://www.dfo-mpo.gc.ca/Library/279501.pdf; and Environmental Stewardship Division. Instream Flow Guidelines for British Columbia - Working Drafts. Webpage: http://www.env.gov.bc.ca/wld/BMP/instreamflow_wkgdrft.html. Last accessed June 23, 2008.
[79] NWCC Siting Subcommittee (2002). *Permitting of wind energy facilities: a handbook.* Revised 2002. Washington. DC, National Wind Coordinating Committee. Available at www.nationalwind.org/publications/siting/permitting2002.pdf. Despite fears of bird deaths, several studies concur that an average wind turbine kills less than one bird per year – making them much less deadly than office buildings or the average housecat. Source: American Wind Energy Association (2005). *Wind power myths vs. facts*. Available at www.awea.org/pubs/factsheets/mythsvsfacts-factsheet.pdf
[80] Tegen, S. (2006). *Comparing statewide economic impacts of new generation from wind, coal, and natural gas in Arizona, Colorado and Michigan*. Golden, CO, National Renewable Energy Laboratory. Available at http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/38154_econdev_compare_statewide.pdf; Jenkins, J. and T. Gagliano (2007). *Wind power and economic development: real examples from the Pacific Northwest*. Portland, OR, Renewable Northwest Project. Available at http://www.rnp.org/Resources/NW_Wind_Econ_Dev_Paper_Solar2007_Conference.pdf

[81] As of June 2007, the JEDI (Jobs and Economic Development Impact) model developed by Marshall Goldberg for the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL) used a job creation factor of nine operations and management jobs created per 100 MW of installed capacity. Personal communication with Marshall Goldberg, MRG and Associates, on June 21, 2007. Heavner and Churchill used projections of direct employment for new natural gas combined-cycle gas turbine (CCGT) plants in California to derive an average of four new jobs per 100 MW of installed capacity. See Heavner, B. and S. Chruchill (2002). *Renewables work: job growth from renewable energy development in California*. Sacremento, CA, CALPIRG Charitable Trust. Available at www.environmentcalifornia.org/reports/energy/energy-program-reports/. The NREL factor for job creation appears to be conservative, especially for smaller wind farms: a case study of a 10.5 MW wind farm in Prince Edward Island, Canada has generated 2 O+M jobs (or 19 jobs per 100 MW), as well as $20,000 annually in land lease payments, and annual tourism benefits of $260,000 and 20 summertime jobs. See Canadian Wind Energy Association (2006). *North Cape Wind Farm*. Ottawa, ON, Canadian Wind Energy Association. Available at www.canwea.ca/images/uploads/File/North_Cape2.pdf

[82] A 1997 Canadian report found that "energy efficiency investments (e.g. building retrofits) create over 35 person years of employment per million dollars invested … three times as many as alternative energy supply (e.g. solar, biomass) and five times as many as conventional energy supply (e.g. oil, gas)." See Campbell, B. and L. Dufay *et. al.* (1997). *Comparative analysis of employment from air emission reduction measures.* Drayton Valley, AB, Pembina Institute for Appropriate Development. Prepared for Environment Canada. Available at http://pubs.pembina.org/reports/CompAnayl_EmplAirEmRed_1997.pdf

[83] The Gold Standard was originally developed by World Wildlife Fund (WWF) International, and is now supported by a broad stakeholder group including businesses, scientists, and environmental organizations from around the world. Gold Standard supporters include Greenpeace International, WWF, David Suzuki Foundation, Pembina Institute, and others. A recent report from Tufts University found "the Gold Standard is the most rigorous standard available to date. Although adhering to the Gold Standard incurs higher transaction costs and can therefore lead to higher prices for consumers, we strongly recommend purchasing offsets that follow these strict guidelines." See Kollmuss, A. and B. Bowell (2007). *Voluntary Offsets For Air-Travel Carbon Emissions: Evaluations and Recommendations of Voluntary Offset Companies*. Medford, MA, Tufts Climate Initiative. p. 15. Available at www.tufts.edu/tie/tci/carbonoffsets/

[84] David Suzuki Foundation (2007). What is a carbon offset? Vancouver, BC, David Suzuki Foundation. Webpage: http://www.davidsuzuki.org/Climate_Change/What_You_Can_Do/carbon_offsets.asp. Last accessed June 23, 2008; The Gold Standard: premium quality carbon credits. Website: http://www.cdmgoldstandard.org. Last accessed June 23, 2008. Until Canada establishes a national registry for offsets and a mechanism for ensuring that emissions reductions generated for the voluntary market are not also counted in Canada's national inventory, double-counting will continue to be an issue for offsets from projects developed in Canada. Projects in Canada can still generate emission reductions, but prospective purchasers should be aware that the reductions will not be truly additional because Canada is already mandated to make those reductions by international law.

[85] Carlson, D. and P. Lingl (2007). *Meeting the challenge: a carbon neutral 2010 Winter Games discussion paper*. Vancouver, BC, The David Suzuki Foundation. Available at http://www.davidsuzuki.org/Publications/Meeting_the_challenge.asp. The David Suzuki Foundation offsets all of its corporate GHG emissions using Gold Standard offsets.

[86] The Gold Standard (2007). Malavalli 4.5 MW low-density biomass residue power plant. Webpage: http://www.cdmgoldstandard.org/dataproject.php?action=show&id=36. Last accessed June 23, 2008.

[87] Det Norske Veritas (2006). *Validation report: 4.5MW biomass (low density crop residues) based power generation unit of Malavalli Power Plant Pvt. Ltd., India*. Hovik, Norway, Det Norske Veritas. Available at http://cdm.unfccc.int/Projects/DB/DNV-CUK1141812568.71

[88] The Gold Standard (2007). Malavalli 4.5 MW low-density biomass residue power plant. Webpage: http://www.cdmgoldstandard.org/dataproject.php?action=show&id=36. Last accessed June 23, 2008.