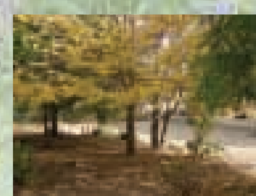
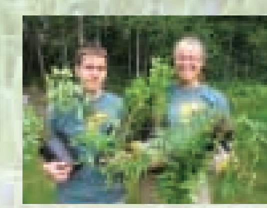
Tree Canada

Forest and Urban Tree Carbon Project Protocol

A Standard for the Eligibility and Measurement of Tree Canada Carbon Offset Projects





TreeCanada

Version 1.1
November 2009

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Prepared In Collaboration with
Dr. Jeremy Williams, Tree Canada Associate,
ArborVitae Environmental Services Ltd.

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Acknowledgements

Protocol 1.0 benefited from review by the following external reviewers:

- Karen Haugen-Kozyra and Tanya Maynes, Climate Change Central, Edmonton, Alta.
- Mark Johnston, Saskatchewan Research Council, Saskatoon, Sask.
- Brian Smart, Smart Forest Biomass Ltd., Halfmoon Bay, B.C.
- Jean-Robert Wells, (Project Lead), Jean-François Boucher, Claude Villeneuve and Simon Gaboury, Université du Québec, Chicoutimi, Que.

Introduction

1 Introduction

Tree Canada is a not-for-profit, charitable organization established in 1992. Under the direction of a volunteer Board of Directors, and with the assistance of numerous regional advisors, provincial and community organizations, Tree Canada provides education, technical assistance, resources and financial support to encourage Canadians to plant and care for trees.

Since 1992, Tree Canada has planted over 76 million trees, greened over 450 schoolyards and helped establish urban forest programs in over 375 communities, making it Canada's largest not-for-profit tree organization. In 2008/9, Tree Canada planted 659,925 trees, in partnership with over 30 of Canada's top companies.

One of the reasons that Tree Canada was founded in 1992 was to plant trees to "…counter the effects of climate change." From there, the organization developed programs and information detailing the relationship between trees and greenhouse gas (GHG) sequestration. Two key Board members, Dr. Nigel Roulet of McGill University and Dr. Bruce Freedman of Dalhousie University, developed *Planting Trees for Carbon Credits* and *The Role of Trees in the Reduction of Atmospheric* CO_2, innovative information pieces. In 2005, Tree Canada launched *Grow Clean Air,* which formalized a program of calculating the theoretical amount of CO_2 sequestered by the "average" Canadian tree. Programs around "carbon neutral event," "company" and "organization" were developed. Today, over 100 meetings, events and conferences have offset their carbon emissions with tree planting with Tree Canada – over 50 companies have sought to do the same. This Protocol builds on this history of carbon-related programming.

Tree Canada plants and maintains trees in both rural and urban sites. It is estimated that about 85% of Tree Canada's trees are planted in rural areas, with the other 15% being planted in urban or peri-urban areas. Agreements are signed with companies who pay Tree Canada to plant and care for a certain quantity of trees in a certain area and in some cases, the funding company retains the right to title of the carbon from the trees. In other cases, Tree Canada retains the rights to the title to the carbon.

Global interest in carbon offset projects is increasing, with the subsequent demand for the validation and verification of trees planted by Tree Canada increasing as well. As part of this trend, individuals, event organizers, organizations and companies increasingly see value in Tree Canada being able to provide greater assurance of the GHG impact of its plantings. Comparisons of offset programs are continually being made by various institutes to assist customers seeking reliable ways to offset GHG emissions. In response to these customer and client demands, Tree Canada has sought to create a carbon standard to increase the rigour of the validation and verification of the carbon offsets created by its plantings.

The projects that Tree Canada undertakes can be grouped into four types:

A. **Afforestation:** Planting trees on land that has been used for a purpose other than forestry – most often old agricultural fields. These projects tend to be classic afforestation projects – planting trees on sites that are presently grassed or are covered in other non-woody vegetation. The ownership of these lands includes private owners and municipalities. In a typical year, Tree Canada expects to plant about 500,000 trees in afforestation projects, representing approximately 88% of its total planting and maintenance effort.

B. **Reforestation:** Tree Canada also plants sites that have recently lost their forest cover as a result of natural disturbance, such as fire, wind, flooding or insect infestation. The sites that are planted are often on municipal lands, but have included private, Crown and First Nation lands. The most challenging aspect of defining these projects from a carbon offset perspective is defining a realistic baseline (i.e. forecast what would have happened on the site in the absence of the project). Reforestation projects typically account for 65,000 trees, or 11% of Tree Canada's annual effort.

C. **Individual Tree Planting in Urban Areas:** Tree Canada also organizes planting projects in parks, along roadsides, in school yards, alongside buildings and other urban areas that are lacking trees. These plantings may not meet the definition of a forest used within an offset system. Rather the aim is to add tree cover to parts of the landscape that are judged to benefit from having additional trees. Frequently these trees are larger in size than typical planting stock (i.e. caliper stock) and expensive to purchase. Approximately 5,000 trees per year (1% of Tree Canada's overall plantings) are planted in projects of this type.

D. **Park Naturalization:** This category is similar to Group C – where an arboreal element is added to an urban landscape. While the plantings are less formal than the Individual Tree projects (Group C), the aim is not to create a closed canopy forest, as in classic plantation style plantings. Instead plantings are arranged to minimize grassy areas with many of the trees being widely spaced and developing a spreading, open-grown form. Tree Canada typically plants 1,000 – 1,400 trees each year in such projects, equivalent to roughly 0.2% of its total activity.

Afforestation and reforestation are recognized in Article 3.3 of the Kyoto Protocol as activities which can generate carbon offset credits, and there are numerous standards in place that can be used to assess the amount of carbon offset credits that can be generated from these types of projects. A tree planting project is considered an afforestation project if there is a land use change, implying that afforestation projects can only take place on lands that are, prior to the project, used for purposes other than supporting a forest. In contrast, reforestation projects involve no change in land use – they involve planting trees on an area that was forested and then lost all or most of its forest cover. Because afforestation and reforestation projects are similar in most respects, they are covered in section 3 of this protocol document.

Individual tree and naturalization projects (Groups C and D above) tend to occur on small areas that individually are too small to be technically considered as forests, as elected by the Canadian government under the Kyoto Protocol. The projects generally take place in urban or other developed areas, and do not have a direct counterpart in the Kyoto Protocol. However, the California Climate Action Registry (CCAR) has developed an urban tree carbon protocol, which was intended to cover projects like the Group C and D projects. These two classes of projects are very similar and a single protocol has been developed for both classes – presented in section 4 of this document.

The two parts of the standard in this document are both structured according the August 2008 draft of Environment Canada's *Guide for Protocol* Developers. This guide, which has not been finalized at the time of writing, is intended to provide direction for organizations that wish to develop a base protocol for Canada's Greenhouse Gas (GHG) Offset System. Canada's Offset System is still in a developmental phase, and it is uncertain what the final requirements will be, however the draft Environment Canada Guide represents the most up-to-date direction at the time this project was undertaken. The part of the standard that applies to afforestation and reforestation projects uses an August 2008 draft of an example afforestation standard prepared by the Canadian Forest Service (CFS). This document is available upon request from the Canadian Forest Service. Elements from the Clean Development Mechanism (CDM) and World Wildlife Fund (WWF) Gold Standard requirement, as well as from the California Climate Action Registry (CCAR) forest carbon project protocol, are also included. The portion of the Tree Canada standard that applies to Group C and D projects (see above) is also based on the format of the draft CFS afforestation protocol, and also derives considerable intellectual content from the CCAR urban tree carbon protocol.

This standard is intended to provide guidance to Tree Canada in planning and developing projects, preparing its contractual arrangements with field contractors and project sponsors, monitoring the projects, and calculating the amount of offset credits that are generated. The protocol will discuss monitoring and, to a lesser extent, verification, and may be used to assist third-party verifiers that may be engaged by Tree Canada to verify the offsets created from its projects.

Base Protocol Identification and Contact Details

2 Base Protocol Identification and Contact Details

2.1 Name of the Protocol

Tree Canada Afforestation, Reforestation and Urban Tree Planting Projects.

2.2 GHGs that will be Reduced/Removed

A project that qualifies under this protocol will create net removals of carbon dioxide from the atmosphere (CO_2 sequestration). Methane and nitrous oxide emissions from Tree Canada projects will generally be *de minimis* and need not be considered in the accounting of GHG emissions in this Protocol. An exception occurs when the project includes fertilization – in this case standard factors are used to account for the emissions caused by the volatization of the fertilizer.[1] The calculations and factors used in this protocol apply to nitrogen-based fertilizer application, which is the most common fertilization approach used in forestry. Fertilizers containing nitrogen lead to increased N_2O emissions. If lime or urea-based fertilizers are used, CO_2 emissions are increased; appropriate factors may be obtained from IPCC documents.[2] Where the pre-project use of the land (i.e. the baseline, in most cases) included fertilization, Tree Canada has the option of accounting for this reduction in emissions or omitting consideration of it – omitting will understate the project benefits.

2.3 Intended Users of the Base Protocol

This Quantification Protocol is written for Tree Canada, which develops afforestation and reforestation projects in rural areas and plants trees in smaller areas within urban areas. This Protocol is intended to provide guidance to Tree Canada staff, Community Advisors and project implementers and verifiers in the design and implementation of Tree Canada's tree planting projects.

As this document is intended to provide a basis for the documentation of Tree Canada's urban tree planting projects, the Offset System Program Authority and third-party certified verifiers will also be using it as the basis for registration and subsequent verification of reductions/removals.

2.4 Lead Protocol Developer

Organization:	**Address:**	
ArborVitae Environmental Services Ltd.	3 Pine Crescent, Toronto, ON M4E 1L1	
Name:	**City:**	
Dr. Jeremy Williams	Toronto	
Title:	**Province:**	**Postal Code:**
President	Ontario	M4E 1L1
E-mail address:	**Website:**	
jeremy.w@sympatico.ca	www.avesltd.ca	
Telephone Number:	**Fax Number:**	
416 694-8123		
Type of Entity		
Consultant		

2.5 Other Protocol Developers

Protocol 1.0 was reviewed by Michael Rosen (President), Jim McCready (Program Forester) and Bruno Chicoine (Project Manager), some members of the Board (Gary Bull, Timo Makinen, William Vander Zalm, and Dorothy Dobbie), and four external reviewer groups:

- Karen Haugen-Kozyra and Tanya Maynes, Climate Change Central, Edmonton, Alta.
- Mark Johnston, Saskatchewan Research Council, Saskatoon, Sask.
- Brian Smart, Smart Forest Biomass Ltd., Halfmoon Bay, B.C. and
- Team led by Jean-Robert Wells, (Project Lead), Research Chair in Éco-Conseil, Université du Québec, Chicoutimi, Que.

[1] Clean Development Mechanism (CDM). 2007. *Estimation of direct nitrous oxide emission from nitrogen fertilization* – Draft methodological tool CDM – A/R WG Fifteenth meeting Report Annex 06.

[2] Intergovernmental Panel on Climate Change (IPCC). 2006. N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application. Chapter 11: of *2006 IPCC Guidelines for National Greenhouse Gas Inventories.* Edited by Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara, and Kiyoto Tanaba.

2.6 Initiating Agency

Organization:	Address:	
Tree Canada	222 Somerset West, Suite 402	
Name:	**City:**	
Michael Rosen	Ottawa	
Title:	**Province:**	**Postal Code:**
President	Ontario	K2P 2G3
E-mail address:	**Website:**	
mrosen@treecanada.ca	www.treecanada.ca	
Telephone Number:	**Fax Number:**	
613-567-5545 (x.222)	613-567-5270	
Rationale/Motive for Initiating Protocol Development:		
Tree Canada was originally launched in part to help address Canada's GHG footprint through the planting and maintenance of trees. Carbon markets and related institutions have now evolved to the point that it makes sense for Tree Canada to develop a program of third party verified carbon credit development from its tree planting activities. There is growing interest from corporate clients, the public and partners for this service. The purpose of this program is to develop a verified standards package for clients, who have increasingly expressed interest in having this service available. The protocol is also intended to assist other parties, such as potential donor companies and project aggregators, as well as third-party verifiers. The protocol will help to ensure that Tree Canada's projects meet the measurement, monitoring and GHG quantification requirements of Canada's developing Offset System.		

2.7 Development Approach

2.7.1 Describe the Approach Taken to Develop the Base Protocol

The development of this quantification protocol was initiated by Tree Canada. A consultant, Jeremy Williams of ArborVitae Environmental Services Ltd., was hired to help develop the protocol. Discussion with Tree Canada staff and Board led to the decision to base the protocol on a draft afforestation protocol prepared by the CFS. The CFS protocol was developed according to Environment Canada's draft *Guide to Quantification Methodologies and Protocols* and the specifications and directives of the International Organization for Standardization (ISO) 14064-2:2006. The protocol also considers the Quantification Protocol for Afforestation Projects (version 1, Sept 2007) prepared for the Alberta government and the on-going development of version 3 of the California Climate Action Registry's Forest Project Protocol (final draft released for public comment on June 22, 2009). This protocol is also informed by the discussions related to the Canada/U.S. harmonized forest carbon standard development.

A timeline of the development of this quantification protocol is outlined in Table 1.

Table 1. Workplan and timeline for the development of the Protocol for Tree Canada Afforestation, Reforestation and Urban Tree Planting Projects.2.7.2 Building on Existing Protocols

Date	Purpose & Objective	Results
February 2009	Tree Canada requested a proposal from Jeremy Williams of ArborVitae Environmental Services Ltd to develop a quantification protocol appropriate for Tree Canada's planting projects.	Dr. Williams prepared a proposal which was accepted by Tree Canada.
March 31, 2009	Jeremy met with Tree Canada staff in Ottawa to review Tree Canada's suite of projects, documentation and intentions.	Discussion aided in development of the draft protocol
April 1 – May 8, 2009	Development of draft protocol by Jeremy Williams.	Draft protocol submitted to Tree Canada for review.
May 9 – June 10, 2009	Tree Canada staff and some Board members reviewed the draft and provided comments	Comments incorporated by Dr. Williams
June 11 – Aug 7, 2009	External Review of the Protocol by four reviewers: Karen Haugen-Kozyra and Tanya Maynes, Climate Change Central, Edmonton, Alta., Brian Smart, Smart Forest Biomass, B.C.; Mark Johnston, Saskatchewan Research Council, Sask., and a team led by Jean-Robert Wells, ing., MGP, Research Chair in Éco-Conseil, Université du Québec, Chicoutimi, Que.	Comments incorporated by Dr. Williams
August 10 – September 2009	Translate, design and print/pdf protocol.	
September 23, 2009	Release of Protocol 1.0.	

2.7.2 Existing Protocols

This protocol is primarily based on the draft afforestation protocol prepared by the CFS, as well as the afforestation protocol developed for Alberta as mentioned above. Some of the content related to reforestation projects was derived from the CCAR forest carbon project and urban forestry standards.

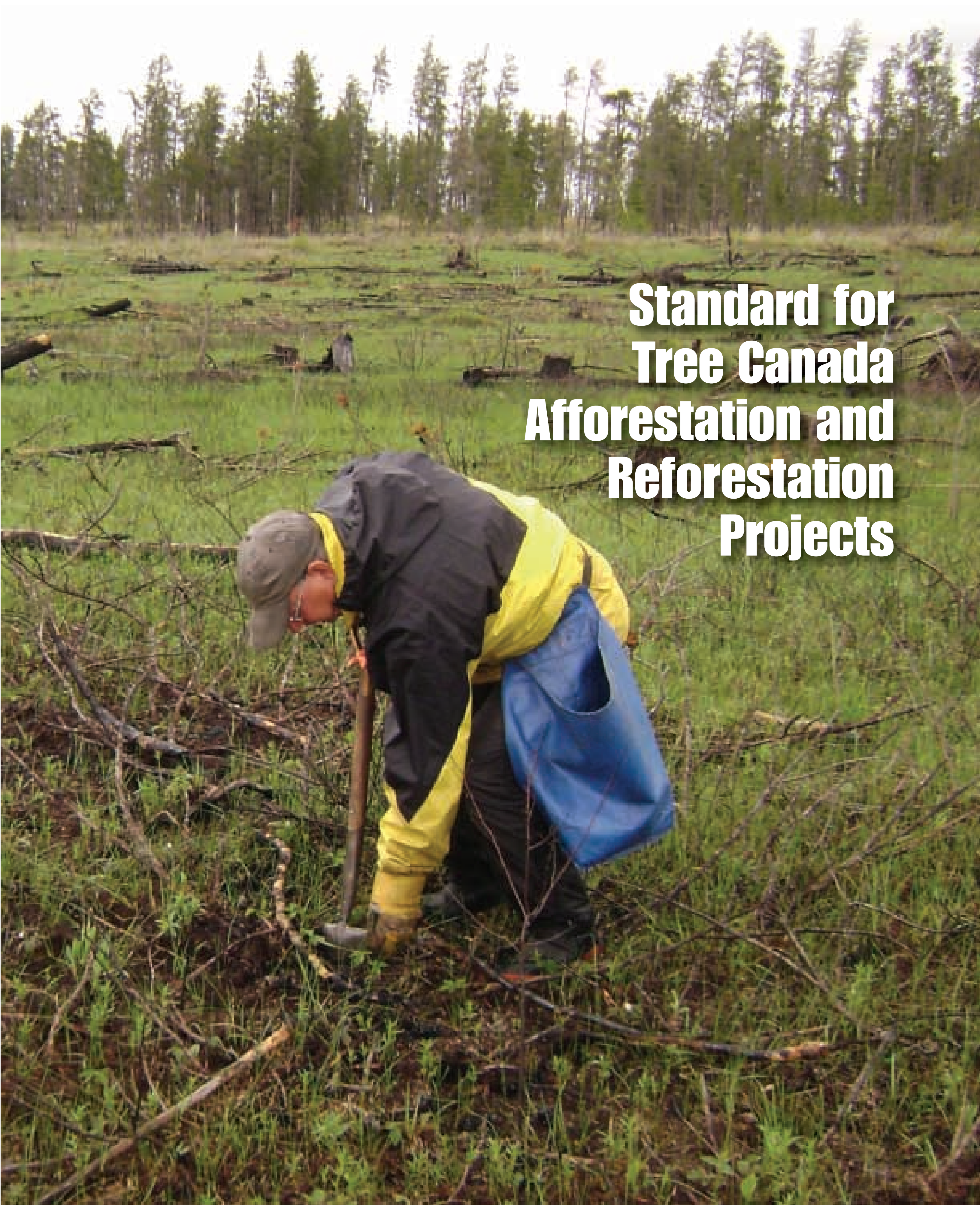
2.7.3 Use of Good Practice Guidance

This Quantification Protocol (QP) was developed in accordance with the Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC GPG LULUCF, 2003). Section 4.3 of the GPG LULUCF lists the guidance available for land use change and forestry projects. The scope of projects eligible under this QP follows GPG LULUCF, as do the methodologies prescribed for project boundaries, measuring and monitoring, data management, and quality assurance/quality control (QA/QC).

2.7.4 Continuous Improvement

This QP was developed to a level of stringency that balanced the availability of data and factors needed to quantify emission reductions /sequestration, the cost of project specific measurements and assessments and the maintenance of credibility and minimization of the risk of overestimating the amount of sequestration or reduction of net emissions. It is recognized as more research is undertaken and as Tree Canada develops a track record, it will be feasible to improve the protocol in a manner that increases the accuracy of the quantification procedures and further reduces the risk of erroneous calculations, especially over-estimates. Some of the external reviewers made a number of comments to the effect that they would like to see additional specific calculations or justifications for assertions. In some cases, the requested modifications were made but in other cases it was felt that the request would have rendered the protocol infeasible.

Tree Canada is working to bring its documentation, practices and procedures into greater conformity with the demands of this protocol and the evolving nature of the offset systems. Tree Canada intends to develop a Practices Guideline for its planting program that would include guidance on verification procedures, when and how credits would be brought to market, and selling prices and conditions of sale.



Standard for Tree Canada Afforestation and Reforestation Projects

3 Standard for Tree Canada Afforestation and Reforestation Projects

3.1 Base Protocol Scope and Development Approach

3.1.1 Scope

a) Description of Base Protocol

This protocol covers two classes of net GHG emission reduction projects that are eligible under Canada's proposed GHG Offset System – afforestation projects ("Group A") and reforestation projects ("Group B"). In addition to requirements specific to each class of project, all eligible projects must meet the following requirements:

I. The project area is greater than or equal to 1 hectare in size, with a minimum width of 20 metres, measured tree-base to tree-base (stump to stump);
II. The trees established under the project are capable of achieving a minimum height of five metres at maturity;
III. The trees will not be managed on a short-rotation (30 years or less) for wood or biomass production or have more than 50% of the volume on site harvested before age 30;
IV. Neither site drainage, prescribed burning nor windrowing are undertaken for site preparation; and
V. The trees established under this project are capable of achieving a minimum crown cover of 25% at maturity.

Project eligibility is not affected by the nature of the ownership of the land – plantings on private land and municipal land, to name just two potential ownership categories, are eligible. In all cases, clear title to the land should be established, as well as clear title to the carbon offsets generated by the project.

Activities eligible for offsets include projects established after January 1, 1992. Projects initiated between 1992 and 2006 are not eligible under the current version of Canada's proposed offset system, however Tree Canada may wish to sell such offsets in the voluntary market or in another market that would accept them. Afforestation and reforestation projects in different years may be aggregated to form individual carbon projects, however it is recommended that there should not be more than five years difference between the projects that are aggregated into a single carbon project. Afforestation and reforestation projects can be aggregated into single pooled projects – this may be desirable to some purchasers of offset credits. It is further recommended that projects initiated before 2006 should not be pooled with projects that started later, in order to avoid ineligibility within the Canadian federal offset system.

Afforestation

An eligible afforestation project must, through human intervention, establish a forest on an area that was not forested as of December 31, 1989, and was not forested prior to project implementation. Implementing an afforestation project converts the project land from its current use (e.g. agriculture) to forest.

The afforestation component of this protocol has been developed for a sub-set of projects that are considered to reflect the most common afforestation project types undertaken by Tree Canada. In practice, much of the land that will be afforested by Tree Canada will be agricultural land (under varying degrees of cultivation), and this protocol will cover most afforestation projects on such lands. In addition to conversion of agricultural land to forest, the scope of this Quantification Protocol (QP) may cover conversion of urban land to plantations or the rehabilitation of degraded industrial lands, such as mine sites. The protocol does not cover planting projects on unforested boreal lands, except where the pre-project land use is agriculture (or the land is abandoned agricultural land). Tree Canada does not plant trees on behalf of sponsors to enable them to meet legal reforestation requirements.

To demonstrate that a project is within the scope of this QP, Tree Canada must provide evidence that there were no trees growing on the project site just prior to project implementation and that the project site was not forested as of December 31, 1989. To qualify as an afforestation project, the project site cannot have been forested for at least 50 years prior to the initiation of the project.

If there are young trees growing on the site, eligible projects can be undertaken on lands where:

- There are fewer than 200 well-distributed young trees per hectare, that are or can be expected to be free-to-grow, or;
- A registered professional forester provides an opinion that the natural renewal will not be sufficient to produce a stand with more than 25% stocking at maturity.

The scope of this QP does not require explicit accounting of GHG emissions from fertilization activities in the baseline scenario (e.g., the fertilization that would be associated with active agricultural cultivation). This exclusion would reduce the estimate of GHG reductions/ removals resulting from the project activities. However, if the Tree Canada project includes fertilization, the emissions from it must be calculated and in that event, Tree Canada may wish to include any fertilization that was practiced in the baseline scenario.

Reforestation

The reforestation component of this protocol has been developed for a sub-set of projects that are considered to reflect the most common reforestation projects undertaken by Tree Canada.

A reforestation project must establish a forest on an area that was forested but, within the past 50 years, the forest cover was removed. There are two classes of eligible reforestation projects, based on the nature of how the forest was removed. The protocol is intended to apply to project areas which were forests that:

- Were cleared intentionally prior to January 1, 1990 but which have not been unforested for a long enough time period to qualify as afforestation projects; or
- Since January 1, 1990 have lost 75% or more of their crown cover due to wildfire, windstorm, insect infestation, or other disturbance that is not the result of intentional management activity or gross negligence on the part of the landowner/ manager.

The presumption is that these areas would not develop into a young forest over the next ten years or more.[3]

Eligible projects can be undertaken on lands where:

- By the end of the fifth year (or later) after the disturbance, there are less than 200 well-distributed young trees per hectare, that are or can be expected to be free-to-grow, or
- By the end of year three after the disturbance, a Registered Professional forester provides an opinion that the natural regeneration will not be sufficient to produce a stand with more than 25% tree crown cover at maturity; and, in all cases
- There must be no legal requirement to reforest the site.

b) Real Reductions

An afforestation project will achieve GHG reductions/removals through the increase in carbon stocks on the project site as a result of the growth of trees, and a reforestation project will achieve GHG reductions/removals by initiating or accelerating regeneration of the forest. Initial carbon stocks vary, but in all cases the project will increase future carbon stocks, both above and below ground. Emissions from the project may occur during plantation establishment due to site preparation, as well as the transport of workers and stock. Other emissions following establishment will occur as a result of the maintenance required by the plantation design. These emissions are expected to be small compared to the carbon sequestered by the project and they may be less than the emissions associated with the pre-project land use.

Users of this QP will demonstrate that the GHG reductions/removals have not been considered in any other Offset System projects through the provision of detailed information on the geographical boundaries of the project activities.

c) Flexibility

This protocol is intended to apply to afforestation projects where there is no existing, pre-project tree cover on site prior to site preparation or planting. While Tree Canada should carry out a field survey of the project site if the eligibility is not obvious, information should be included with the Project Document to support the claim. Such information could include photographs of the project site or records of land management practices (e.g. tilling). This protocol is not appropriate for projects on sites with significant existing tree cover or those sites that have sufficient young trees present that they will develop into forest if left on their own. This strict application of the definition of afforestation permits considerable simplification of the baseline quantification.

There is more likely to be some live tree cover on some of the sites where reforestation projects are undertaken. The live tree cover could include trees surviving from the pre-disturbance condition, post-disturbance renewal, or a combination of both. The guidance given above regarding eligibility is based on the definitions of forest selected by Canada under the Kyoto Protocol,[4] which include the specification that a forest has a minimum of 25% tree crown cover. Sites that have or are expected to naturally attain a tree crown cover factor of 25% or more are not eligible, and this is the basis for the limits provided above.

On sites where there is a small amount of existing woody vegetation, Tree Canada must be able to verify the amount, condition and development path of the existing trees. If the existing trees are retained, then there will be no emission impact associated with the existing forest. If the project replaces the existing forest, Tree Canada must account for the emissions and any foregone future carbon sequestration associated with the existing vegetation.

3.1.2 Permanence

Biological sinks projects, such as afforestation and reforestation, remove CO_2 from the atmosphere but if the plantation is harvested or depleted in some other way, some of the carbon will re-enter the atmosphere. To prevent this, all offset systems mandate that biological sink projects have some degree of permanence.

The Canadian government has recently proposed that forestry sink projects cannot yield offset for longer than 40 years, according to the current draft set of system design documents for a national carbon accounting and offset system (June 2009). However, there is a 25-year liability period after the last credits have been issued.

[3] The choice of a ten-year period is somewhat subjective – this is a reasonable timeframe for renewal to take place and if it doesn't there would be a high probability that the site will not regenerate to forest within the next 40 – 50 years.

[4] Canada's Initial Report Under the Kyoto Protocol, Government of Canada. 2006.

On the other hand, the Intergovernmental Panel on Climate Change (IPCC) has recommended that permanence be considered in terms of 100 years. The final draft of version 3.0 of the CCAR Forest Project Protocol[5] also envisages forest management projects that sequester carbon for at least 100 years. That protocol requires an adequate buffer pool or insurance contract to be held to provide assurance that the offsets will be sequestered for an appropriate length of time, which is an approach that is provided within this protocol. In addition, under the CCAR protocol, monitoring is required for 100 years after the last Offset Tonne is issued from a project. However, there are very few forest projects registered under the CCAR protocol, and the permanence requirements are perceived as an obstacle to participation.

Further, the initial forest carbon CDM projects were a maximum of 60 years in duration, with two types of contract options, either Temporary Certified Emissions Reduction (tCERs) or Long Term Emissions Reduction (ICERs). Some projects in China have lengths of 30 years while 21-year long projects have been established in countries such as Mozambique in the voluntary carbon markets.

In summary, the project lengths vary widely and justifiably so. It can depend on tree species, how a tree is used for a forest product, other land use considerations (e.g. agro-forestry), the interests of the buyers and the dynamics of biological systems, etc. This does not mean that planted trees do not play an important role in the carbon cycle, rather they are essential and all current forest carbon standards or in development continue to wrestle with the concept of permanence. Further, these examples suggest that approaches to provide permanence will continue to evolve, since there is no scientific basis for any particular time period. Therefore it would be imprudent for this standard to be overly prescriptive, given the dynamic environment, where buyers, sellers and intermediaries and other stakeholders are essentially learning by doing.

It is also helpful at this point to recognize that there are two dimensions of permanence – assurance that the land will remain forested or treed and assurance against reversals. It is useful to distinguish the two components because they can be addressed separately.

Many of Tree Canada's projects will retain tree cover for a long time period because they are frequently undertaken on land owned by a municipal government. The project land is usually zoned as park, conservation reserve, or other classification that makes it very difficult to convert or develop the land to a use incompatible with retention of the plantation. For projects on private land, any one of the following conditions, if met, will provide for an appropriate expectation of the first aspect of permanence:

- The project land is subject to an easement or covenant that requires the land to be retained in a forested condition, or otherwise prevents the land being converted to a different use within the next century; or
- The land owner signs a legally binding agreement that is attached to the land title that prohibits the conversion of the land to a non-forest use, either permanently or for a significant specified period of time.

Where private land projects do not have any of the "permanence" conditions just described, the viability of the project may ultimately be little affected. This is because the need for permanence is diminished as the carbon world moves from a voluntary approach to a regulated cap-and-trade approach. The caps, which will be gradually lowered over time, create a significant demand for offset credits. If a plantation is removed after 20 years for development, then the developer is charged with the associated emissions and is responsible for undertaking appropriate offsetting measures. While there are many reasons to encourage the retention of forestry projects, the need for permanence is no longer a critical factor because the national accounts and the regulatory system will ensure that any emissions associated with the early removal of a plantation are quantified and must be accounted for.

When Tree Canada enters into negotiations to develop a contract to sell offsets, Tree Canada will have the greatest likelihood of successfully concluding a contract if it has the flexibility to address permanence directly in the offset contract. In other words, this protocol will not specify required permanence conditions but will recognize that the negotiations between buyer and seller will address permanence on a case-by-case basis.

The second aspect of permanence is related to the need to prevent unexpected shortfalls in the amount of credits that are generated. In order to provide assurance that plantations grow as expected (slower than expected growth would lead to a shortfall in the anticipated number of credits) and the offsets generated by Tree Canada projects will not be lost due to non-catastrophic reversals, it is recommended that Tree Canada establish a buffer. This could take the form of one of the following three approaches:

[5] Released for public comment June 22, 2009.

- Tree Canada will create a reserve of plantings for which offset credits are not sold – this reserve will backstop the issued credits. At this point in time, it seems prudent that the reserve should cover at least 25%[6] of the credits that are issued by Tree Canada; or
- Tree Canada will only issue credits for the above-ground biomass portion of any plantation, reserving the below-ground carbon as assurance against reversals. The underground biomass is typically approximately 25-30% of total project carbon; or
- Tree Canada may enter into a contractual agreement that will provide for a replacement of offset credits that might either be reversed due to a disturbance such as fire or harvesting (e.g. an insurance contract or purchase options to buy carbon credits), or which may not accrue as anticipated, due to factors such as a lower than anticipated rate of plantation growth.

Because there are a number of potential methodologies and programs that may develop to provide a backstop against losses or shortfalls in offsets, this protocol is not strictly prescriptive in this regard. For example, if a large scale (e.g. federal government-backed) insurance program is developed in future, participation in that program might also provide sufficient insurance against reversals or lower than expected growth rates. The intent of this protocol is to provide Tree Canada with wide latitude to use an approach, or a combination of approaches, that is most appropriate. Ultimately, project verification and validation will provide third-party opinions as to whether Tree Canada has used an appropriate approach.

The choice of 25% as a reserve size is based on a subjective assessment that a combination of failure to establish (i.e. mortality in the first few years after planting) and reversal due to clearing, fire, pests or other disturbance is unlikely to exceed 25% of the amount of credits issued by Tree Canada. This level seems prudent however it is anticipated that its appropriateness will be reviewed once Tree Canada's monitoring has been in place for some time.

3.2 Identification of Project SSRs, Baseline Scenario and Baseline SSRs

By planting trees on agricultural, degraded or rehabilitated land, carbon stocks on the project site will increase over time. Initial carbon stocks will vary, but in all cases will be lower than expected future carbon stocks, both above- and below-ground. Of primary interest is above-ground and below-ground carbon stocks associated with the planted trees. Soil carbon stocks may decrease in some situations under some project types (this will be uncommon), however the absolute decline will almost certainly be lower than the amount of carbon sequestered by the planted trees.

Some emissions are expected from the project during plantation establishment due to site preparation and transport of material and workers to the site. Other emissions following establishment may occur as a result of the maintenance required by the plantation design. In most Tree Canada projects, these emissions will be negligible compared to the carbon sequestered by the project. Where the land was actively managed prior to the project, the activities associated with the baseline may produce higher emissions than the activities associated with implementing the project. In such cases, omitting the calculation of these emissions will increase the conservatism of the calculation of offset credits (OCs) from the project. The potential for leakage is considered to be very low, as discussed in section 3.2.9b.

Future disturbance events (such as harvesting, fire, or insects) in the plantations may cause emissions and potential reversal of credited removals. Tree Canada has a number of options to minimize the cost of reversals, ranging from insurance with a third party to self insurance through a conservative approach to estimating offset credit amounts. In the event of a reversal of issued OCs, Tree Canada will be required to replace the reversed OCs with eligible and valid units, unless otherwise stipulated in the offset provision contract.

3.2.1 Identification of Project Sinks, Sources and Reservoirs (SSRs) for Quantification

Carbon is stored in the following four reservoirs, or pools, all of which may be affected by afforestation /reforestation project activities[7] and will be accounted for in eligible projects:

3.2.2 Above-ground live biomass

Above-ground biomass includes all live vegetative biomass above the soil including stem, stump, branches, bark, seeds and foliage. The biomass contained in the trees is the primary source of offsets and will be quantified by the project proponent. In the projects considered under this protocol, the forest understory will be a relatively small component of the above-ground biomass carbon pool and will be at least partially balanced by the vegetation present on the site prior to the project. Hence, the understory vegetation can be ignored in the calculation of carbon storage. However, in the event that the project site contains a significant amount of understory vegetation and/or live trees, whether they be mature or immature, the presence of the understory and/or trees will need to be accounted for in the calculation of project offset credits (See section 3.3.2).

3.2.3 Below-ground biomass

biomass refers to the biomass in the live tree roots. Fine roots of less than 2 mm diameter are often excluded because it is difficult to distinguish them empirically from soil organic matter or litter. There is considerable variety in the procedures used to measure below-ground biomass. A root:shoot ratio, based on values used in Canada's National GHG Inventory system or obtained from other reputable sources, is used in this QP to avoid the need for costly and destructive sampling within the projects.

[6] The 25% was determined on the basis that it is judged to be sufficient to cover most reversals or shortfalls in anticipated offset production. It is noted that risk assessment in Appendix D of version 3 of the California protocol results in a requirement to "hold back" 20% of the available credits, using a 5% risk of wildfire. This is in line with the 25% requirement in this protocol.

[7] Reference: Draft 2006 IPCC Guidelines

3.2.4 Litter (or Dead Organic Matter) and Dead Wood

Litter includes all non-living biomass lying dead, in various states of decomposition above the mineral or organic soil. This includes the litter layer as usually defined in soil taxonomies. The dead wood component includes standing and fallen woody debris that is large enough and discrete enough to be distinguished from the litter layer. On the afforestation sites that will be eligible under this standard, existing litter and dead wood will be minimal, and there will be little dead wood produced in the plantation for many years. The litter layer that develops under the plantation will partially offset the biomass in the litter layer present on the site prior to the project.

In the case of reforestation projects, there may be considerable dead woody material left after the passage of the disturbance. However, since these post-disturbance conditions are not caused by the project, the emissions associated with the decay of the coarse woody debris will not be attributed to the project. If the pre-project disturbance was a severe fire, there may be little or no litter layer left, but since one would develop again whether or not the project was undertaken, there is little value in attempting to claim credits for it.

Overall, the net impact of changes in the litter layer and dead wood due to the project will always be minimal in eligible projects and these pools do not need to be explicitly tracked in the assessment of project impact.

3.2.5 Soil Organic Carbon

Soil organic carbon includes organic carbon in mineral soils and live fine roots that cannot be empirically distinguished from the soil.

If and when the trees planted in the project are harvested and removed from the site, all of the carbon stored in them is assumed to be emitted at the time of harvest.[8] The amount of carbon removed from the project site (and therefore emitted) will be determined through regular monitoring and reporting procedures.

Table 2 lists all of the sinks, sources and reservoirs (SSR) that are potentially controlled by, related to or affected by an afforestation/reforestation project. Each is identified with a "P" for a project-related sink, followed by a number, and in some cases by a letter where there are multiple similar SSR. The standard will identify that many of these SSR are not relevant or are *de minimis* for Tree Canada projects. An SSR that is *de minimis* fails to meet a threshold amount of 10 T or 0.1% of an afforestation project's largest GHG removal, whichever is larger (or 100T/1% in the aggregate). A *de minimis* SSR need not be quantified on the grounds omitting it will not influence the number of offsets calculated for a project.
The criterion for identifying which SSRs are directly controlled by Tree Canada is that the SSRs are under the direction and influence of Tree Canada and are either located in the project area or are due to operations undertaken by Tree Canada to implement the project. In the case of afforestation and reforestation projects these will be: the planted seedlings or trees (above-ground and below-ground biomass) and the fossil fuel emissions from machinery used in establishment and maintenance.

SSRs that are related to the project activities have material or energy flows into, out of, or within the project. A related GHG source, sink or reservoir is generally upstream or downstream from the project, and can be either on or off the project site. SSRs related to an afforestation or reforestation project include harvested wood products (HWP), the CO_2 and other GHG emissions from the use of fertilizers and fossil fuel to establish and maintain the plantation and the combustion of fossil fuel for seedling production in nurseries. If present, leakage is also a related SSR.

Affected SSRs are those that are influenced by the project activity through changes in market demand or supply for products or services associated with the project. For example, an increase in wood supply and production due to a project may apply downward pressure on timber prices and reduce local harvest levels, or lead to a change in land use (i.e. deforestation) where permitted. Impacts on related and affected SSRs that occur off-site are included in this QP, in aggregate, in the "system-wide adjustment factor", which has been calculated as zero.[9] It is acknowledged that the system-wide adjustment factor was calculated by a third-party (the CFS) and it may be subject to revision in future. Those SSR which are included in the system-wide adjustment factor are italicized.

[8] In accordance with current accounting rules for the Offset System

[9] See Annex C of the August 2008 draft CFS Afforestation Protocol. While project proponents will be required to directly account for the most significant components of a project's GHG impact, certain related and affected SSRs are most appropriately accounted for at the offset system level. The system-wide adjustment factor would be used to deduct the net emissions from activity shifting processes and market effects from the value of a project as calculated by the proponent.

Table 2. Identification of SSR controlled by (C), related to (R), or affected by (A) an afforestation/ reforestation project.

SSR	Description	Controlled, Related or Affected SSR
Upstream SSR		
P1a. Fossil fuel combustion – seedling production	Fossil fuel used (for heat or electricity production) in seedling production	R: Project leads to higher seedling production.
P2. Emissions from fertilizer use – seedling production	Non-CO_2 GHG emissions (CO_2 and N_2O) from fertilizer used in seedling production	R: Project leads to higher seedling production.
P3. Fertilizer production	Emissions generated in the production of fertilizer used on project site.	A: Fertilizer use will in theory contribute to upward price/production of fertilizer at the margin; practical impacts will be negligible.
P1b. Fossil fuel combustion – stock & labour transport	Fossil fuel used in transport of planting stock, labour and equipment to project site	R: Transportation requirements associated with project lead to higher CO_2 emissions.
Onsite SSR		
P4. Above-ground C reservoir	Biomass in live trees, branches, foliage	C: Above-ground biomass of planted trees increases over time with growth.
P5. Below-ground C reservoir	Live root biomass	C: Below-ground biomass of planted trees increases over time with growth.
P6. Dead wood & litter C reservoir	Biomass in dead wood and litter	C: Biomass in dead wood and forest litter increases over time as plantation develops.
P7. Soil organic C reservoir	Organic C content of soil	C: Organic C in soil may increase or decrease over time as plantation develops, depending on factors such as past use, soil properties and climate regime.
P1c. Fossil fuel combustion – plantation operations	In vehicles used for site preparation, plantation maintenance, monitoring and harvesting activities.	C: Transportation requirements associated with implementing project, including establishment and tending, may lead to higher CO_2 emissions unless the site was actively managed in its previous use.
P8. GHG emissions – fertilizer	CO_2 and N_2O emissions resulting from application of fertilizer	C: If fertilizer is applied to the site, there will be GHG emissions.
Downstream SSR		
P1c. Fossil fuel combustion – transport of harvested biomass	Transport of harvested biomass to processing facility	R: Transportation of harvested biomass to mill or other facility will lead to higher CO_2 emissions, although there could be a substitution effect here.
P9. Processing facility	Process emissions at wood product or biomass energy facility	R: Processing of harvested biomass at mill or other facility will lead to higher CO_2 emissions, although there could be a substitution effect here.
P10: Harvested wood products	Wood remains for some time in products pool and may be land filled	R: HWP act as reservoir during their lifetime and after land filled, depending on their fate.
P11. Baseline activity shifting (leakage)	Emissions associated with relocation of baseline activity to a new site	R: Activities associated with any shift in the location of the baseline activity may lead to higher CO_2 emissions.
P12. Forest management (FM) activities	Market-related changes in FM activities	A: The project may substitute for, reduce or increase regional level of FM activities.
P13. Afforestation/ reforestation (A/R)	Market-related changes in A/R rates	A: The project may substitute for, reduce or increase regional level of afforestation or reforestation.
P14. Deforestation	Market-related changes in deforestation rates	A: The project may substitute for, reduce or increase regional level of deforestation.
P15. Regional harvest rates	Market impact of increased supply of wood from project	A: The project may influence regional harvesting levels.

3.2.6 Identification of Baseline Scenario – Afforestation

a) Identify the Baseline Scenario(s) to be applied in this Base Protocol and justify why it is appropriate. For each remaining baseline scenario, provide justification as to why is not appropriate for this protocol.

The baseline scenario for an afforestation project under this Offset System Quantification Protocol (OSQP) is as follows:

In the absence of the afforestation project, the current land use will continue and within the project site there will be no change in the current level of the carbon reservoirs and no increase or decrease in sources or sinks. The project site has been non-forest since 1990 and is not expected to naturally convert to forest. There are no plans, directives, regulations or programs that require the site to be afforested.

The scope of this QP, as described in Section 3.1.1, effectively limits the range of potential baseline scenarios. Given the length of time that the land has been non-forested and under another land use, such as agriculture, it is reasonable to assume that the land would not become forested without the project. Therefore, the reasonable baseline scenarios range from no management activity to agricultural activity ranging from grazing to intensive cultivation. These guidelines are consistent with Section 4.3.3.1: Baseline, in the Intergovernmental Panel on Climate Change Good Practice Guidance for Land Use, Land Use Change and Forestry (IPCC GPG LULUCF, 2003). The 'simple' baseline scenario that applies to the scope of the QP is that there will be no change in the current fertilization regime, if any, or in the current size of the carbon reservoirs.

Five other potential baseline afforestation scenarios are outlined below in Table 3 (next page); of these, only the Comparison-based and Projection-based Scenarios are accepted – the others all have significant shortcomings that preclude their use for projects considered under this QP.

Comparison-based approach

This baseline type would be applicable to projects where a representative control site can be established at the same time as the project. Alternatively, the activities and changes in carbon pools that would occur without the project can be demonstrated through similar sites. For example, if Tree Canada afforests a portion of an agricultural area, the remaining area may be used to represent the baseline and monitored accordingly. Alternatively, Tree Canada may use neighbouring farmland for the same purpose if conditions are comparable.

Table 3. Possible Afforestation Baseline Scenarios for Estimating GHG Emissions/Removals

Baseline Option	
Historic Benchmark	
• Description	National or regional trend in reductions/removals on applicable land since 1990.
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to lack of sufficient data and high variability within Canada and across regions.
Performance Standard	
• Description	Typical emissions/removals profile for agriculture land management (within scope of this QP).
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to lack of sufficient data and high variability pre-project land uses.
Comparison-based	
• Description	Establishment and monitoring of control group.
• Static or Dynamic	Dynamic
• Accept or Reject and Justify*	Accept if strong evidence can be provided regarding the validity of the control group. Discussed below.
Projection-based	
• Description	Projection of expected land management activities and related changes in C reservoirs.
• Static or Dynamic	Static
• Accept or Reject and Justify*	Accept due to the limited range of likely activities and biomass growth on applicable land types. Allows use of existing ecosystem C modelling results. Discussed further below.
Direct Measurement	
• Description	Measurement of all emissions and sequestration associated with all direct project activities; emissions associated with indirect effects could be estimated.
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to high costs of measurement and high degree of technical difficulty.

** As this protocol is designed to cover the majority of potential afforestation project circumstances, it is possible that individual projects may be able to apply other baseline scenario options.*

This approach is readily verifiable and adds considerable transparency and consistency to the basic scenario approach, although monitoring and verification costs will likely be higher. The main drawback is that there may not be comparable sites where a strong argument can be made that the site would have followed the same development pathway.

Projection-based scenario

This baseline type would be applicable to afforestation projects where the land is currently in a steady-state of activity and/or the rate of change in carbon pools is stable. Such conditions may be found on agricultural land that has not been intensively managed for a significant length of time (e.g. 20 years or longer), or where the land management practice has been unchanged for an equally significant length of time.

In general, given the economic conditions of the agriculture and forest sectors (including land value, commodity markets and tax structures) it is reasonable to assume that the pre-project activities will continue for at least the length of the project's registration period.

Justification for Baseline Scenario Selection

The projection-based baseline scenario is suitable to apply within the scope of this Quantification Protocol. In most cases, the baseline scenario will be that the land will remain in its current use, however Tree Canada may also use the comparison approach and establish and monitor control plots to improve confidence and accuracy in the project baseline. If the latter approach is being used, the location of the control plots must be recorded and justified (i.e. demonstrate that the control plots are representative of the conditions in the project site baseline scenario). The use of control plots is not discussed further in this QP but may be incorporated into this QP as a field measurement technique where appropriate (e.g. for soil organic carbon) and with acceptable justification. Measurement and monitoring procedures for control sites should be the same as those used in the project site.

b) Explain whether the accepted baseline scenario is static or dynamic

The projection-based baseline scenario for this protocol is static. The emissions profile for the baseline activities is not expected to change during the registration period or for a significant amount of time thereafter.

3.2.7 Identification of Baseline Scenario – Reforestation

a) Identify the Baseline Scenario(s) to be applied in this Base Protocol and justify why it is appropriate. For each remaining baseline scenario, provide justification as to why it is not appropriate for this protocol.

The baseline scenario for a reforestation project under this OSQP is as follows:

In the absence of the project, a natural forest will not develop within 10 years. There will either be no change or a small, gradual increase in the current level of the living biomass reservoirs (i.e. there may be some live trees on site) and either no increase or a small, gradual increase in sinks. There are no plans, government regulations or programs that require the site to be re-forested.

In the case of reforestation projects on land that is being managed for a purpose other than forestry, or which is being rehabilitated, there are unlikely to be any existing trees and the project is essentially the same as an afforestation project except that the land has not been without forest for long enough to meet the requirements of an afforestation project. In some cases, and also in the case of lands which have been disturbed, there are likely to be some live trees on site at the beginning of the project, or some potential for some natural renewal, but there is not enough renewal to produce a forest (or potential forest) within 10 years. However, these trees must be accounted for so they do not contribute to the assessed project benefits.

Tree Canada must demonstrate that under baseline circumstances, the reforestation project area would remain out of forest cover for at least the next 10 years. The qualitative characterization of the baseline must provide an assessment of the vegetation that would likely develop in the absence of the project, taking into consideration any mandatory statutes or regulations that would encourage or require reforestation at the project site. The 'simple' baseline scenario that applies to the scope of the QP is that there will be no change in the current size of the carbon reservoirs.

Three other potential baseline reforestation scenarios are outlined below in Table 4; of these, the Comparison-based and Projection-based Scenarios are accepted. These were both discussed in more detail as part of the afforestation baseline discussion above. The Direct Measurement approach is not suitable for the class of projects considered under this QP.

Justification for Baseline Scenario Selection

The projection-based or comparison-based baseline scenarios are also suitable to apply to reforestation projects that fall within the scope of this Quantification Protocol. In most cases, the baseline scenario will be that the land will remain unforested, and in its current use. Tree Canada may choose to establish and monitor control plots as a baseline or to improve confidence and accuracy in the project baseline. If the latter approach is being used, the location of the control plots must be recorded and justified (i.e. demonstrate that the control plots are representative of the project site baseline conditions). Measurement and monitoring procedures for control sites should be the same as those used in the project site.

b) Explain whether the accepted baseline scenario is static or dynamic

The projection-based baseline scenario for this protocol is static. The emissions profile for the baseline activities does not change during the registration period. Given the scope of this protocol, the soil carbon pool is the only baseline SSR that is expected to change over time. However, the degree of change will be insignificant and the direction of change may alternate between sink and source over time.

Table 4. Possible Reforestation Baseline Scenarios for Estimating GHG Emissions/Removals.

Baseline Option	
Comparison-based	
• Description	Establishment and monitoring of control group
• Static or Dynamic	Dynamic
• Accept or Reject and Justify*	Accept in the case of reforestation of post-disturbance sites.
Projection-based	
• Description	Projection of expected land management activities and related changes in C reservoirs
• Static or Dynamic	Static
• Accept or Reject and Justify*	Accept due to the limited range of likely activities and biomass growth on applicable land types. Allows use of existing ecosystem C modelling results.
Direct Measurement	
• Description	Measurement of all emissions and sequestration associated with all direct project activities; emissions associated with indirect effects could be estimated
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to high costs of measurement and high degree of technical difficulty.

** As this protocol is designed to cover the majority of potential reforestation project circumstances, it is possible that individual projects may be able to apply other baseline scenario options.*

In contrast, the comparison-based baseline scenario is dynamic, since the comparison is against a reference site on which processes will continue to operate through time. However, it is expected that the rate of change in the SSR will be negligible, since the land use of the reference site is not expected to change over time.

3.2.8 Identification of the Baseline SSRs for Quantification

a) List, number and describe all potential SSRs that occur in the baseline scenario of this project-type.

The process used to identify and select the baseline SSR is described in Table 5.

It is adapted from good practices guidance for estimating GHG emissions/removals in the agriculture and forestry sectors (IPCC GPG LULUCF (2003); Sections 4.2.3, 4.2.5, and 4.3.3). Where specific good practices guidance was not available, a process-flow approach was used.

The same baseline SSRs are potentially relevant to a reforestation project or an afforestation project, and hence, Table 5 applies to both types of project.

3.2.9 Comparison of Project and Baseline SSRs

a) Explain how the project and the baseline are comparable in terms of products and/or activity level. Justify any lack of equivalency.

b) Include/exclude any Project and Baseline SSRs

This section combines the analysis of inclusion and exclusion of project SSRs and baseline scenario SSRs. Table 6 allows for a ready comparison of the SSRs in both the project and the baseline scenario, and it can be seen that there is a high degree of overlap. Only B10 has no direct counterpart in the Project SSRs, whereas P2 and P10 – P15 have no direct counterparts in the baseline scenario.

Table 5. Identification of SSR controlled by, related to, and affected by the afforestation or reforestation baseline.

SSR	Description	Controlled, Related or Affected SSR
Upstream SSR during Baseline Operation		
B1a. Fossil fuel combustion and energy use – agriculture	Production of electricity and fossil fuel used in agricultural production that might be conducted on the site	R: Emissions from fuel and power production, etc that is required to undertake agricultural activities.
B2. Fertilizer production	Emissions generated in the production of fertilizer used on project site	R: Upstream emissions from fertilizer production (if used in the baseline activity).
Onsite SSR during Baseline Operation		
B3. Above-ground C reservoir	Biomass in crops or in on-site trees	C: Crops, pasturage or other non-tree vegetation is managed under the baseline scenario.
B4. Below-ground C reservoir	Root biomass	C: The below-ground counterpart to above-ground C.
B5. Dead wood & Litter C reservoir	Biomass in dead wood and litter	C: To the extent that the baseline activity generates litter and dead wood, the management regime impacts production levels.
B6. Soil Organic C reservoir	Organic C content of soil	C: Organic C in soil is influenced by baseline activity, depending on factors such as past use, soil properties, & climate regime.
B1b. Fossil fuel combustion – on-site operations	In vehicles used in management of land	C: Cultivation associated with baseline activity creates CO_2 emissions.
B7. GHG emissions – prescribed burning	Burning of crop residues	C: Burning of crop residues will create non-CO_2 GHG emissions.
B8. GHG emissions – fertilizer	N_2O and CO_2 emissions resulting from application of fertilizer	C: If fertilizer is applied to the site there will be non-CO_2 GHG emissions.
Downstream SSR during Baseline Operation		
B1c. Fossil fuel combustion -transportation	Transport of harvested crops	R: Transportation of harvested crops associated with baseline activity creates CO_2 emissions.
B9. Crop/food processing facility	Emissions related to energy used in processing of crops/foods	R: Processing of harvested crops/livestock will create CO_2 emissions, although there could be a substitution effect here.
B10. Market impacts	Emissions/removals in economic sectors linked through markets to the baseline activities	A: The project may influence regional crop selection, shift cropping or grazing locations to better or poorer lands or impact livestock herd size.

The following paragraphs provide an overview of each of the main SSRs, with the detailed listing in Table 6.

Soil Organic Carbon

Project impacts will usually be relatively low and positive (i.e. a gradual increase in soil carbon storage over time) and so, given the expense associated with assessing soil carbon content, Tree Canada may ignore soil carbon changes in all cases. Tree Canada may undertake to measure soil carbon to improve the accuracy of the estimate of GHG reductions and removals, however there is no requirement to measure soil carbon.

Where a plantation is established on a rich site and will be managed under a short-rotation, there will likely be a loss of soil carbon (Seely *et al.,* 2002; Zhang *et al.,* 2004). However, Tree Canada does not undertake projects of this nature – its plantations are intended to persist for a minimum of 30 years and more frequently, for the lifetime of the trees (usually 80 – 100 years or more).

In the absence of practices such as conservation tillage, agricultural lands, particularly those that are candidates for conversion to forests, generally do not accumulate significant amounts of carbon. Therefore, in the absence of information to the contrary, the baseline assumption

Table 6. Comparison of Afforestation or Reforestation Project and Baseline Scenario SSRs.

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Assessment of Comparability
Upstream SSR during Operation			
P1a. Fossil fuel combustion – seedling production	N/A	R	Fuel used for seedling production for typical project will be negligible.
B1a, P1b. Fossil fuel combustion	R	R	Effectively equivalent. Fossil fuel used in agriculture of same type as used to transport material to site.
P2. Emissions from fertilizer use – seedling production	N/A	R	Fertilizer used for seedling production for typical project will be negligible.
P3, B2. Fertilizer production	A	A	Equivalent. Some fertilizer used may be present in baseline and it may also be used in project, although it may be absent if the baseline is pasture and it is not used to help the young plantation.
Onsite SSR during Operation			
P4, B3. Above-ground C reservoir	C	C	Functionally equivalent. Trees will not be harvested for some time hence no impact of forest product manufacturing; reduction in agricultural output can be compensated by greater cultivation intensity.
P5, B4. Below-ground C reservoir	C	C	See above.
P6, B5. Dead wood & Litter C reservoir	C	C	See above.
P7, B6. Soil Organic C reservoir	C	C	See above.
P1c, B1b. Fossil fuel combustion – plantation/on-site operations	C	C	Equivalent. Number of trips by vehicle per year for management likely comparable.
B7. Non-CO_2 GHG emissions – prescribed burning	C	C	Prescribed fire may be used to burn agricultural residues and will release minor levels of CO_2.
P8, B8. Non-CO_2 GHG emissions – fertilizer	C	C	Equivalent. Project and baseline may each have moderate to zero levels of fertilizer use.
Downstream SSR during Operation			
P1d, B1c. Fossil fuel combustion – transportation	R	R	Equivalent. Impact on fuel consumption resulting from project will be negligible.
P9, B9. Crop/food processing facility	R	R	Marginal agricultural product of project area and marginal woody biomass from project will be negligible within regional context.
P10: Harvested wood products	R	N/A	Effectively equivalent – few of Tree Canada's plantations are likely to be harvested and processed into wood products for many years.
B10. Market impacts – agri-foods	A	N/A	Marginal agricultural product of project area will be negligible within regional context.
P11. Baseline activity shifting	N/A	R	Include in system-wide adjustment factor and Tree Canada may further justify exclusion using land use trends in the Statistics Canada census.
P12. Forest management (FM) activities	N/A	A	Include in system-wide adjustment factor
P13. Afforestation/ reforestation (A/R)	N/A	A	Include in system-wide adjustment factor
P14. Deforestation	N/A	A	Include in system-wide adjustment factor
P15. Regional harvest rates	N/A	A	Include in system-wide adjustment factor

that the area would have remained as agricultural land implies that there is no significant change in carbon stock over time. It is highly unlikely that land which falls within the scope of this QP would show a positive trend in carbon stocks (a sink) under the baseline scenario.

Litter and Dead Wood

Many of the Tree Canada project sites will have no existing tree cover, and so pre-project levels of litter and dead wood will be negligible and do not need to be measured. Omission of dead wood and litter built up during the life of the project adds to the conservatism of the estimate of project impacts. For some reforestation projects, as well as a few afforestation projects, there may be considerable litter and dead wood present. However, because this material was created prior to the project, it would decay in the baseline and this is effectively identical to its fate after the project is implemented. Therefore, there is no requirement for Tree Canada to measure and track the litter and dead woody debris as part of project reporting.

Affected and related SSR – Criteria for exclusion in baseline and project

The estimate of aggregate GHG emissions reductions and removals enhancements may be based solely on the above-ground and below-ground living biomass of the planted trees. Emissions and removals affected by this project are included in a system-wide “adjustment factor” for related and affected SSR from afforestation and reforestation projects in the Offset System. The application of these assumptions for the purposes of projection does not conflict with the principle of conservativeness. Generally, effects included under the adjustment factor are not expected to rise to a significant level compared to the effect of capturing carbon (U.S. Department of Energy, 2004).

The adjustment factor is an estimate of the average emissions and reductions/removals (R/R) from related and affected SSR relevant to projects within the scope of this QP. The adjustment factor calculated by the CFS is currently 0 (zero),[10] but should it be revised over the lifetime of an afforestation or reforestation project using this QP, it will be applied in the calculation of total offsets in a Reductions/ Removals Report.

Leakage, the displacement of an activity from the project area to another area not formerly used for the baseline activity, reduces the impact of a project. A typical example of leakage is when a plantation is established on cropland and, in response, a nearby forest is cleared and converted to cropland. While leakage (SSR P11) was included in the determination of the system-wide adjustment factor, it is a source of concern. Additional evidence to suggest that leakage is unlikely to occur in response to a Tree Canada project comes from Statistics Canada’s census data, which show that the total area of farmland in Canada has remained steady from 1986 to 2006, declining by less than 250,000 ha or 0.5% over this period.[11] Within the total farmland area, the area of cropland did increase, but since Tree Canada projects are not conducted on cropland, there is a low potential for leakage. Tree Canada may cite regional trends in farm land area to further assess whether leakage is likely to be a concern.

c) Include/exclude any Baseline Scenario SSRs

See Table 7 and associated text.

3.2.10 Identification of Key SSRs

All of the Upstream SSRs and Downstream SSRs are excluded because they are either considered to be *de minimis,* static, or essentially equivalent between the project and the baseline scenario, or they are included in the system wide adjustment factor. As stated, the system-wide adjustment factor was calculated as being zero, based on a detailed evaluation of off-site SSR impacts.

Table 8 provides an assessment, using the criteria identified in the Guide for Protocol Developers, of the importance of the SSRs that are specifically included in the project and baseline scenarios.

3.3 Quantification of GHG Reductions/ Removals

3.3.1 Quantification of Project and Baseline SSRs

Table 9 contains the elements required by the draft *Guide for Protocol* Developers to describe how Project and Baseline SSRs will be quantified, including all parameters, units of measurement, measurement frequency and justification. Appendix B provides an example of a recent afforestation project undertaken by Tree Canada, including the estimated GHG emissions reductions /removals.

Quantifying the GHG offsets for a typical Tree Canada afforestation or reforestation project requires measurement of the carbon stocks in the terrestrial carbon reservoirs (or carbon pools) and the changes in these stocks over time. Emissions related to the land-use practices prior to, and over the course of the project may contribute to the net GHG reductions resulting from the project. The quantification methodology prescribed in this protocol limits the number of sinks, sources and reservoirs that must be measured and monitored. Exclusions are justified on the basis that the exclusion will result in a more conservative estimate of the emission R/R.

Emissions associated with fossil fuel combustion for land management are not required to be quantified under this protocol. The measurement and monitoring of emissions directly related to a project’s activities are not required if emissions from these sources are greater in the baseline scenario than with the project. In cases where emissions related to fossil fuel combustion are not greater in the baseline scenario than the project’s, those in the project will still be materially insignificant at less than 5% of the total project GHG emissions/removals.[12]

Where fertilizer is used in the tree project, the emissions associated with it must be assessed. While in most projects these will be *de minimis*, the use of fertilizer is a concern and should be included in the analysis. Tree Canada may omit quantification of emissions from fertilization in the baseline scenario (if any); doing so only makes the project impacts more conservative. However, Tree Canada may wish to include it if fertilization is part of the project in order to balance the project impact.

[10] See Appendix D of the Draft Afforestation Protocol developed by the Canadian Forestry Service (CFS).

[11] http://www40.statcan.gc.ca/l01/cst01/agrc25a-eng.htm

[12] Environment Canada’s Pilot Emission Removals, Reductions and Learning Initiative (PERRL) used a materiality threshold of 5% per excluded element and 10% in aggregate. FROM: Environment Canada PERRL, 2004, Reviewer’s Guide

Table 7. Inclusion and Exclusion of Project SSRs.

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Include or Exclude from Quantificatioan	Justification for Exclusion
Upstream SSR during Operation				
P1a. Fossil fuel combustion – seedling production	N/A	R	In system-wide adjustment factor	
B1a. Fossil fuel combustion – agriculture	R	N/A	Exclude	Exclusion results in more conservative estimate of project's net GHG R/R
P1b. Fossil fuel combustion – labour and materials transport	N/A	R	Exclude	Not significant
P2. Emissions from fertilizer use – seedling production	N/A	R	In system-wide adjustment factor	
P3, B2. Fertilizer production	A	A	Exclude	Change in production due to project is insignificant
Onsite SSR during Operation				
P4, B3. Above-ground C reservoir	C	C	Include: trees only	Non-tree biomass not significant and exclusion results in more conservative estimate of project's net GHG R/R
P5, B4. Below-ground C reservoir	C	C	Include: trees only	Non-tree biomass not significant and exclusion results in more conservative estimate of project's net GHG R/R
P6, B5. Dead wood & Litter C reservoir	C	C	Exclude	Project will have little influence on existing dead wood and litter and omission of litter and dead wood that accrues due to a project results in more conservative estimate of project's net GHG R/R.
P7, B6. Soil Organic C reservoir	C	C	Exclude	Changes not significant and exclusion results in more conservative estimate of project's net GHG R/R
P1c, B1b. Fossil fuel combustion – plantation/on-site operations	C	C	Exclude	Not significant and exclusion results in more conservative estimate of project's net GHG R/R
B7. Non-CO_2 GHG emissions – prescribed burning	C	C	Exclude	Exclusion of B7 results in a more conservative estimate of the project's net GHG R/R.
P8, B8. Non-CO_2 GHG emissions – fertilizer	C	C	nclude if fertilizer applied in project; otherwise optional	Fertilization in project accounts for emissions that can be assessed using default factors. Tree Canada can omit consideration of fertilizer use in baseline if not present in project.
Downstream SSR during Operation				
P1d, B1c. Fossil fuel combustion -transportation	R	R	Exclude	Not significant
P9, B9. Crop/food processing facility	R	R	Exclude	Exclusion results in more conservative estimate of project's net GHG R/R
B10. Market impacts – agri-foods	A	N/A	Exclude	Likely to result in more conservative estimate and very difficult to determine with reasonable accuracy
P10: Harvested wood products	R	N/A	Exclude	Insignificant
P11. Baseline activity shifting	N/A	R	In system-wide adjustment factor and may have additional justification	
P12. Forest management (FM) activities	N/A	A	In system-wide adjustment factor	
P13. Afforestation/ reforestation (A/R)	N/A	A	In system-wide adjustment factor	
P14. Deforestation	N/A	A	In system-wide adjustment factor	
P15. Regional harvest rates	N/A	A	In system-wide adjustment factor	

Table 8. Identification of Key Project and Baseline Onsite SSRs.

Identified SSR	Significance of Reduction/Sequestration	Significance of Emission Growth	Risk Level	Key SSR (Y/N?)
P4, B3. Above-ground C reservoir	Significant sequestration	No emissions growth during the course of the project – harvest may occur prior to project producing significant amounts of dead wood.	Low – Biomass can be directly measured	Yes
P5, B4. Below-ground C reservoir	Significant sequestration	No emissions growth during the course of the project.	Moderate – measurement is difficult and while there is a well established body of science that supports root:shoot ratios, the values are rarely age dependent and quite general in other respects.	Yes
P8, B8. Non-CO_2 GHG emissions – fertilizer	Fertilization may lead to increased growth and/or survival and may increase rates of sequestration	Minor emissions may result from fertilizer application in project	Low - fertilizer use in project can be measured and may be available or estimated for baseline	No

Note that this table is intended to describe the risk that the assumptions or measurements related to an SSR may be invalid or erroneous for a given project site; the assessment of risk here is separate from the assessment of risk associated with reversals.

3.3.2 Overall Equation for Quantification of Total Emission Reduction/Removals from the Project and Baseline Scenario

The equations for quantifying the total emissions from the SSRs included in the afforestation or reforestation project and the associated baseline scenario, are provided below:

Eq 1 ∑Emissions from Project = - P4 - P5 + P8 - Adjustment Factor

The biomass in the Above-ground (SSR P4) and Below-ground biomass (SSR P5) Reservoirs will increase during the project, as the trees grow and sequester carbon. Because the equation calculates the emissions from the project, the negative values of the sequestered CO_2-equivalent are used in Equation 1. Emissions associated with fertilization will detract from the net project benefit, although this may be more than offset by increased survival and/or growth rates. The adjustment factor is currently estimated at zero.

In the most typical baseline scenario, where the project land does not have any woody vegetation, or that vegetation is sparse and is not removed during project establishment, the Above-ground and Below-ground biomass Reservoirs will not be material and can be excluded. Furthermore, soil carbon is expected to be stable. Any burning that may be done in the baseline, such as stubble burning, will release minor amounts of CO_2 and ignoring such emissions only makes the project calculations more conservative. Fertilization is the only potential material SSR in Equation 2, and this protocol does not require Tree Canada to calculate the associated emissions. Thus, Tree Canada may decide to declare P8 = zero.

Eq 2 ∑Emissions under "Typical" Baseline = B8

Where there is some live woody vegetation on the project site that is removed during project establishment, the sum of net emissions under the baseline scenario is quantified according to Equation 3:

Eq 3 ∑Net Emissions under Baseline with Existing Woody Vegetation = B3 + B4

In Equation 3, the values of B3 and B4 represent the mature volume that the existing woody vegetation would attain during the time frame of the project. Its removal and replacement with new project trees must be counted against the amount of carbon that will be sequestered by the project; it is best if Tree Canada can avoid removing existing live woody vegetation on the project site.

This QP uses a "stock" method for quantifying the increase of C in reservoirs relative to the baseline. The proponent quantifies the level of C in the reservoir from both the project and the baseline at the end of a given period. The difference between the C stock in the baseline and the project is the GHG removal for the period.

3.3.3 Justification of the equation for each relevant SSR included in above equations

The equation for the quantification of the above-ground reservoir represents the above-ground C content of the biomass per hectare, multiplied by the number of project hectares and then multiplied by the factor for deriving the amount of CO_2 equivalent from the number of kg of carbon in the above-ground biomass. The C content of the biomass is obtained by multiplying tree volume, which is a readily measured parameter, by a factor based on the weight of carbon per kilogram of biomass.

Table 9. Procedures for measuring/estimating parameters for calculating SSR for each GHG.

Project /Baseline SSR	Parameter / Variable	Unit	Measured/ Estimated	Method	Frequency	Justify measurement or estimation and frequency
	C stock = above-ground tree volume * biomass expansion factor * project area * C-CO_2 conversion					
P4, B3. Above-ground C reservoir	C stock	tCO_2	Estimated (Measurement would result in destruction of project)	Calculation	< 5 years after 1st issuance of OC	Frequency limit specified in OS rules
	above-ground tree volume	m^3/ ha		Field measurements; statistical sampling		
	biomass expansion factor	tC/m^3	Estimated	Species-specific factors	Review at re-registration	C content of trees can vary significantly between samples. Using factors based on larger samples should be more accurate.
	project area	ha	Estimated or measured	Field survey and/or map-based	Total project area must be fixed at registration	Project performance must always be based on total area.
	C-CO_2 conversion	tCO_2/tC	Estimated	Factor (44/12) from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
P5, B4. Below-ground C reservoir	C stock = root-shoot ratio * above-ground tree volume * biomass expansion factor * project area * C-CO_2 conversion					
	root-shoot ratio	no units	Estimated	Species-specific factors	Review at re-registration	Destructive sampling would be required to measure this reservoir.
P8, B8. N_2O emissions from nitrogen fertilizer applied	N_2O emissions = [mass of fertilizer applied * N content * (1.0 – volatization rate)] * emission factor * ratio of molecular weights * Global Warming Potential					
	mass of fertilizer applied	tonnes in given year t	Measured area	Measured as weight of fertilizer applied over project area	Determined each time fertilizer applied	Readily measured – key variable
	N content	g N/ 100 g fertilizer	Estimated	Calculated from N content on fertilizer	Determined each time fertilizer applied	Fertilizer content provides N concentration
	volatization rate	Dimension-less	Estimated	Factor = 0.1 for synthetic fertilizer or 0.2 for organic fertilizer, from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
	emission factor	t-N_2O /t-N input	Estimated	Factor =1% from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
	ratio of molecular weights	t-N_2O /t-N	Estimated	Factor (44/28) from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
	Global Warming Potential of N_2O	kg-CO_2e/kg-N_2O	Estimated	Factor = 310 from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
P1a. Fossil fuel combustion – seedling production	Considered in system-wide adjustment factor					
P2. Emissions from fertilizer use – seedling production						
P10. Harvested wood products						
P11. Baseline activity shifting						
P12. Forest management (FM) activities						
P13. Afforestation/ reforestation (A/R)						
P14. Deforestation						
P15. Regional harvest rates						

Below-ground biomass is difficult and expensive to measure directly and hence is derived by estimating it as a fraction of the above-ground biomass, as established by a range of studies, and then multiplying it by the same series of parameters to quantify the live below-ground CO_2 equivalent.

3.3.4 Description and justification of methods for estimation or measurement of each SSR, parameter or sub-parameter

The IPCC Good Practices Guidance for Land Use, Land-Use Change, and Forestry (2003) is the main reference for the methodologies specified in this QP. Further guidance from national, provincial and non-governmental expert sources on field measurement sampling procedures is identified by reference, below.

Estimates of above-ground and below-ground biomass will be based on statistical samples of field measurements. Table 10 and Table 19 summarizes the monitoring procedures used to quantify the emission reductions and removals; Table 9 provided greater detail.

When calculating the verifiable GHG emissions/removals resulting from the project, field measurements are required for the above-ground biomass, including number of trees per hectare, diameter at breast height (dbh), and height. More detailed measurements may be taken if desired. While the effects of activities can often be estimated using standard tables and computer models, field measurements are preferred.

Measurements shall be undertaken in a manner that is statistically sound and verifiable – permanent sample plots in the project area are not required but may be established and monitored if desired. This QP allows for a combination of field measurement and the use of conversion or expansion factors, including the use of process models. This QP also provides some activity-based factors or coefficients that would reduce the need for on-site measurement.

Field measurements are converted to estimates of carbon stocks using models (expansion factors) that estimate above-ground biomass from the measured field variables. Below-ground biomass is then calculated as a simple ratio of above-ground biomass (root-shoot ratio). The amount of fertilizer applied can be determined as the weight of fertilizer applied, readily measured as number of bags x weight of each bag. The nitrogen content is provided and factors used to calculate the impact of N_2O emissions expressed in CO_2-equivalent units. Table 11 provides factors that should be used in the quantification of emissions, removals or reservoir stocks for each of the selected SSR, including non-biological sources.

P4, B3: Above-ground C reservoir:

Above-ground Tree Volume: The procedures in this protocol aim to provide a simple and cost-effective method for measuring carbon stocks in afforestation and reforestation projects. To achieve this it is not necessary to measure every tree. Instead, trees in small representative areas are measured. The sampling procedure involves the establishment of a series of sample points or 'plots' within the project site. This approach is based on statistical theory and common forest inventory techniques.

Table 10. Summary of procedures for measuring/estimating parameters for calculating SSR for each GHG.

Project / Baseline SSR	Parameter / Variable	Unit	Measured / Estimated	Method
P4, B3: Above-ground C reservoir	above-ground tree volume	m^3/ha	Estimated based on measured indicators	Field measurements; statistical sampling
	biomass expansion factor: converts tree volume to above + below-ground biomass	tC/m^3	Estimated	Calculation
	afforested area	Ha	Estimated	Field survey and/or map-based
P5, B4: Below-ground C reservoir	root-shoot ratio	no units	Estimated	Calculation
P8, B8: N_2O emissions from nitrogen fertilizer application	mass of fertilizer applied	tonnes	Measured	Quantities applied are recorded
	N content	g N/ 100 g fertilizer	Calculated	Calculation

Once the merchantable volume of the trees in the project area has been determined, the biomass expansion factors presented in Appendix D are used to derive the total tree CO_2 stock. In Equation 4, the IPCC default value of 1.45 has been used as a Biomass Expansion Factor (BEF). Similarly, in Equation 5, the IPCC default root:shoot ratio of 0.40 was used – Appendix D provides BEF values for key species in the regions of Canada. If a suitable biomass equation is available (instead of a merchantable volume equation), the calculated biomass can replace the contents of the square brackets in Equation 6 below.

Equation 4:

ABG Biomass (t) = [MerchVol(m^3) x Species Density (t/m^3)] x 1.45

Equation 5:

BLG Biomass (t) = [MerchVol(m^3) x Species Density (t/m^3] x 0.40

Equation 6:

Total Tree Stock (tCO_2) = [ABG(t)+BLG(t)] x $0.5tC/t_{biomass}$ x $3.6667tCO_2/tC$

Where:

ABG Biomass (ABG) = Above-ground biomass in tonnes (t)
BLG Biomass (BLG) = Below-ground biomass in tonnes (t)
MerchVol = Merchantable volume of trees on project site in cubic metres (m^3)
Species Density = Wood density value from Appendix E, in t/m^3

Tree Canada may choose the most appropriate sampling approach for each particular project or individual stratum within a project. However, the sampling procedure must be auditable, repeatable and follow some basic statistical principles, achieving estimates at a precision level of within + 10% of the mean, with 95% confidence. The sampling procedure (or measurement plan) must also follow IPCC GPG LULUCF (2003, Section 4.3.3.4). Verifiable sampling procedures can be found in the following references:

- *Government of Canada, 2004, Canada's National Forest Inventory – Ground Sampling Guidelines:* https://nfi.nfis.org/documentation/index_e.shtml
- British Columbia Ministry of Forests, 2002, *Stocking and free growing surveys procedures manual:* http://www.for.gov.bc.ca/hfp/publications/00099/surveys/SurveysProcManual3.pdf
- Manitoba Conservation, Forestry Branch, 2001, *Silviculture Surveys:* http://www.gov.mb.ca/conservation/forestry/forest-renewal/pdfs/silvisurveys2.pdf

Species-specific allometric equations can be used to derive an estimate of biomass from sampled estimates of merchantable volume (See Appendix D). In the absence of suitable allometric equations, and when measurement occurs prior to the trees achieving merchantable size, stem volume shall be calculated on the basis of a cone, using diameter measurements and estimates of tree height.

Biomass Expansion Factor: Regional BEF and root-shoot ratio (expressed as below-ground biomass-merchantable biomass) shown in Appendix D have been derived by Canada from parameters used in IPCC 2003 (Table 11). Regions are divided by province and terrestrial ecozone. The below-ground BEF is used to estimate the carbon content of root biomass as direct measurement requires destructive sampling that becomes increasingly costly and impractical over time. Care must be taken if tree level equations are applied to stand level data, or vice versa. If stand level equations are used, tree level data must be converted to stand level data to be applicable.

Table 11. Some parameters for estimation of above and below-ground carbon. (Source: IPCC 2003).

SSR or Parameter	Factor
tCO_2e / t Carbon	3.6667
Carbon (t) / dry biomass (t)	0.50
Density index (t/m^3)	See Appendix E
Above-ground biomass (t) / merchantable biomass (t)	1.45
Root: Shoot ratio	0.40

Area Afforested: The project area can be measured directly using a wide range of devices, including chain, measurement of number of steps or paces, or the use of surveyors' instruments. At a minimum, if the project area is a right-angled quadrilateral, at least two adjacent sides must be measured. Alternately, the area can also be derived from a map or photographic image, where the scale is known.

For some projects it will be beneficial to divide the project area into "strata" prior to measurement in order to improve the accuracy and precision of estimates. Stratification often results in lower measurement costs as fewer sample plots are required. Stratification usually creates relatively homogenous units based on similarities in ground condition such as vegetation, topography or management history. All strata within the project site must be delineated on a map and the area measured from the project or using Global Positioning System (GPS). The site characteristics of each stratum should be recorded, including site locator information and area in hectares. All major access routes and physical features of the overall site should be included on the project map.

P5, B4: Below-ground C reservoir

The BEF provided in Appendix D converts a measurement of tree merchantable volume into an estimate of above and below-ground biomass – from this, the below-ground biomass can be identified separately. Alternately, root:shoot ratios can be used to estimate the below-ground biomass, using the tree volume or above-ground biomass as the independent variable.

P8, B8: Emissions associated with N_2O emissions from fertilization

The application of nitrogen-based fertilizers will lead to increased N_2O emissions while urea-based fertilizers and liming will increase the emissions of CO_2. The calculation of the relevant GHG emissions associated with fertilization is essentially undertaken by measuring the amount of fertilizer applied, its nitrogen, ammonia or carbonate content and then applying appropriate factors to translate this into emission levels.

The relevant project specific data required to complete the calculation are readily available. The amount that is applied can easily be measured and the concentration of the relevant ingredient (e.g. nitrogen) is printed on the fertilizer package. The remaining parameters are available from IPCC/CDM publications (See Table 9 for factors related to N_2O emissions):

- Clean Development Mechanism (CDM). 2007. Estimation of direct nitrous oxide emission from nitrogen fertilization - Draft methodological tool CDM – A/R WG Fifteenth meeting Report Annex 06.
- Intergovernmental Panel on Climate Change (IPCC). 2006. N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application. Chapter 11: of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Edited by Simon Eggleston, Leandro Buendia, Kyoko Miwa, Todd Ngara, and Kiyoto Tanaba.

3.3.5 Frequency of Measurement or Estimation of the Parameters

The data collection procedures have been described above. The minimum frequency of collection is specified by the Offset System rules for sinks projects (< 5 years since last issuance of Offset Credits). Annual verification is not necessary given the lasting evidence of the activities (i.e. the number and size of the trees).

3.3.6 Contingency Measures for Continuity of Data Collection

Situations where data cannot be collected through established means (as in Table 9) would affect the field measurements used to calculate above-ground C stocks. Remote sensing imagery could be used to determine if a significant reversal had likely occurred (e.g. due to fire or insect damage) but would not provide a sufficiently accurate estimate of above-ground C stocks for the calculation of a project's GHG removals during the period. However, if growth and yield equations that are applicable to the project site and species are available, these could be used to provide reasonable estimates until field data could be collected.

3.4 Quantify Emission Reductions

3.4.1 Quantification of Total Emission Reduction

The total reduction in emissions attributed to the project is the sum of the project net emissions subtracted from the sum of the baseline scenario net emissions. This is represented by Equation 7:

Eq 7 $$\sum \text{Emission Reductions} = \text{Total Baseline Emissions} - \text{Total Project Emissions}$$

where the Total Baseline Emissions are calculated using either Equation 2 or Equation 3, depending on the circumstances of the site where the project is to be implemented, and Total Project Emissions are calculated according to Equation 1.

3.5 Other Impacts

The project will not contribute any additional air pollutants. If the baseline scenario includes regular burning of the site, then the project will reduce the particulate and other pollutants associated with the baseline scenario. There is no readily available methodology for measuring this impact.

Conversely, forest plantations have the capacity to remove particulates from the atmosphere and to purify air. This would be a positive additional outcome of the project and could be measured using various cover indices and habitat models. However, the assessment and valuation of these benefits is difficult and controversial and they are best expressed qualitatively.

Forested areas generally have greater levels of biodiversity than agricultural fields or pasture land, especially if native, mixed tree species are planted in the project. Thus, another benefit of the project will be enhanced biological diversity. Finally, forested areas may have some positive impacts on the water table, and in regulating water flow and runoff, in comparison to agricultural lands. Although difficult to measure, these may also be benefits of afforestation and reforestation projects.

3.6 Bibliography

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Standard for Tree Canada Urban Tree Planting Projects

4 Standard for Tree Canada Urban Tree Planting Projects

4.1 Base Protocol Scope and Development Approach

4.1.1 Scope

a) Description of Base Protocol

This protocol covers projects that plant individual trees or small groups of trees in urban or other developed areas. The planted areas are too small to be considered as forests and hence the activities do not fall within the scope of afforestation projects under this standard. Nevertheless, these smaller plantings do sequester carbon and are capable of generating offset credits. The trees established under the project must be capable of achieving a minimum height of five metres at maturity.

Activities eligible for offsets include projects established during 1992. Projects initiated between 1992 and 2006 are not eligible under the current version of Canada's proposed offset system, however Tree Canada may wish to sell such offsets in the voluntary market or in another market that would accept them.

Because the number of trees in each individual planting is small, different tree plants undertaken by Tree Canada may be aggregated to form single carbon projects. Planting projects in different years may also be aggregated to form individual carbon projects, however it is recommended that the there should not be more than five years difference between the planting projects that have been aggregated into a single carbon project. Also, planting activities that took place during the early action period cannot be combined with planting activities that took place after the early action period expired. The project documentation must list and describe the aggregated projects.

All of Tree Canada's urban tree planting activities can be considered additional. As described above, Tree Canada was established with a mandate to serve as a vehicle for urban forest projects that would mitigate climate change. *There are no other national organizations with this mandate in Canada.* This is one level of additionality. At the individual project level, there is no legal requirement to plant the project areas. Eligible projects are those for which the funder is interested in demonstrating action towards mitigating climate change, the co-funders often also appreciate the co-benefits associated with tree planting. The projects that this protocol is intended to cover include plantings to beautify roadsides and areas in the urban environment, create visual screens or buffers, naturalize areas, or establish an urban treed area. In some cases, the project will be to replace trees that have died or been lost due to an unplanned disturbance that is not the result of negligence on the part of the landowner or property manager.

The planting agreement between Tree Canada and the funder specifies where the ownership of the carbon credits resides. Tree Canada is frequently the owner of the carbon credits produced from the eligible tree planting activities. Where the funder wishes to retain ownership of the credits, this is specified in the contract. This arrangement is also spelled out in the agreement with the landowner, where the owner differs from the project sponsor.

b) Real Reductions

An eligible tree planting project will achieve GHG reductions/removals through the increase in carbon stocks on the project site as a result of the growth of trees. Emissions from the project may occur during planting or as a result of subsequent maintenance required to keep the tree healthy and mitigate risk that the tree, when mature, may cause damage to structures or people. These emissions are expected to be small compared to the carbon sequestered by the project and they will usually be less than or equal to the emissions associated with the pre-project land use (e.g. lawn-cutting).

The establishment of trees in urban or other built-up locations may provide additional indirect benefits. One source of indirect benefits are potential reductions in energy for heating and cooling (estimated at 15-25%), since trees provide shade during hot weather and buffer wind to reduce winter heating requirements. A second potential source of indirect benefits would occur when the planted trees are removed and used as biofuel in power generation facilities. The fossil fuel consumption that is displaced is an indirect project benefit. While Tree Canada may wish to document them, offset credits are not typically issued for indirect project benefits.

Urban tree planting projects undertaken by Tree Canada are small in relation to the numbers of trees that are planted annually by Canadian urban forest authorities and most municipalities. Therefore, the type of leakage that the California urban forest protocol is designed to assess is unlikely to occur as a result of Tree Canada's activities.

Users of this QP will demonstrate that the GHG reductions/removals have not been considered in any other Offset System projects through the provision of information on the location of the project activities.

c) Flexibility

This protocol is intended to apply to tree planting projects where there is no existing, pre-project tree cover on site, or where existing tree cover is scattered and the project is intended to increase the density of trees on the property, or on a portion of it. Because the projects under consideration involve the planting of individual trees, the amount of carbon sequestered is calculated on the basis of the biomass of the individual planted trees. The presence of existing vegetation on the project site does not entail a requirement to calculate carbon stored in these trees and reduce the anticipated project benefits.

This part of the protocol applies to projects where there is no fertilizer applied as part of the project and fertilization will also be an uncommon baseline activity. However, if fertilizer is applied to the project, there is flexibility to include the project as long as the emissions from fertilization are documented. The approach that is followed to document these emissions is the same as was described in the section of the protocol dealing with afforestation and reforestation projects.

Tree Canada should include information on the condition of the initial site with the Project Document, such as photographs of the project site. This protocol is not appropriate for projects where existing living trees are being removed and replaced with new young trees and Tree Canada does not engage in such projects.

4.1.2 Permanence

Permanence was discussed in section 3.1.2 – the same approach will be applied to urban planting projects that was applied to afforestation and reforestation projects.

4.2 Identification of Project SSRs, Baseline Scenario and Baseline SSRs

By planting trees on urban or other developed land, carbon stocks on the project site will increase over time. This protocol is designed for planting projects on untreed areas such as lawns, fields and other areas covered with grasses or other herbaceous or scrubby vegetation, including rights-of-way and roadsides. Initial carbon stocks in live biomass will be negligible. The project boundary consists of above-ground carbon and below-ground carbon stocks associated with the planted trees and emissions associated with fossil fuel consumption during planting and subsequent maintenance of the trees, including fall leaf cleanup, during the project's lifetime. The emissions during tree planting and maintenance are expected to be small compared to the carbon sequestered by the project.

Mortality of the planted trees may cause emissions and potential reversal of credited removals. Section 4.1.2 sets out a variety of alternative ways that Tree Canada can provide assurance against reversals.

4.2.1 Identification of Project SSRs for Quantification

a) List, number and describe all potential SSRs that occur in the implementation of this project-type.

Carbon sequestered in urban treed areas is stored in the same four reservoirs, or pools, as were described in section 3.2.1. Please see that section for a description of each SSR. If and when the trees planted in an urban tree planting project are removed from the site, all of the carbon stored in them is assumed to be emitted at the time of removal.[13] The permanence and assurance measures (described in section 4.1.2) can be used to mitigate the amount of carbon removed from the project site (and therefore emitted).

Table 2 identified the SSR controlled by, related to, or affected by an afforestation or reforestation project, and due to the overlap in the SSRs affected by those projects and by urban tree planting, readers may refer to Table 2 for that information. Some of the SSR identified in Table 2 do not apply to urban tree planting projects covered under this protocol. This protocol is designed for urban tree planting projects that do not involve the application of fertilizer, although there is flexibility to follow the calculation methodology outlined in section 2.2 if fertilization is undertaken. However, in the absence of fertilization, the SSR numbered P3 and P8 are inapplicable. The SSR identified as P11 – P15 are affected SSR, and the urban planting undertaken by Tree Canada is too small to affect such factors as the regional afforestation rate and other factors that are calculated on a regional basis. Urban planting has the potential to reduce heating and cooling costs in buildings that neighbour the planting, however these impacts have been excluded from consideration in this protocol and so are excluded from the analysis of SSR.[14]

The criterion for identifying which SSRs are directly controlled by Tree Canada is that the SSRs are either located in the project area or are due to operations undertaken to implement the project. In the case of urban planting projects, these will be: the planted seedlings or trees (above-ground and below-ground biomass) and the fossil fuel emissions from machinery used in establishment and maintenance. SSRs that are related to the project activities have material or energy flows into, out of, or within the project. A related GHG source, sink or reservoir is generally upstream or downstream from the project and can be either on or off the project site. SSRs related to an urban planting project include the combustion of fossil fuel for seedling production in nurseries and for the transport of the trees and labour to the planting site. However, because the extent of the related project impacts is negligible compared to the controlled impacts, the related project impacts need not be calculated in eligible projects.

Affected SSRs are those that are indirectly affected by the project or the outcomes from the project. Again, the small size of Tree Canada projects in relation to the total amount of tree planting that is regularly done by municipal forest departments, residents and businesses, means that the impacts of urban planting will be negligible and need not be estimated.

[13] In accordance with current accounting rules for the Offset system.
[14] The CCAR Urban Forestry Protocol also excludes impacts on heating and air conditioning from quantification.

b) Explain how each potential SSR is controlled, related or affected (C/R/A) to the project type.

The potential SSRs that are related and controlled by an urban forest project, and which may have significant emissions or sequestration associated with them, are listed in Table 12. All affected SSRs, and many of the related SSRs have been eliminated from further consideration for the rationale provided above.

Table 12. Manner in which Potential SSRs are controlled, related or affected by the urban planting project.

SSR	Manner of Control, Relation or Effect
Upstream SSR	
P1. Fossil fuel combustion – stock & labour transport	R: Transportation requirements associated with project lead to higher CO_2 emissions.
Onsite SSR	
P2. Above-ground live biomass C reservoir	C: Above-ground biomass of planted trees increases over time with growth.
P3. Below-ground live biomass C reservoir	C: Below-ground biomass of planted trees increases over time with growth.
P4. Fossil fuel combustion – project operations	C: Transportation requirements associated with implementing project, including establishment and tending, may lead to higher CO_2 emissions unless the site was actively managed in its previous use.

4.3 Identification of Baseline Scenario

a) Identify the Baseline Scenario(s) to be applied in this Base Protocol and justify why it is appropriate. For each remaining baseline scenario, provide justification as to why it is not appropriate for this protocol.

The baseline scenario for an urban planting project under this OSQP is as follows:

In the absence of the project, there will be no change in the current level of the carbon reservoirs on the project site and no increase or decrease in sources or sinks. The project site is managed, does not have trees on it or has scattered tree cover, and it is not expected to develop additional tree cover unless the management approach is changed. There are no internal plans, government regulations or programs that require the site to be planted with trees.

In the absence of the project there may be emissions caused by the management of the site, such as mowing, leaf raking and weeding. These operations will likely continue if the project plants scattered trees and the site still supports a lawn or other herbaceous vegetation. If the project plants trees at a sufficient density to preclude retention of grass, then the emissions associated with site maintenance will decline under the project.

The scope of this QP, as described in Section 3.1.1., effectively limits the range of potential baseline scenarios. Due to the nature of the ownership and the active management regime, it is reasonable to assume that the land would not have trees planted on it without the project. If trees were desired on the site, they likely would have been planted already - the carbon benefits of the project can be considered to have been the motivating factor for the project.

The 'simple' baseline scenario that applies to the scope of the QP is that there will be no change in the current size of the carbon reservoirs. A steady-state or "no-change" baseline scenario is most appropriate for urban tree planting projects where:

a) The land has been managed by a municipal authority or other institutional owner for a considerable period of time and there has been no change in the use or function of the land; and
b) The zoning designation of the land has not changed.

For urban plantings on privately owned land, there is generally greater likelihood that the site might be planted in the absence of the project, as ownership changes and lesser levels of institutional inertia create conditions where changes are more likely. On private land, Tree Canada will provide evidence that future tree planting is unlikely. Such evidence may include:

- Length of time of ownership and list of plantings, and year of planting, made during the current ownership;
- A signed affidavit that the owner has no intention of planting the site in the absence of the Tree Canada project.

On the other hand, the owner may have decided that he or she wished to plant trees to primarily, although not exclusively, sequester carbon and decided that Tree Canada was the appropriate organization to undertake this. In such cases, the land owner should document that were it not for the climate change mitigation benefits of the tree planting, the project site would have not been planted to trees.

Three other potential baseline scenarios are outlined in Table 13. All of these have significant shortcomings that preclude their use for the urban planting projects considered under this QP.

Table 13. Possible Baseline Scenarios for Estimating GHG Emissions/ Removals.

Baseline Option	
Historic Benchmark	
• Description	National or regional trends in urban tree planting on applicable land since 1990
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to lack of sufficient data and the local insignificance of regional level data.
Comparison-based	
• Description	Establishment and monitoring of control group
• Static or Dynamic	Dynamic
• Accept or Reject and Justify*	Reject due to high costs and difficulties in ensuring validity of control group.
Direct Measurement	
• Description	Measurement of all emissions and sequestration associated with all direct project activities; emissions associated with indirect effects could be estimated
• Static or Dynamic	Static
• Accept or Reject and Justify*	Reject due to high costs of measurement and high degree of technical difficulty.

** As this protocol is designed to cover the majority of potential afforestation project circumstances, it is possible that individual projects may be able to apply other baseline scenario options.*

Justification for Baseline Scenario Selection

The rationale has been provided above for selecting as the baseline scenario that the land will remain in its current use and there will be no change in the carbon storage on the project site. Tree Canada may opt to estimate the emissions from fossil fuel consumption associated with the maintenance of the site, however these are likely to be minor and more trouble to estimate than they are worth in terms of offsets. Omitting them also increases the conservatism of the estimated offsets associated with the project.

b) Explain whether the accepted baseline scenario is static or dynamic.

The projection-based baseline scenario for this protocol is static because the emissions profile for the baseline activities will not change during the registration period.

4.4 Identification of the Baseline SSRs for Quantification

a) List, number and describe all potential SSRs that occur in the baseline scenario of this project-type.

The process used to identify and select the baseline SSR described in Table 14 is derived from the urban forest project reporting protocol prepared by the California Climate Action Registry (version 1.0 August 2008) and the draft afforestation protocol prepared by the CFS, which was developed according to the structure specified in the draft "Guide to Quantification Methodologies and Protocols" released by Environment Canada in August 2008.

Table 14. Identification of SSR Controlled by, Related to and Affected by the Baseline.

SSR	**Description**	**Manner of Control, Relation or Effect**
Upstream SSR during Baseline Operation		
B1. Fossil fuel combustion – labour and materials transport	Fossil fuel used in transport of labour and materials to project site.	R: Transportation requirements associated with the baseline management activities create CO_2 emissions.
Onsite SSR during Baseline Operation		
B2. Above-ground C reservoir	Biomass in the existing vegetative cover, which does not contain woody material.	C: Grass or other non-tree vegetation is managed under the baseline scenario.
B3. Below-ground C reservoir	Root biomass of existing vegetative cover.	C: The below-ground counterpart to above-ground C.
B4. Fossil fuel combustion – on-site operations	Fossil fuel used by vehicles and equipment used in management of land.	C: Management associated with baseline activity creates CO_2 emissions.
Downstream SSR during Baseline Operation		
None		

4.5 Compare Project and Baseline SSRs

a) Explain how the project and the baseline are comparable in terms of products and/or activity level. Justify any lack of equivalency.

Table 15. Comparison of Project and Baseline Scenario SSRs.

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Assessment of Comparability
Upstream SSR during Operation			
P1, B1. Fossil fuel combustion – labour and materials transport	R	R	Functionally equivalent – fossil fuel emissions for similar types of operations.
Onsite SSR during Operation			
P2, B2. Above-ground C reservoir	C	C	Functionally equivalent.
P3, B3. Below-ground C reservoir	C	C	Functionally equivalent.
P4, B4. Fossil fuel combustion – planting / on-site operations	C	C	See above – project unlikely to affect number of trips for management.
Downstream SSR during Operation			
None			

b) Include /exclude any Project and Baseline SSRs.

Table 15 provides a comparison of the SSRs in both the project and the baseline scenario and shows that there is a high degree of overlap.

However, the estimate of aggregate GHG removals may be based solely on the above-ground and below-ground living biomass of the planted trees. The growth of live biomass provides the main carbon benefit of the project, and hence, these SSRs must be assessed and reported on. The impact of the project on the single relevant, related carbon SSR (P1, B1) will be negligible in most projects. The typical project site is actively maintained (e.g. lawn mowing) prior to the project and will be maintained afterwards at either a similar or lesser intensity. It is difficult to envisage a situation where the intensity of management will increase after the project is initiated. Thus, the project can be expected to lead to either no change in, or lower levels of, fossil fuel use. In such cases, it not necessary to quantify fossil fuel consumption in either the project or baseline.

c) Include /exclude any Baseline Scenario SSRs See Table 16 and associated text.

4.6 Identification of Key SSRs

In many cases, all of the Upstream SSRs and Downstream SSRs can be ignored because they are either negligible or essentially equivalent between the project and the baseline scenario.

Table 17 provides an assessment, using the criteria identified in the *Guide for Protocol* Developers, of the importance of the SSRs that are specifically included in the project and baseline scenarios.

Table 16. Inclusion and Exclusion of Project SSRs.

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Include or Exclude from Quantification	Justification for Exclusion
Upstream SSR during Operation				
P1, B1. Fossil fuel combustion – labour and materials transport	R	R	Exclude	Project is expected to either not affect or reduce the number to trips to manage/care for site.
Onsite SSR during Operation				
P4, B3. Above-ground C reservoir	C	C	Include: trees only	Non-tree biomass not significant and exclusion results in more conservative estimate of project's net GHG R/R
P5, B4. Below-ground C reservoir	C	C	Include: trees only	Non-tree biomass not significant and exclusion results in more conservative estimate of project's net GHG R/R
P8, B1c. Fossil fuel combustion – planting/on-site operations	C	C	Exclude	With the exception of planting, the project is not expected to affect number to trips to manage/care for the site. A single trip to plant the trees will result in insignificant emissions compared to the carbon sequestered in the project.
Downstream SSR during Operation				
None				

Table 17. Identification of Key Projet and Baseline Onsite SSRs

Identified SSR	Significance of Reduction/ Sequestration	Significance of Emission Growth	Risk Level	Key SSR (Y/N?)
P2, B2. Above-ground C reservoir	Significant sequestration. More mortality may occur than forecast but protocol is designed to mitigate impacts.	No emissions growth during the course of the project.	Low – Biomass can be directly measured	Yes
P3, B3. Below-ground C reservoir	Significant sequestration – see above.	No emissions growth during the course of the project.	Moderate – measurement is difficult and while there is a well- established body of science that supports root:shoot ratios, the values are rarely age dependent and quite general in other respects.	Yes

Note that this table is intended to describe the risk that the assumptions or measurements related to an SSR may be invalid or erroneous for a given project site. The assessment of risk here is separate from the assessment of risk associated with disturbances.

4.7 Quantification of GHG Reductions/ Removals

4.7.1 Quantification of Project and Baseline SSRs

Table 18 contains the elements required by the *Guide for Protocol Developers* to describe how Project and Baseline SSRs will be quantified, including all parameters, units of measurement, measurement frequency and justification. Appendix C provides an example, for a hypothetical urban tree planting project, of the estimated GHG emissions reductions /removals.

Quantifying the GHG offsets for an urban tree planting project requires measurement of the carbon stocks in the terrestrial carbon reservoirs (or carbon pools) and the changes in these stocks over time. The quantification methodology prescribed in this protocol limits the number of SSRs that must be measured and monitored. Exclusions are justified by limiting the scope of this protocol and on the basis that the exclusion will result in a more conservative estimate of the emission reductions or removals.

Emissions associated with land management practices, from fossil fuel combustion for example, are excluded from quantification in this protocol. The measurement and monitoring of emissions directly related to a project's activities are not required if the project does not affect emissions from these sources or if they are greater in the baseline scenario than with the project. In cases where emissions related to fossil fuel combustion are not greater in the baseline scenario than the project's, those in the project will still be materially insignificant at less than 5% of the total project GHG emissions/removals.[15]

4.7.2 Overall Equation for Quantification of Total Emission Reduction/ Removals from the Project and Baseline Scenario

The equations for quantifying the total emissions from the SSRs included in the project and the baseline scenario are provided below:

Eq 1 $\sum$Emissions from Project = - P1 — P2

The biomass in the Above-ground (SSR P1) and Below-ground biomass (SSR P2) Reservoirs will be increasing during the project, sequestering carbon. Because the equation calculates the emissions from the project, the negative values of the sequestered CO_2-equivalent are used in Equation 1.

There are no emissions under a typical baseline.

Eq 2 $\sum$Emissions under "Typical" Baseline= 0

This QP uses a "stock" method for quantifying the increase of C in reservoirs relative to the baseline. The proponent quantifies the level of C in the reservoir from both the project and the baseline at the end of a given period. The difference between the C stock in the baseline and the project is the GHG removal for the period.

If TOC are used and the Reductions/Removals report covers more than one year, there must be a methodology to interpolate annual carbon stock changes for the baseline and project reservoir.

[15] Environment Canada's Pilot Emission Removals, Reductions and Learnings Initiative (PERRL) used a materiality threshold of 5% per excluded element, and 10% in aggregate. From: Environment Canada PERRL, 2004, Reviewer's Guide

4.7.3 Justification of the equation for each relevant SSR included in above equations

The equation for the quantification of the above-ground reservoir represents the above-ground C content of the biomass per hectare, multiplied by the number of trees planted in the project and then multiplied by the factor for deriving the amount of CO_2 equivalent from the number of kg of carbon in the above-ground biomass. The C content of the biomass is obtained by multiplying tree volume, which is a readily measured parameter, by a factor based on the weight of carbon per kilogram of biomass.

Below-ground biomass is difficult and expensive to measure directly and hence is derived by estimating the below-ground biomass as a fraction of the above-ground biomass, as established by a range of studies, and then multiplying it by the same series of parameters to quantify the live below-ground CO_2 equivalent.

4.7.4 Description and justification of methods for estimation or measurement of each SSR, parameter or sub-parameter

The IPCC Good Practices Guidance for Land Use, Land-Use Change, and Forestry (2003) has been the main reference for the methodologies specified in this QP. However, guidance on field measurement sampling procedures has been largely adapted from the urban forest project reporting protocol prepared by the California Climate Action Registry (version 1.0 August 2008).

The California Guide has three approved approaches for quantifying carbon stocks:

1. Measure all trees in project tree sites during a single year at 10-year intervals. Use the measurement data with appropriate single-tree allometric equations to estimate carbon stocks. In the intervening years when there are no measurements, use growth and yield estimates to predict annual carbon stocks. Such methods employ growth assumptions and allometric equations to estimate carbon stocks.

   Direct tree measurements or remote sensing techniques may be used. Data from direct tree measurements (i.e. tree diameter at breast height) can be input directly into approved allometric equations. Remote sensing can be used to estimate tree crown area, from which tree trunk diameter is inferred.

2. Measure all trees in project tree sites every 10 years using a rolling sample, which means a minimum of 10% of the tree sites are measured each year and after 10 years, 100% of sites have been measured. Use the measurement data with appropriate allometric equations to estimate carbon stocks. For trees that are not measured in a given year, use growth and yield estimates to predict annual carbon stocks.

Table 18. Procedures for measuring/estimating parameters for calculating SSR for each GHG.

Project / Baseline SSR	Parameter / Variable	Unit	Measured/ Estimated	Method	Frequency	Justify measurement or estimation and frequency
P4, B3. Above-ground C reservoir	C stock = above-ground tree volume * biomass expansion factor * no. trees * C-CO_2 conversion					
	C stock	tCO_2	Estimated (Measurement would result in destruction of project)	Calculation	< 5 years after 1st issuance of OC	Frequency limit specified in OS rules
	above-ground tree volume	m^3/ tree		Field measure-ments; statistical sampling		
	biomass expansion factor	tC/m^3	Estimated	Species-specific factors	Review at re-registration	C content of trees can vary significantly between samples. Using factors based on larger samples should be more accurate
	Number of trees	#	Number planted is known, survival is estimated	Planting records	Number of trees must be fixed at registration	Project performance must always be based on number of trees.
	C-CO_2 conversion	tCO_2/tC	Estimated	Factor (44/12) from published IPCC Guidelines	Review at re-registration	Factor is not likely to change.
P5, B4. Below-ground C reservoir	C stock = root-shoot ratio * above-ground tree volume * biomass expansion factor * number of trees * C-CO_2 conversion					
	root-shoot ratio	no units	Estimated	Species-specific factors	Review at re-registration	Destructive sampling would be required to measure this reservoir.

3. Measure a sample of trees in the project tree population each year, use the measurement data with approved allometric equations to estimate carbon stocks in the samples and extrapolate the carbon stock estimates to the entire tree population.

When calculating the verifiable GHG emissions/removals resulting from the project, field measurements are required for the above-ground biomass, including number of trees per hectare, diameter at breast height (dbh), and optionally, tree height, More detailed measurements may be made if desired. Table 19 summarizes the monitoring procedures used to quantify the emission reductions and removals; Table 18 provided greater detail.

Table 19. Summary of procedures for measuring/estimating parameters for calculating SSR for each GHG.

Project / Baseline SSR	Parameter / Variable	Unit	Measured / Estimated	Method
P1, B1: Above-ground C reservoir	above-ground tree volume	m^3/ tree	Estimated based on measured indicators	Field measurements; statistical sampling
	biomass expansion factor: converts tree volume to above + below-ground biomass	tC/m^3	Estimated	Calculation
	Number of trees planted	#	Measured	In project records
P2, B2: Below-ground C reservoir	root-shoot ratio	no units	Estimated	Calculation

Field measurements are converted to estimates of carbon stocks using models (expansion factors) that estimate above-ground biomass from the measured field variables. Below-ground biomass is then calculated as a simple ratio of above-ground biomass (root-shoot ratio). Table 11 provides factors that should be used in the quantification of emissions, removals or reservoir stocks for each of the selected SSR, including non-biological sources.

P4, B3: Above-ground C reservoir:

Above-ground Tree Volume: The procedures in this protocol aim to provide a simple and cost-effective method for measuring carbon stocks in urban tree planting projects. The methods used may involve measuring every tree or measuring a sample of trees selected from the project. The sampling procedure involves the establishment of a series of sample points or 'plots' within the project site. This approach is based on statistical theory and common forest inventory techniques.

Once the merchantable volume of the measured trees in the project area has been determined, the expansion factors presented in Appendix D are used to derive the total tree CO_2 stock. If a suitable biomass equation is available (instead of a merchantable volume equation), the calculated biomass can replace the contents of the square brackets in Equation 5 below.

Equation 3:

$$\text{ABG Biomass (t)} = [\text{MerchVol}(m^3) \times \text{Species Density } (t/m^3)] \times 1.45$$

Equation 4:

$$\text{BLG Biomass (t)} = [\text{MerchVol}(m^3) \times \text{Species Density } (t/m^3] \times 0.40$$

Equation 5:

$$\text{Total Tree Stock } (tCO_2) = [\text{ABG(t)}+\text{BLG(t)}] \times 0.5tC/t_{biomass} \times 3.6667tCO_2/tC$$

Where:

ABG Biomass (ABG) = Above-ground biomass in tonnes (t)
BLG Biomass (BLG) = Below-ground biomass in tonnes (t)
MerchVol = Merchantable volume of trees on project site in cubic metres (m^3)
Species Density = Wood density value from Appendix E, in t/m^3

The sampling procedure selected by Tree Canada must be auditable, repeatable, and follow some basic statistical principles, achieving estimates at a precision level of within + 10% of the mean, with 95% confidence. References for verifiable sampling procedures were listed in section 3.3.2.

Species-specific allometric equations can be used to derive an estimate of merchantable volume or biomass from sampled estimates of diameter at breast height (dbh). In the absence of suitable allometric equations, and when measurement occurs prior to the trees achieving merchantable size, stem volume shall be calculated on the basis of a cone, using measurements of diameter and height. This method will be used to verify the allometric (biomass) equation(s) for the project site. Note that this will require tree height data to be collected, in addition to dbh and plantation density.

Biomass Expansion Factor: Regional biomass expansion factors (BEF) and root-shoot ratio (expressed as below-ground biomass-merchantable biomass) are derived from parameters used in IPCC 2003 (See Appendix D). Regions are divided by province and terrestrial ecozone (Environment Canada, 1996; Kull *et al,* 2006). The below-ground BEF is used to estimate the carbon content of root biomass as direct measurement requires destructive sampling that becomes increasingly costly and impractical over time. Care must be taken if stand level equations are applied to stand trees.

Number of Trees Planted: The number of trees planted is known from planting records.

P5, B4: Below-ground C reservoir

The BEF described above converts a measurement of tree volume into an estimate of above and below-ground biomass – from this, the below-ground biomass can be identified separately. Alternately, root:shoot ratios can be used to estimate the below-ground biomass, using the tree volume or above-ground biomass as the independent variable.

Root-to-shoot ratios for all provinces and ecozones are listed in Appendix D. To determine root biomass in the project, multiply merchantable volume of the trees (m^3) by the root-to-shoot ratio.

4.7.5 Frequency of Measurement or Estimation of the Parameters

The data collection procedures have been described above. The minimum frequency of collection is specified by the Offset System rules for sinks projects (< five years since last issuance of Offset Credits). The measurement methods that have been identified are intended to provide a high degree of accuracy by the most practical means.

Given the provision of the necessary documentation required to verify that the project is within the scope of this OSQP, verification is unlikely to occur annually. The Offset System rules for sinks projects specify that verification will occur with a minimum frequency of five years since last issuance of Offset Credits Annual verification is not necessary given the lasting evidence of the activities (i.e. the number and size of the trees).

4.7.6 Contingency Measures for Continuity of Data Collection

Situations where data cannot be collected in a given year through direct field measurement would only affect the field measurements used to calculate above-ground C stocks. The preferred approach in this case is to use applicable growth and yield equations to provide reasonable estimates until field data can be collected. Remote sensing imagery would not be able to provide a sufficiently accurate estimate of above-ground C stocks for the calculation of a project's GHG removals during the period.

There are no procedures for backfilling missing data and no contingency plans for equipment failure or downtime.

4.8 Quantify Emission Reductions

4.8.1 Quantification of Total Emission Reduction

In general, the total reduction in emissions attributed to the project is the sum of the project net emissions subtracted from the sum of the baseline scenario net emissions. In the case of projects described under this QP, the baseline emissions will be zero, hence emission reductions from the project can be represented by Equation 5, above.

4.9 Other Impacts

Urban trees have the capacity to provide numerous co-benefits. They can remove particulates from the atmosphere and purify air. Trees also provide additional elements of biodiversity and they may have some positive impacts on the water table, and in regulating water flow and runoff. They also contribute positive aesthetic values to neighbourhoods and views. While difficult to measure, these benefits of tree planting are often key reasons for planting trees in an urban setting.

Data Management

5 Data Management

5.1 Data Quality Management

In general, data quality management must comply with all requirements of the Offset System Rules. The June 2009 draft GHG Offset *Program Rules and Guidelines for Project Proponents,* released by Environment Canada, states that the Offset System Quantification Protocol will detail the monitoring, data quality assurance/quality control and record-keeping requirements. The Project Proponent is required to develop, practice and document the data management system and controls. Failure to record and maintain the necessary data in accordance with the data management system and controls will likely result in an adverse conclusion in a Verification Statement.

This section of the Protocol sets out the necessary data management requirements. It is recommended that Tree Canada should establish and apply quality management procedures to manage data and information. A data template for recording the overall description of a planting project of any of the four Groups is provided in Appendix A. Once this template has been tested and refined, Tree Canada would be able to draft standard operating procedures for each measurement task outlining who's responsible, when the task is to be performed, what information is to be recorded and how, and where the records are to be kept.

5.1.1 Record keeping

Each project requires the following documentation and assessments:

- Documentation and quantification of pre-project site conditions;
- Documentation of the project;
- Survival assessment after one year;
- Survival assessment after two years; and
- Survival and growth assessment after five years.

Subsequent reporting depends on when Tree Canada chooses to register the project, the start of the crediting period and the reporting periods that are selected. In order to register the project, the project needs to be verified by a third party. Depending on the timing of registration, the verifier may wish to conduct measurements of the project, but that would be done according to the verification protocol being used. A registration period lasts up to eight years, and forest-based biological sinks projects are potentially allowed to be registered for up to five registration periods, according to draft guidelines released by Environment Canada in June 2009.

Once a project begins to sequester carbon, the crediting period begins and this time period is further divided into reporting periods. Offset credits are claimed for each reporting period, and the Minister of the Environment is required to accept a variety of documented evidence before she or he will agree to issue credits. Tree Canada has considerable discretion over the periodicity of reporting. However, reporting periods cannot span multiple registration periods.

For each reporting period, Tree Canada will be required to prepare a Greenhouse Gas Assertion (i.e. a statement quantifying the net emissions from the project during the reporting period) and a Project Monitoring Report. The Assertion must be verified by a qualified third-party. Thus, there are costs associated with each issuance from credits from a project, and Tree Canada will need to balance costs and revenues under various options to determine the optimal frequency of reporting.

The one and two year assessments are intended only to assess tree survival, while the fifth year assessment also gathers data required to estimate growth and yield – i.e. diameter at breast height (1.5 m) and tree height. Subsequent monitoring will also assess these factors.

As recommended in the IPCC GPG LULUCF (2003, Section 4.3.4.4), given the long-term nature of forest projects involving tree planting, data archiving (maintenance and storage) should take several forms and copies of all data should be provided to each project participant/proponent.

Copies (electronic and/or paper) of all field data, digital photos and maps, data analyses, and models; estimates of the changes in carbon stocks and non-CO_2 GHG and corresponding calculations and models used; any GIS products; and copies of the measuring and monitoring reports shall be stored in a dedicated and safe place. These records should be backed regularly and the back-up device should be kept at a second site. Keep all records available for review by a Verification Body or for audit upon request of the Offset System Program Authority.

The June 2009 draft GHG *Offset Program Rules and Guidelines for Project Proponents,* requires project proponents to retain copies of pertinent information and reports for at least eight years after the project registration period has expired, and in fact this required retention period will be longer for projects of the type undertaken by Tree Canada due to the imposition of a 25-year liability period after the last issuance of credits from a project. (Monitoring and reporting is required to continue during this liability period.) Required records include:

- Registered Project Application Form;
- Proof of project start date and project descriptions;
- Proof of Verification Body eligibility;
- All relevant data and information necessary to support the verification, as specified in the Offset System Quantification Protocol;
- Greenhouse Gas Assertion and Project Monitoring Report; and
- Other records that the Minister may specify as appropriate.

5.1.2 Quality Assurance/Quality Control (QA/QC)

Those responsible for the measurement work must be fully trained in all aspects of the field data collection and data analysis. Tree Canada should develop Standard Operating Procedures (SOPs) for each step of the field measurements described above, in accordance with IPCC GPG LULUCF (2003, Section 4.3.4). These SOPs would detail all phases of the field measurements and contain provisions for documentation for verification purposes, so that field personnel can check previous results and verifiers can reproduce the measurement results. The SOPs should also provide for a listing of the names of the field team and show that the required steps have been followed.

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include but are not limited to:

- Protecting data records (storage in two locations; electronic copies of paper records);
- Checking data integrity (manual assessment, comparing redundant metered data, and detection of outstanding records/data);
- Comparing current estimates with previous estimates as a 'reality check'; and
- Performing recalculations to make sure no mathematical errors have been made.

5.1.3 Uncertainty Assessment Methodology

The overall target error acceptable in field measurements used as the basis for calculating merchantable or total stem volume has been set at a maximum of 10% of the mean, with a confidence level of 95%. That is, it has been set so that the estimate of mean stem volume will fall within 10% of the actual mean 95% of the time. Carbon stocks are calculated from stem volume using conversion equations. In practice, this means that sites must be sampled with an intensity sufficient to produce estimates within this level of error. This can be achieved by ensuring that sampling plots are of an appropriate size and number.

The target maximum error of 10% applies only to the overall error associated with measurements of tree height, diameter and tree density. The uncertainty assessment methodology is consistent with the IPCC GPG LULUCF 2003, (Section 4.3.3.4.1).

5.2 Project Description and Scope

Environment Canada's Project Guide sets out the requirements for the level of detail required. At a minimum for this OSQP, the proponent must provide:

- Extent of project
- Status prior to project
- Technology used
- Detail on the level of activity
- Overview of the projected reductions (assertion)
- Contact information
- List of stakeholders, roles and responsibilities
- Chronology of events and time period covered
- Identify any incentives and obligations related to this project

A template for recording the descriptive information for a Tree Canada project is provided in Appendix A.

5.2.1 Evidence Required to Demonstrate That a Project is within the Scope

This protocol has been developed to apply to the majority of Tree Canada's planting projects, and the eligibility requirements are provided in section 1. To demonstrate that an afforestation /reforestation project (Group A and B) is within the scope of this QP, Tree Canada must provide evidence that:

a. The project area was non-forest as of December 31, 1989 (all afforestation projects);
b. The project area has been non-forested for at least 50 years (all afforestation projects);
c. That since January 1, 1990, the forest has lost 75% or more of its crown cover due to wildfire, windstorm, insect infestation, or other disturbance;
d. By the end of the fifth year (or later) after the disturbance, there are less than 200 well-distributed young trees per hectare, that are or can be expected to be free-to-grow, or by the end of year three after the disturbance, a registered professional forester provides an opinion that the natural regeneration will not be sufficient to produce a stand with more than 25% tree crown cover at maturity (reforestation projects)
e. There is no legal requirement or other agreement to afforest, reforest or otherwise plant trees on a project site (all projects)
f. The project area is greater than or equal to 1 hectare in size, with a minimum width of 20 metres, measured tree-base to tree-base (stump to stump);
g. The trees established under the project are capable of achieving a minimum height of five metres at maturity;
h. The trees established under this project are capable of achieving a minimum crown cover of 25% at maturity;
i. Less than 50% of the stand will be harvested prior to age 30 and
j. There are currently no or few trees growing on the project site.

The proponent must clearly demonstrate that the project is within the scope of this protocol.

For urban tree planting projects (Groups C and D), Tree Canada must provide evidence that:

a. The trees established under the project are capable of achieving a minimum height of five metres at maturity;
b. The project trees do not displace or crowd out existing live trees on the project site; and
c. There is no legal requirement or other agreement to afforest, reforest or otherwise plant trees on a project site (all projects).

5.2.2 Project Location

Tree Canada must provide information about the location of the project site, or if the site consists of more than one parcel of land, the location of each parcel must be documented. The location must be described to the extent that a third-party could locate the site without difficulty: a third-party certified verifier will be required to verify that the site identified on the maps and photographs falls within the location description provided in the Project Document. Provide the following information at a minimum:

a) Identify the closest community to the site.
b) Provide a map or aerial photo **and** driving directions from the closest community to the site. Include highway numbers, directions and distances in kilometres of the primary access to the site. On the map, outline the site and show a North Arrow. Also include the direction from the primary access to the site. *For example: From Edmonton, travel 14.6 km south on Hwy# 2. Site is adjacent to HWY # 2 on the east side.*
c) Provide the GPS (global positioning system) coordinates of the site perimeter, a legal survey of the boundaries, or if the other two methods are not available, the dimensions and area (length and width in metres; area in hectares) of the site. Where sites are not rectangular provide an estimate of the average length and width of each project side. When using GPS, ensure the receiver is set using NAD83 datum and the readings should be recorded in the dd/mm/ss.s format.
d) Photographs of the site that will assist in its location.

For a Group A or B project on land that was not forested as of December 31, 1989, Tree Canada must state whether these conditions apply to the project site and provide some evidence to support this claim.

Evidence may involve the use of archives and/or maps of land use or land cover, aerial photography or satellite imagery if available, or other types of information that could be verified, around 1990 and for a recent date before the start of the project. Archival records or other information is also required to support a claim that the project land was not forested for at least 50 years prior to the project initiation.

Tree Canada should describe in detail the various operations that would have been likely to occur in the absence of a project being implemented on agricultural land, for example ploughing, fertilization, and pest control applications (numbers of times per year, intensity of application, equipment used).

For a reforestation project on a site that lost 75% or more of its crown cover due to disturbance, the disturbance must be documented and photos or other evidence provided that would support the loss of crown cover.

5.2.3 Activities Outside of Scope

This protocol only applies to projects where there is no or little existing, pre-project tree cover on site prior to site preparation or planting. While Tree Canada should carry out a field survey of the project site if the eligibility is not obvious, additional information should be included with the Project Document to support the claim. Such information could include photographs of the project site, or records of land management practices (e.g. tilling).

It is not appropriate to apply this protocol to projects that involve planting trees on land that has recently been cleared of trees. The scope of this QP does not require explicit accounting of GHG emissions from fertilization activities in the baseline scenarios. This exclusion can result in a lower estimation of GHG reductions/removals resulting from the project activities. However, if the project includes fertilization, the emissions associated with the fertilizer must be calculated and integrated into the quantification analysis.

The scope of this QP does not cover any substitution or emission-delaying effects related to the future use of the biomass harvested from the project. Biomass leaving the site is assumed to be immediately emitted to the atmosphere (consistent with Environment Canada's National GHG Inventory procedures for Kyoto Protocol reporting).[16] This protocol does provide for the calculation of carbon stored in harvested wood products. Tree Canada will not be in a position to have any harvesting that would yield marketable products in its project sites for at least 20 years – when the time comes to take HWP into account, an improved methodology will be in place. Thus the calculation methodology is not specified in this protocol.

[16] http://www.ec.gc.cz/pdb/ghg/

5.2.4 Protocol Flexibility

Flexibility in field sampling design and survey techniques and equipment is permitted, provided that the estimates based on statistical samples are within prescribed bound of accuracy and uncertainty. If applicable, the proponent must indicate and justify why flexibility provisions have been used.

5.3 Data Quality

5.3.1 Reservoirs monitored for potential reversals of removals

Monitoring of above-ground C reservoirs is sufficient over the lifetime of the project to determine whether a significant reversal has occurred. The methodology for quantifying reversals is the same as that for quantifying removals.

Reversal of credited GHG offsets may occur as a result of harvesting, fire, high wind, disease, insects or other pests. As a stock method is described in this protocol for quantifying the sequestered carbon, the quantification of reversals shall be calculated using the same method. That is, the magnitude of the reversal is quantified as the negative change in carbon stocks relative to the previously verified Reduction/Removal report.

Where a reversal has occurred but seasonal conditions restrict Tree Canada from carrying out the required field measurements within the specified time by the Offset System, a provisional estimate of the magnitude of the reversal may be derived using recognized models or peer-reviewed emissions factors.

Appendix A: Template for Tree Canada Planting Project Records

Project Name: ______________________
Tree Canada File #: ______________________
Project Type: A: Afforestation B: Reforestation C: Individual Tree Planting in Rural Areas D: Park Nauralization

Tree Planting Contractor Contact Information:
Name: ______________________
Surface Mail Address: ______________________
Telephone: ______________________ E-mail: ______________________
Role and responsibilities: ______________________

Project Site Owner and Contact Information:
Name: ______________________
Surface Mail Address: ______________________
Telephone: ______________________ E-mail: ______________________
Role and responsibilities: ______________________

Carbon Buyer /Aggregator:
Name: ______________________
Surface Mail Address: ______________________
Telephone: ______________________ E-mail: ______________________
Date of purchase: ______________________ Term of purchase: ______________________

Project Location (prov, municipality, UTM Coordinates): ______________________

Driving Directions: ______________________
Other location information: ______________________
Describe other appended location information (e.g. maps, aerial photos): ______________________

Historic Site Condition (Afforestation Only):
For how many years has the land been cleared of forest? ______________________

Describe the evidence provided that the land has not been forested for at least 50 years: ______________________

December 31, 1989 Site Condition (Afforestation Only): ______________________

Describe the land use and cover on the project site on December 31, 1989 ______________________

Describe the evidence provided of the project site condition at this date. ______________________

Pre-Project Site Condition:
Describe the pre-project land use (e.g. Intensive agriculture, hay cropping, grassland, pasture, no active management) ______________________

(Aff) Is the land expected to stay in the current use if this project is not undertaken? ______________________

(Ref) Is the site eligible due to a recent disturbance? ☐ Yes ☐ No

(Ref) Nature and date of disturbance: ____________________

Describe the pre-project site condition: ____________________

Describe the evidence being provided of the pre-project site condition. ____________________

Are there live trees on the land (before project start)? ☐ Yes ☐ No

If Yes, describe species, size, density (#/ha) ____________________

RPF Opinion Attached? ____________________

Baseline Scenario: General Description:

Location of control plots/ comparison area(s) ____________________

Project: Total area of planting site ________ ha or N/A (?) ________

Number of Planting Sites: ____________________ Date Planted: ____________________

Species /number/size trees /shrubs planted: ____________________

Site Preparation: No ________ Yes (describe) ____________________

Post Plant Treatment No ________ Yes (describe) ____________________

General Description: ____________________

Signatures at Time of Establishment:

Tree Canada /Contractor ____________________

Date ____________________ Print: ____________________

Survival Assessment (Year 1):

Date of Assessment ____________________

Assessment Methodology ____________________

Survival Percentage: ____________________

Comments /Notes (e.g. Distribution of mortality): ____________________

Tree Canada /Assessor ____________________

Date ____________________ Print: ____________________

Assessment (Year 2):

Date of Assessment ____________________

Assessment Methodology ____________________

Survival Percentage: ____________________

Comments /Notes): ____________________

Tree Canada /Assessor ____________________

Date ____________________ Print: ____________________

Stocking Assessment (Year 5):

Date of Assessment ____________________

Assessment Methodology ____________________

Survival Percentage: ____________________

Comments /Notes (e.g. Avg. Height): ____________________

Tree Canada /Assessor ____________________

Date ____________________ Print: ____________________

Appendix B: Afforestation Project Example

In the fall of 2008, Tree Canada implemented an afforestation project on two separate blocks of land, each 2 ha in area, for a total project area of 4 ha. Both blocks of land are located in the rural municipality of Springfield, Manitoba, which is located on the eastern boundary of Winnipeg.

The template in Appendix B is used to provide the basic information related to the project. The template is truncated by the removal of the space for assessment results, since no assessments have yet taken place.

Project Name: Springfield Rural Municipality
Tree Canada File #:
Project Type: **A: Afforestation** B: Reforestation C: Individual Tree Planting in Rural Areas D: Park Nauralization

Tree Planting Contractor Contact Information:
Name: Ken Fosty, Tree Canada Community Advisor-Manitoba
Surface Mail Address: 590 Rupertsland Ave., Winnipeg, MB R2V 0H4
Telephone: 204 586-1365 E-mail: kfosty@icentre.net
Role and responsibilities: To inspect and prepare site, transport and plant trees, clean up site after planting, undertake maintenance and pest control as needed, and infill so as to guarantee 60% survival after 5 years. Assessments at years 1, 2 and 5 are also required.

Project Site Owner and Contact Information:
Name: Rural Municipality of Spring field
Surface Mail Address: 628 Main Street, Oakbank, Manitoba, R0E
Telephone: 204 444-3321 E-mail:
Role and responsibilities: Landowner and eventual manager of the plantations.

Carbon Buyer /Aggregator:
Name:
Surface Mail Address:
Telephone: E-mail:
Date of purchase: Term of purchase:

Project Location (prov, municipality, UTM Coordinates): Cook's Creek SW 8 - 12 - 6E N49" 59.473' x W096" 44.774' Anola NW 20 - 10 - 7E N49" 51.294' x W096" 36.876
Driving Directions:
Other location information: Parcels are about 30 km east of Winnipeg
Describe other appended location information (e.g. maps, aerial photos):

Historic Site Condition (Afforestation Only):
For how many years has the land been cleared of forest? It has been documented as being cleared since the 1970s; which is an approximately 40-year length of time.
Describe the evidence provided that the land has not been forested for at least 50 years:

December 31, 1989 Site Condition (Afforestation Only):

Describe the land use and cover on the project site on December 31, 1989 Both sites have been in grass / hay cover before and after 1989.
Describe the evidence provided of the project site condition at this date. Provincial government photos of the planting site from 1987 support this.

Pre-Project Site Condition:

Describe the pre-project land use (e.g. Intensive agriculture, hay cropping, grassland, pasture, no active management) Both sites were farmed to produce hay or grass during the 1970's - 90's. Conversations with local farmers confirmed this.

(Aff) Is the land expected to stay in the current use if this project is not undertaken? Yes - there is no evident alternative.

(Ref) Is the site eligible due to a recent disturbance? ☐ Yes ☐ No

(Ref) Nature and date of disturbance: ____

Describe the pre-project site condition: ____

Describe the evidence being provided of the pre-project site condition. The site was being used to grow hay.

Are there live trees on the land (before project start)? ☐ Yes ☒ No

If Yes, describe species, size, density (#/ha) ____

RPF Opinion Attached? No

Baseline Scenario: General Description:

The land would continue to remain in hay production.

Location of control plots/ comparison area(s) A one-hectare control plot was identified by the contractor.

Project: Total area of planting site 4 ha or N/A (?) ____

Number of Planting Sites: ____ Date Planted: Sept 22, 2008

Species /number/size trees /shrubs planted: 12,300 trees

Site Preparation: No x Yes (describe) ____

Post Plant Treatment No ____ Yes (describe) ____

General Description: The Cook's Creek plantation (one of the sites) had 6,000 trees planted on it and the second site, Anola, had 6,300 seedlings planted. The stock used was white spruce container stock that was planted by First Nations planters.

Signatures at Time of Establishment:

Tree Canada /Contractor ____

Date ____ Print: ____

The relevant carbon pools for consideration in this project are the above and below-ground live biomass pools. Under the baseline scenario, there are no relevant SSRs to consider, since the land is expected to remain in hay production for the foreseeable future.

The Freedman and Keith publication (1995) does not provide growth and yield curves for managed stands in Manitoba. Of the two adjacent provinces, only for Ontario is there growth and yield data for white spruce on a site of medium productivity. The yield data that are provided are shown in Table B1, as well as the amounts of above- and below-ground biomass and total amount of carbon stored per ha.

Table B1: Biomass and carbon yields.

Age	Merch volume (m^3/ha)	Above-ground biomass (t/ha)	Below-ground biomass (t/ha)	Total live biomass (t/ha)	Total Carbon (TC/ha)
20	4	3.0	0.5	3.5	1.8
40	28	21.0	3.6	24.6	12.3
60	88	66.0	11.2	77.2	38.6
80	172	129.0	21.9	150.9	75.5
100	269	201.8	34.3	236.0	118.0
120	350	262.5	44.6	307.1	153.6

The merchantable volume is converted into equivalent above-ground live biomass by applying a biomass expansion factor of 0.75 for the Prairies (See Appendix D) and the below-ground live biomass is calculated by multiplying the above-ground amount by a root:shoot ratio. The above and below-ground biomass amounts are then multiplied by 50% to arrive at the estimate of carbon. (One tonne of carbon per hectare is equivalent to 3.6667 tonnes of CO_2-equivalent.)

If the Springfield sites can be considered as moderately productive sites, then the plantations in the project can be expected to sequester a total of 472 tonnes of carbon in the first 100 years. Carbon offsets are priced in terms of $/tonne of CO_2 equivalent (CO_2e), and one tonne of carbon is equivalent to 3.6667 tonnes of CO_2e, and thus the plantations are estimated to produce roughly 1730 tonnes CO_2e at 100 years. Over the last few years, prices have ranged from about $5 – 10/$CO_2e$ in North America, with higher prices being accorded to voluntary projects (under the VCS) and projects on the California Climate Action Registry, and lower prices for offset credits sold on the Chicago Climate Exchange. European prices tend to be in the $20 – 30 range, due to a more rigourous regulatory system that is already in place.

There are some sources of uncertainty in the estimates provided above. One of the most obvious is that the site may turn out to be more than moderately productive. This could be because the more fertile lands were generally converted to agriculture so that even relatively poor agricultural land is often more productive than the average forest land. The most black spruce productive sites, according to Plonski (1981), are 66% more productive at 100 years than the next lowest productivity level. (Plonski doesn't have information for white spruce.) Applying this factor to the yields used in Table B1 gives the calculations shown in Table B2.

Table B2. Biomass and carbon using improved yields.

Age	Merch volume (m^3/ha)	Above-ground biomass (t/ha)	Below-ground biomass (t/ha)	Total live biomass (t/ha)	Total Carbon (TC/ha)
20	6.6	5.0	0.8	5.8	2.9
40	46.5	34.9	5.9	40.8	20.4
60	146.1	109.6	18.6	128.2	64.1
80	285.5	214.1	36.4	250.5	125.3
100	446.5	334.9	56.9	391.8	195.9
120	581.0	435.8	74.1	509.8	254.9

These values imply that the 4 ha would yield almost 2870 tonnes of CO_2e at age 100. Because the site quality information is only very general (i.e. it might be considered a good site), this suggests that the plantations may be more productive than the moderate levels reported by Freedman and Keith, although perhaps not as productive as indicated in Table B2. In any event, by the time the plantations are aged 10–15 years, it should be possible to develop a more accurate assessment of future yields and thus if Tree Canada starts with a conservative estimate of offset credits, it will be able to increase its estimate if the plantations turn out to be more productive than expected.

It is also important to recognize that the yields shown in the above tables are based on a fully stocked stand, and so if survival is at a lower level, say 75%, then the yields and carbon storage needs to be adjusted downwar

Appendix C: Urban Tree Planting Project Example

In the spring of 2007, Tree Canada partnered with Trees Ontario to plant trees in Ottawa, Brampton, Vaughan, North Bay, Wasaga Beach, Brockton, Pembroke, and Marathon. The purposes of these projects varied by community, and included the planting of street trees, naturalizing urban areas, and replacing trees killed by the Asian Long-Horned beetle.

The template in Appendix C is used to provide the basic information related to the project. The template is truncated by the removal of the space for assessment results, since no assessments have yet taken place.

Project Name: Trees Ontario 2007-08 Planting
Tree Canada File #:
Project Type: A: Afforestation B: Reforestation **C: Individual Tree Planting in Rural Areas** D: Park Nauralization

Tree Planting Contractor Contact Information:
Name: individual's name, Toronto Region Conservation Authority
Surface Mail Address: 5 Shoreham Drive, Downsview, Ontario M3N 1S4
Telephone: 416 661-6600 E-mail: info@trca.on.ca
Role and responsibilities: To inspect and prepare site, transport and plant trees, clean up site after planting, undertake maintenance and pest control as needed, and infill so as to guarantee 60% survival after 5 years. Assessments at years 1, 2 and 5 are also required.

Project Site Owner and Contact Information:
Name: City of Brampton
Surface Mail Address: 2 Wellington St. W, Brampton, ON L6Y 4S2
Telephone: 905-874-2000 E-mail: info@brampton.on.ca
Role and responsibilities: Landowner and eventual manager of the trees.

Carbon Buyer /Aggregator:
Name:
Surface Mail Address:
Telephone: E-mail:
Date of purchase: Term of purchase:

Project Location (prov, municipality, UTM Coordinates): Elgin Woods Park, X=601,414 Y=4,836,151

Driving Directions: South of the intersection of Elgin Dr. and Main St. S
Other location information: Etobicoke Creek runs through it
Describe other appended location information (e.g. maps, aerial photos): A map of the site has been appended.

Historic Site Condition (Afforestation Only):
For how many years has the land been cleared of forest? It has been parkland since 1945.

Describe the evidence provided that the land has not been forested for at least 50 years: Municipal survey records

December 31, 1989 Site Condition (Afforestation Only):

Describe the land use and cover on the project site on December 31, 1989 N/A for this project type.

Describe the evidence provided of the project site condition at this date. Municipal park staff knowledgeable of the history of Brampton park lands, planning records.

Pre-Project Site Condition:

Describe the pre-project land use (e.g. Intensive agriculture, hay cropping, grassland, pasture, no active management) the site was maintained as a grass lawn before and after 1989.

(Aff) Is the land expected to stay in the current use if this project is not undertaken? N/A for this projec type

(Ref) Is the site eligible due to a recent disturbance? ☐ Yes ☐ No

(Ref) Nature and date of disturbance:

Describe the pre-project site condition: This site was maintained as grass lawn.

Describe the evidence being provided of the pre-project site condition. Digital photo

Are there live trees on the land (before project start)? ☐ Yes ☒ No

If Yes, describe species, size, density (#/ha) Planting is at the density of approx 575 trees/ha, of various species as described below.

RPF Opinion Attached? No

Baseline Scenario: General Description:

The land would continue to remain in as maintained grass lawn.

Location of control plots/ comparison area(s) None

Project: Total area of planting site 0.3 ha or N/A (?)

Number of Planting Sites: 172 trees Date Planted: October 15, 2007

Species /number/size trees /shrubs planted: 28 red maple; 20 white spruce; 26 sugar maple, 25 silver maple, 15 white cedar, 10 each of white pine, linden, poplar; 5 black walnut, 5 beech, 4 red oak and 3 each of European hornbeam, ironwood & crabapple

Site Preparation: No x Yes (describe)

Post Plant Treatment No x Yes (describe)

General Description: A number of shrubs and herbaceous plants were planted as well as the trees; the planting was done near the bank of Etobicoke Creek and was designed to establish a small wetland naturalized area.

Signatures at Time of Establishment:

Tree Canada /Contractor

Date Print:

The relevant carbon pools for consideration in this project are the above and below-ground live biomass pools. Under the baseline scenario, there are no relevant SSRs to consider, since the land is expected to be managed as grass lawn for the foreseeable future. The carbon in the shrubs was not quantified, since the shrubs doe not reach the size required to be considered as a tree.

Diameter and height growth rates were estimated for tolerant hardwoods, white pine and white spruce and cedar for Ontario for sites of medium high productivity. The yield data that are provided are shown in Tables C1-3, as well as the conversion to conical volume and to merchantable above-ground biomass (tonne/ha).

Table C1: Volume Yields from Tolerant Hardwoods

Yrs since Estab	Dbh (cm)	Height (m)	Radius (m)	Indiv Tree Vol (m^3)	All Trees Vol (m^3)	Total Above-ground biomass (t/ha)
0	5	3	0.025	0.00	0.24	0.39
20	20	10	0.1	0.10	12.77	20.95
40	40	15	0.2	0.63	76.65	125.71
60	50	19	0.25	1.24	151.70	248.79
80	60	22	0.3	2.07	252.94	414.83

Table C2: Volume Yields from White Pine

Yrs since Estab	Dbh (cm)	Height (m)	Radius (m)	Indiv Tree Vol (m^3)	All Trees Vol (m^3)	Total Above-ground biomass (t/ha)
0	5	3	0.025	0.00	0.02	0.03
20	30	12	0.15	0.28	2.83	1.03
40	50	18	0.25	1.18	11.78	8.24
60	65	25	0.325	2.77	27.65	22.08
80	80	30	0.4	5.03	50.26	43.76

Table C3: Volume Yields from White Spruce & Cedar

Yrs since Estab	Dbh (cm)	Height (m)	Radius (m)	Indiv Tree Vol (m^3)	All Trees Vol (m^3)	Total Above-ground biomass (t/ha)
0	5	3	0.025	0.00	0.07	0.11
20	20	10	0.1	0.10	3.66	6.01
40	35	16	0.175	0.51	17.96	29.45
60	50	22	0.25	1.44	50.39	82.64
80	60	25	0.3	2.36	82.46	135.24

Table C4: Above- and Below-ground Biomass and Carbon.

Yrs since Estab	Total above Grnd Biomass (t/ha)	Total Above & Below Grnd Biomass (t/ha)	Total Above & Below Grnd Carbon (t/ha)	Total Above & Below Grnd CO_2e (t/ha)
0	0.45	0.08	0.24	0.89
20	23.91	4.10	12.74	46.72
40	141.56	23.91	76.54	280.68
60	292.85	51.73	154.91	568.04
80	490.14	86.90	260.07	953.67

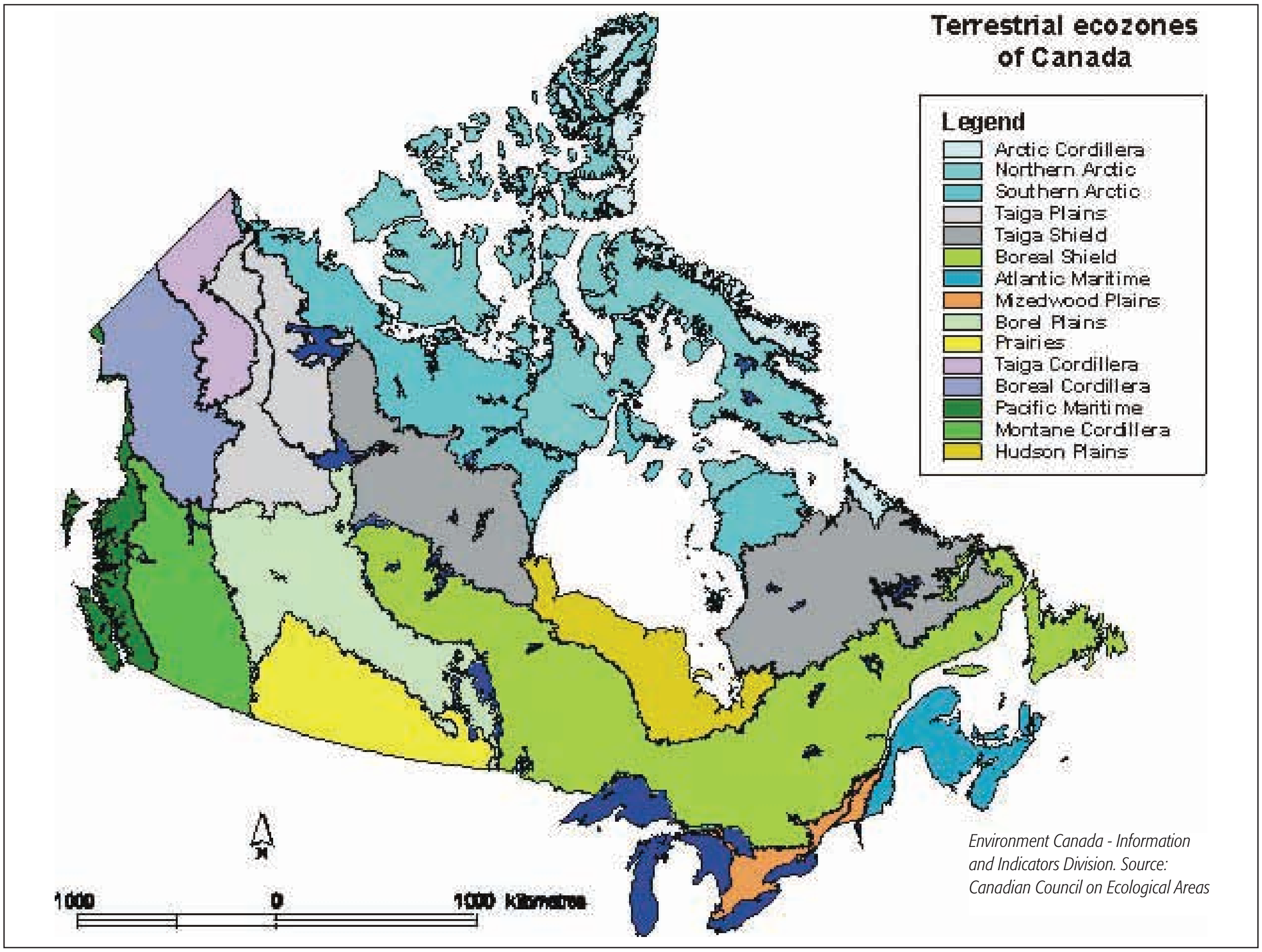
Merchantable volume was converted to total above-ground biomass using a biomass expansion factor of 1.64, from Freedman and Keith (1995), for tolerant hardwoods and a BEF of 0.69 for white pine and cedar/spruce (See Appendix D). The merchantable tree volume was multiplied by the root: shoot ratios for the Ontario Mixedwood Plains Ecozone to estimate the below-ground biomass, and then the total biomass was divided in half to develop the estimate of carbon.

The total biomass volumes and carbon volumes are as shown in Table C4. The total potential amount of offset credits produced over an 80 year period would be 954, if all trees survived and grew according to the projected development rate. If an assurance factor of 25% was set aside, then roughly 715 tonnes of CO_2-e could be sold as offset credits.

Appendix D: Allometric Equations

Figure D1 shows the terrestrial ecozones of Canada (Environment Canada, 1996; Kull *et al*, 2006), by which the biomass expansion factors (Table D1) and root-shoot ratios (Table D2) shown below are organized.

Figure D1. The Terrestrial Ecozones of Canada (Environment Canada, 1996; Kull *et al.,* 2006).



BEF (t/m³) convert merchantable volume (m³/ha) to above-ground biomass (t/ha). All factors standardized to 100 m³/ha. BEF derived from CBM-CFS3 (Kurz *et al,* 2009). Volumes are net merchantable for British Columbia; all other jurisdictions use gross merchantable volume. Source: Kurz, W.A., Dymond, C.C., White, T.M., Stinson, G., Shaw, C.H., Rampley, G.J., Smyth, C., Simpson, B.N., Neilson, E.T., Trofymow, J.A., Metsaranta, J., Apps, M.J. 2009. CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards, Ecological Modelling, 220: 480–504, doi:10.1016/j.ecolmodel.2008.10.018.

Note that the "Other Hardwood" column in Tables D1 and D2 is appropriate for intolerant hardwoods such as birch and poplar, but is too low for tolerant and mid-tolerant hardwoods such as maple, cherry, and beech. For such species, a factor of 1.64 was used by Freedman and Keith (1995).

Table D1. Stand level BEF for different regions and species in Canada. BEF convert merchantable volume (m^3/ha) to biomass (t/ha). All factors standardized to 100 m^3/ha.

	Region	Species				
Province	**Terrestrial Ecozone**	**Hybrid poplar**	**Pine**	**Spruce**	**Other HW**	**Other SW**
AB	Boreal Plains	0.28	0.23	0.27	0.31	0.24
AB	Boreal Shield West	0.29	0.24	0.24	0.29	0.24
AB	Montane Cordillera	0.26	0.27	0.27	0.31	0.26
AB	Prairies	0.29	0.24	0.24	0.31	0.24
AB	Taiga Plains	0.27	0.19	0.21	0.27	0.22
AB	Taiga Shield West	0.27	0.22	0.22	0.27	0.22
BC	Boreal Cordillera	0.37	0.28	0.30	0.32	0.30
BC	Boreal Plains	0.34	0.25	0.24	0.33	0.24
BC	Montane Cordillera	0.35	0.26	0.26	0.35	0.33
BC	Pacific Maritime	0.35	0.46	0.32	0.34	0.38
BC	Taiga Plains	0.33	0.20	0.24	0.31	0.23
Lab.	Boreal Shield East	0.26	0.26	0.24	0.26	0.26
Lab.	Taiga Shield East	0.26	0.22	0.18	0.26	0.22
MB	Boreal Plains	0.22	0.15	0.18	0.22	0.17
MB	Boreal Shield West	0.23	0.15	0.18	0.23	0.16
MB	Hudson Plains	0.23	0.16	0.16	0.23	0.16
MB	Prairies	0.22	0.17	0.17	0.22	0.17
MB	Taiga Shield West	0.23	0.16	0.16	0.23	0.16
NB	Atlantic Maritime	0.27	0.18	0.19	0.27	0.18
Nfld.	Boreal Shield East	0.26	0.26	0.24	0.26	0.26
NS	Atlantic Maritime	0.26	0.34	0.19	0.29	0.19
NU	Hudson Plains	0.26	0.18	0.18	0.26	0.18
NU	Taiga Shield West	0.24	0.20	0.20	0.24	0.20
NWT	Boreal Cordillera	0.26	0.19	0.19	0.26	0.19
NWT	Boreal Plains	0.29	0.24	0.24	0.29	0.24
NWT	Taiga Cordillera	0.26	0.19	0.19	0.26	0.19
NWT	Taiga Plains	0.24	0.20	0.20	0.24	0.2
NWT	Taiga Shield West	0.24	0.20	0.20	0.24	0.20
ON	Boreal Shield East	0.23	0.16	0.18	0.23	0.17
ON	Boreal Shield West	0.23	0.16	0.18	0.23	0.17
ON	Hudson Plains	0.26	0.18	0.18	0.26	0.18
ON	Mixedwood Plains	0.24	0.15	0.15	0.24	0.15
PEI	Atlantic Maritime	0.26	0.19	0.18	0.28	0.19
QC	Atlantic Maritime	0.25	0.17	0.19	0.28	0.19
QC	Boreal Shield East	0.24	0.16	0.18	0.27	0.18
QC	Hudson Plains	0.26	0.18	0.18	0.26	0.18
QC	Mixedwood Plains	0.24	0.16	0.20	0.26	0.17
QC	Taiga Shield East	0.26	0.18	0.18	0.26	0.18
SK	Boreal Plains	0.23	0.16	0.19	0.23	0.18
SK	Boreal Shield West	0.23	0.18	0.19	0.23	0.19
SK	Taiga Shield West	0.23	0.16	0.16	0.23	0.16
SK	Prairies	0.22	0.17	0.17	0.22	0.17
YT	Boreal Cordillera	0.26	0.19	0.19	0.26	0.19
YT	Pacific Maritime	0.34	0.38	0.38	0.34	0.38
YT	Taiga Cordillera	0.26	0.19	0.19	0.26	0.19
YT	Taiga Plains	0.31	0.23	0.23	0.31	0.23

Root-to-shoot ratios for all provinces and ecozones are listed in Table D2.

The root:shoot ratio (t/m^3) is used to convert merchantable volume (m^3/ha) to below-ground (i.e., roots) biomass in t/ha. All factors standardized to 100 m^3/ha. R:S derived from CBM-CFS3 (Kurz *et al,* 2009). Volumes are net merchantable for British Columbia; all other jurisdictions use gross merchantable volume. Source: Kurz, W.A., Dymond, C.C., White, T.M., Stinson, G., Shaw, C.H., Rampley, G.J., Smyth, C., Simpson, B.N., Neilson,

E.T., Trofymow, J.A., Metsaranta, J., Apps, M.J. 2009. CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards, Ecological Modelling, 220: 480–504, doi:10.1016/j.ecolmodel.2008.10.018.

To determine root biomass (t/ha), multiply merchantable volume of the stand (m^3/ha) by the root-to-shoot ratio. For reference purposes, the Terrestrial Ecozones of Canada are shown in Figure D1.

Table D2. Stand level root-to-shoot ratios for different regions and species in Canada. Root-to-shoot ratios convert merchantable volume (m^3/ha) to biomass (t/ha). All factors standardized to 100 m^3/ha.

	Region	Species				
Province	**Terrestrial Ecozone**	**Hybrid poplar**	**Pine**	**Spruce**	**Other HW**	**Other SW**
AB	Boreal Plains	0.28	0.23	0.27	0.31	0.24
AB	Boreal Shield West	0.29	0.24	0.24	0.29	0.24
AB	Montane Cordillera	0.26	0.27	0.27	0.31	0.26
AB	Prairies	0.29	0.24	0.24	0.31	0.24
AB	Taiga Plains	0.27	0.19	0.21	0.27	0.22
AB	Taiga Shield West	0.27	0.22	0.22	0.27	0.22
BC	Boreal Cordillera	0.37	0.28	0.30	0.3	20.30
BC	Boreal Plains	0.34	0.25	0.24	0.33	0.24
BC	Montane Cordillera	0.35	0.26	0.26	0.35	0.33
BC	Pacific Maritime	0.35	0.46	0.32	0.34	0.38
BC	Taiga Plains	0.33	0.20	0.24	0.31	0.23
Lab.	Boreal Shield East	0.26	0.26	0.24	0.26	0.26
Lab.	Taiga Shield East	0.26	0.22	0.18	0.26	0.22
MB	Boreal Plains	0.22	0.15	0.18	0.22	0.17
MB	Boreal Shield West	0.23	0.15	0.18	0.23	0.16
MB	Hudson Plains	0.23	0.16	0.16	0.23	0.16
MB	Prairies	0.22	0.17	0.17	0.22	0.17
MB	Taiga Shield West	0.23	0.16	0.16	0.23	0.16
NB	Atlantic Maritime	0.27	0.18	0.19	0.27	0.18
Nfld.	Boreal Shield East	0.26	0.26	0.24	0.26	0.26
NS	Atlantic Maritime	0.26	0.34	0.19	0.29	0.19
NU	Hudson Plains	0.26	0.18	0.18	0.26	0.18
NU	Taiga Shield West	0.24	0.20	0.20	0.24	0.20
NWT	Boreal Cordillera	0.26	0.19	0.19	0.26	0.19
NWT	Boreal Plains	0.29	0.24	0.24	0.29	0.24
NWT	Taiga Cordillera	0.26	0.19	0.19	0.26	0.19
NWT	Taiga Plains	0.24	0.20	0.20	0.24	0.20
NWT	Taiga Shield West	0.24	0.20	0.20	0.24	0.20
ON	Boreal Shield East	0.23	0.16	0.18	0.23	0.17
ON	Boreal Shield West	0.23	0.16	0.18	0.23	0.17
ON	Hudson Plains	0.26	0.18	0.18	0.26	0.18
ON	Mixedwood Plains	0.24	0.15	0.15	0.24	0.15
PEI	Atlantic Maritime	0.26	0.19	0.18	0.28	0.19
QC	Atlantic Maritime	0.25	0.17	0.19	0.28	0.19
QC	Boreal Shield East	0.24	0.16	0.18	0.27	0.18
QC	Hudson Plains	0.26	0.18	0.18	0.26	0.18
QC	Mixedwood Plains	0.24	0.16	0.20	0.26	0.17
QC	Taiga Shield East	0.26	0.18	0.18	0.26	0.18
SK	Boreal Plains	0.23	0.16	0.19	0.23	0.18
SK	Boreal Shield West	0.23	0.18	0.19	0.23	0.19
SK	Taiga Shield West	0.23	0.16	0.16	0.23	0.16
SK	Prairies	0.22	0.17	0.17	0.22	0.17
YT	Boreal Cordillera	0.26	0.19	0.19	0.26	0.19
YT	Pacific Maritime	0.34	0.38	0.38	0.34	0.38
YT	Taiga Plains	0.31	0.23	0.23	0.31	0.23
YT	Taiga Cordillera	0.26	0.19	0.19	0.26	0.19

Appendix E: Wood Density by Species

Source of wood density data:

Forest Products Laboratory, 1999, *Wood handbook–Wood as an engineering material.* Gen. Tech. Rep. FPL–GTR–113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 463p.
http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr113/fplgtr113.htm

The following density values (converted from specific gravities) for a selection of species, and additional data may be found in the above reference. The data is for green wood and are taken from Chapter 4 of the above-noted reference, Tables 4-3a and 4.4a. The data on woods grown in Canada originally came from:

Kennedy, E.I., 1965, *Strength and related properties of woods grown in Canada.* Government of Canada, Department of Forestry, Headquarters, Ottawa, Ontario. Department of Forestry Publication 1104.

SpeciesDensity	**(t/m³)**
Trembling aspen	0.37
Black cottonwood	0.30
Willow (US)	0.39
White birch	0.51
Sugar maple	0.60
White ash	0.57
Red oak	0.58
Black walnut	0.55
Balsam fir	0.34
Lodgepole pine	0.40
Ponderosa pine	0.44
Red pine	0.39
Jack pine	0.42
White pine (eastern & western)	0.36
White spruce	0.35
Douglas-fir	0.45
Western larch	0.55
Western red cedar	0.31
Tamarack	0.48

If the species planted is not included in the listed references, then the following “default” densities may be used:

Softwoods and hybrid poplars	0.37
Deciduous hardwoods	0.60

Appendix F: Definitions of Key Terms

Above-Ground Live Biomass
Live trees including the stem, branches, leaves or needles, brush and other woody live plants above ground.

Additionality
Forest project practices that exceed the baseline characterization, including any applicable mandatory land use laws and regulations.

Allometric equation
An equation that utilizes the genotypical relationship among tree components to estimate characteristics of one tree component from another. Allometric equations allow the below-ground root volume to be estimated using the above-ground bole volume.

Baseline Activity
The volume/biomass of harvest, inventory and growth of forests and forest products associated.

Biological emissions
For the purposes of the forest protocol, biological emissions are GHG emissions that are released directly from forest biomass, both live and dead, including forest soils. In the first three years of reporting the only biological emission type that is required to be reported for forest entities and projects is CO_2, as identified in the Quantification Section of the protocol. Biological emissions are deemed to occur when the reported tonnage of carbon stocks decline at the project level.

Biomass Expansion Factor
A scientifically established factor which when applied to a tree can convert a readily measurable entity (e.g. volume) into an estimate of biomass, either above-ground or below-ground.

Biomass
The total mass of living organisms in a given area or volume; recently dead plant material is often included as dead biomass.

Bole
A trunk or main stem of a tree.

Carbon Pool
A reservoir that has the ability to accumulate and store carbon or release carbon. In the case of forests, a carbon pool is the forest biomass, which can be subdivided into smaller pools. These pools may include above-ground or below-ground biomass or harvested wood products, among others.

Carbon Reservoir
Physical unit or component of the biosphere, geosphere or hydrosphere with the capacity to store or accumulate carbon removed from the atmosphere by a sink or a carbon captured from a source. This refers to either naturally occurring areas that have the ability to hold carbon or manmade areas.

Carbon Sink
Physical unit or process that removes a GHG from the atmosphere.

Carbon Source
Physical unit or process that releases carbon into the atmosphere.

Carbon Stocks
The carbon contained in identified forest biomass categories (i.e. carbon pools), such as above and below-ground biomass.

De minimis
The emissions associated with a carbon pool at any point during the project life is so minor as to merit disregard; defined as less than or equal to 5% on a cumulative basis for total carbon stocks.

Downed woody debris
Any piece(s) of dead woody material from a tree, e.g. dead boles, limbs, and large root masses, on the ground in forest stands. The Reserve requires the carbon in lying dead biomass with a minimum diameter of six inches to be measured.

Direct emissions
Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.

Forest Management
The commercial or noncommercial growing and harvesting of forests.

Forest Project
A planned set of activities to remove, reduce or prevent carbon dioxide emissions in the atmosphere by conserving and/or increasing forest carbon stocks.

Forest project baseline
A long-term forecast of the forest practices (or absence thereof) that would have occurred within a project's boundaries in the absence of the project activity.

Forest project greenhouse gas reduction
Removals or reductions of CO_2 and prevented CO_2 emissions resulting from Reserve-approved forest projects. GHG reductions are calculated as gains in carbon stocks over time relative to the project baseline.

Free-to-Grow
A condition in which a forest is considered established based on a minimum stocking standard, a minimum height and freedom from competition that could impede growth.

Good Practices Guidance
A practice or usually a combination of practices that are determined by a survey of experts to be the most effective and practicable means (including technological, economic, and institutional considerations) of undertaking the intended operation. In 2003, the IPCC released a widely-used good practice guide for land use, land use change and forestry projects.

GHG Assessment Boundary
Encompasses all primary and significant secondary effects associated with the project activities.

GHG Reductions
See forest project greenhouse gas reduction. Greenhouse Gases

(GHG)
For the purposes of the Reserve, GHGs are the six gases identified in the Kyoto Protocol: Carbon Dioxide (CO_2), Nitrous Oxide(N_20), Methane(CH_4), Hydroflourocarbons (HFCs), Perflourocarbons (PFCs), and Sulphur Hexafluoride(SF_6).

Grossly Negligent
Conscious and voluntary disregard of the need to use reasonable care, which is likely to cause foreseeable grave injury or harm to persons, property, or both.

Leakage
A situation where emissions shift from one location to another resulting in a direct increase in emissions.

Mean Annual Increment
The average volume production per year for a forest of known age.

Native Forest
For the purposes of this protocol native forests shall be defined as those occurring naturally in an area, as neither a direct nor indirect consequence of human activity post-dating European settlement.

Non-Biological Emissions
Greenhouse gas emissions that are not directly released from biomass. For example, GHGs from fossil fuel combustion qualify as non-biological emissions.

Non-Forest Cover
Land with a tree canopy cover of less than 10 percent.

Permanence
Refers to the duration of the greenhouse gas reductions that are achieved and maintained as a consequence of the forest project. Pursuant to this protocol, forest-based reductions shall be permanent and are considered permanent when maintained for 100 years.

Primary Effects
The intended change caused by a project activity in GHG emissions, removal, or storage associated with a GHG source, sink, or reservoir.

Project Developer (PD)
An entity that undertakes a project activity, as identified in the Forest Project Protocol. A Project Developer may be an independent third-party or the forest owner.

Project Guidance
Outline of process and requirements for undertaking projects.

Project Life
Refers to the duration that a project activity and its associated monitoring and verification are maintained.

Quantification Protocol (QP)
A document that describes the procedures for defining a carbon project of a specific class and for determining the quantity of carbon offsets produced.

Reforestation
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 10 years or have been subject to a significant disturbance within the last ten years that is not the result of intentional or grossly negligent acts of the landowner or reporting entity. This activity is also a type of project for public or private forest lands

Registered Professional Forester (RPF)
A professional engaged in the science and profession of forestry who is credentialed in provinces that have professional forester licensing laws and regulations. Where a province or territory does not have a professional forester law or regulation, then a professional forester is defined as having the Certified Forester credentials managed by the Canadian Institute of Foresters (see www.certifiedforester.org).

Reversal
The loss of verified reductions.

Secondary Effects
An unintended change caused by a project activity. A secondary effect may result in a GHG reduction or a GHG emission.

Sequestration
The process of increasing the carbon content of a carbon reservoir other than the atmosphere. Biological approaches to sequestration include direct removal of CO_2 from the atmosphere through land-use changes and changes in forest management.

Significant disturbance
Any natural impact that results in a loss of least 20% of the above-ground live biomass that is not the result of intentional or grossly negligent acts of the forest entity or Project Developer.

Sinks, Sources and Reservoirs
A sink is any process, activity or mechanism that removes a greenhouse gas from the atmosphere. A source is any process or activity that releases a greenhouse gas into the atmosphere. A reservoir is a physical unit or component of the atmosphere, geosphere or hydrosphere with the capability to store or accumulate a greenhouse gas removed from the atmosphere.

Standing dead biomass
Standing dead tree or section thereof, regardless of species, with minimum diameter of three inches.

Tree
A woody plant that is usually single-stemmed and has the potential to reach a height of 5 m at maturity. This definition excludes woody shrubs but it would include agroforestry projects that include the planting of a sufficient number of trees, including fruit trees that meet the height requirements.

Validation
The process of establishing evidence that provides a high degree of assurance that a product, service, or system accomplishes its intended requirements. This often involves acceptance of fitness for purpose with end users and other product stakeholders.

Verification
The process used to ensure that a given participant's greenhouse gas emissions or emissions reductions has met the minimum quality standard and complied with the requirements of the offset system under which the project is to be registered.

Appendix G: List of Acronyms

A/R	Afforestation/ Reforestation
BEF	Biomass Expansion Factor
CCAR	California Climate Action Registry
CFS	Canadian Forest Service
CO_2	Carbon Dioxide
FM	Forest Management
GHG	Greenhouse Gas
HWP	Harvested Wood Products
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change and Forestry
N_2O	Nitrous Oxide
OC	Offset Credits
OSQP	Offset System Quantification Protocol
QA/QC	Quality Assurance/Quality Control
QP	Quantification Protocol
R/R	Reductions and/or Removals
SOP	Standard Operating Procedure
SSR	Sinks, Sources and Reservoirs