GHG Report
CSA Standards GHG CleanProjects™ Registry

Carbone boréal
Afforestation project

http://carboneboreal.uqac.ca/

Université du Québec à Chicoutimi

555 boul. Université

Chicoutimi, Qc, G7H 2B1

Canada

418-545-5011 x-2343

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Glossary, Abbreviations and Key terms

Accuracy - Reduce bias and uncertainties as far as practical.

"Affected" GHG source, sink or reservoir - GHG source, sink or reservoir influenced by a project activity by changes in market demand or supply for associated products or services, or through physical displacement.

Baseline Scenario - A hypothetical reference case against which the performance of a project will be measured.

BSFM - Black Spruce-Feathermoss forest stand type.

Carbon dioxide equivalent - A unit that expresses any greenhouse gas in terms of carbon dioxide that is calculated using the mass of a given greenhouse gas multiplied by its global warming potential.

Carbon stock – The quantity of carbon held within a reservoir at a specified time, expressed in units of mass.

CBM-CFS3 – The Carbon Budget Model of the Canadian Forest Sector, version 3.

Conservativeness - Use of conservative assumptions, values and procedures to ensure that GHG emission reductions are not over-estimated.

"Controlled" GHG source, sink or reservoir - GHG source, sink and reservoir whose operation is under the direction and influence of a Project Proponent through financial, policy, management or other instruments.

CSA – The Canadian Standard Association.

"Downstream" Source, Sinks and Reservoirs (SSRs) - Transportation of product(s) from the project/baseline site

Dynamic Baseline – A baseline is dynamic if the method to quantify the baseline's emissions depends on parameters that will change during the registration period. For example the amount of energy needed to heat a building varies due to the weather. The level of emissions of a Dynamic Baseline is determined ex-post (i.e., once the parameters have been quantified) but the formula to calculate the baseline's emissions is provided in the Project application form.

Emission Factor – An emission factor (EF) is a representative value that can be used to estimate the rate (or quantity) at which a pollutant is released into the atmosphere (or captured) as a result of a process or activity. The EFs used may be average or general EFs, or technology-specific.EFs. They are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e. g., kilograms of particulate emitted per megagram of coal burned).

FAO – The Food and Agriculture Organization of the United Nations (www.fao.org).

Forest - Area of 1 ha or more where tree formations can reach at least 25% crown cover and 5 m in height in situ (Environment Canada 2006).

Functional equivalence - The quantity and quality of the services or products in the project case must be equivalent to the quantity and quality of the services or products in the baseline scenario.

Global Warming Potential (GWP) - A GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. By definition the GWP of carbon dioxide is 1. The GWP values for all other greenhouse gases are greater than 1, and are provided in the last IPCC guidelines (IPCC 2006).

Good Practice Guidance - A set of recognized criteria, methodologies tools and guidance for a specific project type or sector.

Greenhouse gas (GHG)- A gas emitted to the atmosphere from natural sources and /or as the result of human activity. GHGs both absorb and reflect the sun's radiation. GHGs normally covered under most protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perflurocarbons, and sulphur hexafluoride.

Incremental - An eligibility criterion defining the conditions beyond which Offset Projects can create reductions. Conditions include the start date, baseline, legislative and voluntary requirements, and treatment of incentives.

IPCC – The Intergovernmental Panel on Climate Change (www.ipcc.ch).

Justify – To include a reasonable explanation of why decisions were made; how decisions are appropriate to the specific circumstances of the GHG project and why alternative options were declined.

"Key" Sources, Sinks and Reservoirs – GHG source, sink or reservoir that are determined to be high risk and/or which have the potential for a large amount of reductions/removals.

LCA - Life-cycle assessment.

Monitor - To observe any changes that may occur over time.

MRNF – The *Ministère des Ressources naturelles et de la Faune*, Province of Québec, Canada.

Offset Credit - A credit issued by Environment Canada to a Project Developer for eligible GHG reductions/removals achieved from an Offset Project. One credit represents one tonne of carbon dioxide equivalent emissions reduced or removed.

Offset Project - A GHG reduction project that has been registered in the Offset System.

"On-site" S**ources, Sinks and Reservoirs – A**ctivities related to the operation of the project/baseline that occur in the physical location of the project and/or baseline.

OW – An open woodland stand type.

Quantifiable - An eligibility criterion requiring that the emissions and removals in both the baseline and project scenarios can be measured or estimated in accordance with an approved Offset System Quantification Protocol.

Real - An eligibility criterion requiring that the Offset Project be a specific and identifiable action that results in net GHG emission reductions or removals after leakage (emissions being shifted to another site or source) is taken into account.

Reduction (greenhouse gas reduction) - A decrease in GHG emissions released into the atmosphere by a source.

"Related" source, sinks and reservoirs - GHG source, sink or reservoir that has material or energy flows into, out of, or within the project.

Note 1. 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.

Note 2. A related GHG source, sink or reservoir also may include activities related to design, construction and decommissioning of a project.

"Relevant" greenhouse gas sources, sinks and reservoirs - The set of controlled, related and affected GHG sources, sinks and reservoirs for the baseline and project scenarios, which must be measured or estimated to quantify the greenhouse gas reduction or removal achieved by the project.

Removal (emission removal) - The process of increasing the carbon stock in a reservoir other than the atmosphere.

Reservoir – For the purpose of this *Guide*, a reservoir means a physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate GHGs

Reversal – A reversal is a decrease in the stored carbon stocks associated with quantified GHG reductions and removals that occurs before the end of the project duration. In this project (and in agreement with the QP used in this project), a reversal is deemed to have occurred if there is a decrease in the difference between project and baseline onsite carbon stocks from one measurement period to the next, regardless of the cause of this decrease – i.e. if the result of ($Afforestation_{OW\ at\ time\ X} = \Sigma$ net $removals_{project\ at\ time\ X} - \Sigma$ net $removals_{baseline\ at\ time\ X}$) in Equation [11] of the QP is lower than that at the preceding measurement period.

Sink - For the purpose of this *Guide*, a sink means any process, activity or mechanism that removes a GHG from the atmosphere.

Source - For the purpose of this *Guide*, a source means any process or activity that releases GHGs into the atmosphere.

Sequestration - The holding or storage of carbon in a reservoir.

Static Baseline - Baseline emission estimates that do not change during the registration period.

Unique - An eligibility criterion requiring that a greenhouse gas reduction or removal be used only once to create an Offset Credit.

UQAC – The *Université du Québec à Chicoutimi*, Qc, Canada.

Variable - A number or amount that can change over time.

Verifiable - An eligibility criterion requiring that government-recognized third-party Verification Bodies be able to confirm that the reductions or removals have been achieved as claimed.

Verification Body – An independent entity, similar to an auditor, that has been recognized as having the qualifications and experience to verify the greenhouse gas reduction/removal claims related to specified project types.

"Upstream" Sources, Sinks and Reservoirs - include the production of project inputs used on an ongoing basis during project/baseline system operation.

Table of contents

List of tables

List of figures

1. ISO 14064 principles

Relevance

The Carbone boréal project proponent selected GHG sources, sinks reservoirs (GHG SSRs), data and methodologies from existing best practices that are appropriate and are consistent with the project. The chosen methodology, developed from the clean development mechanism (CDM) AR-ACM001 is specifically adapted to afforestation in boreal ecosystems and was validated by an expert committee.

Completeness

All relevant GHG SSRs are quantified and included within the project documentation. Rationale is provided for all relevant GHG emissions and removals as per the methodology used for the project.

Consistency

The methodology used is accurate and appropriate for the OW's afforestation and project and allows for meaningful comparison. Quantification between the baseline and project scenario demonstrate equivalent level of service.

Accuracy

Bias and uncertainties on estimations were reduced as far as practical.

Transparency

The Carbone boréal team disclose openly and transparently all sources of information, calculations, data, and assumptions via its web site (http://carboneboreal.uqac.ca), and also via an advisory committee. The GHG Report and the GHG assertion contained therein to allow intended users to make decisions with reasonable confidence. Project documentation includes numerous references to data sources and calculation methodology and allows for easy understanding and/or reproduction of the calculation and is readily accessible on CSA's GHG CleanProject™ registry.

Conservativeness

The Carbone boréal project uses conservative assumptions, values and procedures to ensure that GHG emission removal enhancements are not over-estimated.

2. Project Description

2.1. Project title

Carbone boréal; afforestation of open woodlands (OWs) in Québec's boreal forest.

2.2. The project's purpose(s) and objective(s)

The Université du Québec à Chicoutimi (UQAC)'s Chaire en éco-conseil develops this research project, which is also a carbon offset program. The offsets are provided by the establishment of experimental plantations in naturally occurring (due to regeneration failures, e.g. after successive wildfires) open black spruce-lichen woodlands (hereafter shortened to open woodlands or OWs) and that do not self-regenerate. These types of OW are present within the Canadian closed-crown boreal forest. In Québec's closed-crown boreal forest, OWs are located on crown lands. Restocking of OWs complies with the Kyoto's protocol definition of afforestation. Quantification of carbon sequestration will be documented based on ISO 14064-2 standard and quantified with a specific quantification protocol that was elaborated by UQAC's researcher and validated though an independent experts' panel. Plantations and carbon sequestration affirmations are to be verified, accordingly to ISO 14064-3, by an independent third party: the Bureau de normalisation du Québec (BNQ). The experimental plantations are protected by Québec's forest Law under the "Experimental forest" status, so that they cannot be accounted in the province's forest potential and are therefore fully additionals.

2.3. Expected lifetime of the project

2008-2018 for the afforestation period and 2118 for the total ex-post sequestered carbon.

2.4. Type of greenhouse gas emission reduction or removal project

Removal project through afforestation of OWs that comply with the Kyoto Protocol definition of non-forest (article 3.3).

2.5. Legal land description of the project or the unique latitude and longitude

The experimental plantations are protected by Québec's forest Law under the "Experimental forest" status. (Loi sur les forêts, Chapitre V, Section I, Articles 107-109).

2008 afforested plots: 50.59°N-71.76°W

2009 afforested plots: 50.64°N-71.83°W

2010 afforested plots: 50.12°N, 73.22°W

2011 afforested plots: 48.37°N, 72.55°W

2012 afforested plots: 50.23°N, 72.52°W

2013 afforested plots: 50.50°N, 72.66°W

2014 afforested plots: Bloc 1: 50.15°N, 72.30°W

Bloc 2 and 3: 50.42°N, 72.40°W

2016 afforested plots: 51.26°N, 71.31°W

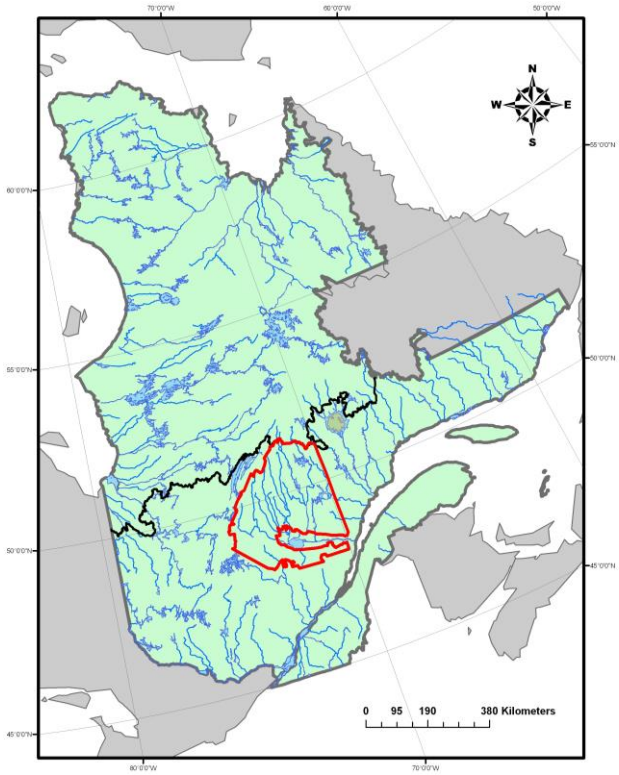


Figure 1: Carbone boréal plantation territory. The territory is within the closed-crown boreal forest zone (Québec's Ministère des Ressources naturelles et de la Faune).

2.6. Conditions prior to project initiation

No activities prior to project.

2.7. Description of how the project will achieve GHG emission reductions or removal enhancements

Baseline scenario is that naturally OWs are in a steady state of non-

forests. These types of OW are present within the Canadian closed-crown boreal forest, on Crown lands. Restocking of OWs complies with the Kyoto's protocol definition of afforestation.

It was scientifically demonstrated that regeneration failure in the boreal forest can sometimes occur, resulting in the irreversible conversion of closed-crown black spruce-feathermoss stands to OWs (Payette, 1992; Gagnon and Morin, 2001; Jasinski and Payette, 2005). To this day, there is no evidence of natural redensification of OWs, i.e. a shift to closed-crown BSFM stand (Payette, 1992; Jasinski and Payette, 2005). Moreover, a recent study showed a gradual increase in OW generation over the past 50 years (Girard et al., 2008). The most recent Quebec forest inventory reveals that approximately 7% (1.6 M ha) of the boreal zone is made up of OWs (MNRF, 3rd decennial forest inventory).

Initial carbon stocks in OWs may vary, but in all cases the increase in stocks over time is expected to be much lower than that in the project scenario, particularly in both the above and belowground C stocks (Gaboury et al. 2009). The Carbone boréal project aims at afforesting OW's to achieve a minimal carbon net average sequestration increase of 4 tons CO2 per hectare over a 70 years period (see figure 2). Project activities include the monitoring of both intact OWs (baseline scenario) and afforested OWs, in compliance with the CDM-AR_ACM001 methodology, which includes the monitoring of the five carbon pools: above-ground biomass, below-ground biomass, dead wood, litter and soil organic carbon. Afforestation of naturally OWs will increase carbon stocks over time. The long-term approach adopted by the Carbone boréal program for the baseline scenario, in order to generate credible ex-ante C credits, is based on the estimated growth of an intact OW that presents the highest possible tree crown cover (25% of projected crown), while respecting the definition of non-forest at the end of project (see Fig. 3).

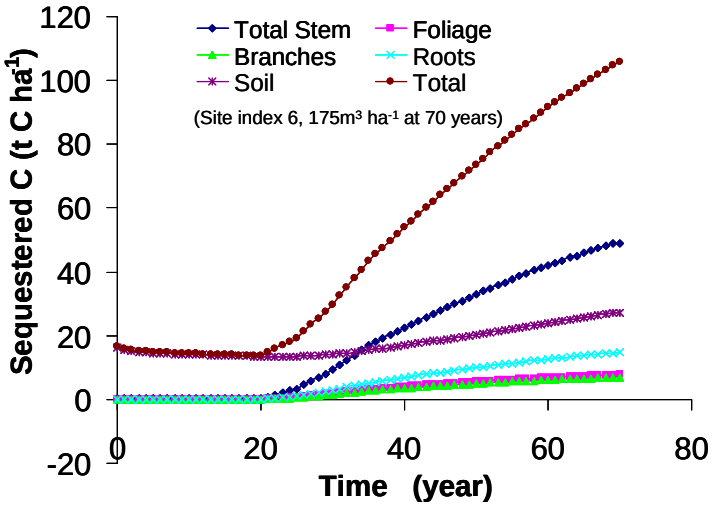


Figure 2: Carbon accumulated in the different biomass compartments of the afforestation project over 70 years.

Notes:Results are from the CO2FIX model (Masera et al., 2003; Schelhaas et al., 2004). Source: Gaboury et al. (2009).

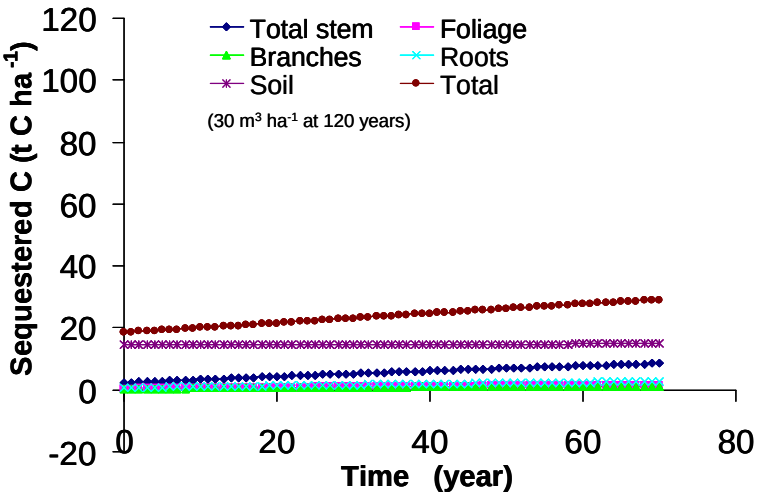


Figure 3: Carbon accumulated in the different biomass compartments of the OW, described as the baseline scenario.

Note: Results are from the CO2FIX model (Masera et al., 2003; Schelhaas et al., 2004). Source: Gaboury et al. (2009).

2.8. Project technologies, products, services, site selection and the expected level of activity

The quantification methodology is fully described in the "Quantification protocol for afforestation projects in open woodlands of the closed-crown boreal forest". No unique technology is used since the afforestation follows standard manual afforestation methods, including a mechanical soil scarification of planting plots prior to planting activities. In order to comply with ISO 14064-2, all related, associated and affected emissions are accounted for. Site selection is base on the proximity of potential site with current year sylvicultural activities in order to reduce transport associated emissions, accessibility through existing road network and the admissibility of the site to the non-forest criteria as describe in the Kyoto protocol (art. 3.3).

2.9. Total GHG emission reductions and removal enhancements (GHG Assertion)

Removal enhancements from OW afforestation are based on ex-ante accounting that follows net sequestration enhancements based on black spruce plantations. Net increased are based on a life cycle carbon assessment including all relevant sources, sinks and reservoirs (SSR).

The following table illustrates the distribution of afforested areas over the 10 years of plantation (2008-2018). The GHG removal enhancements will be totally achieved over 70 years, separated by each unique vintage year for the 10 years of the project. On area afforested annually, each tree should allow a net 0.14 tons CO2 enhancement over 70 years (Gaboury et al. 2009). Accordingly with best actual practices, project duration (plantation + monitoring) is 100 years.

Table 1: Area of afforested OWs, number of trees planted and total forecasted (ex ante) sequestration enhancement

Year of plantation	Area afforested (ha)	Number of trees planted	Total ex-ante sequestration enhancement (ton CO_2 e) after 70 years
2008	10.74	10 350	1 449
2009	17.57	29 999	4 199.86
2010	62.39	108 808	15 233.12
2011	56.60	71 671	10 033.94
2012	40.56	77 500	10 850
2013	77.17	138 116	19 336.24
2014	97.60	211 379	29 593.06
2016	70.49	161 462	22 604.68
Total project	476.61	809 285	113 299.90

Note: See table in annex 1 for simulated net accumulation on yearly basis.

2.10. Identification of risks

Risk Matrix adapted from Voluntary Carbon Standard (VCS) AFOLU[1] projects

The VCS risk matrix has been adapted to assess the risk in different categories, which shall meet ISO 14064-2 requirements and CSA CleanProjectRegistry (Table 2).

Table 2: Risk Assessment of Carbone boréal afforestation project

Risk factor	Risk rating	Carbone boréal Project
Project Risk		
Risk of unclear land tenure and potential for disputes	Low	The experimental plantations are on public «crown» land and are protected by Québec's forest Law under the "Experimental forest" status (Loi sur les forêts, Chapitre V, Section I, Articles 107-109). This status is granted for 30 years and renewable upon demand.
Risk of financial failure	Low	The project is a partnership between 2 research groups based at UQAC and the Ministry of natural resources (MRNF). The project costs are kept to a minimum since trees are provided for free by the MRNF and are planted at no extra cost through the MRNF annual budget for silvicultural expenditures.
Risk of technical failure	Low	The project Proponent partners to support the Carbone boréal project team are MRNF and the Consortium de recherche sur la forêt boréale commerciale – UQAC. Both are entities for which forestry is a main core activity. A plantation «service agreement» is also granted between MRNF and a forestry companies for plantation activities on open woodlands accessible by existing roads. Plantation camps are already established for regulatory forestry activities.
Risk of management failure	Low	The project team at UQAC is specialized on carbon sequestration and GHG management, and graduate level teaching is also provided on these topics by the same research team. The team wrote a specific quantification protocol for the project, which protocol was validated by a panel of experts. The validation committee was conducted by CSA. Moreover the Carbone boréal GHG project being also a research project, stock monitoring (frequency and acquisition method) and management of data (QC/AC) go beyond

[1] AFOLU stands for Agriculture FOrestry and Land Use

		accepted requirements.
Economic risk		
Risk of rising land opportunity cost that cause reversal of sequestration and/or protection	Low	There are very few risk of rising land opportunity costs that could cause the reversal of sequestration by the project. The OWs are not accounted for in the province allowable cuts since they do not bear logging potential. The Carbone boréal project sites are on public (crown) land and are, by law, experimental forests and therefore protected from any activities other than research. The UQAC's research team and MRNF employees are to manage the plantations over the 100 year-long project. The land owner (the Government) is unlikely to reverse the OW status owing to the Government interest in research results, given that the boreal forest of the Province bears a 1.6 M ha potential of available OWs.
Regulatory and social risk		
Risk of political instability	Low	The project is not vulnerable to political instability. The current and foreseeable political tenure are very stable in Québec and Canada.
Risk of social instability	Low	Social instability is not a stake in Québec and Canada. The country ranks year after year amongst the highest rank of the Human Development Index (HDI) of the United Nation Development Program (UNDP). In 2010 Canada was at the 8th, place. Some risk may associated with first nation claims on which Carbone boréal project is developed, but from the start the Carbone boréal team worked in partnership with the Masteuiasth first nation representatives and a letter of approval was formerly provided in 2009.
Natural disturbance risk		
Risk of devastating fire	High	Wildfires in the northern Québec region are relatively frequent. See section below on how Carbone boréal manages the risk associated to wildfire.
Risk of pest and disease attacks	High	Insect outbreaks in the northern Québec region are relatively frequent. See section below on how Carbone boréal manages the risk associated to insect outbreaks.

Eventual natural disturbance events (such as wildfire, insects and windthrow) in the plantations may cause emissions and potential reversal of credited removals. The Carbon boréal program manages the risk of reversal in three different ways.

1. First, planted trees are widely distributed spatially, so that the risk is distributed among all contributors and, consequently, diminished

at the individual level. The width of the territory where the Carbone boréal plantations to be established at the end of the first establishment period (2008-2011) is over 75 000 km^2, comprised between the longitudes 69º to 75º W and the latitudes 49º to 51º N (see Fig. 1).

2. Secondly, mature trees of the baseline scenario are not harvested prior to soil scarification, so that they offer a seed bank for natural regeneration in the event of a wildfire (Riverin and Gagnon 1996, Tremblay 2009). Though it does not replace the lost C stocks, that may at least allow the reestablishment of the regeneration by natural means into the scarification furrows.
3. Thirdly, in the case of a reversal, Carbone boréal has a 10 year-old backup plantation network (established from 1999 to 2001) in OWs of approximately 200 000 trees that will allow tree replacement after reversal, up to one third of all existing planted trees within the project. This backup plantation network has also the "Experimental forests" status of the MRNF, so that the trees therein are protected from commercial harvesting and are available as backup trees throughout the project duration and for research purposes. Furthermore, the Carbone boréal research program explicitly includes the question of reversibility/permanence, so that the C accounting will be under a constant process of improvement in the reversibility risk integration.

As mentioned the OW's are not considered in Québec's allowable cuts so there is no loss of opportunity that could lead to logging activities, more so that Carbone Boréal plots are protected by law as experimental forests.

2.11. Roles and Responsibilities

Project developer:

Chaire en éco-conseil (eco-advising), Université du Québec à Chicoutimi (UQAC)
555 boul. Université, Chicoutimi, Québec, G7H 2B1
Project coordinator
Claude Villeneuve, 418-545-5011 x-5059
Claude_Villeneuve@uqac.ca

Partners:

Consortium de recherche sur la forêt boréale commerciale (UQAC)

555 boul. Université, Chicoutimi, Québec, G7H 2B1
Contact/ project quantifier
J-François Boucher, 418-545-5011 x-5385

Québec's Ministère des Ressources naturelles et de la Faune (MRNF)
(Ministry of Natural resources and wildlife)
3950 boul. Harvey, Jonquière, Québec, G7X 8L6
Contact
Damien Côté, (418) 695-8125 poste 251

Verifier:

Bureau de normalisation du Québec
333, rue Franquet, Québec (Québec), G1P 4C7
Contact
Isabelle Landry, Responsable des programmes en environnement, GES et SST, Certification de systèmes
Tél. 418 652-2238, poste 2882
Courriel isabelle.landry@bnq.qc.ca

Broker:

None. Carbone boréal credits are sold directly by the Chaire en éco-conseil (OTC sales at 28$/tonne CO_2). A registry of buyers is publicly available on the project's web site:
http://carboneboreal.uqac.ca/registre.php

2.12. Eligibility of the GHG project under a GHG program

There is no other relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and temporal information as related to the project.

The project follows ISO 14064-2 guidelines and verification under ISO 14064-3 will insure that the project meets the requirements of the GHG CleanProjects™ registry.

Project quantification protocol is specific to afforestation of boreal OW's and was validated through a panel of independent experts. The quantification protocol aims at being compliant with regulatory organism requirements, like those in the Western Climate Initiative (WCI).

2.13. Summary environmental impact assessment

Afforestation activities shall meet provincial requirement guidelines for plantation site access and plantation activities since the project is on public Crown land.

2.14. Stakeholder consultations and mechanisms for on-going communication

The project promoter (Chaire en éco-conseil) established a public advisory committee for the research/offset project and have obtained a formal written approval from the Innu fist nation which traditional lands includes the project experimental plots. The committee held a first meeting on May 14th 2010. Minutes of the meeting are publicly available on the project web site (http://carboneboreal.uqac.ca/comite_consultatif.php?lang=AN)

2.15. Detailed chronological plan

Table 3: Chronological plan of the Carbone boréal afforestation project

1999-2001	Afforestation of approximately 100 ha of OWs (200 000 trees) for a UQAC Consortium de recherche sur la forêt boréale experimental project. These 100 ha, which is closely monitored to research purposes, is now accounted as a buffer for the Carbone boréal project.
April 2008	Signature of the 1st agreement 2008-2011 with the MRNF for the allocation to the Chaire en éco-conseil de l'UQAC of 300 ha of OWs, with the eventual status of experimental forests upon demand.
Summer 2008	Afforestation of the first 11 ha of OWs for the Carbone boréal project.
September 2008	Official launch of the Carbone boréal project. The "Fondation des Cowboys fringants" (http://www.cowboysfringants.com/fondation/) publicly announced that it allowed a grant of 100 000$ to the project.
September 2008	Signature of agreement with the Canadian Standard Association (CSA) to register Carbone boréal

	project in its GHG CleanProject Registry, and make Carbone boréal the first serialized forest project with ex-ante CO2 sequestration enhancements.
March 2009	Launch of the Carbone boréal web site with the publicly available registry: http://carboneboreal.uqac.ca/index.php
Summer 2009	Afforestation of 32 ha of OWs for the Carbone boréal project.
Summer 2010	Afforestation of 86.3 ha of OW for the Carbone boréal project.
March 2010	Formal letter sent to MRNF to assess the ownership of carbon credits generated on public Crown land through the Carbone boréal project.
January 2011	Meeting with the MRNF to extend the initial agreement to another 700 ha (2011-2018) of OWs for a total of 1 000 ha.
Summer 2018	Afforestation of the last planned 100 ha of OWs.
Summers 2008-2118	Frequency of monitoring is done on a yearly basis between 2008 and 2018 and every 10 years afterward. Reporting will be done in 2011, 2018 and every 10 years afterward between 2018 and 2118.

3. Selection and Justification of the Baseline Scenario

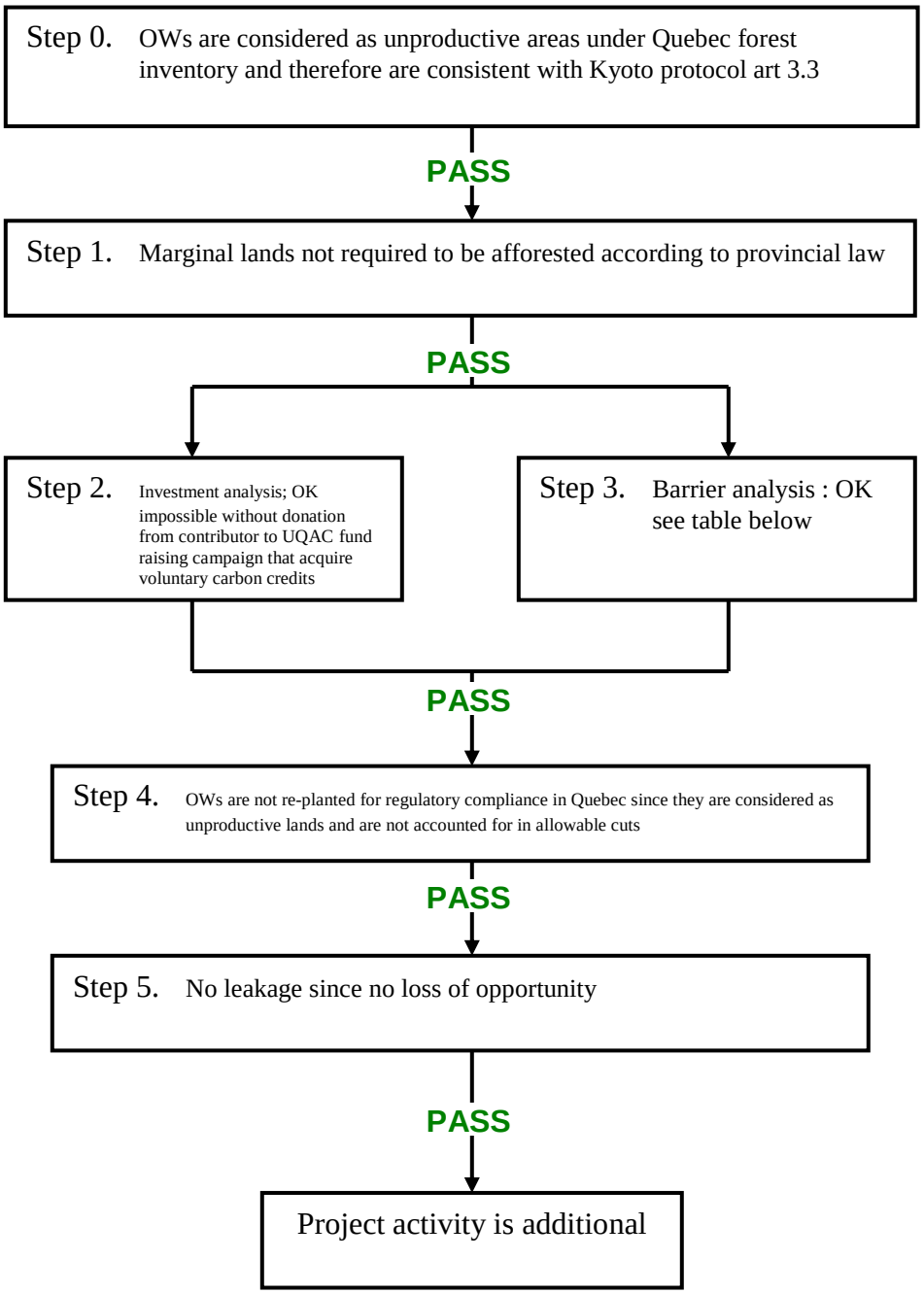
The baseline condition here is considered to be a boreal OW, within the limits of allowable cuts territory, that presents a tree (of at least 5 m of height) crown cover of less than 25% on a minimum land area of 1 ha. In the absence of the afforestation project, the stand structure will remain open (less than 25% of tree cover) during the duration of the project (ie. 100 years), while small changes in the level of the carbon reservoirs are expected (Gaboury et al. 2009). There are no plans, directives, regulations or programs that require the site to be

afforested, and there is no management activity on these OWs (MRNF 2003). The five carbon pools identified in the IPCC guidelines for land use and land use change and forestry (LULUCF) are expected to change slowly enough to be accounted for over time, considering the relatively modest C stock growth over time in the afforestation scenario (Gaboury et al. 2009). For that reason, this is the most appropriate baseline approach foreseeable.

4. Project additionnality test and Barrier analysis

The additonnality of the project was assessed with the Kyoto protocol CDM guidelines (UNFCCC 2004) to which ISO 14064-2 refers.

Figure 4: Additionality test, adapted from the CDM additionnality tool



Note that under the Western Climate Initiative (WCI), the financial additionality should not be mandatory.

Table 4: Barrier Analysis

Barrier	**Existing or alternative activity 1** **Boreal open woodland afforestation**	**Existing or alternative activity 2** **No alternative**
Financial Economic Barrier Discussions	Yes. No commercial value since considered as unproductive.	
Technology Operation, Maintenance and Disposal Barrier Discussions	Access to forest camp for planting and maintenance granted by Ministry (MRNF) and industrial partners of the Carbone boréal project.	
Data Reliability and Limitation Barrier Discussions	Research project QA/CA very important.	
Present, Future Conditions and Proliferation Barrier Discussions	Research forest status needs to be renewed every 30 years.	
Legislative Barrier Discussions	None. There is no regulation enforcing OW afforestation.	
Socio-cultural Barrier Discussions	Some OWs may be on first-nation claimed lands.	
Environment Barrier Discussions	Woodland caribou issue. This question is addressed within Carbone boréal research program.	
Geographic Barrier Discussions	Accessibility to OWs may be problematic since most are far north. Afforestation activity needs to be supported with plantation camps and planters need to travel on long distances.	
Site Specific Barrier Discussions	Access road to OWs may not exist. Carbone boréal OW sites are all within 5 km of existing access roads.	
Temporal Barrier Discussions	Monitoring on long period (100 years) may be problematic. Carbone boréal partnership with MRNF and the Consortium as well as the Experimental forest status granted to OW's afforested sites provide required assurance of long-term monitoring.	
Prevailing Practice Discussion	None. OW site preparation as well as afforestation methods are standard silvicultural practices.	

5. Identification of Project SSRs

SSRs for all activities related to a Carbone boréal project occurring offsite prior to implementation, upstream and downstream during project implementation, upstream and downstream prior and after project implementation were identified. These SSRs are listed in

Table 5, which also specifies whether the SSRs are controlled, related or affected by the project proponent.

Table 5. Identification of SSR controlled by, related to, or affected by Carbone boréal OW afforestation project (i.e. project scenario).

SSR	Description	Controlled, Related or Affected
Upstream SSRs		
P1. Seed production	Cone harvesting, transportation and processing, building and installation heating, seed storage, extraction and drying, etc.	Related
P2. Seeding production	Container production and transportation, peat moss extraction and transportation, herbicide production and transportation, fertilizer production and transportation, perlite and vermiculite extraction, processing and transportation, building and nursery heating, use and maintenance, etc.	Related
P3. Land access	Road construction and maintenance, employee housing and accommodation	Controlled
Onsite SSRs during operations		
P4. Harvesting operations	Logging, hauling and lopping, loading, roundwood and machinery transportation	Controlled
P5. Site preparations and silvicultural treatments	Machinery and operator transportation, soil scarification, fertilizer applications, drainage, slash burning, herbicide applications	Controlled
P6. Tree planting	Seedling and tree planter transportation	Controlled
P7. Aboveground C reservoir	Biomass in live trees, branches, foliage	Controlled
P8. Belowground C reservoir	Live root biomass	Controlled
P9. Litter and humus C reservoir	Biomass in litter and humus	Controlled
P10. Soil organic C reservoir	Organic C content of mineral soil	Controlled
P11. Dead wood C reservoir	Biomass in dead wood (both above and belowground)	Controlled
P12. Plantation monitoring	Transportation and housing	Controlled
Downstream SSRs		
P13. Afforestation/reforestation (A/R)	Market-related changes in A/R rates	Affected

6. Quantification and calculation of GHG emissions/removals

6.1. Comparison of Project and Baseline SSRs

All afforestation-related operations (from P1 to P6, P12 and P13) are deemed irrelevant SSRs in the context of silvicultural and monitoring operations in Québec's boreal forest, since these

emissions were only a fraction of 1% of the total C budget of a simulated afforestation project in a LCA approach study (Gaboury et al. 2009), and also because site fertilisation is not allowed on Québec's Crown land and the OW selection in the project is based on immediate proximity to existing forest roads. Only onsite C reservoirs (B1 and P7 to B5 and P11) are comparable and functionally equivalent between both scenarios (Table 6). Since the afforestation of OWs leads to a significant increase in tree density (Gaboury et al. 2009), both above and belowground C reservoirs are the most important SSRs. Because even a modest C growth in an afforested OW could have a contribution in the overall C budget at the end of a project, all C reservoirs of both scenarios are considered relevant SSRs, with the exception of the dead wood C reservoir (B5 and P11). This latter reservoir is expected to contribute little to the overall C budget, since no harvesting operations are planned prior to planting, and the 100 year long-time frame of an afforestation project in the boreal forest will generate low tree mortality. Consequently, this C reservoir is excluded from the quantification. This exclusion can be considered conservative with regards to the C balance of the project, since the quantity of dead wood will be minimally equal between both scenarios, or higher in the project scenario in most conditions (due to the higher number of growing, and dying, trees in the project compared to the baseline scenario).

Table 6: Comparison and relevance of Afforestation Project and Baseline Scenario SSRs.

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Assessment of comparability	Relevance of SSRs (Y/N)
Upstream SSRs				
P1. Seed production	n/a	C	n/a	N
P2. Seeding production	n/a	C	n/a	N
P3. Land access	n/a	C	n/a	N
Onsite SSRs during operation				
P4. Harvesting operations	n/a	C	n/a	N
P5. Site preparations and silvicultural treatments	n/a	C	n/a	N
P6. Tree planting	n/a	C	n/a	N
B1. P7. Aboveground C reservoir	C	C	Functionally equivalent. Baseline and project scenarios will be compared with the same metrics, i.e. carbon sequestered per ha.	Y
B2. P8. Belowground C reservoir	C	C	Idem	Y
B3. P9. Litter and humus C reservoir	C	C	Idem	Y

Identified SSR	Baseline (C,R,A)	Project (C,R,A)	Assessment of comparability	Relevance of SSRs (Y/N)
B4. P10. Soil organic C reservoir	C	C	Idem	Y
B5. P11. Dead wood C reservoir	C	C	Idem	N
P12. Plantation monitoring	n/a	C	n/a	N
Downstream SSRs				
P13. Afforestation/ reforestation (A/R)	n/a	A	n/a	N

6.2. Equation for each "relevant" SSR in the project and baseline

Note: The 5.2 section is an excerpt from the Quantification protocol (hereafter QP) on which the Carbone boreal quantification is based. Please, refer to the QP for all details.

a) Equation for each relevant SSR in the baseline scenario

B1. Baseline aboveground C reservoir

This reservoir is split into four different vegetation groups, namely: trees higher than 2.0 m, trees lower than 2.0 m, shrub vegetation, and non-vascular organisms (mosses and lichens). The equation for the aboveground C reservoir is:

[1] $TA_{B1} = (AGBM_{TR\geq 2.0} + AGBM_{TR<2.0} + AGBM_{BR} + BM_{NV}) * CD * CO2_{CONV}$

where:
- TA_{B1} is the total absorptions for the baseline aboveground reservoir (in tonne CO_2 per ha);
- $AGBM_{TR\geq 2.0}$ is the aboveground biomass of all trees with height ≥ 2.0 m (in Mg ha^{-1});
- $AGBM_{TR<2.0}$ is the aboveground biomass of all trees with height < 2.0 m (in Mg ha^{-1});
- $AGBM_{BR}$ is the aboveground biomass of all brush vegetation (in Mg ha^{-1});
- BM_{NV} is the biomass of all non-vascular organisms (mosses and lichens) (in Mg ha^{-1});
- CD is the carbon density of the biomass (0.5 (IPCC, 2003));
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);

A specific set of equations is associated to each of these four vegetation groups. First, for $AGBM_{TR\geq 2.0}$ the equations from Lambert et al. (2005) are recommended, with all boreal forest tree species included therein (see Appendix 2 of the QP). Since estimated biomasses from these

equations are in kg and from a 400 m^2 sampling plot, cumulated biomasses need to be multiplied by 10^{-3} (from kg to Mg) and by 25 (from 400 m^2 to 1 ha) before using equation [1].

Then, the equations provided in Tremblay et al. (2006) are recommended for both $AGBM_{TR<2.0}$ and $AGBM_{BR}$ (see Appendix 3 of the QP). Since estimated biomasses from these equations are in g and from 1 or 400 m^2 subplots and sampling plots, cumulated biomasses need to be multiplied by 10^{-6} (from g to Mg) and by 25 (from 400 m^2 to 1 ha) for $AGBM_{TR<2.0}$ or by 10^4 (from 1 m^2 to 1 ha) for $AGBM_{BR}$, before using equation [1].

Finally, BM_{NV} needs to be estimated by the project proponent, since no simple and reliable equations (eg. based on % cover visual evaluation) are available in the literature for this group of organisms. The methodology for the measurement of BM_{NV} is provided in section 4.1d of the QP. There again, the calculated biomasses in g need to be multiplied by 10^{-6} (from g to Mg) and by 10^4 (from 1 m^2 to 1 ha) before using equation [1].

B2. Baseline belowground C reservoir

This reservoir is split into two different vegetation groups, namely: tree and brush species. The equation for the belowground C reservoir is:

[2] $TA_{B2} = (BGBM_{TR} + BGBM_{BR}) * CD * CO2_{CONV}$

where:
- TA_{B2} is the total absorptions for the baseline belowground reservoir (in tonne CO_2 per ha);
- $BGBM_{TR}$ is the total belowground biomass of all trees (in Mg ha^{-1});
- $BGBM_{BR}$ is the total belowground biomass of all brush vegetation (in Mg ha^{-1});
- CD is the carbon density of the biomass (0.5(IPCC, 2003));
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);

Belowground biomass of trees ($BGBM_{TR}$) is estimated according to Li et al. (2003) calculations. The equations for the belowground biomass of trees are:

[2.1] $BGBM_{STR} = AGBM_{STR} * 0.222$

[2.2] $BGBM_{HTR} = AGBM_{HTR}^{0.615} * 1.576$

where $BGBM_{STR}$ and $BGBM_{HTR}$ are belowground biomass of softwood and hardwood tree species, respectively, and where $AGBM_{STR}$ and $AGBM_{HTR}$ are aboveground biomass of softwood and hardwood tree species, respectively, both calculated with equation [1]. The belowground biomass of brush vegetation ($BGBM_{BR}$) needs to be estimated by the project proponent, since no simple and reliable equations are available in the literature for this group of vegetation. The methodology to determine $BGBM_{BR}$ is provided in section 4.1d of the QP. The calculated biomass in g needs to be multiplied by 10^{-6} (from g to Mg) and by 10^4 (from 1 m^2 to 1 ha) before using equation [2].

B3. Baseline litter and humus C reservoir

Litter and humus C reservoir is estimated by the project proponent before using the following equation:

[3] $TA_{B3} = BM_{LH} * CD * CO2_{CONV} * SEF$

where:
- TA_{B3} is the total absorptions for the baseline litter and humus reservoirs (in tonne CO_2 per ha);
- BM_{LH} is the total litter and humus biomass (in Mg m^{-2});
- CD is the carbon density of the biomass (0.5 [2](IPCC, 2003));
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);
- SEF is the surface expansion factor, from 1 m^2 to 1 ha (10^4).

The methodology for BM_{LH} is described in section 4.1d of the QP. The calculated biomass in g needs to be multiplied by 10^{-6} before using equation [3].

B4. Baseline soil organic C reservoir

[2] To be determine precisely with the LECO.

The soil organic C reservoir is estimated by the project proponent before using the following equation:

[4] $TA_{B4} = CO2_{SOC} * CO2_{CONV} * SEF$

where:
- $TA_{B4.P10}$ is the total absorptions for the baseline soil organic C reservoir (in tonne CO_2 per ha);
- $CO2_{SOC}$ is the total CO_2 measured from the soil organic C combustion (in g per m^2);
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);
- SEF is the surface expansion factor, from 1 m^2 to 1 ha (10^4).

The methodology for $CO2_{SOC}$ is based on Brown et al. (2004) and described in section 4.1d of the QP.

b) Equation for each relevant SSR in the project scenario

P7. Project aboveground C reservoir

This reservoir is split into four different vegetation groups, namely: trees higher than 2.0 m, trees lower than 2.0 m, shrub vegetation, and non-vascular organisms (mosses and lichens). The equation for the aboveground C reservoir is:

[5] $TA_{P7} = (AGBM_{TR\geq2.0} + AGBM_{TR<2.0} + AGBM_{BR} + BM_{NV}) * CD * CO_{2\ CONV}$

where:
- TA_{P7} is the total absorptions for the project aboveground reservoir (in tonne CO_2 per ha);
- $AGBM_{TR\geq2.0}$ is the aboveground biomass of all trees with height ≥ 2.0 m (in Mg ha^{-1});
- $AGBM_{TR<2.0}$ is the aboveground biomass of all trees with height < 2.0 m (in Mg ha^{-1});
- $AGBM_{BR}$ is the aboveground biomass of all brush vegetation (in Mg ha^{-1});
- BM_{NV} is the biomass of all non-vascular organisms (mosses and lichens) (in Mg ha^{-1});
- CD is the carbon density of the biomass (0.5(IPCC, 2003));
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);

A specific set of equations is associated to each of these four vegetation groups. First, for $AGBM_{TR\geq 2.0}$ the equations from Lambert et al. (2005) are recommended, with all boreal forest tree species included therein (see Appendix 2 of the QP). Since estimated biomasses from these equations are in kg and from a 400 m^2 sampling plot, the project proponent needs to multiply the cumulated biomasses by 10^{-3} (from kg to Mg) and by 25 (from 400 m^2 to 1 ha) before using equation [5].

Then, the equations provided in Tremblay et al. (2006) are recommended for both $AGBM_{TR<2.0}$ and $AGBM_{BR}$ (see Appendix 3 of the QP). Since estimated biomasses from these equations are in g and from 1 or 400 m^2 subplots and sampling plots, cumulated biomasses need to be multiplied by 10^{-6} (from g to Mg) and by 25 (from 400 m^2 to 1 ha) for $AGBM_{TR<2.0}$ or by 10^4 (from 1 m^2 to 1 ha) for $AGBM_{BR}$, before using equation [5].

Finally, BM_{NV} needs to be estimated by the project proponent, since no simple and reliable equations (eg. based on % cover visual evaluation) are available in the literature for this group of organisms. The methodology for the measurement of BM_{NV} is provided in section 4.1d of the QP. There again, the calculated biomasses in g need to be multiplied by 10^{-6} (from g to Mg) and by 10^4 (from 1 m^2 to 1 ha) before using equation [5].

P8. Project belowground C reservoir

This reservoir is split into two different vegetation groups, namely: tree and brush species. The equation for the belowground C reservoir is:

[6] $TA_{P8} = (BGBM_{TR} + BGBM_{BR}) * CD * CO2_{CONV}$

where:
- TA_{P8} is the total absorptions for the project belowground reservoir (in tonne CO_2 per ha);
- $BGBM_{TR}$ is the total belowground biomass of all trees (in Mg ha^{-1});
- $BGBM_{BR}$ is the total belowground biomass of all brush vegetation (in Mg ha^{-1});
- CD is the carbon density of the biomass (0.5(IPCC, 2003));

- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);

Belowground biomass of trees ($BGBM_{TR}$) is estimated according to Li et al. (2003) calculations. The equations for the belowground biomass of trees are:

[8.1] $BGBM_{STR} = AGBM_{STR} * 0.222$

[8.2] $BGBM_{HTR} = AGBM_{HTR}^{0.615} * 1.576$

where $BGBM_{STR}$ and $BGBM_{HTR}$ are belowground biomass of softwood and hardwood tree species, respectively, and where $AGBM_{STR}$ and $AGBM_{HTR}$ are aboveground biomass of softwood and hardwood tree species, respectively, both calculated with equation [5]. The belowground biomass of brush vegetation ($BGBM_{BR}$) needs to be estimated by the project proponent, since no simple and reliable equations are available in the literature for this group of vegetation. The methodology to determine $BGBM_{BR}$ is provided in section 4.1d of the QP. The calculated biomass in g needs to be multiplied by 10^{-6} (from g to Mg) and by 10^4 (from 1 m^2 to 1 ha) before using equation [6].

P9. Project litter and humus C reservoir

Litter and humus C reservoir is estimated by the project proponent before using the following equation:

[7] $TA_{P9} = BM_{LH} * CD * CO2_{CONV} * SEF$

where:
- TA_{P9} is the total absorptions for the project litter and humus reservoir (in tonne CO_2 per ha);
- BM_{LH} is the total litter and humus biomass (in Mg ha^{-1});
- CD is the carbon density of the biomass (0.5 [3](IPCC, 2003));
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667).

[3] To be determine precisely with the LECO.

The methodology for BM_{LH} is described in section 4.1d of the QP. The calculated biomass in g needs to be multiplied by 10^{-6} before using equation [7].

P10. Project soil organic C reservoir

The soil organic C reservoir is estimated by the project proponent before using the following equation:

[8] $TA_{P10} = CO2_{SOC} * CO2_{CONV} * SEF$

where:
- TA_{P10} is the total absorptions for the project soil organic C reservoir (in tonne CO_2 per ha);
- $CO2_{SOC}$ is the total CO_2 measured from the soil organic C combustion (in g per m^2);
- $CO2_{CONV}$ is the conversion factor, from C to CO_2 (3.6667);
- SEF is the surface expansion factor, from 1 m^2 to 1 ha (10^4).

The methodology for $CO2_{SOC}$ is based on Brown et al. (2004) and described in section 4.1d of the QP.

c) Entire set of equations used to quantify total removals

The total GHG removals of an OW afforestation project is obtained by subtracting the net removals of the baseline scenario from the net removals of the project scenario at each of the measurement period ("at time X"):

[9] $Afforestation_{OW \text{ at time } X} = \Sigma \text{ net removals}_{project \text{ at time } X} - \Sigma \text{ net removals}_{baseline \text{ at time } X}$

The total net removals of the baseline and the project scenarios at time X are defined by:

[10] $\Sigma \text{ removals}_{baseline \text{ at time } X} = TA_{B1} + TA_{B2} + TA_{B3} + TA_{B4}$

where: - TA_{B1} is the total absorptions for the baseline aboveground reservoir at time X (in tonne CO_2 per ha) (see equation [1]);
- TA_{B2} is the total absorptions for the baseline belowground reservoir at time X (in tonne CO_2 per ha) (see equation [2]);
- TA_{B3} is the total absorptions for the baseline litter and humus reservoir at time X (in tonne CO_2 per ha) (see equation [3]);
- TA_{B4} is the total absorptions for the baseline soil organic C reservoir at time X (in tonne CO_2 per ha) (see equation [4]);

[11] $\Sigma \text{ removals}_{\text{project at time X}} = TA_{P7} + TA_{P8} + TA_{P9} + TA_{P10}$

where: - TA_{P7} is the total absorptions for the project aboveground reservoir at time X (in tonne CO_2 per ha) (see equation [5]);
- TA_{P8} is the total absorptions for the project belowground reservoir at time X (in tonne CO_2 per ha) (see equation [6]);
- TA_{P9} is the total absorptions for the project litter and humus reservoir at time X (in tonne CO_2 per ha) (see equation [7]);
- TA_{P10} is the total absorptions for the project soil organic C reservoir at time X (in tonne CO_2 per ha) (see equation [8]);

7. Monitoring the Data information management system and data controls

Carbone boréal being first and foremost a university research project, equipment calibration procedures and frequency, precision of measurements, data collection, manipulation and archiving procedures as well as internal quality assurance procedures that are performed on the calculations are thorough by obligation.

7.1. Field sampling, crew member, material and lab measurement

In order to collect reliable data, field crew are adequately formed and familiar with sampling protocol and method before getting to the field. Any new field crew member work with an experienced member before being allowed to work on his own.

Data collecting form (electronic media or field sheet) include a "Check list" in order to avoid missing data. This form also include reference note, table or figure describing each step of the sampling method with a particular attention to special case i.e.; how to measure diameter a breast height or how to adjust plot size in terrain with strong slope. Any sheet of the collecting form must be sign by the member of the field crew in order to be able to contact these persons if any trouble is detected during the computation of the data. (see example of check list in annex 2)

Cross checking of the sampling or measuring method between field crew members is done as frequently as possible in order to avoid error that can originate from repetitive routine measurement. Field measurement is done every summer as part of students' fieldwork. Using the most precise tool available.

Above ground carbon reservoir

Diameter tape is used for tree greater than 4 cm in diameter. For height measurement, measuring tape, graduated telescopic pole and hypsometer are used. The later provide direct and precise data without any calculation. Electronics measurement tool are calibrated every year.

Below ground carbon reservoir

Based on best practices (see the QP), belowground biomass is a calculated ratio relative to aboveground biomass.

Soil carbon reservoirs (including litter, humus, and mineral soil)

Determining mineral soil bulk density and carbon content required rigorous sampling and preparation. Soil carbon content samples are air dried and passed through a 2 mm sieve before combustion. Periodically, sample of known concentration are included in combustion run to confirm method efficiency. Bulk density sample are collected with soil corer which allow collecting a soil sample of known volume without affecting sample density. Sampling is done by an experienced technician. Sample are oven dried at 105 °C until constant mass before weighting. Balance used to determine sample weight should be calibrated against known weights periodically.

7.2. Data entry and data archiving

When entering field data (electronic or paper) in a work sheet, a software is used to detect if any data is over or under values observed in the field. Anomalies are discussed with the field crew in order to correctly integrate these anomalies to the final dataset. It is also strongly recommended to have a sub-sample of the dataset double-check by another person and immediately correct the dataset. If too many errors are found, the entire dataset is then reviewed.

Once computed, field sheets are kept in a safe place at the laboratory of plant ecology at UQAC. Photocopies of these sheets are physically stored in a different UQAC's building to avoid complete loss of the data in case of fire. Numerical version of the dataset, scanned field sheet, electronic work sheet, GIS products and results of carbon stocks are kept in a computer and on a external hard drive especially dedicated to the project and protected

by a certified antivirus software. Protected copies of all these data are burned on cd-roms or dvd-roms and kept in two different places with the field sheets. Information on control procedures such as passwords and permission levels are under the supervision of the UQAC IT service. Testing of algorithms, report distribution, and management's role in the review of reports are under direct supervision of graduated students' professors and research professionals associated to Carbone boréal.

The monitoring plan is the start of the data flow process and links the data information management system with the SSRs and the inputs to estimate the GHG emission removals. A monitoring plan example is provided in annex 3. Data controls and procedures that ensure the integrity, completeness, accuracy, transparency and verifiability are found in annex 4. Data flow charts are found in annex 5.

8. Reporting and verification details

The assertion of that GHG Report is prepared in accordance with ISO 14064-2 and GHG CleanProjects™ requirements.

The chosen verifier, the Bureau de normalisation du Québec, is an independent third-party and is accredited by the Conseil Canadien des Normes (CCN) as a certified verifier complying with ISO 14065 requirements. A Verification Report template is provided for CSA GHG CleanProjects™. And it was agreed between both parties that the BNQ would use it.

The verification scope includes the following elements

- conforms to ISO 14064-3,
- includes a signed Verification Statement,
- is prepared by an independent third-party,
- provides details on how conflict of interest issues are managed or mitigated,
- demonstrates that the verification body is competent to perform the verification of the GHG project that includes the GHG Report, GHG Assertion(s), and the calculations of the GHG emission reductions or removal enhancements,
- includes in its scope the fact that the project conforms to the requirements of ISO 14064-2, and
- verifies the project to a reasonable level of assurance, including all GHG Assertion(s) and calculations of GHG emission reductions or removal enhancements.

In the case of a negative verification statement or opinion a new or updated GHG Report will be required, if one is already registered on GHG CleanProjects™. If necessary, the project may also be delisted until a new GHG Report is registered by the project proponent.

9. References

Note: These references are supplementary to those provided in the QP.

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Annexes

Annex 1: Table of simulated C accumulation (From Gaboury et al. 2009)

Année	Stocks totaux projet (t C ha^{-1})	Stocks totaux baseline (t C ha^{-1})	Bilan net (t C ha^{-1})
0	18.52	18.63	-0.11
1	17.77	18.76	-0.99
2	17.3	18.89	-1.59
3	16.96	19.03	-2.07
4	16.69	19.16	-2.47
5	16.47	19.29	-2.82
6	16.28	19.43	-3.15
7	16.1	19.57	-3.47
8	15.95	19.71	-3.76
9	15.8	19.85	-4.05
10	15.66	20	-4.34
11	15.53	20.14	-4.61
12	15.4	20.29	-4.89
13	15.28	20.44	-5.16
14	15.16	20.59	-5.43
15	15.05	20.74	-5.69
16	14.94	20.9	-5.96
17	14.83	21.05	-6.22
18	14.73	21.21	-6.48
19	14.63	21.36	-6.73
20	14.54	21.52	-6.98
21	15.54	21.67	-6.13
22	16.59	21.83	-5.24
23	17.67	21.98	-4.31
24	18.77	22.14	-3.37
25	19.89	22.3	-2.41
26	21.93	22.46	-0.53
27	23.99	22.62	1.37
28	26.09	22.78	3.31
29	28.21	22.94	5.27
30	30.35	23.1	7.25
31	33	23.26	9.74
32	35.67	23.41	12.26
33	38.37	23.57	14.8
34	41.09	23.73	17.36
35	43.82	23.89	19.93

Année	Stocks totaux projet (t C ha^{-1})	Stocks totaux baseline (t C ha^{-1})	Bilan net (t C ha^{-1})
36	45.92	24.05	21.87
37	48.02	24.2	23.82
38	50.12	24.36	25.76
39	52.22	24.52	27.7
40	54.32	24.68	29.64
41	56.32	24.83	31.49
42	58.32	24.99	33.33
43	60.33	25.14	35.19
44	62.34	25.3	37.04
45	64.35	25.45	38.9
46	66.27	25.6	40.67
47	68.19	25.76	42.43
48	70.11	25.91	44.2
49	72.03	26.06	45.97
50	73.96	26.21	47.75
51	75.79	26.36	49.43
52	77.63	26.51	51.12
53	79.46	26.66	52.8
54	81.3	26.81	54.49
55	83.14	26.96	56.18
56	84.89	27.1	57.79
57	86.64	27.25	59.39
58	88.39	27.39	61
59	90.14	27.54	62.6
60	91.89	27.69	64.2
61	93.36	27.83	65.53
62	94.83	27.97	66.86
63	96.29	28.11	68.18
64	97.76	28.25	69.51
65	99.22	28.4	70.82
66	100.68	28.53	72.15
67	102.14	28.67	73.47
68	103.6	28.81	74.79
69	105.06	28.94	76.12
70	106.02	28.99	77.03

Annex 2: Example of check list for field measurement

Parcelles Permanentes Projet Carbone Boréal

Localisation Site	
UAF:	
Secteur:	
Distance:	
Longitude:	
Latitude:	

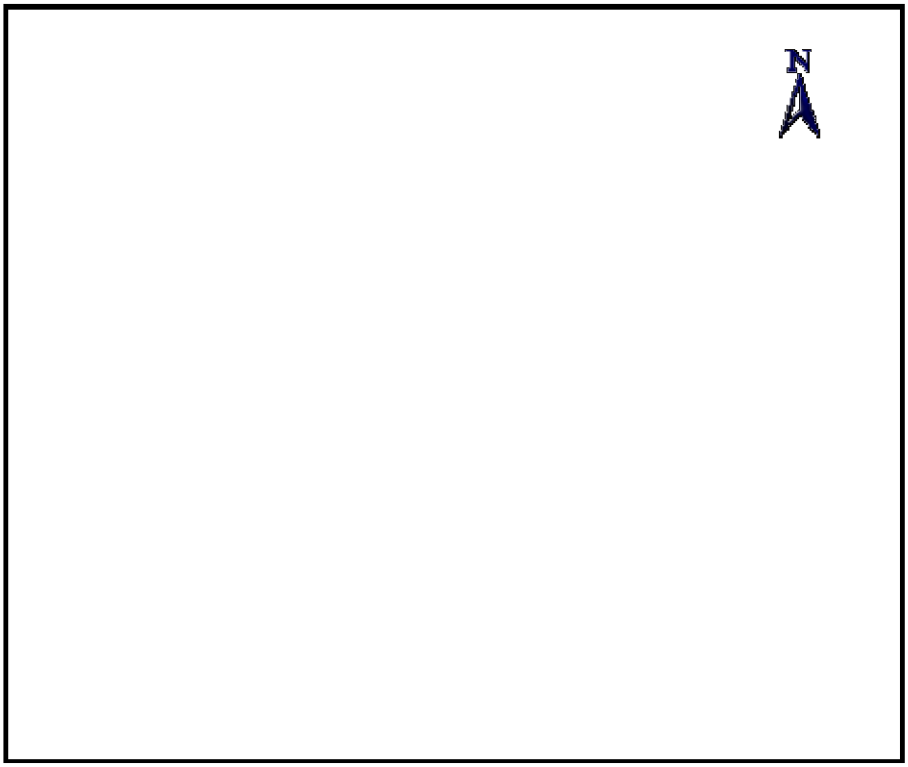
Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Centre de la parcelle (11,28 m de rayon, (400 m2)

Coordonnées Géographique	
Lat (1):	
Long (1):	
Lat (2):	
Long (2):	
Lat (3):	
Long (3):	
Lat (4):	
Long (4):	
Lat (5):	
Long (5):	

Repères Témoins	
Repère 1	Azimute:
	Distance:
Repère 2	Azimute:
	Distance:
Repère 3	Azimute:
	Distance:
Remarques:	

Shéma Localisation Parcelle



Parcelles Permanentes Projet Carbone Boréal
Arbres Plantés

Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Secteur:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Dénombrement Arbres Plantés

Plant	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
P-1					
P-2					
P-3					
P-4					
P-5					
P-6					
P-7					
P-8					
P-9					
P-10					
P-11					
P-12					
P-13					
P-14					
P-15					
P-16					
P-17					
P-18					
P-19					
P-20					
P-21					
P-22					
P-23					
P-24					
P-25					
P-26					
P-27					
P-28					
P-29					
P-30					

Parcelles Permanentes Projet Carbone Boréal
Arbres Plantés (suite)

Plant	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
P-31						
P-32						
P-33						
P-34						
P-35						
P-36						
P-37						
P-38						
P-39						
P-40						
P-41						
P-42						
P-43						
P-44						
P-45						
P-46						
P-47						
P-48						
P-49						
P-50						
P-51						
P-52						
P-53						
P-54						
P-55						
P-56						
P-57						
P-58						
P-59						
P-60						
P-61						
P-62						
P-63						
P-64						
P-65						
P-66						
P-67						
P-68						
P-69						
P-70						

Parcelles Permanentes Projet Carbone Boréal
Arbres Plantés (suite)

Plant	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
P-71						
P-72						
P-73						
P-74						
P-75						
P-76						
P-77						
P-78						
P-79						
P-80						
P-81						
P-82						
P-83						
P-84						
P-85						
P-86						
P-87						
P-88						
P-89						
P-90						
P-91						
P-92						
P-93						
P-94						
P-95						
P-96						
P-97						
P-98						
P-99						
P-100						

Remarques:

Parcelles Permanentes Projet Carbone Boréal
Gaules

Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Secteur:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Dénombrement Gaules (DHP 1.0 ≤ 9.0 cm)

Gaules	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
G-1						
G-2						
G-3						
G-4						
G-5						
G-6						
G-7						
G-8						
G-9						
G-10						
G-11						
G-12						
G-13						
G-14						
G-15						
G-16						
G-17						
G-18						
G-19						
G-20						
G-21						
G-22						
G-23						
G-24						
G-25						
G-26						
G-27						
G-28						
G-29						
G-30						

Parcelles Permanentes Projet Carbone Boréal
Dénombrement Gaules (DHP 1.0 ≤ 9.0 cm) (suite)

Arbres	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
G-31						
G-32						
G-33						
G-34						
G-35						
G-36						
G-37						
G-38						
G-39						
G-40						
G-41						
G-42						
G-43						
G-44						
G-45						
G-46						
G-47						
G-48						
G-49						
G-50						
G-51						
G-52						
G-53						
G-54						
G-55						
G-56						
G-57						
G-58						
G-59						
G-60						
G-61						
G-62						
G-63						
G-64						
G-65						
G-66						
G-67						
G-68						
G-69						
G-70						

Parcelles Permanentes Projet Carbone Boréal
Arbres

Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Secteur:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Dénombrement Arbres (DHP 9.1 cm et +)

Arbres	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
A-1						
A-2						
A-3						
A-4						
A-5						
A-6						
A-7						
A-8						
A-9						
A-10						
A-11						
A-12						
A-13						
A-14						
A-15						
A-16						
A-17						
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A-22						
A-23						
A-24						
A-25						
A-26						
A-27						
A-28						
A-29						
A-30						

Parcelles Permanentes Projet Carbone Boréal
Dénombrement Arbres (DHP 9.1 cm et +) (suite)

Arbres	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
A-31						
A-32						
A-33						
A-34						
A-35						
A-36						
A-37						
A-38						
A-39						
A-40						
A-41						
A-42						
A-43						
A-44						
A-45						
A-46						
A-47						
A-48						
A-49						
A-50						
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A-63						
A-64						
A-65						
A-66						
A-67						
A-68						
A-69						
A-70						

Parcelles Permanentes Projet Carbone Boréal
Quantification Bois Mort

Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Secteur:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Arbre Mort	Esp	D. base (cm)	D. 1/3h (cm)	D. 1.3m (cm)	Haut/Long (m)	Position	Remarques
AM-1							
AM-2							
AM-3							
AM-4							
AM-5							
AM-6							
AM-7							
AM-8							
AM-9							
AM-10							
AM-11							
AM-12							
AM-13							
AM-14							
AM-15							
AM-16							
AM-17							
AM-18							
AM-19							
AM-20							
AM-21							
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AM-23							
AM-24							
AM-25							
AM-26							
AM-27							
AM-28							
AM-29							
AM-30							

Parcelles Permanentes Projet Carbone Boréal
Quantification Bois Mort

Arbre Mort	Esp	D. Base (cm)	D 1/3h (cm)	DHP (cm)	Hauteur (m)	Remarques
AM-31						
AM-32						
AM-33						
AM-34						
AM-35						
AM-36						
AM-37						
AM-38						
AM-39						
AM-40						
AM-41						
AM-42						
AM-43						
AM-44						
AM-45						
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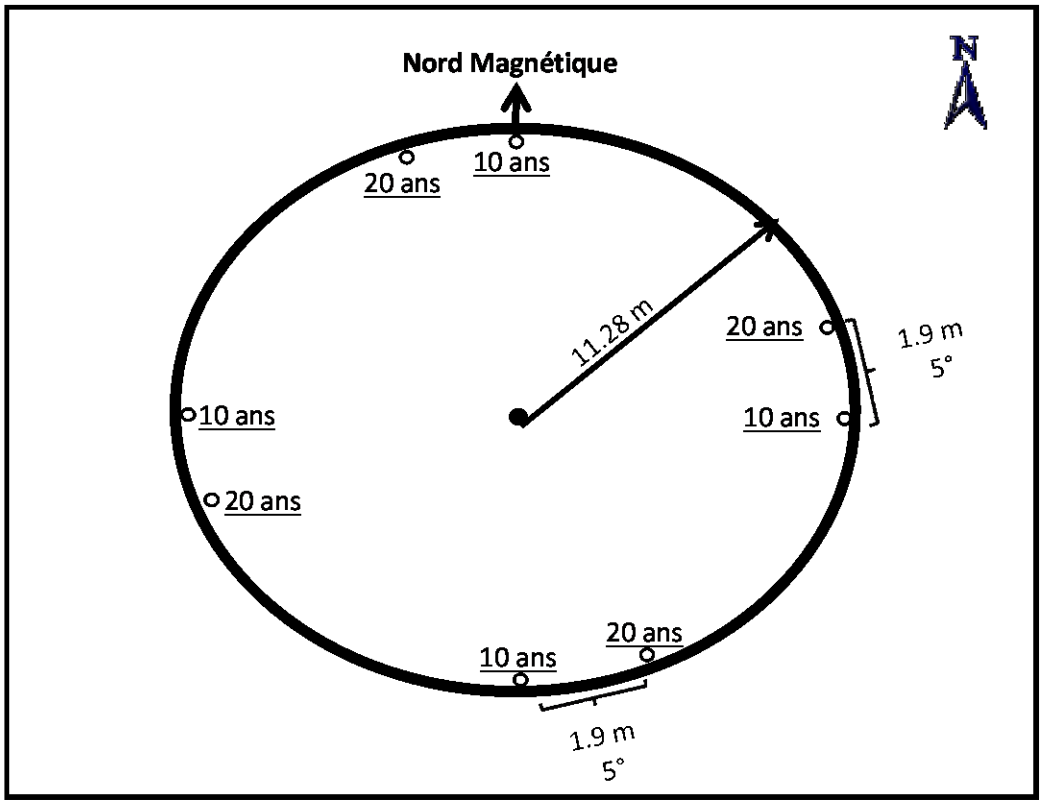
AM-62						
AM-63						
AM-64						
AM-65						
AM-66						
AM-67						
AM-68						
AM-69						
AM-70						

Parcelles Permanentes Projet Carbone Boréal
Quantification Humus

Caractéristiques Parcelle	
Année Plantation:	
Année du Relevé:	
Secteur:	
Bloc et Traitement:	
Espèce:	
Remarques:	

Prélèvement Sol Organique



Transects Épaisseur Humus

Transect / Point d'échantillonnage	1 (cm)	2 (cm)	3 (cm)	4 (cm)	5 (cm)
1					
2					
3					
4					
5					

Remarques:

Parcelles Permanentes Projet Carbone Boréal
Check List

Localisation de site:	
Caractéristiques Parcelle:	
Coordonnées Géographique:	
Repères Témoins:	
Shéma Localisation Parcelle:	
Déombrement et Mesures Arbres Plantés:	
Contre vérification (3 individus):	
Déombrement et Mesures Gaules:	
Contre vérification (3 individus):	
Déombrement et Mesures Arbres:	
Contre vérification (3 individus):	
Déombrement et Mesures Bois Mort:	
Contre vérification (3 individus):	
Prélèvement Sol Organique:	
Mesure Épaisseur Humus:	

Remarques:

Signature:

Signature:

Signature:

Signature:

Signature:

Stocking Plantation Carbone Boréal													
Identification						Plants		Semis				Pré-établis	
Secteur	Bloc-année	Trait	Esp	Transect	Placette	(1/0)	den	(1/0)	Sp den	Sp den	Sp den	(1/0)	den
					1								
					2								
					3								
					4								
					5								
					6								
					7								
					8								
					9								
					10								
					11								
					12								
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					48								
					49								
					50								

Remarques:

Annex 3: Monitoring plan

SSR name	Data parameter	Estimation, modeling, measurement or calculation approaches	Data Recording (electronic or paper)	Data unit	Sources/ Origin	Monitoring frequency	Description and justification of monitoring method	Uncertainty	Details for any deviations from methodology including the justification and rationale.
B1 and P7: Aboveground C reservoir	Carbon stocks	Calculations from allometric equations	Paper first for field measurements, then electronic data treatment	Ton of C per ha (then converted to ton CO_2eq. ha^{-1})	Aboveground alive vegetation present on-site	Every 10 years, plus yearly checks of eventual reversals	Estimation of C stocks from published (in peer-reviewed journals) allometric equations is the most appropriate method available for project-level monitoring	Uncertainty kept within ±10% of the true value of the mean for each plantation, estimated through measured stem diameter of trees in transects (see QP)	
B2 and P8: Belowground C reservoir	Carbon stocks	Calculations from allometric equations (ratio from aboveground reservoir)	Paper first for field measurements, then electronic data treatment	Ton of C per ha (then converted to ton CO_2eq. ha^{-1})	Alive roots present on-site	Every 10 years, plus yearly checks of eventual reversals	Estimation of C stocks from published (in peer-reviewed journals) allometric equations is the most appropriate method available for project-level monitoring	Uncertainty kept within ±10% of the true value of the mean for each plantation, estimated through measured stem diameter of trees in transects (see QP)	
B3 and P9: Litter and humus C reservoir	Carbon stocks	Direct mass determination from a plot sampling	Paper first for field measurements, then electronic data treatment	Ton of C per ha (then converted to ton CO_2eq. ha^{-1})	All litter and humus material present on-site	Every 10 years, plus yearly checks of eventual reversals	Estimation of C stocks from published (Brown et al. 2004) plot sampling method is the most appropriate method available for project-level monitoring	Uncertainty kept within ±10% of the true value of the mean for each plantation, estimated through measured stem diameter of trees in transects (see QP)	
B4 and P10: Soil organic C reservoir	Carbon stocks	Direct measurement of C content from LECO combustion of soil samples (see QP)	Paper first for field measurements, then electronic data treatment	Ton of C per ha (then converted to ton CO_2eq. ha^{-1})	All organic C within the mineral soil layer (30 cm depth) present on-site	Every 10 years, plus yearly checks of eventual reversals	Estimation of C stocks from published (Brown et al. 2004) plot sampling and combustion method is the most appropriate method available for project-level monitoring	Uncertainty kept within ±10% of the true value of the mean for each plantation, estimated through measured stem diameter of trees in transects (see QP)	

Annex 4: Reversal risk procedure

Procédure pour réduire les risques de pertes associées aux activités anthropiques

- Communiquer avec les responsables de chacune des unités de gestion (UG) du MRNF régulièrement pour être informer de l'avancement de la planification des travaux sylvicoles.
    - UG Roberval-St-Félicien : Frédéric Bouchard (418-679-3700 (310))
    - UG Mistassini : Nicolas Paradis (418-276-1400 (309))
    - UG Péribonka : Denis Lalonde (418-668-8319 (230))

- Dès que les plans d'interventions sylvicoles (PIS) pour l'année à venir sont disponible, les consulter à l'aide d'un SIG afin de les comparer aux superficies plantés dans le cadre du programme Carbone Boréal.
- En plus du PIS, il est très important de consulter la planification de voirie forestière afin d'éviter les pertes de superficies relatives à la création de chemins.
- Si le PIS ou la planification de voirie forestière empiète sur les superficies plantés dans le cadre du programme Carbone Boréal il faut aviser immédiatement le responsable de l'UG concernée.
- En plus des responsables des UG, il faut contacter Mr. Jean Chouinard du bureau régional du MRNF, Jean Massicote de Rexforet (418-275-5790) et Mme Andrée Michaud de la DRF afin de les informer de la situation afin qu'ils puissent réagir le plus rapidement possible.
- Faire le suivi auprès des responsables aussi longtemps que l'on a pas obtenus la confirmation que la planification fautive n'a pas été corrigée.

N.B. : Il est extrêmement important de faire cette vérification régulièrement.

Procédure de vérification annuelle de perte par les perturbations naturelles

- Profiter des visites terrain nécessaires à la mise en place et au suivi des plantations annuelles afin de visiter les autres plantations situé dans le même secteur pour vérifier l'état d celles-ci.
- À chaque année, préférablement à l'automne, contacter Mr. Pascal Baillargeon du MRNF (418-695-8125 (254)) afin d'obtenir les polygones (shapefiles) des mises à jours de feux pour l'année en cours.
- Comparer les fichiers de mises à jour de feux à ceux des dispositifs de Carbone Boréal à l'aide d'un SIG afin de déterminer s'il y a eu des pertes de superficie.
- Une fois les mises à jour de feux analysées, contacter Mr. Rémi Néron du MRNF (418-698-3660) afin d'obtenir les mises à jour des superficies affectées par la tordeuse des bourgeons de l'épinette (TBE).
- Comparer les fichiers des superficies affectées par la TBE à celles de Carbone Boréal à l'aide d'un SIG afin de déterminer s'il y a eu des superficies atteintes.
- Dans le cas où l'une ou l'autre des perturbations naturelles aurait affectées des superficies de Carbone Boréal, générer les polygones de superficies affectées et planifier les visites terrain afin de déterminer les superficies réellement affectées pour quantifier les pertes.

Annex 4: Data controls and procedures

Note: The following is an excerpt from the quantification protocol.

Method for uncertainty assessment and sampling plot number

As recommended in Brown et al. (2004), a reasonable level of precision for the estimate of C stock change with time in A/R projects can be achieved by targeting ±10% of the true value of the mean. Since they represent a significant proportion of the total C stocks and they can be easily measured (Brown et al. 2004), trees of height ≥ 2.0 m (from the ground line to the top of the apical shoot) will serve as representatives of the overall C stock uncertainty, and hence help finding the number of permanent sampling plots that needs to be established in both scenarios.

An adaptation of the cluster sampling method (Blais et al. 1996) is recommended to determine the overall variability in each scenario. Firstly, the contour of the total project area (including the area that will be secured for the baseline scenario) has to be delineated, and a series of parallel transects separated by 25 m each is then sketched on the entire area. At every 10 m in each transect, the stem diameter at breast height (DBH, at 1.3 m from the ground level) of the nearest tree (of height ≥ 2.0 m) is measured and recorded, in order to establish the average tree DBH of the total project. Then, four representative 400 m^2 sampling plots are selected, two for each scenario. The selection of each representative sampling plot must comply with the two following criteria: i) average measured tree DBH of all trees (of height ≥ 2.0 m) in the plot within 10% of the average tree DBH of the whole project (previously determined with the transects), ii) equivalent tree density (number of trees of height ≥ 2.0 m per 400 m^2 plot), dominant tree age (with an increment borer at 1 m-height, using the 4 largest trees per plot), soil deposit and drainage (visual evaluation of soil texture in small ground pits), and site slope and aspect (with a clinometer and a compass), between plots of each scenario.

Once the sampling plots are established, the perimeter of the baseline can be determined and secured for the complete duration of the project. A buffer (undisturbed) strip at least 20 m of width between the afforestation and baseline scenarios has to be planned, in order to keep the

baseline area unaffected by the adjacent afforestation activities (or any other activities around). Only one sampling plot per scenario is kept for detailed measurement and quantification (hereafter) and considered as the permanent plot for the complete duration of the project. The second sampling plot per scenario is kept as a backup plot, in case of an accidental reversal in the first selected plot. However, tree DBH of all trees (of height ≥ 2.0 m) in the backup plots must be remeasured at each decennial quantification period, to insure that each backup plot is still within 10% of the average DBH of the correspondent permanent plot. In case of deviation from this 10% uncertainty, an other backup must then be selected on the basis of both criteria described earlier.

The total height (in cm) is then measured on all trees of height ≥ 2.0 m in each sampling plot, using a flexible ruler when possible, or a clinometer for taller trees. The stem diameter (in cm) is measured on all remaining trees (less than 2 m-high), using a calliper – except for tree species for which an equation is provided by Roussopoulos and Loomis (1979) in Appendix 3, where stem diameter is measured at 15 cm height. The same measurement specifications apply for shrubs, except that they are measured only within the four subplots per sampling plot detailed hereafter.

Within each sampling plot, four 4-m^2 subplots (one in each of the 4 corners of the sampling plot at the beginning of the project) will be used for the determination of shrubs, mosses, and lichens biomass, as well as for the extraction of the litter, humus, mineral soil, and roots. Since these subplots are used for destructive measurements, adjacent 4-m^2 subplots are sequentially used (clock-wise rotation) at every 10-year measurement period (see Fig. 5).

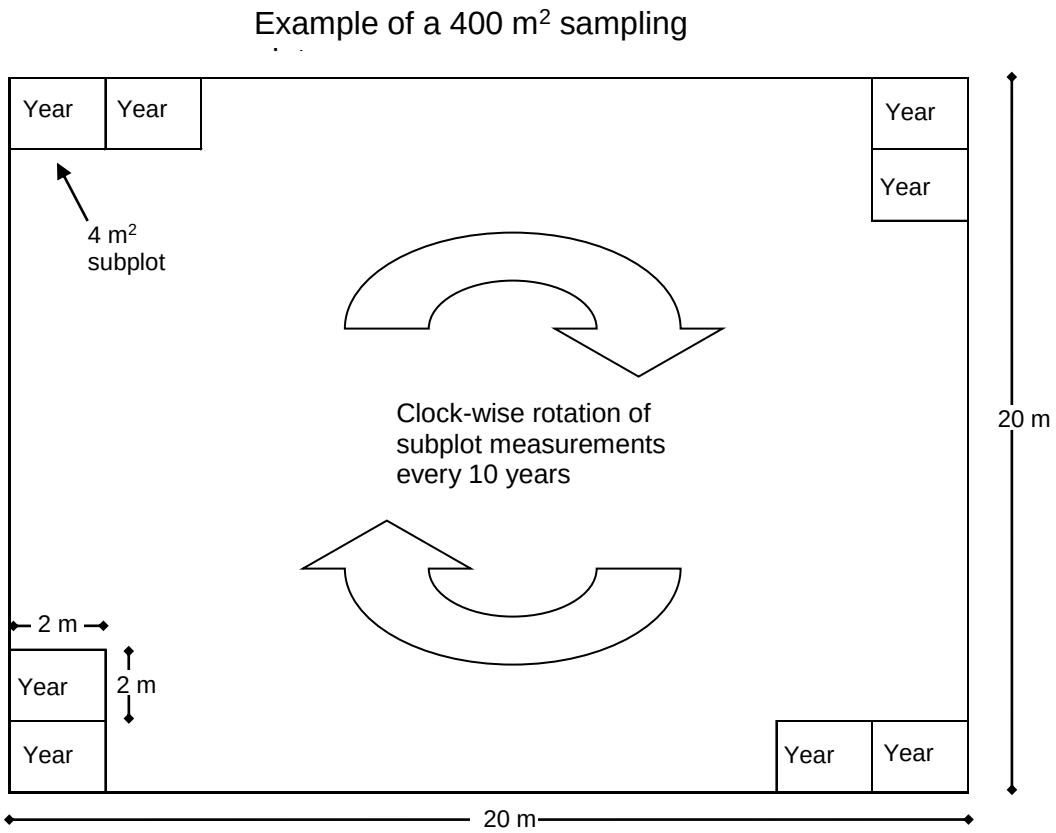


Figure 5. Example of a 400 m^2 sampling plot, also showing the 4 m^2 subplots therein (4 per measurement period every 10 years).

d) Methods for quantification of each SSR or parameter

Once the sampling plots and subplots therein are established, the methodology consists of four main phases:

1. the measurement of the height and diameter of all trees within the sampling plots and of the shrubs in the subplots;
2. the extraction of mosses and lichens in the subplots for their dry mass determination;
3. the extraction of the litter and humus layers in the subplots, followed by their sieving to remove and weight the roots of brush vegetation and weight the humus and litter;
4. the sampling of mineral soil cores within the subplots for the measurement of CO_2 from combustion.

Starting from year 0 to year 100 of the project, all steps need to be made every 10 years, because of the slow change expected from the C stock growth.

Step 1- The measurement of the height and diameter of all trees within the sampling plots and of the shrubs in the subplots has already been explained in the previous section (4.1c). Here again the method: the total height (in cm) is measured on all trees of height ≥ 2.0 m in each sampling plot, using a flexible ruler when possible, or a clinometer for taller trees. The stem diameter (in cm) is measured on all trees, using a calliper, at the stump height for trees less than 2 m high – except for tree species for which an equation is provided by Roussopoulos and Loomis (1979) in Appendix 3, where stem diameter is measured at 15 cm height – or at breast height (DBH) for trees of height ≥ 2.0 m. The same measurement specifications apply for shrubs, except that they are measured only within the four subplots per sampling plot.

Step 2- Mosses and lichens are carefully extracted from 1 m^2 in the center of each of the 4 subplots per sampling plot, for their dry mass determination. Beforehand, all aboveground brush vegetation (already measured in step 1) shall be cut. Then, care must be taken to extract only the living part of mosses and lichens, and to leave the litter on the surface of the humus layer. The extracted mosses and lichens are then allowed to desiccate during 48 hours at 65 ºC, or at constant weight. The dry mass determination is done to the nearest g and then reported in g m^{-2} for the entire sampling plot.

Step 3- The litter and the entire humus layer, including the roots therein, are extracted from 1 m^2 in the center of each of the 4 subplots per sampling plot. To accurately extract 1 m^2 of humus (and litter) just on the top of the mineral soil surface, the subplot perimeter should be first sliced up to the mineral soil with a sharpen shovel, or by other means. Once air-dried, the humus is then sieved with a 2 mm wide-mesh, in order to extract all non-decomposed roots. These roots are considered the belowground biomass from the brush vegetation, unless the roots from trees can be identified (and thus removed from the sample). The humus, litter and the brush roots are then allowed to desiccate during 48 hours at 65 ºC, or at constant weight. The dry mass determination of the humus and litter, on one hand, and the brush roots, on the other hand, is done to the nearest g and then reported in g m^{-2} for the entire sampling plot. It is recommended to keep a subsample

of the litter and humus to determine more precisely the C content of this biomass with the LECO (see next step). It is possible that the C content of the humus and litter can be significantly different from the normally accepted 50% of the dry mass in organic material (unpublished data).

Step 4- As described in Brown et al. (2004), for an accurate determination of organic C stocks in the mineral soil, three types of variables must be measured: (i) the soil depth, (ii) the soil bulk density (calculated from the oven-dry weight of soil from a known volume of sampled material), and (iii) the concentration of organic carbon within the sample. Since most of boreal forest podzols are relatively shallow (less than 1 m) and that the bulk of tree root systems are within 30 cm of depth, it is recommended to characterize the mineral soil to a depth of 30 cm. Two different soil samplings are made in each of the 4 subplots per sampling plot: one sampling for the soil bulk density determination, and the other sampling for the C concentration. The sampling for the bulk density shall be made using a 30 cm-long soil corer of known volume. The bulk density is determined by weighting (to the nearest g) the oven-dried soil sample at 105 ºC for a minimum of 48 hrs. If the soil contains coarse rocky fragments, they must be retained and weighed. For soil carbon determination, the material is air-dried and then sieved through a 2-mm sieve and a composite sample (from the 4 subplot samples) is then thoroughly mixed to obtain one C concentration per sampling plot. The dry combustion method using a specialized controlled-temperature furnace (eg. a LECO CHN-2000) is the recommended method for determining total C in the soil (Nelson and Sommers 1996). Soil samples should then be sent to a professional lab for analysis. Finally, the C concentrations (in % of dry mass) obtained are multiplied by the mean bulk density measured in the 4 subplots (in g cm^{-3}) and by the soil depth (30 cm), to result in g C cm^{-2}, which is then expended to g m^{-2} by multiplying by 10^4, before being used in equations [4] and [10].

e) Monitoring of reversals

As reversals by natural means can occur at any moment between the measurement periods (every 10 years), the project proponent is required to monitor every sampling plots of a project on a yearly basis in order to capture any reversal in a timely manner. Once a reversal is observed, a buffer plantation (and its corresponding baseline scenario) of equivalent C stocks (compared to

those in the reversed plantation) is identified from the buffer pool as a replacement plantation in the project. Measures are then taken to estimate the residual C stocks in the reversed plantation (and its baseline counterpart), and to evaluate the need to eventually regenerate the disturbed site. The re-established C stocks in the reversed plantation can ultimately contribute in the introduction of this plantation in the buffer pool.

Note: The following 4 figures are excerpts from MRNF's "Normes d'inventaire forestier - Placettes-échantillons temporaires peuplements de 7 m et plus de hauteur, Édition 2002"

Figure 1 : Installation de la borne identifiant le centre de la parcelle permanente et des repères

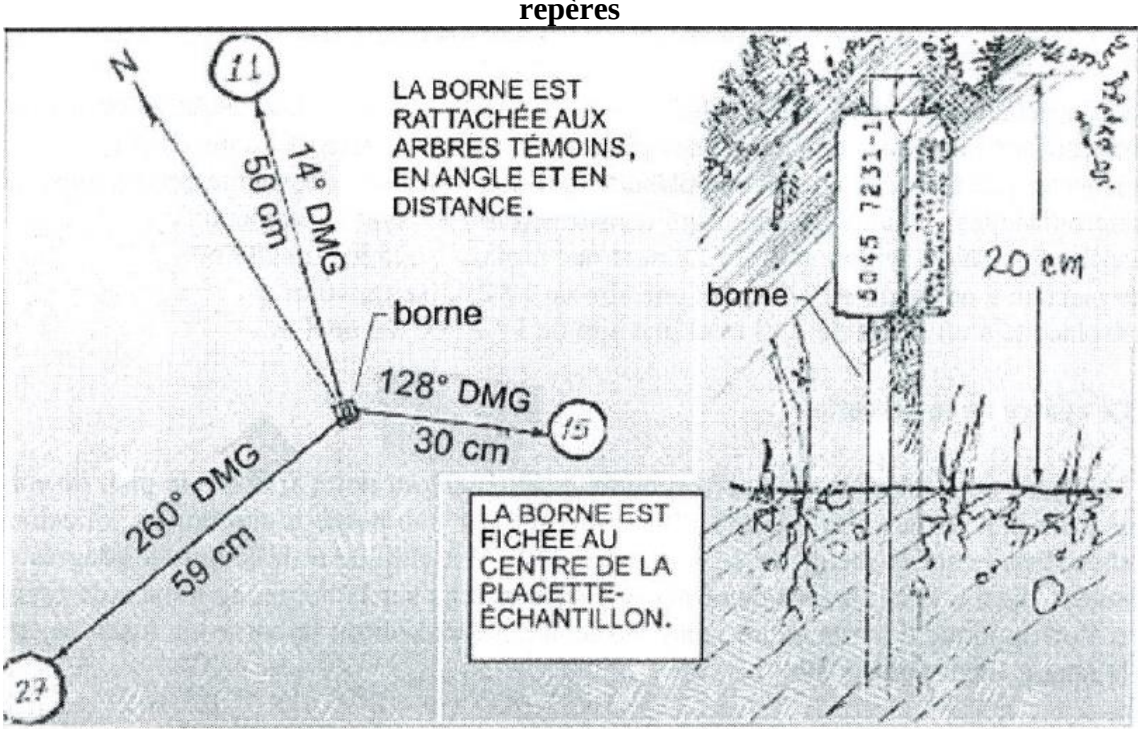


Figure 2 : Critères d'admissibilité des arbres à l'intérieure d'une parcelle permanente circulaire à rayon définie.

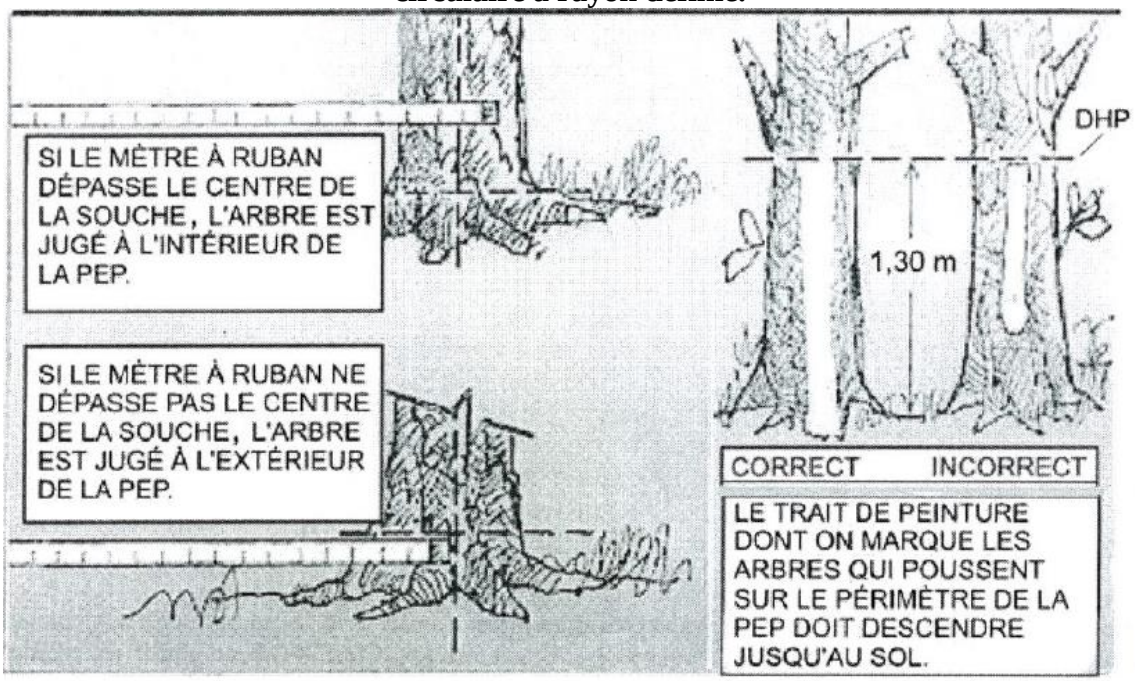


Figure 3 : Identification des arbres d'une parcelle permanente à l'aide de peinture

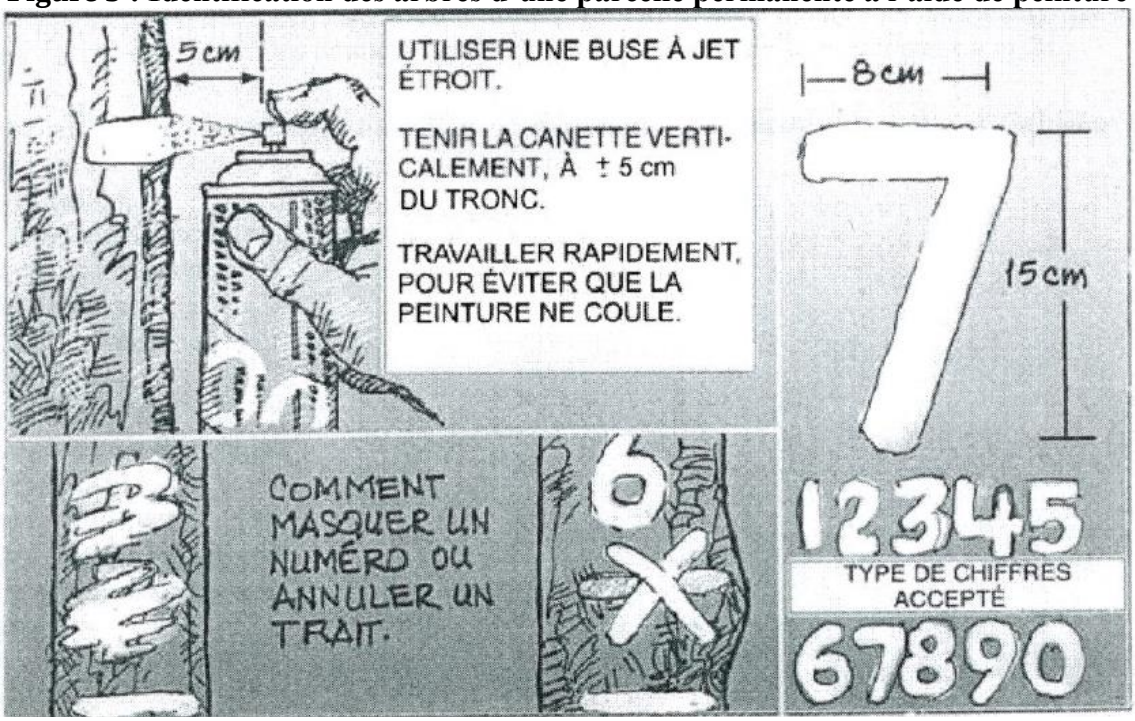


Figure 4 : Emplacement de la prise de mesure du DHP en présence de cas particulier

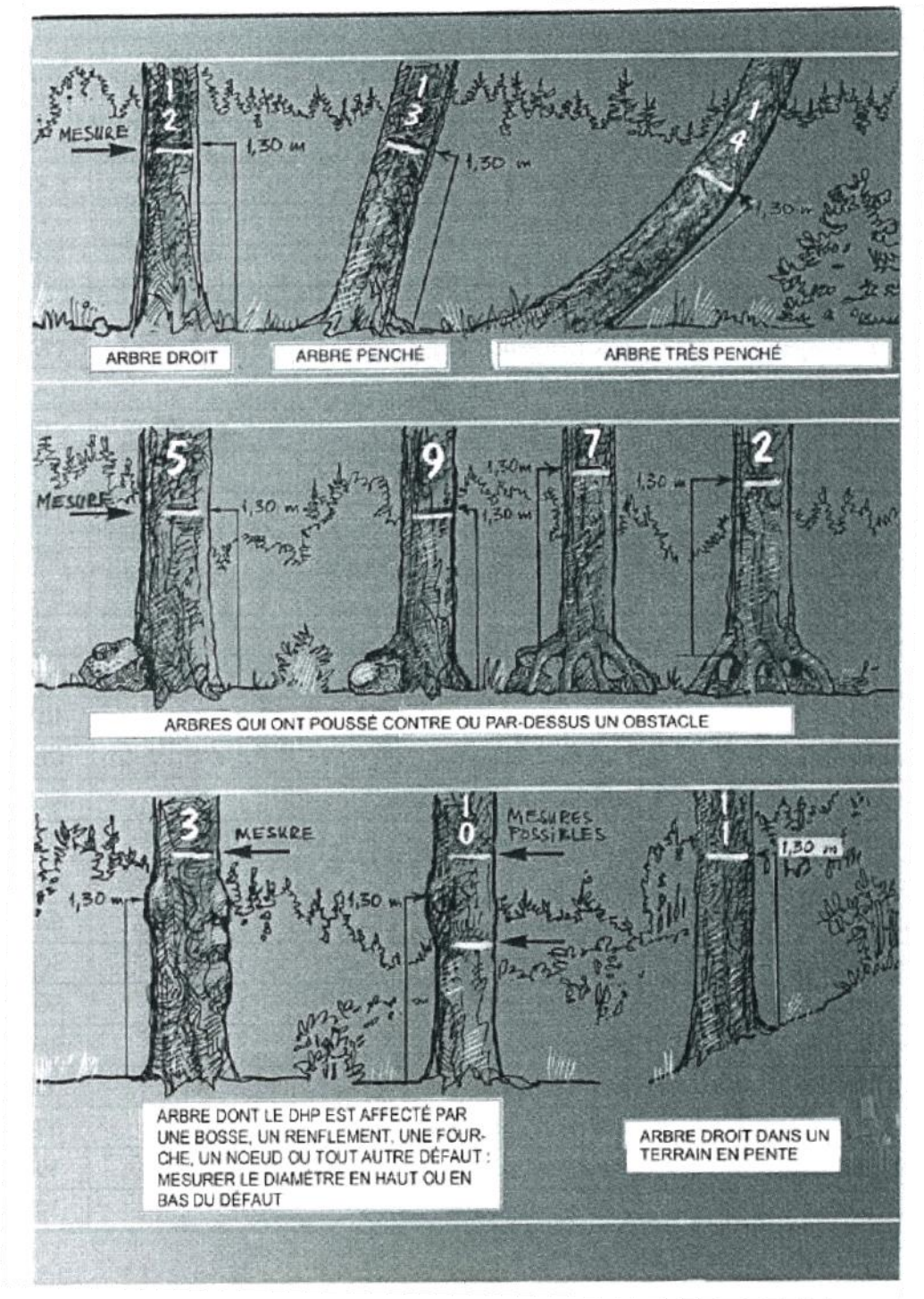
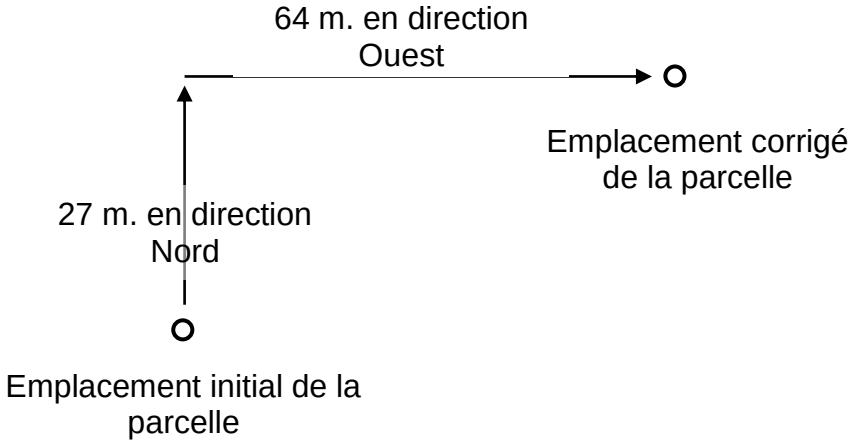


Figure 5 : Table des nombres aléatoires

	00-04	05-09	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
00	22808	04391	45529	53968	57136	98228	85485	13801	68194	56382
01	49305	36965	44849	64987	59501	35141	50159	57369	76913	75739
02	81934	19920	73316	69243	69605	17022	53264	83417	55193	92929
03	10840	13508	48120	22467	54505	70536	91206	81038	22418	34800
04	99555	73289	59605	37105	24621	44100	72832	12268	97089	68112
05	32677	45709	62337	35132	45128	96761	08745	53388	98353	46724
06	09401	75407	27704	11569	52842	83543	44750	03177	50511	15301
07	73424	31711	65519	74869	56744	40864	75315	89866	96563	75142
08	37075	81378	59472	71858	86903	66860	03757	32723	54273	45477
09	02060	37158	55244	44812	45369	78939	08048	28036	40946	03898
10	94719	43565	40028	79866	43137	28063	52513	66405	71511	66135
11	70234	48272	59621	88778	16536	36505	41724	24776	63971	01685
12	07972	71752	92745	86465	01845	27416	50519	48458	68460	63113
13	58521	64882	26993	48104	61307	73933	17214	44827	88306	78177
14	32580	45202	21148	09684	39411	04892	02055	75276	51831	85686
15	88796	30829	35009	22695	23694	11220	71006	26720	39476	60538
16	31525	82746	78935	82980	61236	28940	96341	13790	66247	33839
17	02747	35989	70387	89571	34570	17002	79223	96817	31681	15207
18	46651	28987	20625	61347	63981	41085	67412	29053	00724	14841
19	43598	14436	33521	55637	39789	26560	66404	71802	18763	80560
20	30596	92319	11474	64546	60030	73795	60809	24016	29166	36059
21	56198	64370	85771	62633	78240	05766	32419	35769	14057	80674
22	68266	67544	06464	84956	18431	04015	89049	15098	12018	89338
23	31107	28597	65102	75599	17496	87590	68848	33021	69855	54015
24	37555	05069	38680	87274	55152	21792	77219	48732	03377	01160
25	90463	27249	43845	94391	12145	36882	48906	52336	00780	74407
26	99189	88731	93531	52638	54989	04237	32978	59902	05463	09245
27	37631	74016	89072	59598	55356	27346	80856	80875	52850	36548
28	73829	21651	50141	76142	72303	06694	61697	76662	23745	96282
29	15634	89428	47090	12094	42134	62381	87236	90118	53463	46969
30	00571	45172	78532	63863	98597	15742	41967	11821	91389	07476
31	83374	10184	56384	27050	77700	13875	96607	76479	80535	17454
32	78666	85645	13181	08700	08289	62956	64439	39150	95690	18555
33	47890	88197	21368	65254	35917	54035	83028	84636	38186	50581
34	56238	13559	79344	83198	94642	35165	40188	21456	67024	62771
35	36369	32234	38129	59963	99237	72648	66504	99065	61161	16186
36	42934	34578	28968	74028	42164	56647	76806	61023	33099	48293
37	09010	15226	43474	30174	26727	39317	48508	55438	85336	40762
38	83897	90073	72941	85613	85569	24183	08247	15946	02957	68504
39	82206	01230	93252	89045	25141	91943	75531	87420	99012	80751
40	14175	32992	49046	41272	94040	44929	98531	27712	05106	35242
41	58968	88367	70927	74765	18635	85122	27722	95388	61523	91745
42	62601	04595	76926	11007	67631	64641	07994	04639	39314	83126
43	97030	71165	47032	85021	65554	66774	21560	04121	57297	85415
44	89074	31587	21360	41673	71192	85795	82757	52928	62586	02179
45	07806	81312	81215	99858	26762	28993	74951	64680	50934	32011
46	91540	86466	13229	76624	44092	96604	08590	89705	03424	48033
47	99279	27334	33804	77988	93592	90708	56780	70097	39907	51006
48	63224	05074	83941	25034	43516	22840	35230	66048	80754	46302
49	98361	97513	27529	66419	35328	19738	82366	38573	50967	72754

1ere sélection = 1 (Nord)
2e sélection = 27
3e sélection = 64



Annex 5 : Internal and/or peer review procedure

Procédure de révision aux fins de réalisation d'un projet de fin d'études de premier cycle universitaire (Baccalauréat)

Lors de la réalisation d'un projet de fin d'études de premier cycle au Baccalauréat en biologie dans le cadre du projet Carbone Boréal les étudiants commencent d'abord par se familiariser avec le plan d'échantillonnage associé au projet sur lequel ils travaillent. Par la suite ceux-ci sont amenés à participer à la saisie de données sur le terrain en collaboration et sous la supervision d'un professionnel de recherche expérimenté. Par la suite la saisie des données sur ordinateur est effectuée par les étudiants en question et contre-vérifiée par le superviseur du projet (professeur attitré, professeur associé, chargé de cours, professionnel de recherche). L'analyse et l'interprétation des données sont réalisées avec le superviseur. Les résultats de recherche sont présentés aux superviseurs sous forme de rapport scientifique et soumis à une révision complète avant le dépôt du rapport final. Par la suite ces résultats sont diffusés au publique sous forme de présentation orale dans le cadre d'un mini-congrès tenu à cette fin. Les rapports finaux découlant des travaux de recherche sont archivés aux bureaux des superviseurs ainsi qu'à la bibliothèque de l'UQAC afin d'être disponible pour l'ensemble de la communauté.

Procédure de révision aux fins de réalisation d'un projet de 2^{e} cycle universitaire (Maîtrise)

Lors de la réalisation d'un mémoire de maîtrise, les étudiants-chercheurs travaillent avec plus d'autonomie mais demeurent toujours en contact avec leurs superviseurs ou le professionnel de recherche associé au projet et une contre vérification des données est effectuée à de nombreuses reprises au cours de la durée du projet. Lors de la soumission du mémoire de maîtrise l'étudiant chercheur doit fournir un minimum de 3 copies de son document qui seront remis 1- au directeur de maîtrise, 2- à un autre professeur chercheur ou professeur associé du département des sciences fondamentales et 3- à un correcteur externe reconnu comme étant un expert sur le sujet. Le document sera analysé par toutes ces personnes afin de valider que les approches méthodologiques, statistiques, les interprétations et les conclusions soient valides et conforme à la méthode scientifique. Chacun de ces correcteurs remettra à l'étudiant une liste de corrections et commentaires qui devront être intégrés afin que le document puisse être finalement déposé. Après le dépôt le document en question est rendu disponible à l'ensemble de la communauté via la bibliothèque de l'établissement qui émet le diplôme ainsi qu'à la bibliothèque nationale du Canada. Le processus assure la qualité du travail effectué et la conformité aux standards internationaux en termes d'études de cycle supérieur.

Procédure de révision aux fins de réalisation d'un projet de 3e cycle universitaire (Doctorat)

Lors de la réalisation d'un projet de projet de doctorat les étudiants chercheurs font preuve d'un maximum d'autonomie et sont responsable de la presque totalité de chacune des étapes de leur projet. Il assure la rigueur et la qualité des données en définissant clairement les méthodologies à utilisées et en validant les banques de données. Lors de la soumission d'une thèse de doctorat l'étudiant chercheur doit fournir un minimum de 5 copies de son document qui seront remis 1- au directeur de maîtrise (et au co-directeur si tel est le cas), 2- à un comité de révision externe reconnu comme étant des expert sur le sujet. Le document sera analysé par toutes ces personnes afin de valider que les approches méthodologiques, statistiques, les interprétations et les conclusions soient valides et conforme à la méthode scientifique. Chacun de ces correcteurs remettra à l'étudiant une liste de corrections et commentaires qui devront être intégrés afin que le document puisse être finalement déposé. Suite à cette première étape l'étudiant chercheurs intègre les corrections et prépare une soutenance de thèse qui consiste en une présentation verbale des résultats de recherche devant un comité d'expert où le projet en entier sera ré-analysé. Si la soutenance est couronnée de succès l'étudiant-chercheur est autorisé à faire le dépôt final de sa thèse de doctorat. Après le dépôt le document en question est rendu disponible à l'ensemble de la communauté via la bibliothèque de l'établissement qui émet le diplôme ainsi qu'à la bibliothèque nationale du Canada. Le processus assure la qualité du travail effectué et la conformité aux standards internationaux en termes d'études de cycle supérieur.

Procédure de révision aux fins de la publication d'un article scientifique (surtout en lien avec l'utilisation de l'article Gaboury *et al*. 2009 dans le projet).

La soumission d'un article scientifique dans une revue avec comité de révision implique que tous les auteurs d'un document aient révisé celui-ci avant la soumission. Lorsque chacun des auteurs considère que le document est mûr pour la soumission celui-ci est transmis à l'éditeur de la revue visée. L'éditeur consulte alors le document et peut dès cette étape rejeter le manuscrit pour de multiple raisons. Si le manuscrits réussi l'épreuve de l'éditeur, celui-ci recherche alors des experts reconnus (réviseurs) sur le sujet dont traite l'article afin que ceux-ci puissent en faire l'analyse afin de valider les approches méthodologique et statistique utilisées ainsi que l'interprétation et les conclusions tirées dans cet article. L'analyse de l'article peut mener à trois options différentes : 1- le rejet de l'article (sujet inapproprié pour la revue visée, portée trop locale, grave erreur méthodologique, etc.), 2- l'acceptation de l'article avec corrections mineurs et 3- l'acceptation de l'article avec corrections majeurs. Pour chacun des trois scénarios, les réviseurs fournissent une liste de correctifs à apporter afin d'améliorer le manuscrit. Ces correctifs devront être intégrés ou justifiés avant la publication de l'article. Après l'intégration des correctifs, l'article est resoumis à une révision afin que

l'éditeur s'assure que les modifications nécessaires ont été apportées à l'article. De cette façon, on s'assure que les articles publiés sont toujours le fruit d'un travail original, rigoureux, pertinent et contribuant à l'avancement des connaissances scientifiques.

Annex 6: Plantation localisation and installation procedure

Validation Carbone Boréal
Procédure de localisation et d'installation d'une plantation

- Communiquer avec les responsables de chacune des unités de gestion (UG) du MRNF régulièrement pour être informer de l'avancement de la planification des travaux sylvicoles.
    - UG Roberval-St-Félicien : Frédéric Bouchard (418-679-3700 (310))
    - UG Mistassini : Nicolas Paradis (418-276-1400 (309))
    - UG Péribonka : Denis Lalonde (418-668-8319 (230))
- Dès que les plans d'interventions sylvicoles (PIS) sont disponible, les consulter à l'aide d'un SIG afin de les comparer aux superficies planté dans le cadre du programme Carbone Boréal.
- En plus du PIS, il est très important de consulter la planification de voirie forestière afin d'éviter les pertes de superficies relatives à la création de chemins.
- Si le PIS ou la planification de voirie forestière empiète sur les superficies plantés dans le cadre du programme Carbone Boréal il faut aviser immédiatement le responsable de l'UG concerné
- Lorsque l'accessibilité aux peuplements potentiels est adéquate, utiliser les orthophotos les plus récentes disponibles afin de déterminer que les peuplements ciblés correspondent bien aux besoins du programme Carbone Boréal en terme de densité des tiges et du couvert arborescent (< 25%). Si nécessaire consulter les responsables des UG mentionnés ci-haut afin d'obtenir des renseignements sur les peuplements potentiels car ce sont eux qui possèdent la meilleure connaissance du territoire. Autrement si les informations disponibles ne sont pas adéquates afin d'assurer la validité des peuplements, planifier une visite terrain afin de déterminer l'admissibilité des peuplements ciblés.
- Lorsque les peuplements sont validés, utiliser un SIG afin de procéder au découpage de ceux-ci, d'éliminer les secteurs non désirables et de préciser le traitement à attribuer à chacun des polygones. Il est très important de s'assurer d'identifier une portion de peuplement d'un minimum de 1 ha. sur laquelle aucun traitement ne sera appliqué afin de servir de scénario de référence pour la plantation localisé à cet endroit.
- Transmettre le fichier issu des opérations mentionnées dans le paragraphe précédent aux responsables des UG sur lesquelles seront installées des plantations ainsi qu'a Mr. Jean Chouinard du bureau régional du MRNF car ce sont eux qui sont responsable de l'application des traitements sylvicole relatifs au programme Carbone Boréal.
- Une fois les préparations de terrains et les plantations effectuées, découper les contours des superficies traitées à l'aide d'un GPS et importer ces contours dans un SIG. Transmettre ces contours et un formulaire de demande de création d'une Forêt d'expérimentation (FE) dûment rempli à Mme. Andrée Michaud de la DRF (418-643-7994 (6681)). Le statu est attribué pour une durée maximale de 30 ans, il faut donc laisser une note au dossier afin de refaire la demande lors de l'échéance de la première demande.
- Par la suite il est important d'aller installer une affiche permettant d'identifier le territoire comme faisant parti du réseau de plantation du programme Carbone Boréal où les coordonnées des responsables et la durée du projet seront indiquées. Cela permettra d'informer le public et d'éviter les pertes associées aux activités anthropiques dans ces secteurs.