



VCS Methodology

VM0034

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# CANDIAN FOREST CARBON OFFSET METHODOLOGY

Version 2.0

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Sectoral Scope 14

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# 1 SOURCES

In developing this methodology, a range of good practice guidance has been consulted, including both general greenhouse gas (GHG) quantification guidance and guidance specific to forestry projects. Written guidance consulted in the development of this methodology includes, but was not limited to the documents listed below.

## 1.1 General GHG Quantification Guidance

- Canada's Offset System for GHG Guide for Protocol Developers, Draft for Consultation, 2008<sup>1</sup>
- CDM Tool 02 *Combined tool to identify the baseline scenario and demonstrate additionality*
- IPCC 2003 GPG for LULUCF
- ISO 14064-2<sup>2</sup>
- IPCC Guidelines for National GHG Inventories (2006)
- System of Measurement and Reporting for Technologies<sup>3</sup>
- *VCS Program Definitions*
- *VCS Program Guide*
- WRI / WBCSD GHG Protocol for Project Accounting<sup>4</sup>

## 1.2 Forestry-Specific Guidance and Methodologies

- American Carbon Registry *Improved Forest Management Methodology* September 2010<sup>5</sup>
- British Columbia Forest Offset Guide Version 1.0<sup>6</sup>
- Climate Action Reserve Forest Project Protocol Version 3.2<sup>7</sup>

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<sup>1</sup> Turning the Corner, Canada's Offset System for GHG Guide for Protocol Developers, Draft for Consultation, Environment Canada (2008).

<sup>2</sup> ISO 14064-2:2006, GHG - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements (2006).

<sup>3</sup> Climate Change Technology Early Action Measures (TEAM) Requirements and Guidance for the System of Measurement And Reporting for Technologies (SMART), Government of Canada (2004).

<sup>4</sup> World Resources Institute / World Business Council for Sustainable Development, The GHG Protocol for Project Accounting, November, 2005.

<sup>5</sup> American Carbon Registry / Finite Carbon, Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberland, September 2010.

<sup>6</sup> British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009

<sup>7</sup> Climate Action Reserve, Forest Project Protocol Version 3.2, August 31, 2010

- Draft North American Forest Carbon Standard<sup>8</sup>
- IPCC 2006 Guidelines for Forest Land<sup>9</sup>
- VCS AFOLU Non-Permanence Risk Tool

## 2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project method
Crediting Baseline	Project method

The methodology is designed to quantify the GHG reductions achieved by a range of project activities including improved forest management, reforestation and avoided conversion activities implemented in forests in Canada. The approach included in the methodology to quantify carbon in forest carbon pools is based on the extensive scientific knowledge base which exists regarding the dynamics of Canadian forest at the provincial level. This methodology specifically allows users to select appropriate models and sampling protocols from a suite of well-established models and monitoring methods covering the full range of forest activities and forest carbon pools in the provinces of British Columbia (BC) and Quebec (QC). These models and protocols are well calibrated for the range of forest ecosystems in these respective provinces, and are consistent with national and Intergovernmental Panel on Climate Change (IPCC) standards.

Project proponents developing projects in other provinces of Canada must select appropriate models and sampling protocols and demonstrate that they are well-calibrated for the range of forest ecosystem of the relevant province, as well as to demonstrate their consistency with national and IPCC standards<sup>10</sup>.

<sup>8</sup> For more information, see <http://forestcarbonstandards.org/home.html>

<sup>9</sup> IPCC, 2006 IPCC Guidelines for National GHG Inventories, Volume 4, Chapter 4: Forest Land, 2006

<sup>10</sup> Any alternative model must meet the following minimum requirements:

- The model is scientifically sound, and has been peer reviewed in a process that: (i) primarily involved reviewers with the necessary technical expertise (e.g., modeling specialists and relevant fields of biology, forestry, ecology, etc.), and (ii) was open and rigorous;
- The model is based on empirical evidence, and has been parameterized and validated for the general conditions of the project land area;
- Application of the model is limited to the scope for which the model was developed and evaluated;
- The model's scope of application, assumptions, known equations, data sets, factors or parameters, etc., are clearly documented;
- The models must provide accurate modelling of time dependent parameters such as decay, below ground biomass and soil carbon changes, etc. The model must not assume that such changes take place instantaneously or within a short period of time.

In addition alternative models must consider the requirements set out in the *VCS Methodology Requirements, v4.0*.

A wide range of practices and technologies are available for use in forest projects. This methodology will not attempt to describe them here or restrict the applicability of the methodology to specific practices or technologies. Instead, project proponents must clearly describe their project and associated practices and technologies in a project description.

The steps to be undertaken in developing a project under this methodology are:

1. Determination of methodology applicability.
2. Determination of project eligibility under the *VCS Standard*.
3. Identification of the project boundary, including both the geographic boundary, and the carbon pools and emission sources to be accounted.
4. Determination of the baseline scenario for the project.
5. Determination of whether the project meets the relevant criteria for the determination of additionality.
6. Ex-ante estimation of the changes in carbon pools and GHG emissions under the baseline scenario. Because the methodology requires updating of baselines for some project categories, the ex-ante baseline estimates may or may not be updated ex-post prior to later verification events.
7. Ex-ante estimation of the changes in carbon pools and GHG emissions under the project scenario. Updating of the project estimates will be undertaken on an ex-post basis prior to later verification events.
8. Ex-ante estimation of emissions due to leakage.
9. Summation of the estimated GHG benefits of the project.
10. Preparation of a monitoring plan.

## 2.1 GHG(s) Included in Methodology

This methodology focuses on enhancing sequestration of carbon dioxide by forests, reducing carbon dioxide emissions from forests and forestry operations, and maintaining or increasing stores of carbon in forest and wood product carbon pools. Depending on project-specific circumstances, comparatively small changes (either increases or decreases) in the emissions of methane and nitrous oxide may also be realized. GHG sources are described in Table 1 below.

Table 1: GHG Sources included in this Methodology

GHG	Source/Sink	Included?	Explanation
CO <sub>2</sub>	Forest biomass (living and dead)	Yes	Primary sink/source in the target project activities
	Soil carbon	Yes	Potential sink/source in many project activities

	Harvested wood products	Yes	Potential sink/source in many project activities
	Fossil fuel combustion	Yes	Changes in emissions typically associated with changes in management
CH <sub>4</sub>	Biomass combustion	Conditionally	Where biomass burning occurs in the baseline or project scenarios
	Anaerobic decomposition	Conditionally	Where anaerobic decomposition occurs as part of the harvested wood product cycle
	Fossil fuel combustion	Yes	Changes in emissions typically associated with changes in management
N <sub>2</sub> O	Biomass combustion	Conditionally	Where biomass burning occurs in the baseline or project scenarios
	Fertilizers	Conditionally	Where changes in nitrogen fertilizer use occur between the baseline and project scenarios
	Fossil fuel combustion	Yes	Changes in emissions typically associated with changes in management

### 2.3 Methodology Flexibility

This methodology is applicable to a wide range of forest carbon projects. To facilitate this, the following general flexibility mechanisms are included, with more detail on each provided in appropriate sections of this methodology:

- **Specific project activities.** A wide range of project activities are permitted, as long as they fall within the general eligible project type categories described in this methodology.
- **Baseline scenario selection approach.** For some project activities, flexibility is given in the methodology with respect to the approach used to identify the baseline scenario.
- **Exclusion of sources, sinks and pools (SSPs).** Where justified based on project and baseline-specific details, project proponents may exclude some additional SSPs from quantification beyond those excluded by default in the methodology. This would include SSPs that are not present in the project and baseline for the specific project, emission sources where project emissions are less than baseline emissions (this is a requirement for related emission sources), or SSPs that can be demonstrated to be *de minimis*.
- **Forest carbon quantification approaches.** This methodology allows project proponents to choose appropriate forest carbon pool inventory, modeling, and/or other related approaches from the options given, subject to meeting the requirements stipulated in this methodology.

- **Emission source quantification methods.** For some emission sources, more than one option is provided for quantification, with project proponents being free to choose the method most suited to available data.
- **Project-specific emission factors and assumptions.** Where justified, appropriately documented, and permitted by the quantification methodologies provided in this methodology, project-specific emission factors and assumptions may be used instead of default references sources and/or factors noted in the methodology.
- **Assessing leakage.** Various options are presented for project proponents to address activity shifting and/or market leakage, as appropriate, for their projects.
- **Project-specific monitoring approaches.** To account for the wide variety of potential project applications, project-specific monitoring approaches may be used if justified and if they conform to the general requirements stipulated in the methodology.
- **Project-specific data quality management approaches.** To account for the wide variety of potential project applications, project-specific data quality management approaches are to be developed. This methodology does not prescribe specific data quality management approaches that must be followed.
- **Managing risk of reversal.** Project proponents are able to develop their own detailed approach to assessing and managing reversal risks, subject to the general requirements stipulated in this methodology.



### 3 DEFINITIONS

In addition to the definitions set out in VCS document *Program Definitions*, the below definitions and acronyms apply to this methodology. In some cases, for projects being developed in the province of British Columbia (BC), it has been necessary to provide definitions of terms in this methodology which are also defined in the VCS *Program Definitions* document, in order to ensure consistency with the BC Emission Offset Regulation (EOR), or to avoid confusion with standard BC practices or usages. In these cases, the definitions given in this methodology must be used. Where projects are developed in other provinces of Canada, the VCS definitions must be applied.

#### **Activity Shifting Leakage**

An increase in GHG emissions from areas outside the project area, which is caused by the project activity, and which occurs when the actual agent of deforestation and/or degradation moves to or undertakes activities in an area outside of the project area and continues their deforesting and/or degrading activities in that location

#### **Additionality**

The concept that a project's emission reductions and removal enhancements must go beyond (ie, be additional to) what would have occurred in the absence of the GHG offset project. In the BC EOR, projects are deemed additional where they can demonstrate that the incentive of having a GHG reduction recognized as an emission offset is a key factor in overcoming financial, technological or other obstacles to carrying out the project. Additionality is determined following the procedure described in Section 7.

#### **Affected SSP**

A GHG source, sink, or carbon pool influenced by a project activity through changes in market demand or supply for associated products or services, or through physical displacement

#### **Afforestation, Reforestation and Revegetation (ARR)<sup>11</sup>**

See definition in the *VCS Methodology Requirements*.

#### **Baseline Scenario**

The most likely sequence of events and actions which would be expected to occur in the absence of the project activity

#### **CO<sub>2</sub> Equivalent (CO<sub>2</sub>e)**

The universal unit of measurement to indicate the global warming potential (GWP) of each of the six GHG, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate releasing (or avoiding releasing) different GHG against a common basis.

#### **Controlled SSP**

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<sup>11</sup> The term "afforestation" is used interchangeably with ARR within this methodology because "afforestation" is a defined term within British Columbia's Forest Inventory legislation.

A GHG source, sink, or carbon pool whose operation is under the direction and influence of project proponents through financial, policy, management or other instruments

### **Crediting Period**

The time period for which GHG emission reductions or removals generated by the project are eligible for issuance as VCUs, the rules with respect to the length of such time period and the renewal of the project crediting period being set out in the *VCS Standard*.<sup>12</sup> Equivalent to the “validation period” under the BC EOR.

### **Crown Land(s)**

Land, whether or not it is covered in water, or an interest in land, vested in the government of the Province of British Columbia.

### **De Minimis**

Carbon pools or GHG sources may be deemed *de minimis* and are not required to be accounted for if together the total decrease in carbon stocks or increase in GHG emissions under the project scenario as compared with the baseline scenario for the omitted pools and sources amounts to less than 5% of the total GHG benefit generated by the project

### **Emission factor**

A factor allowing GHG emissions or removals to be estimated from available activity data (e.g., tonnes of fuel consumed, tonnes of product produced)

### **Ex-ante**

An analysis or quantification of future events or conditions

### **Ex-post**

An analysis or quantification of past events or conditions

### **FCOP**

BC Forest Carbon Offset Protocol

### **Forest Land**

Land on which a forest is found, with the definition of forest being the current definition used by Canada for reporting under the United Nations Convention on Climate Change (UNCCC). Project proponents must check to ensure that they are using the most current version of this definition. At the time of writing of this methodology, the definition was<sup>13</sup>:

An area:

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<sup>12</sup> This definition is as given in the *VCS Program Definitions*. The most recent definition given by the VCS may be used.

<sup>13</sup> <http://cfs.nrcan.gc.ca/pages/97>

- That is greater than or equal to one hectare in size measured tree-base to tree-base (stump to stump), and has a minimum width of 20 m, and;
- Where trees on the area are capable of achieving:
  - A minimum height of 5 metres at maturity; and
  - A minimum crown cover of 25% at maturity.

Forest land may include areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting, or as a result of natural causes, but which are expected to revert to forest.

### **Global Warming Potential (GWP)**

A factor describing the radiative forcing impact of one mass-based unit of a given GHG relative to an equivalent unit of carbon dioxide over a given period of time.

### **Greenhouse Gases (GHG)**

GHGs include the six gases listed in the Kyoto Protocol: carbon dioxide (CO<sub>2</sub>); methane (CH<sub>4</sub>); nitrous oxide (N<sub>2</sub>O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF<sub>6</sub>)

### **Grouped Projects**

See definition as set out in the *VCS Program Definitions* and specific requirements as set out in the *VCS Standard*.

### **Harvested Wood Products**

Equivalent to “wood products” as defined in the *VCS Program Definitions*

### **Improved Forest Management (IFM)**

See definition in the *VCS Methodology Requirements*.

### **Leakage zone**

An area or areas in the region of, but outside of, the project area where activities could be undertaken which are similar to those undertaken within the project area under the baseline scenario. Assessment of activity shifting leakage will be undertaken within the leakage zone.

### **Market Leakage**

An increase in GHG emissions from areas outside the project area, which occurs as a result of the project significantly reducing the production of a commodity, causing a change in the supply and market demand equilibrium, which results in a shift of production elsewhere to make up for the lost supply

### **Monitoring**

The continuous or periodic assessment and documentation of GHG emissions and removals or other GHG-related data

**Monitoring Report**

A document which records data to allow the assessment of the GHG emission reductions or removals generated by the project during a given time period in accordance with the monitoring plan set out in the project description, prepared using the *VCS Monitoring Report Template*. Where projects are developed within the province of BC, the report must contain data relevant to the project as required in Section 5 or Section 7 of the BC EOR, whichever is applicable.

**Parameter**

A variable. A characteristic of an object, process or analysis for which quantitative values can be determined.

**Project Area**

The area or areas of land on which project proponents will undertake the project activities.

**Project Description**

The document that describes the project's GHG emission reduction or removal activities, and that uses the *VCS Project Description Template*. This document is referred to as the project plan within the BC Emission Offset regulation. The project description must be prepared in accordance VCS rules, and with Section 3 or 7, whichever applies, of the BC Emission Offset regulation.

**Project Report**

See the definition of monitoring report.

**Project Scenario**

The actions and events which are expected to occur as a result of implementing the project.

**Project Plan**

See definition of project description.

**Reduced Emissions from Deforestation and Degradation (REDD)**

See definition in the *VCS Methodology Requirements*.

**Registered Professional**

An applied scientist who is:

- Registered and in good standing in the respective province with an appropriate professional organization constituted under corresponding provincial legislation, acting under the organization's code of ethics and subject to disciplinary action by that organization, and;
- Acting within that individual's area of expertise.

**Related SSP**

A GHG source, sink, or carbon pool that has material or energy flows into, out of, or within the project

**Sink**

Any physical unit or process that removes GHGs from the atmosphere

**Source**

Any physical unit or process that releases GHG into the atmosphere

**SSP**

Acronym for sources, sinks and carbon pools. Equivalent to SSR (sources, sinks, and reservoirs), as per ISO 14064-2.

## 4 APPLICABILITY CONDITIONS

This methodology is applicable under the following conditions:

1. Projects must be located within Canada.
2. The project start date must be after November 29, 2007.
3. Project activities located within the province of BC must comply with the BC EOR. In the case of projects within other provinces, projects must comply with existing and relevant provincial emission offset regulations.
4. Project activities must not include actions expected to significantly impact the hydrology of any site within the project area, including but not limited to flood irrigation or drainage.
5. Where a project involves planting, the project must use genetically diverse and productive seed stock. For projects within the province of BC, projects must apply the BC Chief Forester's Standards for Seed Use<sup>14</sup>. In the case of projects within other provinces, projects must comply with relevant provincial legislation and use genetically diverse and productive seed stock.
6. This methodology applies to the following VCS project categories<sup>15</sup>:
  - Afforestation, Reforestation and Revegetation (ARR)
  - Improved Forest Management – Reduced Impact Logging (IFM – RIL) -
  - Improved Forest Management – Logged to Protected Forests (IFM – LtPF)
  - Improved Forest Management – Extended Rotation Age (IFM – ERA)
  - Improved Forest Management – Low to High Productivity (IFM – LtHP)
  - Reduced Emissions from Deforestation and Degradation – Avoided Planned Deforestation (REDD – APD)
7. Projects in the following project categories must also meet the following conditions:

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<sup>14</sup> Available at <http://www.for.gov.bc.ca/code/cfstandards/>

<sup>15</sup> For details on VCS project categories refer to section 3.2.1 of the VCS Standard v4.0

- ARR: Project proponents must demonstrate that the project area has not been forest land for at least 10 years prior to project commencement.
- IFM: Project area must be forest land at the time of project commencement.
- REDD: Project area must be forest land at the time of project commencement, and must have been forest land for not less than 10 years prior to the project start date.

## 5 PROJECT BOUNDARY

### 5.1 Identification of the Project Area

Project proponents must provide geographical information about the location where the project will be carried out and any other information allowing for the unique identification of the project area. Projects within the province of BC must comply with the latest version of the BC EOR.<sup>16</sup> The project area can be contiguous or separated into tracts.

This information must include a geo-referenced map that shows the project area in accordance with VCS rules. Project proponents are encouraged to use provincial base mapping, corporate spatial data stored in the Land and Resource Data Warehouse (LRDW), and GIS-based analytical and reporting tools and map viewers such as iMapBC, MapView, or SeedMap.

The map provided must be at a sufficiently large scale (eg, 1:20,000 or larger, though in some cases a smaller scale map may be appropriate), and include sufficient features, place names and administrative boundaries to enable field interpretation and positive identification of the project site.

The following information must be provided on the map:

- Forest ownership or license area and project boundaries
- Size of forest ownership or license area
- Latitude/longitude, or land title or land survey
- Existing land cover and land use
- Project proponents may also wish to include the following information on the map:
  - Topography
  - Forest vegetation types
  - Site classes

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<sup>16</sup> The relevant information was contained in section 3(2)(f) of the BC EOR as it existed on Dec. 6 2010.

- Watercourses in area<sup>17</sup>

In addition to the above, projects with areas within the province of BC must also provide other project identification and description information as required by Section 3 of the BC EOR.

For all project activities, project proponents must demonstrate sufficient control over the area, such that any emission reductions and/or removals can be maintained. For ARR and IFM-RIL projects on Crown land, project proponents must be able to demonstrate that they have the rights necessary to maintain the benefits of the project. For the other project activities on Crown land, project proponents must demonstrate that they have primary management control over the project area through a renewable area based license, or through another mechanism granting equivalent control.

For IFM and REDD projects, project proponents must also provide evidence that the project area meets the national definition of a forest, and has done so for the required time period.

For IFM projects, project proponents must also provide evidence that the project area is designated, sanctioned or approved for wood product management. Such evidence could include:

- For Crown or any other type of public lands:
  - Evidence that the area is licensed for timber production by the Crown or the relevant authority.
- For private lands
  - Registration under the Private Managed Forest Lands Act in the case of projects implemented in the province of BC, or the relevant registry if required by provincial legislation.
  - Zoning as forestry land, or agricultural land based on the production of timber from a stand of trees meeting the national definition of a forest, for tax purposes

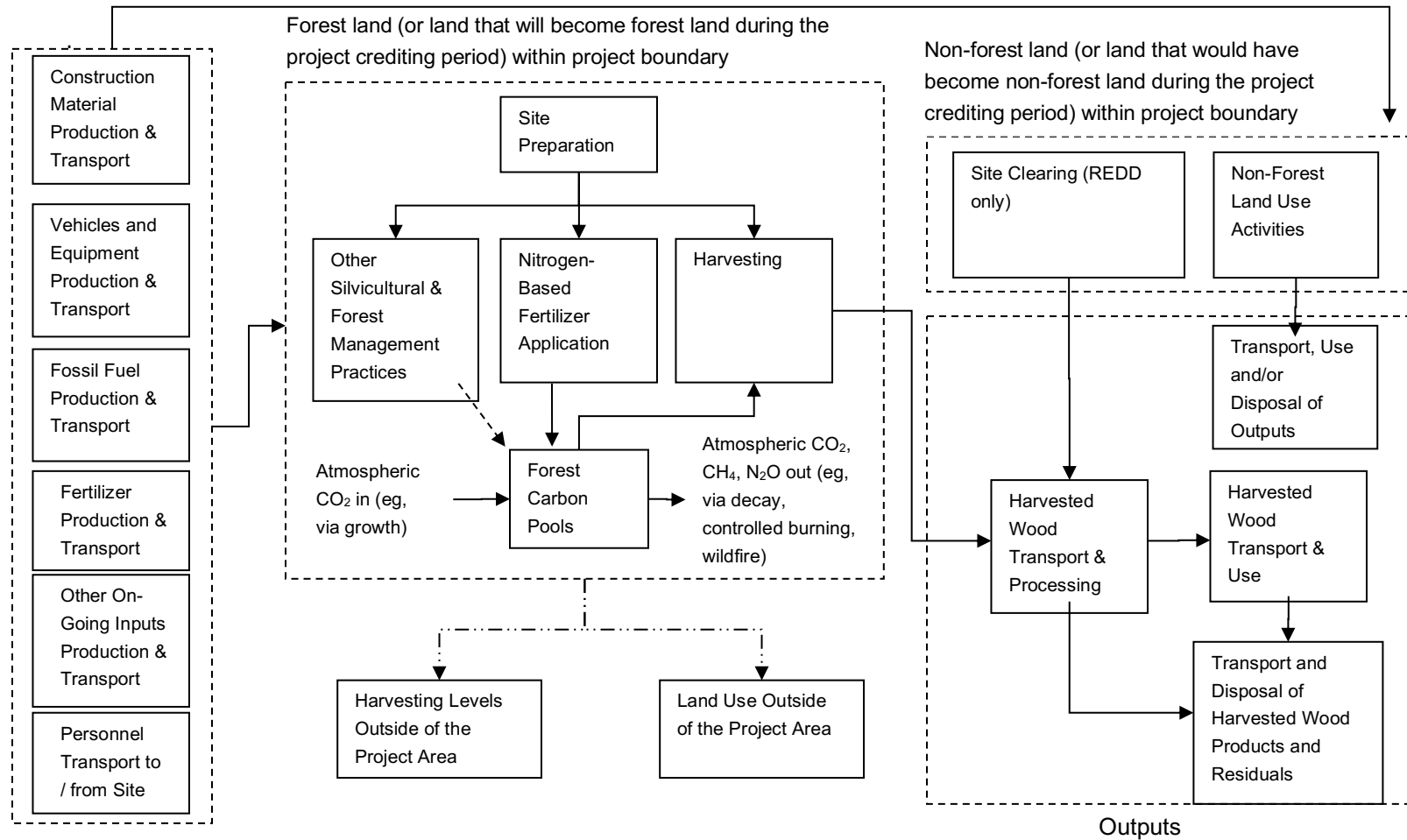
## 5.2 Identification of Project SSPs

The general flow of inputs, onsite processes and outputs by which forestry projects impact SSPs is shown in Figure 1 below.

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<sup>17</sup> This project area identification approach taken, with modifications, from the British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009.

**Figure 1: Project and Baseline Model – All Eligible Project Categories**





## 5.2.1 Definitions of the SSPs Accounted for Under this Methodology

Project SSPs are defined in Table 2 (controlled carbon pools), Table 3 (controlled and related emission sources) and Table 4 (affected SSPs).

SSPs are categorized as controlled (C), related (R) or affected (A), based on their relation to project proponents, where project proponents is assumed to control all SSPs within the geographic boundary of the forest project area, and upstream and downstream SSPs are assumed to be controlled by others and thus are related to the project.

Table 2: Controlled Project/Baseline Carbon Pools (PP/BP)

On-site Controlled Carbon Pools			
PP/BP1 Standing Live Trees	Carbon pool	Standing live trees include all above ground live biomass (the stem, stump, branches, bark, seeds and leaves or needles), regardless of species.	Controlled
PP/BP2 Shrubs and Herbaceous Understory	Carbon pool	All above-ground live woody and other plant biomass that does not meet the description of Standing Live Trees.	Controlled
PP/BP3 Live Roots	Carbon pool	Portions of living trees, shrubs or herbaceous biomass located below-ground, principally roots.	Controlled
PP/BP4 Standing Dead Trees	Carbon pool	Standing dead trees include the stem, branches, roots, or section thereof, regardless of species. Stumps are considered standing dead stocks.	Controlled
PP/BP5 Lying Dead Wood	Carbon pool	Any piece(s) of dead wood material from a tree, eg, dead boles, limbs, and large root masses, on the ground in forest stands. Lying dead wood is all dead tree material with a minimum average diameter of 10.0 cm. Anything not meeting the measurement criteria for lying dead wood will be considered litter.	Controlled
PP/BP6 Litter & Forest Floor	Carbon pool	Any piece(s) of dead wood material from a tree, eg, dead boles, limbs, and large root masses, on the ground in forest stands that is smaller than material identified as lying dead wood. Also all other organic matter on the forest floor that has not become integrated into the mineral soil, except on organic soils, where all non-woody material may be considered part of the soil.	Controlled
PP/BP7 Soil	Carbon pool	Belowground carbon not included in other pools, to a depth appropriate considering the full project-specific soil profile and potential project effects on soils.	Controlled

PP/BP8 Harvested Wood Products In Use	Carbon pool	Wood that is harvested or otherwise collected from the forest, transported outside the forest project boundary, and being processed or in use, but excluding harvested wood that has been landfilled. Includes raw wood products, finished wood products, and any wood residuals / waste generated during the harvested wood product lifecycle that is still in use (ie., has not been burned, disposed of, etc.).	Controlled <sup>18</sup>
PP/BP9 Harvested Wood Products in Landfill	Carbon pool	Wood that is harvested or otherwise collected from the forest, transported outside the forest project boundary, and landfilled. Includes raw wood products, finished wood products, and any wood residuals / waste generated during the harvested wood product lifecycle that is sent to landfill for disposal.	Controlled

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<sup>18</sup> HWP carbon pools (in-use HWPs and landfilled HWPs) are considered controlled carbon pools for the purposes of the protocol. This reflects that HWPs are directly controlled by forest project proponents during harvesting and up to the point of initial sale, which plays a significant role in determining the ultimate fate of the wood product and associated permanence of the removals.

Table 3: Controlled and Related Project/Baseline Emission Sources (PE/BE)

Name	Source	Description	Accounted GHGs	Controlled, related or affected
<b>Upstream Related Emission Sources</b>				
PE/BE 1 Fossil Fuel Production <sup>19</sup>	Source	Emissions resulting from the extraction and production / refining of the fuel used to operate vehicles and equipment throughout the project, including for both site development activities (eg, site clearing, road construction, etc.) and on-going silvicultural and other forest management activities.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Related
PE/BE 2 Fertilizer Production	Source	Emissions resulting from raw material extraction through to final production of fertilizers that are used throughout the project.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Related
PE/BE 3 Transport of Material, Equipment, Inputs, and Personnel to Site	Source	Emissions resulting from transportation of all construction materials, equipment, inputs, and personnel to the project site as required during the project.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Related
<b>On-site Controlled Emission Sources</b>				
PE/BE 4 Fossil Fuel Combustion – Vehicles and Equipment	Source	Emissions from vehicles and equipment which burn fossil fuels.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Controlled

<sup>19</sup> Where emission factors used for the calculation of GHG emissions from the use of fossil fuels include emission from fuel production, this emissions source is not required for consideration.

PE/BE 5 Fertilizer Use Emissions	Source	Emissions of N <sub>2</sub> O resulting from fertilizer application.	N <sub>2</sub> O	Controlled
PE/BE 6 Biomass Combustion	Source	Combustion of harvested forest biomass at the project site for various purposes, including for heating or as part of land clearing.	CH <sub>4</sub> , and N <sub>2</sub> O	Controlled
PE/BE 7 Forest Fire Emissions	Source	Combustion of forest carbon pools in place due to natural fire events as well as human induced fire events (eg, accident, arson, etc.).	CH <sub>4</sub> , and N <sub>2</sub> O	Controlled
Downstream Related Emission Sources				
PE/BE 8 Harvested Wood Transport	Source	Emissions resulting from the transport of harvested wood from the forest to the processing site, and of finished wood products to the end user.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Related
PE/BE 9 Harvested Wood Processing	Source	Emissions resulting from energy used to process wood from raw logs to finished product.	CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O	Related
PE/BE 10 Harvested Wood Combustion	Source	Emissions resulting from the combustion of harvested wood for energy.	CH <sub>4</sub> , and N <sub>2</sub> O	Related
PE/BE 11 Harvested Wood Products and Residuals Anaerobic Decay	Source	Emissions of methane resulting from the decomposition of wood product under anaerobic conditions in landfills.	CH <sub>4</sub>	Related

Table 4: Affected Project SSPs

Name	Source	Description	Controlled, related or affected
Affected SSPs			
PE 12 Leakage	Source	Emissions occurring as a result of Activity Shifting Leakage or Market Leakage.	Affected

## 5.2.2 Selection of Pools and Emission Sources

Selection of pools and sources to be quantified must be made based on the guidance given in Tables 5 and 6 below and in the accompanying notes. Notwithstanding the guidance given in the tables, if a pool or source can be shown to be *de minimis* for the full project crediting period, project proponents may choose not to quantify that pool or source.

Table 5: Selection of Carbon Pools

	ARR	IFM-RIL (<25% impact on total timber extracted)	IFM-RIL (>=25% impact on total timber extracted)	IFM - LtPF	IFM - ERA	IFM - LtHP	REDD - APD (Annual crop as baseline)	REDD - APD (Pasture grass as baseline)	REDD- APD (Urban/ development/ infrastructure as baseline)
Above-ground tree biomass (Standing Live Trees PP/BP 1)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Above-ground non-tree biomass (Shrubs and herbaceous understory PP/BP 2)	S	N	N	N	N	N	O	O	O
Below ground biomass (Live roots PP/BP 3)	S	O	O	O	O	O	O	O	Y
Dead wood (standing PP/BP4 and lying PP/BP 5)	S	Y	Y	Y	O	O	O	O	Y
Detritus (Litter and forest floor PP/BP 6)	S	S (Note 1)	S (Note 1)	S (Note 1)	S (Note 1)	S (Note 1)	N	N	O
Soil (PP/BP 7)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)	S (Note 2)

Harvested wood products (In use PP/BP 8 and in landfill PP/BP 9)	Y	Y	Y	Y	Y	Y	Y	Y	Y
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Where:

Y: Must be accounted

S: Must be accounted where project activities may significantly reduce the pool or increase the emission. Optional otherwise.

O: Accounting is optional

N: In general, the carbon pool or emission need not be accounted, unless failure to account the pool or emission would potentially result in an overestimation of the GHG benefits of the project

Notes:

- 1: Unless it can be shown that the project will involve the same or more carbon being stored in this pool in the project area under the project scenario as compared with the baseline scenario
- 2: Required if the project exceeds the soil disturbance limits set out in Section 35(3), Part 4, Practice Requirements, Division 1 — Soils of the Forest and Range Practices Act, Forest Planning and Practices Regulation , regardless of whether or not the Regulation would otherwise apply to the project area.

Table 6: Selection of Emission Sources

	ARR	IFM-RIL (<25% impact on total timber extracted)	IFM-RIL (>=25% impact on total timber extracted)	IFM - LtPF	IFM - ERA	IFM - LtHP	REDD - APD (Annual crop as baseline)	REDD - APD (Pasture grass as baseline)	REDD- APD (Urban/ development/ infrastructure as baseline)
Emissions from production of fertilizers (PE/BE 1)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)
Emissions from transport, vehicles and equipment (PE/BE 2 and PE/BE 3)	Y	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	Y	S	S	S

Emissions from fertilizer application (PE/BE 4)	Y	N	N	N	N	Y	N	N	N
Emissions from biomass burning and forest fires (PE/BE 5 and PE/BE 6)	O (note 4)	O (note 4)	O (note 4)	O (note 4)	O (note 4)	O (note 4)	O (note 4)	O (note 4)	O (note 4)
Harvested wood transport (PE/BE 7)	S (Note 3)	Y	Y	Y	Y	S (Note 3)	Y	Y	Y
Harvested wood processing (PE/BE 8)	S (Note 3)	Y	Y	Y	Y	S (Note 3)	Y	Y	Y
Harvested wood products and residuals anaerobic decay (PE/BE 9)	S (Note 3)	Y	Y	Y	Y	S (Note 3)	Y	Y	Y
Harvest shifting leakage (PP 10 in part)	N	O (Note 5)	O (Note 5)	O (Note 5)	O (Note 5)	O (Note 5)	Y	Y	Y
Land use shifting leakage (PP 10 in part)	Y	Y	Y	Y	Y	N	Y	Y	Y

Where:

Y: Must be accounted.



- S: Must be accounted where project activities may significantly increase the emission. Optional otherwise.
- O: Accounting is optional.
- N: In general, the emission need not be accounted, unless failure to account the emission would potentially result in an overestimation of the GHG benefits of the project.

Notes:

- 3: Required if project emissions exceed baseline emissions.
- 4: Required if project emissions from biomass burning exceed baseline emissions from biomass burning.
- 5: Required where the project results in a decrease in HWP production relevant to the baseline.

### 5.2.2.1 Guidance on Pools and Sources

Any of the carbon pools and emission types noted in tables 5 and 6 as S, O, or N, including carbon pools and GHG sources that cause project or leakage emissions, may be deemed *de minimis* and do not have to be accounted for if together the omitted decrease in carbon stocks (in carbon pools) or increase in emissions (from GHG sources) amounts to less than five percent of the total GHG benefit generated by the project. In order to determine any emission or pool to be *de minimis*, project proponents must:

- Use the ex-ante pool or emissions procedures specified in the relevant subsection of section 8 to project the net change in carbon stocks (or GHG emissions) for that pool or emission type for the crediting period, and
- Subtract the total of all projected increases in emissions from the total of all projected decreases in pools caused by the emitted pools and emissions for each 5 year verification period within the crediting period.
- Demonstrate that at no time over the crediting period does the total decrease in carbon stocks (in carbon pools) and increase in emissions (from GHG sources) amount to more than five percent of the total GHG benefit generated by the project
- Demonstrate that this result remains true across the expected range of conditions which could impact the project scenario, not counting force majeure reversals which would have been expected to impact both the project and baseline scenarios.

## 6 BASELINE SCENARIO

In order to calculate the net emission reductions and/or removal enhancements that have resulted from a particular project, it is necessary to identify and select a baseline scenario representing what would have most likely occurred within the project area in the absence of the project. Within this methodology, baselines are determined on a project-specific basis, such that each project proponent must prepare and justify their own baseline estimates, following the guidance given in the methodology.

Steps for determining the baseline scenario are given in Section 7.1 below, as part of the procedure for determining additionality.

## 7 ADDITIONALITY

### 7.1 Project Additionality

The project baseline and additionality must be determined using a Project Method, following the procedures detailed in this section, and the guidance given in Section 7.2. The methods given in this section are based on the CDM Tool 02 *Combined tool to identify the baseline scenario and demonstrate additionality*<sup>20</sup>.

#### 7.1.1 Introduction

Identification of the baseline scenario and determination of additionality for a project must follow a step-wise approach. The required steps are:

Step 1: Identification of alternative scenarios;

Step 2: Barrier analysis;

Step 3: Investment analysis; and

Step 4: Common practice analysis.

#### 7.1.2 Steps

##### **Step 1: Identification of baseline and alternative scenarios**

This step serves to identify all the alternative scenarios to the proposed project activity(s) which could be the baseline scenario.

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<sup>20</sup> Found at: <http://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-02-v5.0.0.pdf>

Where the proponent has a history of managing the project area, the proponent must provide documented evidence of the project proponent's operating history, such as five or more years of management records, to provide evidence of normal historical practices, and this information must be considered in defining and evaluating the alternative baseline scenarios. Note however that evidence of operating history over a specified time period does not itself determine the baseline scenario, as special factors, not expected to exist in the future, may have influenced the proponent's management of the area during that time.

For REDD projects, where ownership of the project area has not changed, the project proponent must provide evidence to demonstrate, based on government plans (for publicly owned and managed lands), community plans (for publicly owned and community managed lands), licensee plans (for publicly owned lands managed by licensees) or landowner plans (for privately owned lands), that the project area was intended to be cleared.

Where the project proponent is a new owner or manager, for REDD, RIL and LtPF projects the baseline scenario must be based on the projected management activities of the most likely owner or manager or class of owner or manager who would have managed the project area in the absence of the project, providing that these actions were consistent with law, government land use planning, and other constraints. The most likely management activities must be determined using the procedures outlined in steps 1b, 2 and 3 below. In cases where a specific "most likely owner or manager" cannot be identified, the baseline scenario must be based on the common characteristics and rates of deforestation for the most likely types of owners or manager expected to manage the project area. Determination of these characteristics and rates of deforestation must be based on an analysis of the recent historic practices of this type of owner or manager within the region around the project area.

For ARR and IFM projects, the baseline scenario must reflect at minimum the local common practices for areas comparable to the project area, and must not result in projected baseline GHG emissions from the project area greater than those that would occur under the relevant local common practice. However, if local common practices are unsustainable, and unsustainable practices are inconsistent with the mission or historical practices of the new owner or management entity, the baseline must reflect at minimum sustainable practices.

Step 1a: Define alternative scenarios to the proposed project activity

Identify all alternative scenarios that:

1. Are available to the project proponent, or an alternative owner or manager who might be managing the project area under the proposed scenario, and;
2. Cannot be implemented in parallel to the proposed project activity, and can occur within the project area, and;
3. Are based on environmental practices not less rigorous than common practice among forest managers in the area.

These alternative scenarios must include:

4. Type S1: The proposed project activity undertaken without being registered as a GHG reduction project.
5. Type S2: Where applicable, a situation where no investment or action is undertaken by the project proponents, but third party(s) undertake(s) investments or actions which provide the same output to users of the project activity. For example, in the case of an ARR project, an alternative scenario may be that the project proponent would not invest in planting, but that trees would be planted by others.
6. Type S3: Where applicable, the continuation of the current situation, not requiring any investment or expenses beyond business as usual expenses to maintain the current situation, such as, for example:
  - i. The continued management of an area for forest harvest, instead of conversion and development.
  - ii. Land continuing in an unused, degraded state.
7. Type S4: Where applicable, the continuation of the current situation, requiring an investment or expenses to maintain the current situation, such as, for example:
  - iii. Continued harvest and processing of timber at existing rates and using existing silvicultural and manufacturing techniques and technologies.
8. Type S5: Other plausible and credible alternative scenarios to the project activity scenario, including the common practices in the relevant sector, which could occur on the same land base.

If the proposed project activity includes several different facilities, technologies, or outputs, or areas of land with different potential uses, alternative scenarios for each of them may be identified separately. Plausible combinations of these may be considered as possible alternative scenarios to the proposed project activity.

For the purpose of identifying relevant alternative scenarios, provide an overview of other technologies or practices that provide the same output as the proposed project activity, or that can occur on the same land base, and that have been implemented previously or are currently underway in the applicable geographical area. The applicable geographical area may include preferably at least ten areas that provide the same output or occur on the same kind of land base as the proposed project activity, not including other projects which include GHG reduction incentives. Provide relevant documentation to support the results of the analysis.

The description of the alternative baseline scenarios must provide relevant information concerning present or future conditions, such as legislative, technical, economic, socio-cultural, environmental, geographic, site-specific and temporal factors, assumptions or projections, and these factors must be considered in the steps below.

**Outcome of Step 1a:** A description of plausible alternative scenarios to the project activity, to be considered when selecting the project's baseline scenario, using the steps below.

### **Step 1b: Consistency with mandatory applicable laws and regulations**

The alternative scenario(s) must be in compliance with all mandatory applicable legal and regulatory requirements, even if these laws and regulations have objectives other than GHG reductions, eg, to mitigate local air pollution. (National, provincial or local policies that do not have legally-binding status are not required to be considered.)

If the proposed project activity is the only alternative scenario among the ones considered by the project proponent that is in compliance with all mandatory regulations, the proposed project activity is not additional.

**Outcome of Step 1b:** List of alternative scenarios to the project activity that are in compliance with mandatory legislation and regulations.

If the above-mentioned list contains only one scenario, namely: S1 - the proposed project activity undertaken without being registered as a GHG reduction project activity, then the proposed project activity is not additional and any remaining procedures of this tool are not applicable.

### **Step 2: Barrier analysis**

This step serves to identify barriers and to assess which alternative scenarios are prevented by these barriers.

In applying Steps 2a and 2b, provide transparent and documented evidence, and offer conservative interpretations of this evidence, as to how it demonstrates the existence and significance of the identified barriers and whether alternative scenarios are prevented by these barriers. The type of evidence to be provided must include at least one of the following:

1. Relevant legislation, regulatory information or industry norms;
2. Relevant (sectoral) studies or surveys (eg, market surveys, technology studies, etc.) undertaken by universities, research institutions, industry associations, companies, bilateral/multilateral institutions, etc.;
3. Relevant statistical data from national or international statistics;
4. Documentation of relevant market data (eg, market prices, tariffs, rules);
5. Written documentation from the company or institution developing or implementing the project activity or the project proponent, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information, etc.;

6. Documents prepared by the project proponent, contractors or project partners in the context of the proposed project activity or similar previous project implementations; written documentation of independent expert judgements from industry, educational institutions (eg, universities, technical schools, training centres), industry associations and others.

### **Step 2a: Identify barriers that would prevent the implementation of alternative scenarios**

Establish a complete list of plausible and credible barriers that may prevent alternative scenarios from occurring. Such plausible and credible barriers may include:

1. Investment barriers, other than insufficient financial returns as analyzed in Step 3. For instance, situations where similar activities have only been implemented with grants or with other non-commercial finance. Similar activities are defined as activities that rely on a broadly similar technology or practices, are of a similar scale, take place in a comparable environment with respect to regulatory framework, and are undertaken in the applicable geographical area as defined in Step 1a above.
2. Technological barriers, inter alia:
  - i. Skilled and/or properly trained labor to operate and maintain the scenario are not available in the applicable geographical area, which leads to an unacceptably high risk of failure or underperformance;
  - ii. Lack of infrastructure for implementation and logistics for maintenance of the scenario (eg, road network does not allow efficient forest fertilization);
  - iii. Risk of technological failure: the process/technology failure risk in the local circumstances is significantly greater than for other technologies that provide services or outputs comparable to those of the proposed project activity, as demonstrated by relevant scientific literature or technology manufacturer information (eg, use of ground based equipment for selective harvesting within the project area may result in unacceptable damage to harvested or retained timber);
  - iv. The particular technology used in the proposed scenario is not available in the applicable geographical area (eg, the project involves importing new logging machinery that has never been used in context of the geographical area).
3. Legal barriers. The project activity faces certain legal barriers that prevent it from being undertaken. However, the potential to generate emission reductions/removals help to convince regulators (provincial, municipal, etc.) to reconsider the project activities, work with the proponent to address any areas of concern, and adjust the legal requirements to permit the activity. The situation where a project creates emission reductions or removals partially or wholly through an agreement with government to change legislation or regulation for the purposes of increasing carbon sequestration and thereby creating incremental emissions reductions may constitute evidence of additionality.

**Outcome of Step 2a:** A description of the barriers that may prevent one or more alternative scenarios from occurring, including a justification of the reasonableness of the identified barriers.

**Step 2b: Eliminate alternative scenarios which are prevented by the identified barriers**

Identify which alternative scenarios are prevented by at least one of the barriers listed in Step 2a, and eliminate those alternative scenarios from further consideration. All alternative scenarios must be compared to the same set of barriers. The assessment of the significance of barriers may take into account the level of access to and availability of information, technologies and skilled labour in the specific context of the industry where the project type is located. For example, projects located in sectors with small and medium sized enterprises may not have the same means to overcome technological barriers as projects in a sector where typically large or international companies operate.

**Outcome of Step 2b:** A list of alternative scenarios to the project activity that are not prevented by any barrier.

**Outcome of Step 2:**

If there is only one scenario that is not prevented by any barrier, then the following applies:

1. If this alternative scenario is the proposed project activity undertaken without being registered as a GHG reduction activity, then the project activity is not additional.

If this alternative scenario is not the proposed project activity, then this alternative is identified as the baseline scenario. In this case, demonstrate, using quantitative and/or qualitative evidence, how the registration of the project activity as a GHG reduction activity overcomes identified barriers which prevent the proposed project activity from occurring in the absence of registration as a GHG reduction activity. If registration alleviates these barriers, proceed to Step 3. Otherwise, it is not additional.

2. If there is more than one alternative scenario that is not prevented by any barrier, then the following applies:
  - i. If the alternative scenarios include the proposed project activity undertaken without being registered as a GHG reduction project activity, then proceed to Step 3 (investment analysis).
  - ii. If the alternative scenarios do not include the proposed project activity undertaken without being registered as a GHG reduction project activity, then:
    - a. If registration alleviates the identified barriers that prevent the proposed project activity from occurring, project participants must complete Step 3 (investment analysis).
    - b. If registration as a GHG reduction activity does not alleviate the identified barriers that prevent the proposed project activity from occurring, then the project activity is not additional.

**Step 3: Investment analysis**

The objective of Step 3 is to compare the economic or financial attractiveness of the alternative scenarios remaining after Step 2 by conducting an investment analysis. The analysis must



include all alternative scenarios remaining after Step 2, including scenarios where the project proponent does not undertake an investment (S2 or S3).

### **Step 3a: Identification of the financial indicator**

Identify the financial indicator, such as IRR, NPV, cost benefit ratio, or unit cost of production (eg. Production cost per cubic meter of processed timber or per bone dry tonne of pulp) most suitable for the project type and decision-making context. If one of the alternative scenarios remaining after Step 2 corresponds to the situation described in S2 or S3, then use either the NPV or the IRR as financial indicator in the analysis.

### **Step 3b: Calculation of alternatives**

Calculate the suitable financial indicator for all alternative scenarios remaining after Step 2. Include all relevant costs (including, for example, investment operations and maintenance costs), and revenues (including subsidies/fiscal incentives, etc. where applicable), and, as appropriate, non-market costs and benefits in the case of public investors if this is standard practice for the selection of public investments.

For alternative scenarios that correspond to the situation described in S2 or S3 and that do not involve any investment costs, operational costs or revenues, use the following values for the financial indicator to reflect such a situation:

1. If the financial indicator is the NPV: Assume a value of NPV equal to zero;
2. If the financial indicator is the IRR: Use as the IRR the financial benchmark, as determined through the options (1) to (5) below.

The financial/economic analysis must be based on parameters that are standard in the market, considering the specific characteristics of the project type, but not linked to the subjective profitability expectation or risk profile of a particular project proponent. In the particular case where the project activity can only be implemented by the project proponent, the specific financial/economic situation of the company undertaking the project activity can be considered.

The discount rate (in the case of the NPV) or the financial benchmark (in the case of the IRR) may be derived from one or more of:

3. Government bond rates, increased by a suitable risk premium to reflect private investment and/or the project type, as substantiated by an independent (financial) expert or documented by official publicly available financial data;
4. Estimates of the cost of financing and required return on capital (eg, commercial lending rates and guarantees required for the country and the type of project activity concerned), based on banker's views and private equity investors/funds' required return on comparable projects;

5. A company internal financial benchmark (weighted average cost of capital of the company), only in the particular case that the project activity can only be implemented by the project proponent. The project proponents must demonstrate that this financial benchmark has been consistently used in the past, ie, that project activities under similar conditions developed by the same company used the same financial benchmark;
6. A government/officially approved financial benchmark where it can be demonstrated that such financial benchmarks are used for investment decisions;
7. Any other indicators if the project proponent can demonstrate that the above options are not applicable and their indicator is appropriately justified.

Present the investment analysis in the documentation submitted for validation in a transparent manner and provide all the relevant assumptions, so that a reader can reproduce the analysis and obtain the same results. Refer to critical techno-economic parameters and assumptions (such as capital costs, fuel prices, lifetimes, and discount rate or cost of capital). Justify and/or cite assumptions in a manner that can be validated. In calculating the financial indicator, the risks of the alternative scenarios can be included through the cash flow pattern, subject to project-specific expectations and assumptions (eg, insurance premiums can be used in the calculation to reflect specific risk equivalents). Assumptions and input data for the investment analysis must not differ across alternative scenarios, unless differences can be well substantiated.

Each of the scenarios examined must be ranked according to the financial indicator.

Include a sensitivity analysis to assess whether the conclusion regarding the financial attractiveness of each scenario is robust to reasonable variations in the critical assumptions. The investment comparison analysis provides a valid argument in identifying the baseline scenario only if it consistently supports (for a plausible range of assumptions) the conclusion that one alternative scenario is the most economically and/or financially attractive.

**Outcome of Step 3:** Ranking of the short list of alternative baseline scenarios according to the most suitable financial indicator, taking into account the results of the sensitivity analysis.

If the sensitivity analysis is not conclusive, then the alternative scenario to the project activity with greatest GHG removals (or least emissions, in the case that all alternatives are net emitters) over the crediting period among the alternative scenarios is considered as the baseline scenario. If the sensitivity analysis confirms the result of the investment comparison analysis, then the most economically or financially attractive alternative scenario is considered as baseline scenario.

Note that the baseline scenario for a REDD project must result in a Land Use and Land Cover change from a forested to an unforested state. If at this stage the identified baseline scenario does not include a Land Use and Land Cover change – for instance, if the area remains forest used for timber production under the most likely baseline, then the project cannot be a REDD project, although it is possible that it may be an IFM project,

If the alternative identified in step 3 as the baseline scenario is the proposed project activity undertaken without being registered as a British Columbia GHG reduction activity, then the project activity is not additional. Otherwise, proceed to Step 4.

#### **Step 4: Common practice analysis**

Complete an analysis of the extent to which the proposed project type (eg, technology or practice) has already diffused in the relevant sector and applicable geographical area. This test is a credibility check to demonstrate additionality and complements the barrier analysis (Step 2) and, where applicable, the investment analysis (Step 3).

Provide an analysis of the extent to which similar activities to the proposed project activity have been implemented previously or are currently underway. Similar activities are defined as activities (ie, technologies or practices) that are of similar scale, take place in a comparable environment, inter alia, with respect to the regulatory framework, and are undertaken in the applicable geographical area as defined in Step 1a above. Other registered or validated GHG reduction project activities are not to be included in this analysis. Provide documented evidence and, where relevant, quantitative information. On the basis of that analysis, describe whether and to which extent similar activities have already diffused in the applicable geographical area.

If similar activities to the proposed project activity are identified, then compare the proposed project activity to the other similar activities and assess whether there are essential distinctions between the proposed project activity and the similar activities. If this is the case, point out and explain the essential distinctions between the proposed project activity and the similar activities and explain why the similar activities enjoyed certain benefits that rendered them financially

attractive (eg., subsidies or other financial flows) and which the proposed project activity cannot use or why the similar activities did not face barriers to which the proposed project activity is subject.

Essential distinctions may include a serious change in circumstances under which the proposed GHG reduction project activity will be implemented when compared to circumstances under which similar projects were carried out. For example, new barriers may have arisen, or promotional policies may have ended, leading to a situation in which the proposed GHG reduction project activity would not be implemented without the incentive provided by registration of the activity as a GHG reduction activity. The change must be fundamental and verifiable.

The proposed project activity is regarded as “common practice” if similar activities can be observed and essential distinctions between the proposed GHG reduction project activity and similar activities cannot be identified.

**Outcome of Step 4:** If outcome of Step 4 is that the proposed project activity is not regarded as “common practice”, then the proposed project activity is additional.

If outcome of Step 4 is that the proposed project activity is regarded as “common practice” then the proposed project activity is not additional, unless it can be demonstrated that material and lasting changes in conditions have occurred since similar projects were carried out, which make it unlikely that further projects of this type would be implemented in the absence of incentives for GHG benefits.

### 7.1.3 Documentation Requirements

Documentation of the steps and process completed to determine the project’s baseline scenario, must include elements identified in the steps above. In addition to the information required in the VCS project document and representations, these must include:

1. An assertion by the proponent that the baseline scenario will result in a conservative estimate of the greenhouse gas reduction to be achieved by the project, considering:
  - i. existing or proposed regulatory requirements relevant to any aspect of the baseline scenario;
  - ii. provincial or federal incentives relevant to any aspect of the baseline scenario, including tax incentives or grants that may be available;
  - iii. the financial implications of carrying out a course of action referred to in the baseline scenario, and
  - iv. any other factor relevant to justify the claim that the baseline scenario is reasonably likely to occur if the project is not carried out;

2. An assertion by the proponent that there are financial, technological or other obstacles to carrying out the project that are overcome or partially overcome by the incentives resulting from the greenhouse gas project, and a justification for the assertion (Steps 2 and 3);
3. An assertion by the proponent that the project start date is no earlier than November 29, 2007.

## 8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

### 8.1 Overview of Quantification Approach

The quantification methods for SSPs are presented below and in the sub-sections that follow. These methods must be used each time a monitoring report is prepared by project proponents to calculate the net change in emissions and removals that have occurred since the previous monitoring report was issued (ie, over the current reporting period for the project), as well as to establish initial project and baseline carbon stocks. The methods also describe the key parameters that must be monitored during the reporting period.

Project proponents must use the 2003 IPCC Good Practice Guidance for Land Use, Land Use Change and Forestry as guidance for application of the specific quantification methods described in this section.

The overall equation used to calculate net project emission reductions and removal enhancements is as follows:

Equation 1

$$\Delta\text{CO}_2e_{\text{net},t} = (\Delta\text{TR}_{\text{PP},t} + \Delta\text{TE}_{\text{PS},t}) - (\Delta\text{TR}_{\text{BP},t} + \Delta\text{TE}_{\text{BS},t}) \quad [1]$$

Where:

Parameter	Description
$\Delta\text{CO}_2\text{E}_{\text{net}, t}$	The net emission reductions and removal enhancements, achieved by the project during reporting period $t$ . A net increase in emission reductions and removal enhancements is expressed as a positive number. Expressed in tCO <sub>2</sub> e.
$\Delta\text{TR}_{\text{PP/BP}, t}$	The net incremental GHG removals by project or baseline pools, achieved by the project or the baseline during monitoring period $t$ . A net increase in total removals is expressed as a positive number. Expressed in tCO <sub>2</sub> e.
$\Delta\text{TE}_{\text{PS/BS}, t}$	The net incremental GHG emission reductions by project or baseline sources of emissions, achieved by the project or the baseline during reporting period $t$ . A net increase in total emission reductions is expressed as a positive number. Expressed in tCO <sub>2</sub> e.

Quantification methods given for individual pools and emission sources below must be used for the calculation of both baseline (Section 8.2) and project (Section 8.3) emission reductions and removal enhancements.

### 8.1.1 Quantification of Controlled Carbon Pools

#### 8.1.1.1 PP1/BP1 – PP7/BP7 Live and Dead Forest Carbon Pools (Excluding Harvested Wood Products)

The procedures set out in this section apply to the following carbon pools for both the project and baseline scenarios:

- PP1/BP1 Above-ground tree biomass (Standing Live Trees)
- PP2/BP2 Above-ground non-tree biomass (Shrubs and Herbaceous Understory)
- PP3/BP3 Below-ground biomass (Live Roots)
- PP4/BP4 Dead wood (Standing Dead Trees)
- PP5/BP5 Dead wood (Lying Dead Wood)
- PP6/BP6 Litter (Litter & Forest Floor)
- PP7/BP7 Soil carbon (Soil)

Pools that are required to be quantified is dependent on which pools are identified by project proponents as relevant based on the requirements contained in Section 5.2. The approaches used to quantify these pools, as described in Section 5.2, do not necessarily need to treat each pool separately, use the categories listed above, or report results separately for each pool.

However, any such approach must be able to show that the components of forest carbon included in the definitions of each relevant pool were assessed as part of the approach used.

#### 8.1.1.1.1 Quantification Approach and Associated Uncertainty

Measurement of carbon pool changes may be done in two ways:

- Periodic direct measurement by sampling coupled with assumptions or models used to convert the measured forest biomass into amount of stored carbon (option A, below); or
- Projection of project area inventories, disturbance events and stand types using suitable stand level growth and/or carbon models, with some minimum amount of periodic direct observation (option B, below).

Option A may provide precision for projects on single stands or simple forest estates, whereas Option B may be more effective for complex forest estates characterized by a diversity of stands, treatments, and disturbances as direct measurement of baseline forest carbon is typically not possible since the project occurs instead of the baseline. Therefore, the project scenario may utilize Option A while the baseline scenario must be assessed using Option B.

##### **Option A: Field Sampling Method (Direct Measurement):**

When using this approach, project proponents must:

- Stratify the project area to produce strata which are relatively homogenous in terms of carbon content and structure/process. Strata may be different for different pools. For instance the stratification for soil may not be the same as that for standing live trees. Stratification may also be different for the baseline and project scenarios. For REDD projects, baseline stratification must take into account factors which may tend to drive the location and timing of land use and land cover change. These factors may result in different strata than would be arrived purely on ecological grounds. For instance, accessibility may determine that some areas would be developed, while others would not, even if ecologically the areas are similar.
- Map, and calculate the total area of, each stratum.
- Conduct sampling using VRI<sup>21</sup>, DIF<sup>22</sup> or NFI<sup>23</sup> standards for conducting field sampling and forest inventories, or appropriate VCS modules for the pool in question.
- Ensure that the sampling is supervised by a qualified registered professional.

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<sup>21</sup> Change Monitoring Inventory Ground Sampling Quality Assurance Standards and (2002) Change Monitoring Inventory Ground Sampling Quality Assurance Procedures, [www.for.gov.bc.ca/hts/vri/standards/index.html](http://www.for.gov.bc.ca/hts/vri/standards/index.html)

<sup>22</sup> Quebec's norms for the implementation of permanent monitoring plots, developed by the Forestry Inventory Directorate. <https://www.mffp.gouv.qc.ca/publications/forets/connaissances/Norme-PEP.pdf>

<sup>23</sup> Canada's National Forest Inventory National Standard for Establishment of Ground Plots.

- Choose sample plot locations and numbers using a justified statistically valid approach appropriate for the project site (eg, that reflects any site stratification, etc.).
- Ensure that sampling approaches are comparable each time sampling is done. Preferably, the same sampling methods are used during each sampling event. However, where changes in technology or standards make new sampling methods preferable, the new sampling methods must be calibrated to ensure that they produce results consistent with those produced by the previous method.

Results of the sampling must be converted into amounts of stored carbon in relevant forest carbon pools using a forest carbon model (see Section 8.2.1.1.2). The areas of the strata and the sampled results for the pools are the inputs for the forest carbon model, replacing the results of the growth and yield and forest estate and landscape dynamics models used in Option b).

To manage associated uncertainty and ensure that results are conservative, field sampling must be conducted at minimum once every ten years, including at the start of the project and at the end of the project. While forest sampling is not required in each reporting period, modelled results must be updated to accurately reflect other activities conducted and monitored during the reporting period (eg, harvesting activities, fertilizer use, burning, etc.), as well as other relevant factors identified as affecting the project and baseline (eg, pests, disease, etc.).

When sampling is conducted, results must be used to re-calibrate modeling outputs.<sup>24</sup>

As noted above, sampling locations and intensities must be determined using a justified statistically valid approach appropriate for the project site. Where the width of the 90 percent confidence interval of the sampled data exceeds +/-10% of the estimated value, the amount that the calculated confidence interval is greater than +/- 10% must be added to the average (in the case of the baseline scenario), or subtracted from the average (in the case of the project scenario), and the resulting number used in quantification of carbon in the sampled carbon pool. Methods used for estimating uncertainty must be based on recognized statistical approaches such as those described in the IPCC Good Practice Guidance and Uncertainty Management in National GHG Inventories. This approach will discount the amount of carbon stored in project pools where the amount of sampling is not sufficient to address a site's inherent variability / non-homogeneity. Where more sampling is undertaken, the difference between the lower bound of the 90% confidence limit and the sample mean must diminish, minimizing the discount applied to the project.

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<sup>24</sup> VCS has internal modalities for dealing with credit issuance, buffers, etc., which do not need to be detailed in a methodology. The sentence "If it is determined that reporting based on modeled results in years between field sampling led to over crediting of the project, then the proponent must retire or replace any credits issued in excess of what has actually been achieved to date." has thus been removed from this version of FCOP.



For sites with significant stratification, it may be appropriate for the proponent to sample each stratum separately, and then combine results using appropriate statistical methods to generate a result representative of the overall project area. In this way, it may be possible to achieve a given lower (or upper) 90% confidence limit with less sampling than would be needed if the entire project area were sampled as a whole.

In converting sampling results to amount of forest carbon, uncertainty associated with assumptions or carbon models used must be considered and managed in a way that ensures a conservative result. In the case of carbon model uncertainty, the requirements provided below in the section on the Inventory / Modelling Method would apply.

Note that where reporting is conducted more frequently than field sampling, verifiers will still need to conduct a site audit as part of each verification.

Where Option A is chosen, it can be used to quantify project forest carbon pools at project commencement, as well as after project commencement under the project scenario. Quantification of baseline forest carbon pools for times after project commencement will still require some use of the modelling methods described in Option B, below, since the baseline is necessarily a hypothetical case.

#### **Option B: Inventory / Modelling Method (Indirect Linkage)**

While rigorous re-measurement of field conditions typically provides more precision than modeled projections, for large and diverse forest estates (or in some cases small but remote projects) intensive sampling may be prohibitively expensive. For diverse project areas, modelling forest carbon changes for each stand, or for stratified groupings of similar stands, over time with amalgamation of results across the project land base may provide sufficiently accurate estimates without intensive field sampling. This approach is based on tracking and verification of the timing and extent of any project activities, along with some minimum level of field measurement at the project site, though the type and level of measurement would be determined by project proponents (see below for further details).

NFI data and statistically valid ground sample data, will be used as the base inventory for project development. Additionally, VRI data may be used for projects located in the province of BC, and DIF data may be used for projects located within the province of QC. At each reporting period, proponents must update projections for any disturbances that have occurred on the land base (harvesting etc.) and based on the results of any sampling that is conducted. Accuracy assessments and quality assurance associated with these three datasets are currently available and updated on an ongoing basis. Project proponents are required to use the best available inventory data available at project reporting intervals. Where the project start date is later than the date that the VRI datasets were last updated, the models being used for the project must be used to project forest carbon forward to the start date of the project using assumptions for baseline pre-project forest management practices, and that result must be used as the basis for assessing starting carbon levels in the project and baseline.

To manage the associated uncertainty and ensure that results are conservative, the following requirements must be met:

- As noted above, some minimum level of field measurement at the project site is required even where a project proponent is relying primarily on modelled results, to assist with minimizing the uncertainty associated with modeling, especially over time. The type and level of measurement is to be determined by project proponents. However, the type and level of measurement must be reflected in an overall assessment of uncertainty prepared by project proponents. Such field measurement must be conducted at least once every ten years, to align with the requirements given in the section on the field sampling method, above.
- In assessing the overall uncertainty of the forest carbon pool quantification approach, project proponents must conduct a sensitivity analysis of modelled results to determine the key potential sources of uncertainty and then evaluate the uncertainty associated with those sources. During this process, any field measurements conducted and their impact on associated model uncertainty must be considered.
- Based on the results of this uncertainty assessment, the proponent must justify an appropriate approach to managing uncertainty that will ensure that reported changes in forest carbon pools between project and baseline are conservative.
- When sampling is conducted, results must be used to re-calibrate model results.<sup>25</sup>

#### 8.1.1.1.2 Selection of Appropriate Models

There are three main functions for models that are used for producing estimates of forest carbon values, which may be performed by linking two or more models or with a single integrated model:

1. **Growth and yield models:** estimate values for existing and projected tree volume and other characteristics (eg, diameter at breast height) given starting conditions and site characteristics. The growth and yield models shown in Table 7A and 7B are commonly used in British Columbia and Quebec, respectively, and are recommended for use by project proponents in these provinces.

The proponent has the option of using the below suggested models or other justified models. If growth and yield model(s) are selected for estimating yields, any project-specific parameters / variables used by any selected model(s) must be independently validated for appropriateness and consistency throughout the project (note, this does not preclude a project from using different models for different parts of their project area, as

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<sup>25</sup> VCS has internal modalities for dealing with credit issuance, buffers, etc., which do not need to be detailed in a methodology. The sentence “If it is determined that reporting based on modeled results sampling led to over crediting of the project, then the proponent must retire or replace any credits issued in excess of what has actually been achieved to date.” has thus been removed from this version of FCOP.

long as the approach taken in any given part of the project area is consistently applied). It is also the proponent's responsibility to justify or reconcile the differences of volume estimates that may arise between/within models, and the differences between model estimates and field measurements in Section 8.1.1.1.1.

Table 7A: Commonly Used Growth and Yield Models in BC

Model name	Range of applicability	
	Geographic/biogeoclimatic area*	Stand types
TASS <sup>26</sup>	Province-wide	Second growth, simple stands
TIPSY <sup>27</sup>	Province-wide	Second growth, simple stands
VDYP <sup>28</sup>	Province-wide	Natural stands
PrognosisBC <sup>29</sup>	IDF, ICH, ESSF, MS	Existing mixed species, complex stands
Sortie-ND <sup>30</sup>	SBS, ICH (north-west)	Mixed species, complex stands, MPB areas

\* IDF = Interior Douglas Fir ; ICH = Interior Cedar-Hemlock ; ESSF = Engelmann Spruce-Sub alpine Fir ; MS = Montane Spruce ; SBS = Sub-Boreal Spruce ; ICH (north-west) = Interior Cedar-Hemlock

Table 7B: Commonly Used Growth and Yield Models in QC

Model name	Range of applicability	
	Geographic/biogeoclimatic area*	Stand types
Natura <sup>31</sup>	Province-wide	Existing mixed stands, simple stands
Artemis <sup>32</sup>	Province-wide	Existing mixed stands, simple stands

<sup>26</sup> Tree and Stand Simulator. See <http://www.for.gov.bc.ca/hre/gymodels/tass/index.htm> for further details.

<sup>27</sup> Table Interpolation Program for Stand Yields. See <http://www.for.gov.bc.ca/hre/gymodels/TIPSY/> for further details.

<sup>28</sup> Variable Density Yield Prediction. See <http://www.for.gov.bc.ca/hts/vdyp/> for further details.

<sup>29</sup> See <http://www.for.gov.bc.ca/hre/gymodels/proqbc/> for further details

<sup>30</sup> See <http://www.bvcentre.ca/sortie-nd> for further details.

<sup>31</sup> See <ftp://ftp.mrn.gouv.qc.ca/Public/Drf/CAPSIS/Natura-2014/> for further details

<sup>32</sup> See <ftp://ftp.mrn.gouv.qc.ca/Public/Drf/CAPSIS/ARTEMIS-2014/> for further details

- 2. Forest estate and landscape dynamics models:** project forest dynamics over time across large areas due to management and/or natural processes. May be used for identifying sustainable harvest levels in a timber supply analysis, for modelling natural disturbances (eg, fire, mountain pine beetle), etc. Use growth and yield as inputs, among others, such as geospatial inventory attributes.

Some forest estate and landscape dynamics models that have been used in British Columbia and are recommended for consideration by project proponents within BC include FSSAM<sup>33</sup>, FSOS<sup>34</sup>, FSSIM<sup>35</sup>, Patchworks<sup>36</sup>, SELES-STSM<sup>37</sup>, CASH6<sup>38</sup>, Woodstock/Stanley<sup>39</sup>, and LANDIS-II<sup>40</sup>.

- 3. Ecosystem carbon projection models:** project changes in carbon stocks in various pools, as well as some emissions sources from forestry operations, over time given initial conditions (eg, inventory), growth and yield data and projected disturbance events.

Some ecosystem carbon projection models that have been used in British Columbia and recommended for consideration by project proponents include CBM-CFS3 (Kurz et al. 2009)<sup>41</sup> and FORECAST (Kimmins et al., 1999)<sup>42</sup>. CBM-CFS3 is used for national-level and forest management unit-level forest carbon accounting in Canada. FORECAST has also been calibrated for use in B.C. Both of these models have been parameterized using field data from B.C. forest ecosystems.

Ecosystem carbon model developers must provide evidence that the models have been calibrated for the ecosystems and management regimes found in the project area. Such calibration must include results from relevant current peer reviewed research on carbon dynamics in the ecosystem(s) in question. Data on the calibration data set used must include statistical confidence interval estimates for the model outputs. Where such calibration has not occurred, and where existing peer reviewed data which can be used to calibrate the model is not found, field measurements will be needed to initially calibrate

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<sup>33</sup> Forest Service Spatial Analysis Model: <http://www.barrsdale.com/bcs/index.php/timber-supply-model>

<sup>34</sup> Forest Simulation and Optimization System: [http://www.forestecosystem.ca/technology\\_fsos.html](http://www.forestecosystem.ca/technology_fsos.html)

<sup>35</sup> Forest Service Simulator: <http://www.cortex.org/case-mana-case17b.html>

<sup>36</sup> <http://www.spatial.ca/>

<sup>37</sup> Spatially Explicit Landscape Event Simulator: [http://www.seles.info/index.php/Main\\_Page](http://www.seles.info/index.php/Main_Page)

<sup>38</sup> Critical Analysis by Simulation of Harvesting version 6.21, Timberline Natural Resource Group Ltd.

<sup>39</sup> <http://www.remsoft.com/>

<sup>40</sup> See <http://www.landis-ii.org/> for further details.

<sup>41</sup> Kurz, W.A., C.C. Dymond, T.M. White, G. Stinson, C.H. Shaw, G.J. Rampley, C. Smyth, B.N. Simpson, E.T. Neilson, J.A. Trofymow, J. Metsaranta, and M.J. Apps 2009. CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards. *Ecological Modelling* 220: 480–504.

<sup>42</sup> See <http://www.forestry.ubc.ca/ecomodels/moddev/forecast/forecast.htm> for further details.

the model. Plot or other data for calibration must be gathered using sound and reliable measurement methods consistent with VRI<sup>43</sup>, EFI<sup>44</sup> or NFI<sup>45</sup> standards, or methods contained in validated VCS modules. In cases where model calibration has been completed, but confidence intervals are still wide (>+/- 10% of the mean value at 90% confidence), proponents must consider the possibility of undertaking field work to reduce confidence intervals.

The above lists of recommended models may be used as a guideline when deciding which modeling approach to use. Each model has its own advantages and limitations (eg, some growth and yield models can capture the effects of fertilization, some forest estate and landscape dynamics models can integrate with the timber supply review process, some carbon projection models are capable of modeling certain aspects of landscape dynamics). The proponent must justify why a particular model is used and how precisely models are linked (ie, what information is passed between different models in the overall approach).

Other models may also be suitable for use by projects in any province in Canada. If other models are used, they must be justified by considering the appropriateness of the selected models versus models recommended above, considering project-specific circumstances. Proponents must pay special attention to justifying the use of alternative models rather than the recommended models listed above. In addition, any selected alternative model must meet the following minimum requirements:

- The model is scientifically sound, and has been peer reviewed in a process that: (i) primarily involved reviewers with the necessary technical expertise (eg., modeling specialists and relevant fields of biology, forestry, ecology, etc.), and (ii) was open and rigorous;
- The model is based on empirical evidence, and has been parameterized and validated for the general conditions of the project land area;
- Application of the model is limited to the scope for which the model was developed and evaluated;
- The model's scope of application, assumptions, known equations, data sets, factors or parameters, etc., are clearly documented;

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<sup>43</sup> Change Monitoring Inventory Ground Sampling Quality Assurance Standards and (2002) Change Monitoring Inventory Ground Sampling Quality Assurance Procedures, [www.for.gov.bc.ca/hts/vri/standards/index.html](http://www.for.gov.bc.ca/hts/vri/standards/index.html)

<sup>44</sup> Quebec's Ecoforestry Inventory (*l'inventaire écoforestier du Québec*) <https://mffp.gouv.qc.ca/les-forets/amenagement-durable-forets/inventaire-ecoforestier/>

<sup>45</sup> Canada's National Forest Inventory National Standard for Establishment of Ground Plots.

- The models must provide accurate modelling of time dependent parameters such as decay, below ground biomass and soil carbon changes, etc. The model must not assume that such changes take place instantaneously or within a short period of time.

Regardless of whether a recommended model or alternative model is selected, project proponents must justify the selection by indicating how the selected model is the best choice for modeling the range of activities, conditions and other relevant site-specific details included in both the project and baseline scenario in comparison to other options available, and by considering the approaches and assumptions used in the various models.

Where an existing model meeting the above requirements is modified based on localized, project area-specific considerations, several factors must be considered by the proponent and rationalized to the auditor:

1. The amount of peer reviewed empirical data behind the model in use – specifically around the stand types and treatments/responses being contemplated in the project.
2. The evidence to support any cause/effect relationships altered in, or added to, the project scenario. For example, if fuel reduction treatments are proposed to reduce stand replacing fire severity or extent, the evidence behind modeling assumptions must be presented and its degree of uncertainty described.
3. The need to put in place field based data collection and/or monitoring where models or data are insufficient to provide credible, reliable predictions according to BC Ministry published standards (VRI)<sup>46</sup> or the Quebec Forest Inventory Directorate (DIF)<sup>47</sup> for projects within BC or QC, respectively.
4. The need for more conservative estimates of carbon change is necessary as data certainty decreases.

Gaming or exploiting differences between models in project planning is not acceptable.

#### **8.1.1.1.3 Estimating Harvest Flow for Ex-Ante Modelling of Carbon Pools**

The following requirements apply to estimating harvest flow on Crown land. Note that these requirements apply to estimating harvest flow, not to determining harvest volumes based on monitored harvest data. During the crediting period, project harvest data is to be monitored, and where comparison-based baselines are used monitoring of baseline harvest data will also be possible. In other cases, including preparation of pre-project estimates, these requirements will apply.

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<sup>46</sup> Vegetation Resources Inventory Guidelines for Preparing a Project Implementation Plan for Ground Sampling and Net Factor Sampling. [www.for.gov.bc.ca/hts/vri/standards/index.html](http://www.for.gov.bc.ca/hts/vri/standards/index.html)

<sup>47</sup> <http://mffp.gouv.qc.ca/les-forets/inventaire-ecoforestier/>

For non-Crown land, proponents must develop and justify an approach appropriate for their project, and subject to requirements detailed elsewhere in this methodology (eg, Section 7).

For Crown land, estimating sustainable harvest flows for the baseline and project scenarios must be done in accordance with timber supply analysis standards commonly used by Forest Analysis and Inventory Branch in Timber Supply Reviews in the case of projects within BC and in accordance with timber supply analysis standards used by the Forestier en Chef in the case of projects within QC. Timber supply projection must be generated using methods that are repeatable and not overly dependent on the tool or model used. Specifically:

1. The long-term level must be sustainable, as indicated by a stable total growing stock;
2. Any declines in harvest levels in the early to mid-term must be no more than 10% per decade;
3. Any “dip” in timber supply in the mid-term below that long-term level must be minimized;
4. Current AAC (allowable annual cut or “*possibilité forestier*” in Quebec) level must be maintained in the short term if possible, while being consistent with the previous principles. If the current AAC cannot be achieved while meeting the other principles, such as maximum 10% per decade rate of decline and maintaining the maximum mid-term level, project documentation must describe why. Such an explanation may simply be that any increase above the timber supply levels shown in the forecasts would result in disruption in the forecast during the specified time period [note: this does not mean that the AAC must be used as the sole basis for harvest flow – as detailed in Section 7, other information (eg, historic harvesting levels, etc.) must also be considered to ensure that the assessed harvest flow is conservative].

In the above, short, medium and long-term have the following meanings:

- Long-term – usually a period starting from 60 to 100 years from now, and is the time period during which the projected harvest level is at the sustainable long-term level (which in turn is defined as the level that results in a flat total growing stock over the long term).
- Short-term – the first 20 years of the forecast.
- Mid-term – the time period between the short and long terms.

The same methodology for deriving the harvest flow must be used for ex-ante modelling of carbon pools under both the baseline and the project scenarios, and the specific method must be documented (including quantities such as maximum allowable inter-period change in long-term growing stock in determining the long-term sustainable level and the inter-period change in projected timber supply level).

#### 8.1.1.1.4 Modelling PP7/BP7 Soil

Where soil carbon is a mandatory relevant carbon pool or is selected as an optional carbon pool by the proponent, the proponent must ensure that either:

- The forest carbon models employed have the capability to quantify changes in soil carbon between the project and baseline over time, or
- An appropriate approach for assessing soil carbon (whether field sampling-based or modelling-based) is selected and paired with the selected forest carbon models.

A project proponent must justify their selection of a soil carbon quantification method, considering the specific details of the project and baseline. For the selected approach, the proponent must indicate how the approach will result in a conservative assessment of the change between project and baseline, considering the associated uncertainty. The approach used must include the use of some level of field measurement at the project site at a frequency consistent with the requirements for assessing other forest carbon pools as described later in this methodology (ie, at least every ten years), to help ensure the project-specific accuracy of any modelling that may be used. The extent of field measurement employed may be determined by project proponents, but will naturally have a bearing on the uncertainty associated with the quantification approach that must also be managed. Soil carbon must be assessed through the full site-specific soil profile.

In cases of large uncertainty or where uncertainty cannot be effectively managed, and where soil carbon is an optional pool in Table 5, this carbon pool may be deemed not relevant.

#### **8.1.1.1.5 Quantifying Loss Events**

While carbon is continually cycling in and out of a forest due to growth and decay processes, other natural and human-induced events can cause unexpected losses of stored carbon to occur on relatively short timescales. Carbon that is lost in this manner less than 100 years after being initially removed from the atmosphere does not have an atmospheric effect that will endure for at least 100 years, as required by the BC EOR. Examples include natural losses due to fire, pest, disease, etc., and human-induced losses due to legal and illegal harvesting activities, arson, negligence, etc.

For the purposes of this methodology, the term loss refers to significant disturbances that are not anticipated based on the anticipated carbon fluxes for the project area. Disturbances and harvesting that are anticipated to occur on a predictable basis for the project area must be included within the modeling of the project and baseline. This will be particularly appropriate for smaller disturbances that might be difficult to detect through regular project monitoring. Care must be taken by project proponents to ensure that the impact of a disturbance is not double counted (which could occur where the disturbance has been factored into models as well as is monitored and reported separately).

Project proponents must monitor for natural and human-induced loss events, and when detected assess and report on the impact of the event in the next project report prepared for the project. Assessment of the impact of a loss must be consistent with the same field sampling, modeling,



and quantification procedures employed by the project for assessing project and baseline emissions and removals.

When assessing the impact of a particular loss event, one of two approaches is to be taken:

1. For natural losses that would have also affected the baseline:

The impact of the loss on forest carbon must, in addition to being assessed for the project, also be modeled for the baseline (except where the baseline is non-forest land such as in ARR or REDD where the baseline is 100% deforestation). Such modeling must draw on observations of the type and extent of loss experienced by the project, as well as assumptions regarding the baseline scenario. In preparing this baseline assessment, project proponents must demonstrate how the assessment is conservative (ie, does not overstate the impact of the loss event on the baseline) in order to manage the inherent uncertainty of predicting the impact of a particular loss event on a hypothetical baseline scenario.

Note that this approach of modeling the impact of loss events on the baseline is not a common approach taken in existing forest carbon methodologies, , but it is considered the most accurate and appropriate approach to events that would reasonably be expected to affect both the project and baseline.

2. For human-induced losses or natural losses that would not have affected the baseline:

The impact of the loss is to be assessed for the project only. Note that for legal harvesting activities controlled by project proponents, a portion of the harvested forest carbon may be transferred to HWP pools according to the HWP methodologies described in Section 8.1.1.2.

Where the net impact of the loss event and other forest SSRs is that the project emission reductions and removal enhancements are less than baseline emission reductions and removal enhancements for that reporting period, the event is called a “reversal”.

#### **8.1.1.2 PP8/BP8 & PP9/BP9 Harvested Wood Products (In use and in landfill)**

The methodology recognizes that significant portions of Canadian forest products are now exported for end use outside of North America. The method thus now contains methods for calculating C quantities in the HWP pool for both North America and offshore uses. Emission curves for both North American and offshore use, as well as for standard product mixes, or custom product mixes tailored to the specific project are provided. Project proponents must ensure that they include in their project calculations any changes which may have been made to these factors as a result of this re-assessment.

The methods described in this section apply to the following carbon pools for both the project and baseline:

- PP8/BP8 Harvested Wood Products in use

- PP9/BP9 Harvested Wood Products in landfill

Given the linkage between carbon stored in the in-use and landfill pools, they will be quantified below as part of a single overall approach.

This methodology recognizes that carbon storage can be achieved in harvested wood products (HWPs). However, since a portion of the carbon initially stored in HWPs is known to be lost over time, the approach presented here involves assessing the amount of wood product carbon that is lost at various stages along the HWP lifecycle. The methodology uses separate data sets to estimate retention of HWP carbon pools for HWPs in North America, and in the rest of the world.

Note: harvest flow for both project and baseline must be developed in accordance with the requirements stipulated in Section 8.1.1.1.3.

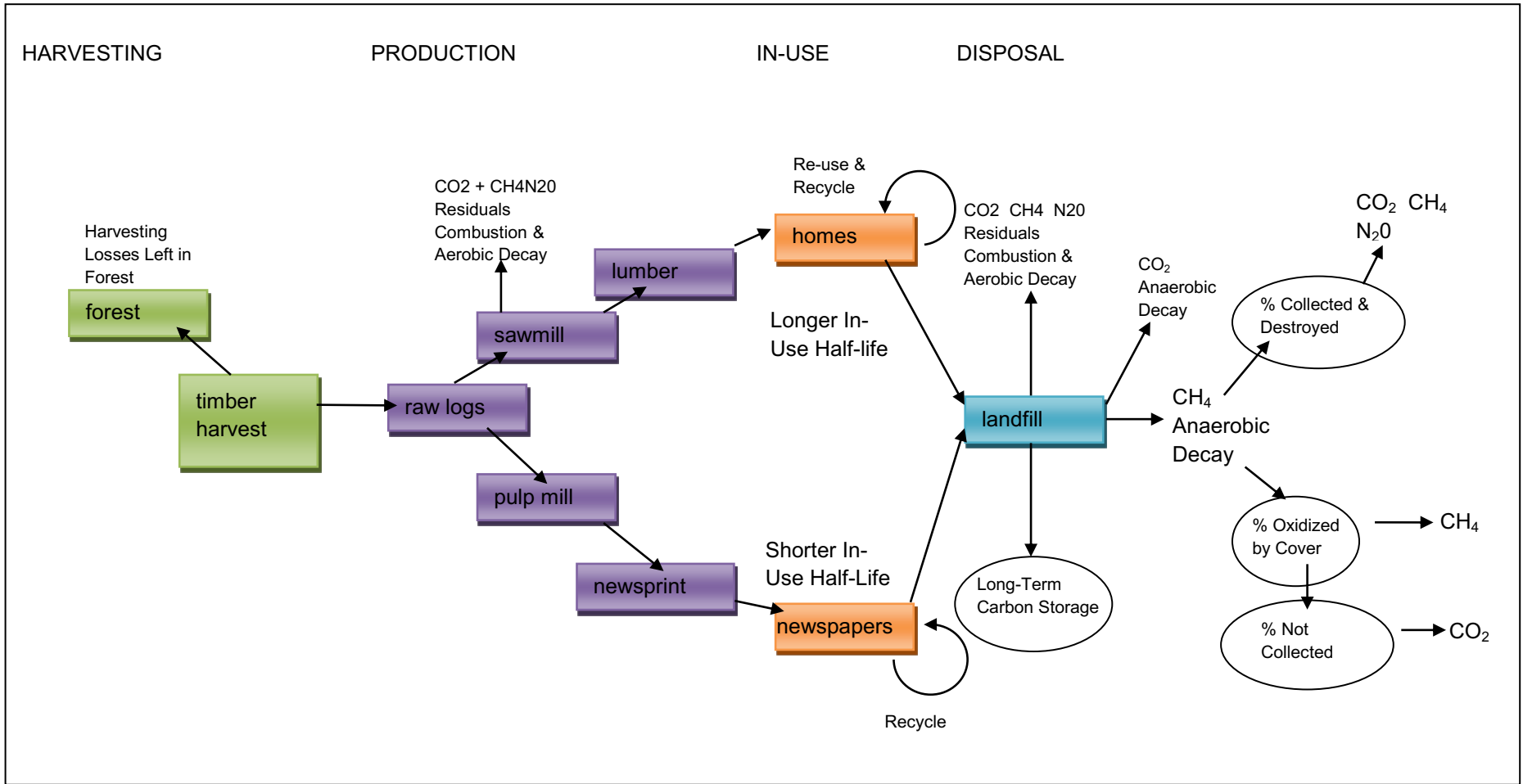
The proponent may choose one of the following two approaches for quantifying HWP storage:

1. Default approach – standard HWP mixes for both North American and offshore HWP utilization.

Using this approach, in-use and in-landfill storage is based on standard product mixes for North American and offshore markets. This approach allows project proponents to calculate HWP Pools and related methane emissions (calculated in section 8.1.2.11) using standard tables.

The default approach is described in detail in Figure 2 below.

**Figure 2: Harvested Wood Product Lifecycle**



## 2. Optional advanced approach – project specific HWP mixes.

This approach allows the proponent to calculate HWP pools using the same factors and methods as those used in the default approach, but tailored to the specific product mix. Use of this approach requires the availability of good historical data on wood delivery by mill type (for North American use) or wood product end use (for offshore use) for wood sourced from within the project area, as well as projections of future wood product processing and end use that can be validated. This data is more likely to be available for North American markets than for offshore markets, and it is permissible to use this approach for wood used in North America only, while using the default approach for wood used offshore.

Based on this lifecycle diagram, assessment of the amount of carbon stored in HWPs in-use and in landfill over a 100-year period must consider the following:

- i. Amount of carbon removed from the forest in harvested wood (net of on-site harvesting losses);
- ii. Amount of carbon lost during production of wood products (eg, at the sawmill, during the pulp & paper process, etc.) and assumed combusted (and emitted as CO<sub>2</sub> with minor amounts of CH<sub>4</sub> and N<sub>2</sub>O) and/or otherwise aerobically lost to the atmosphere as CO<sub>2</sub>;
- iii. Amount of carbon in primary HWPs that remains in-use over the 100-year period;
- iv. Amount of carbon in primary HWPs that does not remain in use for the full 100-year period but that is at some point:
  - Combusted and emitted as CO<sub>2</sub> with minor amounts of CH<sub>4</sub> and N<sub>2</sub>O) and/or otherwise aerobically lost to the atmosphere as CO<sub>2</sub>, or
  - Sent to landfill, and:
    - Retained over the 100-year period (non-degradable portion of the HWP and the part of the degradable portion that has not had sufficient time to degrade)
    - aerobically or anaerobically decays to CO<sub>2</sub> and CH<sub>4</sub> and is lost to the atmosphere in various ways (the part of the degradable portion of the HWP that has had sufficient time to degrade).

For HWPs in use in North America, quantification of these processes has been conducted by Dymond<sup>48</sup> with some data from Skog et al<sup>49</sup>, quantifying carbon storage in HWPs in use, and in landfills and dumps, for British Columbia forest products. In the case of Quebec, the model proposed by Dymond (2012) has been used including QC provincial data to adjust the results for projects within the province. In order to determinate default values for other provinces, project proponents may use one of the following options:

1. Use the procedure proposed by Dymond (2012), replacing data sources from BC with appropriate data from the provinces where the project will be carried out. The choice and appropriateness of these data as well as its sources must be justified during validation by the project proponent. The project proponent must also justify during validation the rightness and the transparency of calculation during the project validation process.
2. Use other models that may be considered as suitable to determinate HWP default values required by the methodology. If other model is used, the project proponent must justify its choice by considering the appropriateness of the selected models versus the model recommended above, considering project-specific circumstances. In addition, any selected alternative model must meet the following minimum requirements:
  - The model must be scientifically sound, and must have been peer reviewed in a process that primarily involved reviewers with the necessary technical expertise;
  - The model must have been parameterized and validated for the general conditions of the province where the project will be implemented;
  - The model's scope of application, assumptions, known equations, data sets, factors or parameters, etc., must be clearly documented.

For HWP in use offshore, Winjum et al<sup>50</sup> provides general use and decay factors for developing world markets.

These two sources have been used to develop the figures given in Tables 9A, 9B and 11 below.

### **Default Approach**

Using these two sources, quantification of the harvested wood product pool using the default approach is calculated using the following steps:

1. Calculate or estimate volume of roundwood delivered to the mill (or exported), from the project area, by species, year and wood product destination (NA or offshore). Harvest

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<sup>48</sup> Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012.

<sup>49</sup> K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.

<sup>50</sup> Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998.

flow for both project and baseline must be developed in accordance with the requirements stipulated in Section 8.1.1.1.3. Volumes must be for wood only (not including bark).

- For each year, and location of use, convert volumes to tonnes of dry biomass, using equation 2, and the standard wood density figures given in Table 8A and 8B.

Tonnes of dry biomass in delivered roundwood per year, by wood product destination.

Equation 2

$$RWbiomass_{y,d} = \sum_s (Vol_{s,y,d} \times wd_s) \quad [2]$$

Where:

Parameter	Description	Default Value
$RWbiomass_{y,d}$	The dry mass of the delivered roundwood extracted from the project area in year $y$ , for each wood product destination $d$ (North America or offshore). Expressed in t.	N/A
$Vol_{s,y,d}$	The volume of delivered roundwood of species or group of species $s$ for each wood product destination $d$ , extracted from the project area in year $y$ . Expressed in $m^3$ .	N/A
$wd_s$	The wood density for species or group of species $s$ , from tables 8A and 8B <sup>51</sup> . Expressed in $t/m^3$ .	Given in tables 8A and 8B

Table 8A: BC-specific wood density (wd) for oven-dry roundwood to convert from inside-bark harvested (green) volume ( $m^3$ ) to mass – Derivation detailed in Appendix D.

BC Species or genus	Wood density to 2 significant figures <sup>52</sup> ( $t\ m^{-3}$ )
Red alder ( <u>Alnus rubra</u> )	0.37
Trembling aspen ( <u>Populus tremuloides</u> )	0.38
Western red cedar ( <u>Thuja plicata</u> )	0.32

<sup>51</sup> Where new data of wood density is provided at validation for provinces other than BC or Quebec, the project proponent must justify these data as well as its sources and demonstrate that they are correct and applicable to the project in the context of the province where the project activity is being developed. During the validation the project proponent needs to demonstrate that these data result in a conservative estimate.

<sup>52</sup> Values after J.S. Gonzalez. Wood density of Canadian tree species. Edmonton: Forestry Canada, Northwest Region, Northern Forestry Centre, 1990, Inform. Rept. NOR-X-315.

Yellow cypress ( <i>Chamaecyparis nootkatensis</i> )	0.42
Douglas-fir ( <i>Pseudotsuga menziesii</i> )	0.44
True firs ( <i>Abies spp.</i> ) <sup>53</sup>	0.35
Western hemlock ( <i>Tsuga heterophylla</i> )	0.42
Western larch ( <i>Larix occidentalis</i> )	0.50
Lodgepole pine ( <i>Pinus contorta</i> )	0.41
Ponderosa pine ( <i>Pinus ponderosa</i> )	0.41
Spruce ( <i>Picea spp.</i> ) <sup>54</sup>	0.36
Sitka spruce ( <i>Picea sitchensis</i> )	0.35

Table 8B: QC-specific wood density (wd) for oven-dry roundwood to convert from inside-bark harvested (green) volume (m<sup>3</sup>) to mass – Derivation detailed in Appendix D.

QC Species or genus	Wood density to 2 significant figures <sup>55</sup> (t m <sup>-3</sup> )
<i>Abies spp</i>	0.40
<i>Acer spp</i>	0.52
<i>Alnus spp</i>	0.45
<i>Betula spp</i>	0.51
<i>Fagus grandifolia</i>	0.60
<i>Fraxinus spp</i>	0.57
<i>Juglans spp</i>	0.53
<i>Larix laricin</i>	0.44
<i>Picea glauca</i>	0.34
<i>Picea mariana</i>	0.44
<i>Picea rubra</i>	0.44

<sup>53</sup> The trees known in BC as “balsam” are true firs

<sup>54</sup> Spruce includes Engelmann Spruce, White Spruce, and Hybrid Spruce.

<sup>55</sup> Values after J.S. Gonzalez. Wood density of Canadian tree species. Edmonton: Forestry Canada, Northwest Region, Northern Forestry Centre, 1990, Inform. Rept. NOR-X-315.

Pinus banksiana	0.40
Pinus resinosa	0.38
Pinus strobus	0.32
Pinus sylvestris	0.42
Populus spp	0.35
Prunus spp	0.49
Quercus spp	0.58
Salix spp	0.45
Thuja occidentalis	0.30
Tilia	0.43
Tsuga	0.42
Ulmus	0.65

- Convert tonnes of biomass to tonnes of CO<sub>2</sub>, for each year, using equation 3.

Tonnes of CO<sub>2</sub> in delivered roundwood for year y

Equation 3

$$G_{HWPCO2_{y,d}} = RWbiomass_{y,d} \times CF_{RW} \times (44/12) \quad [3]$$

Where:

Parameter	Description	Default Value
G <sub>HWPCO2<sub>y,d</sub></sub>	The mass of CO <sub>2</sub> in delivered roundwood extracted from the project area in year y, for each wood product destination d (North America or offshore). Expressed in tCO <sub>2</sub>	N/A
RWbiomass <sub>y,d</sub>	The dry mass of the delivered roundwood extracted from the project area in year y, for each wood product destination d (North America or offshore). Unit of measure: t (See Equation 2)	N/A
CF <sub>RW</sub>	Carbon fraction of roundwood dry mass, dimensionless.	0.5
44/12	Molecular weight ratio between carbon dioxide and carbon, dimensionless.	44/12



- Calculate the total GHGs (in tonnes CO<sub>2e</sub>), remaining in HWPs in use and in landfills, at a given time *t*, using equation 4.

Total GHGs remaining in HWPs derived from the project area up to time *t*

Equation 4

$$GHG_{CO_2,HWP,t} = \sum_{y \leq t} (G_{HWPCO_2,y,NA} \times HWPf_{NA,t-y} + G_{HWPCO_2,y,O} \times HWPf_{O,t-y}) \quad [4]$$

Where:

Parameter	Description	Default Value
$GHG_{CO_2,HWP,t}$	Mass of CO <sub>2</sub> stored in project or baseline HWPs up to time <i>t</i> . Expressed in tCO <sub>2e</sub>	N/A
$G_{HWPCO_2,y,NA}$	The mass of CO <sub>2</sub> in delivered roundwood extracted from the project area in year <i>y</i> , destined for use in North America. Expressed in tCO <sub>2e</sub> (See Equation 3)	N/A
$G_{HWPCO_2,y,O}$	The mass of CO <sub>2</sub> in delivered roundwood extracted from the project area in year <i>y</i> , destined for use outside of North America, Expressed in tCO <sub>2e</sub> (See Equation 3)	N/A
$HWPf_{NA,t-y}$	The factor, derived from table 9, for the percentage of CO <sub>2</sub> remaining stocked in HWP (in-use and landfill) after the number of years between harvest and time <i>t</i> , for products used in North America <sup>56</sup> .	Table 9
$HWPf_{O,t-y}$	The factor, derived from tables 9, for the percentage of CO <sub>2</sub> remaining stocked in HWP (in-use and landfill) after the number of years between harvest and time <i>t</i> , for products used outside of North America.	Table 9
$y \leq t$	Any year <i>y</i> up to year <i>t</i>	

<sup>56</sup> If the fraction of CO<sub>2</sub> remaining in-use and in-landfill per year is not available in this document, the project proponent must provide the necessary data during the validation process.

Table 9: Fraction of CO<sub>2</sub> remaining stocked in HWP (in-use and in landfill) per year – Derivation detailed in Appendix F<sup>57</sup>

Year	BC products used in North America - % of total delivered CO <sub>2</sub> stored after y years	QC products used in North America - % of total delivered CO <sub>2</sub> stored after y years	Products used offshore - % of total delivered C stored after y years
0	65.9%	65.2%	76.0%
1	64.6%	63.3%	72.7%
2	63.5%	60.9%	72.4%
3	62.5%	58.8%	72.1%
4	61.6%	56.9%	71.0%
5	60.7%	55.2%	69.8%
6	59.9%	53.7%	68.6%
7	59.2%	52.3%	67.4%
8	58.5%	51.0%	66.2%
9	57.8%	49.9%	65.1%
10	57.2%	48.9%	63.9%
11	56.6%	47.9%	62.8%
12	56.0%	47.0%	61.6%
13	55.5%	46.2%	60.5%
14	54.9%	45.4%	59.4%
15	54.4%	44.7%	58.3%
16	53.9%	44.1%	57.3%
17	53.4%	43.5%	56.2%

<sup>57</sup> Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998 and K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)

18	53.0%	42.9%	55.2%
19	52.5%	42.3%	54.2%
20	52.1%	41.8%	53.2%
25	50.0%	39.5%	48.4%
30	48.1%	37.7%	44.0%
35	46.4%	36.1%	40.1%
40	44.8%	34.7%	36.5%
45	43.4%	33.5%	33.2%
50	42.0%	32.4%	30.2%
55	40.7%	31.4%	27.5%
60	39.5%	30.5%	25.1%
65	38.3%	29.7%	22.9%
70	37.2%	28.9%	20.8%
75	36.2%	28.2%	19.0%
80	35.2%	27.6%	17.3%
85	34.2%	27.0%	15.8%
90	33.3%	26.5%	14.4%
95	32.4%	26.0%	13.1%
100	31.6%	25.6%	12.0%

**Advanced approach**

If the advanced approach is used for North American or offshore products, or both, the same steps will be used as for the default approach, except that at each step either the deliveries by mill type (for North American use) or product types (for offshore use) will be accounted separately. The types to be used are shown in Table 10.

**Table 10:** Mill/Product categories for North America and offshore

North America
Lumber mills
Plywood mills
Panel mills (all non-ply panel products)

Pulp and Paper
Offshore
Lumber
Panel (including plywood)
Other industrial roundwood
Paper and paperboard

In step 4, the mill type or use categories are calculated separately, using the values given in Table 11

**Table 11:** Fraction of CO<sub>2</sub> remaining stocked in HWP (in-use and in landfill) in-use and in landfill per year, by product category – Derivation detailed in Appendix F<sup>58</sup>

Year	BC products used in North America - % of total delivered CO <sub>2</sub> stored after y years				QC products used in North America - % of total delivered CO <sub>2</sub> stored after y years.				Products used offshore - % of total delivered C stored after y years			
	Lumber mills	Plywood mills	Panel mills	Pulp/ Paper	Lumber mills	Plywood mills	Panel mills	Pulp/ Paper	Lumber	Wood panel	Other roundwood	Paper
0	64.9%	79.7%	84.5%	49.4%	67.5%	81.5%	84.5%	56.7%	76.0%	76.0%	76.0%	76.0%
1	63.6%	78.8%	84.1%	47.1%	65.8%	80.2%	84.3%	54.1%	73.8%	74.9%	72.7%	69.6%
2	62.5%	78.1%	83.8%	45.1%	63.1%	78.3%	84.0%	51.7%	73.6%	74.8%	72.4%	69.0%
3	61.5%	77.3%	83.5%	43.1%	60.7%	76.7%	83.8%	49.5%	73.5%	74.7%	72.2%	68.5%
4	60.6%	76.6%	83.1%	41.4%	58.6%	75.2%	83.6%	47.5%	73.0%	74.0%	70.8%	66.1%
5	59.7%	76.0%	82.8%	39.7%	56.8%	73.9%	83.3%	45.6%	72.5%	73.2%	69.5%	63.7%
6	59.0%	75.4%	82.5%	38.2%	55.2%	72.8%	83.1%	43.8%	72.0%	72.4%	68.1%	61.3%
7	58.2%	74.8%	82.1%	36.8%	53.8%	71.8%	82.8%	42.2%	71.4%	71.5%	66.8%	59.0%
8	57.5%	74.2%	81.8%	35.4%	52.6%	70.9%	82.6%	40.6%	70.9%	70.7%	65.5%	56.8%
9	56.9%	73.6%	81.5%	34.2%	51.5%	70.0%	82.3%	39.2%	70.4%	69.8%	64.2%	54.6%
10	56.3%	73.1%	81.2%	33.0%	50.5%	69.3%	82.1%	37.8%	69.8%	68.9%	62.9%	52.4%
11	55.7%	72.6%	80.8%	31.9%	49.7%	68.6%	81.8%	36.5%	69.2%	68.1%	61.6%	50.4%

<sup>58</sup> Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998, and K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)

12	55.1%	72.1%	80.5%	30.8%	48.9%	68.0%	81.5%	35.3%	68.7%	67.2%	60.3%	48.4%
13	54.6%	71.6%	80.2%	29.8%	48.2%	67.5%	81.3%	34.1%	68.1%	66.3%	59.0%	46.4%
14	54.0%	71.2%	79.9%	28.9%	47.6%	67.0%	81.0%	33.0%	67.5%	65.3%	57.8%	44.5%
15	53.5%	70.7%	79.5%	28.0%	47.1%	66.5%	80.7%	32.0%	66.9%	64.4%	56.6%	42.7%
16	53.0%	70.3%	79.2%	27.1%	46.6%	66.1%	80.5%	31.0%	66.3%	63.5%	55.4%	40.9%
17	52.6%	69.8%	78.9%	26.3%	46.1%	65.7%	80.2%	30.0%	65.7%	62.6%	54.2%	39.2%
18	52.1%	69.4%	78.6%	25.5%	45.7%	65.3%	79.9%	29.1%	65.1%	61.7%	53.0%	37.5%
19	51.7%	69.0%	78.3%	24.7%	45.3%	65.0%	79.6%	28.2%	64.4%	60.7%	51.8%	35.9%
20	51.2%	68.6%	77.9%	24.0%	45.0%	64.6%	79.4%	27.4%	63.8%	59.8%	50.7%	34.4%
25	49.2%	66.6%	76.3%	20.8%	43.5%	63.2%	78.0%	23.6%	60.6%	55.2%	45.3%	27.6%
30	47.4%	64.8%	74.7%	18.1%	42.4%	61.9%	76.6%	20.4%	57.4%	50.7%	40.4%	22.0%
35	45.7%	63.1%	73.1%	15.8%	41.5%	60.8%	75.2%	17.7%	54.2%	46.4%	36.0%	17.5%
40	44.1%	61.5%	71.6%	13.8%	40.8%	59.8%	73.8%	15.4%	51.1%	42.3%	32.0%	13.9%
45	42.7%	59.9%	70.0%	12.1%	40.0%	58.8%	72.5%	13.4%	48.0%	38.5%	28.5%	11.0%
50	41.3%	58.4%	68.5%	10.7%	39.4%	57.8%	71.2%	11.7%	45.0%	34.9%	25.3%	8.7%
55	40.1%	57.0%	67.0%	9.4%	38.7%	56.9%	69.9%	10.2%	42.1%	31.6%	22.4%	6.8%
60	38.9%	55.6%	65.5%	8.2%	38.1%	56.1%	68.8%	8.9%	39.3%	28.5%	19.9%	5.4%
65	37.7%	54.3%	64.0%	7.2%	37.5%	55.2%	67.6%	7.7%	36.6%	25.7%	17.7%	4.3%
70	36.7%	53.0%	62.6%	6.4%	37.0%	54.4%	66.5%	6.7%	34.1%	23.1%	15.7%	3.4%
75	35.6%	51.8%	61.1%	5.6%	36.5%	53.6%	65.5%	5.9%	31.7%	20.8%	13.9%	2.6%
80	34.6%	50.6%	59.7%	4.9%	36.0%	52.9%	64.5%	5.1%	29.4%	18.7%	12.3%	2.1%
85	33.7%	49.4%	58.4%	4.4%	35.5%	52.2%	63.6%	4.5%	27.3%	16.7%	10.9%	1.6%
90	32.8%	48.3%	57.0%	3.9%	35.1%	51.5%	62.7%	3.9%	25.3%	15.0%	9.7%	1.3%
95	31.9%	47.2%	55.7%	3.4%	34.7%	50.9%	61.8%	3.4%	23.4%	13.4%	8.6%	1.0%
100	31.1%	46.1%	54.4%	3.0%	34.3%	50.3%	60.8%	3.0%	21.6%	12.0%	7.6%	0.8%

**8.1.2 Quantification Methodologies – Controlled and Related Sources**

**8.1.2.1 General Approach for Quantifying Emission sources**

For each controlled and related emission source quantified, a calculation method is provided and justified for quantifying associated GHG emissions in the following section. Note that if a published quantification methodology for a parameter required for a controlled or related source in this section is referenced or directly incorporated by the national or provincial reporting regulation (e.g., BC Reporting Regulation), the quantification methodology, including relevant

sampling, analysis and measurement requirements, may be used<sup>59</sup>. Deviation from the referenced or directly incorporated methodologies for a parameter requires appropriate explanation from project proponents.

A typical, universally accepted emission factor-based equation has been used for most SSPs to calculate total emissions, as follows:

Equation 5

$$TE_{ESi,t} = \sum_i (GHG_{j,ESi,t} \times GWP_j) \quad [5]$$

Where:

Parameter	Description	Default Value
$TE_{ESi,t}$	Total emissions from Emission Sources (ES) $i$ , during reporting period $t$ . Expressed in tCO <sub>2</sub> e	
$GHG_{j,ESi,t}$	Emissions of GHG $j$ , from Emission Source (ES) $i$ during reporting period $t$ . Expressed in t GHG $j$ . (See Equation 6)	N/A
$GWP_j$	Global warming potential of GHG $j$ . Dimensionless.	N/A
$j$	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
$t$	The reporting period in question, where the value of $t$ indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 6

$$GHG_{j,ESi,t} = EF_{i,j} \times AL_i \times CF \quad [6]$$

Where:

<sup>59</sup> The Reporting Regulation, under authority of the GHG Reduction (Cap and Trade) Act, was approved by Order of the Lieutenant Governor in Council on November 25, 2009. Referenced Western Climate Initiative quantification methods can be found at <http://www.env.gov.bc.ca/cas/mitigation/ggrcta/pdf/Final-Essential-Requirements-of-Mandatory-Reporting--Dec-17-2010.pdf>

Parameter	Description	Default Value
GHG <sub>j,ESi,t</sub>	Emissions of GHG <i>j</i> , from Emission Source (ES) <i>i</i> during reporting period <i>t</i> . Expressed in <i>t</i> .	N/A
EF <sub>i,j</sub>	Emission factor (EF) for GHG <i>j</i> and Emission Source (ES) <i>i</i> . Expressed in tGHG <sub>j</sub> /unit of activity or input/output	N/A
AL <sub>i</sub>	Quantity of input/output or “activity level (AL)” for Emission Source (ES) <i>i</i> (eg, volume of fuel combusted, amount of fertilizer applied, etc.). Expressed in the corresponding unit of activity or input/output.	N/A
CF	Conversion factor to be used when the units of the activity level do not match those of the emission factor. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A

In most cases, emissions will be calculated using this equation or a variation of this equation. Where the methodologies described below require selecting an emission factor from a recognized source, the provincial GHG Inventory may be used where appropriate, followed by the National GHG Inventory and then other recognized sources.

Below, equations and parameters are provided and justified for each relevant SSP for the project and baseline.

Note that, as indicated in Table 6, where project emissions are less than baseline emissions for a related SSP, that SSP is deemed not relevant in most cases, and the net change in emissions between project and baseline set to zero.

### 8.1.2.2 PE1/BE1 Fossil Fuel Production

This quantification method is to be applied to both the project and baseline.

Emissions from production of fossil fuels consumed on-site are to be calculated using the standard emission factor multiplied by the activity level, using the approach described by Equation 7 and restated here:

PE1/BE1 fossil fuel production emissions

Equation 7

$$TE_{PE1/BE1,t} = \sum_i (GHG_{j,PE1/BE1,t} \times GWP_j) \quad [7]$$

Where:

Parameter	Description	Default Value
TE <sub>PE1/BE1,t</sub>	Total emissions from production of fossil fuels consumed by on-site vehicles and equipment during reporting period <i>t</i> . Expressed in tCO <sub>2e</sub>	
GHG <sub>j,PE1/BE1,t</sub>	Emissions of GHG <i>j</i> , from production of fossil fuels consumed by on-site vehicles and equipment during reporting period <i>t</i> . Expressed in t GHG <i>j</i> . (See Equation 8)	N/A
GWP <sub>j</sub>	Global warming potential of GHG <i>j</i> . Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 8

$$GHG_{j,PE1/BE1,t} = EF_{f,j} \times AL_{f,t} \times CF_f \quad [8]$$

Where:



Parameter	Description	Default Value
GHG <sub>j, PE1/BE1, t</sub>	Emissions of GHG <i>j</i> , from production of fossil fuels consumed by on-site vehicles and equipment during reporting period <i>t</i> . Expressed in <i>t</i> .	N/A
EF <sub>f, j</sub>	The emission factor for GHG <i>j</i> and fuel type <i>f</i> . Note: it is likely that fuel production emission factors may only be available in units of CO <sub>2</sub> e. Expressed in t GHGj/ unit of fuel	See below under the title “Determining the emission factor” the emission factor requirements
AL <sub>f, t</sub>	The quantity of fuel of type <i>f</i> consumed by on-site vehicles and equipment during reporting period <i>t</i> . Expressed in volumetric measure (eg, l, m <sup>3</sup> , etc.) or mass measure (kg, t, etc.) with appropriate conversion.	N/A
CF <sub>f</sub>	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular fuel type <i>f</i> . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A

### Determining the emission factor

Fossil fuel production emission factors tend to be uncertain, given the range of factors that can influence overall emissions. Emission factors appropriate for the fuels in question must be selected from the following reference sources in order of preference (where an appropriate factor is not available from a preferred reference source, the next source on the list may be consulted):

3. The provincial reporting regulation, corresponding to the province where the project is developed.
4. Latest version of the provincial GHG Inventory Report, corresponding to the province where the project is developed.
5. Latest version of Canada’s National GHG Inventory Report
6. Latest version of the GHGenius transportation fuel lifecycle assessment model<sup>60</sup>

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<sup>60</sup> Available at <http://www.ghgenius.ca/>

7. Other recognized sources, including federal (Canada) or provincial government institutions (corresponding to the province where the project is developed), the IPCC or the UNFCCC, with a preference to provincial data over national or international level data.

*Note: at time of methodology development, 3.19 was the most recent version of the GHGenius model. In this version, default emission factors for various fuels can be found on worksheet “Upstream Results HHV”, rows 19 and 33 (one or the other depending on the fuel), in units of g CO<sub>2e</sub> per GJ (HHV) of fuel.*

Note: these emission factors also include transport / distribution-related emissions which would overlap with SSP PE4/BE4. If these emission factors are used, then fuel transportation emissions do not need to be included in SSP PE6/BE6.

8. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data. These sources must be peer reviewed, and not more than 10 years old.

### Determining the activity level

For fuel combustion in equipment and vehicles, the most accurate approach is to use fuel consumption records by type of equipment or vehicle and fuel type. However, for calculating fuel production emissions it is equally appropriate to track total volumes of each type of fuel consumed for the entire project site.

Since it is not possible to directly monitor fuel consumption in the baseline, baseline fuel consumption must be estimated based on justified vehicle and equipment usage estimates in the baseline and considering fuel consumption observed during the project period as applicable

#### 8.1.2.3 PE2/BE2 Emissions from Fertilizer Production

This quantification method is to be applied to both the project and baseline.

Emissions from production of fertilizer are to be calculated using the standard emission factor multiplied by the activity level, using the approach described by Equations 9 and 10 and restated here:

Equation 9

$$TE_{PE2/BE2,t} = \sum_j (GHG_{j,PE2/BE2,t} \times GWP_j) \quad [9]$$

Where:

Parameter	Description	Default Value
TE <sub>PE2/BE2,t</sub>	Total emissions from fertilizer production, during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e	
GHG <sub>j,PE2/BE2,t</sub>	Emissions of GHG <i>j</i> , from fertilizer production during reporting period <i>t</i> . Expressed in t GHG <i>j</i> . (See Equation 10)	N/A
GWP <sub>j</sub>	Global warming potential of GHG <i>j</i> . Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 10

$$GHG_{j,PE2/BE2,t} = \sum_f EF_{f,j} \times AL_{f,t} \times CF_f \quad [10]$$

Where:

Parameter	Description	Default Value
GHG <sub>j,PE2/BE2,t</sub>	Emissions of GHG <i>j</i> , from fertilizer production applied during reporting period <i>t</i> . Expressed in t.	N/A
EF <sub>f,j</sub>	The emission factor for GHG <i>j</i> and fertilizer type <i>f</i> . Note: it is likely that fertilizer production emission factors may only be available in units of CO <sub>2</sub> e. Expressed in t GHG <sub>j</sub> / t fertilizer type <i>f</i>	See below under the title “Determining the emission factor” the emission factor requirements
AL <sub>f,t</sub>	The quantity of fertilizer of type <i>f</i> applied during reporting period <i>t</i> . Expressed in t,	N/A
CF <sub>f</sub>	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular fertilizer type <i>f</i> . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A

**Determining the emission factor**

Emission factors appropriate for the nitrogen-based fertilizers in question must be selected from the following reference sources in order of preference (where an appropriate factor is not available from a preferred reference source, the next source on the list may be consulted):

1. The provincial reporting regulation, corresponding to the province where the project is developed.
2. Latest version of the provincial GHG Inventory Report, corresponding to the province where the project is developed.
3. Latest version of Canada’s National GHG Inventory Report
4. Latest version of the GHGenius transportation fuel lifecycle assessment model.
5. Other recognized sources, including federal (Canada) or provincial government institutions (corresponding to the province where the project is developed), the IPCC or the UNFCCC, with a preference to provincial data over national or international level data.

Note, at time of methodology development, 3.19 was the most recent version of the GHGenius model. In this version, a default emission factor for nitrogen-based fertilizer can be found on worksheet “W”, cell B27, in units of g CO<sub>2e</sub> per kg of nitrogen-based fertilizer produced (not per kg of nitrogen). The emission factor provided is 2,792 g CO<sub>2e</sub> / kg Nitrogen-based fertilizer. Note, this emission factor also includes a small amount of transport-related emissions which would overlap with SSP PE6/BE6. If this emission factor is used, then fertilizer transportation emissions do not need to be included in SSP PE6/BE6.

Proponents may tailor the assumptions used in GHGenius to derive this emission factor (eg, type of energy sources, ratio of finished fertilizer to nitrogen, etc.) to produce an emission factor customized for the project, as long as all changes are justified.

**Determining the activity level**

Quantities of different types of fertilizer applied are to be monitored during the project.

Since it is not possible to directly monitor fertilizer application in the baseline, baseline fertilizer application must be estimated based on justified application rate based on the practices described for the selected baseline scenario.

**8.1.2.4 PE3/BE3 Emissions from Transport of Material, Equipment, Inputs, and Personnel to Site**

This quantification method is to be applied to both the project and baseline. Emissions from transportation of materials, equipment, inputs, and personnel to the project / baseline site are to be calculated using the standard emission factor multiplied by the activity level approach described by Equation 6 and restated here:

Equation 11

$$TE_{PE3/BE3,t} = \sum_j (GHG_{j,PE3/BE3,t} \times GWP_j) \quad [11]$$

Where:

Parameter	Description	Default Value
$TE_{PE3/BE3,t}$	Total emissions from transport of material, equipment, inputs and personnel to site, during reporting period $t$ . Expressed in tCO <sub>2</sub> e	
$GHG_{j,PE3/BE3,t}$	Emissions of GHG $j$ , from transport of material, equipment, inputs and personnel to site, during reporting period $t$ . Expressed in t GHG $j$ . (See Equation 12; Equation 13, Equation 14)	N/A
$GWP_j$	Global warming potential of GHG $j$ . Dimensionless.	N/A
$j$	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
$t$	The reporting period in question, where the value of $t$ indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 12

$$GHG_{j,PE3/BE3,t} = \sum_m (EF_{m,j} \times AL_{m,t} \times CF_m) \quad [12]$$

Where:

Parameter	Description	Default Value
$GHG_{j,PE3/BE3,t}$	Emissions of GHG $j$ , from transportation of materials, equipment, inputs and personnel to the project / baseline site during reporting period $t$ . Expressed in $t$ .	N/A
$EF_{m,j}$	Emission factor (EF) for transportation mode $m$ and GHG $j$ . Expressed in $t$ /unit of transported material using transportation mode $m$ .	N/A
$AL_{m,t}$	The quantity of materials, equipment, inputs, and personnel transported by mode $m$ during reporting period $t$ . Expressed in units of transported material: persons, items or tonnes, as appropriate.	N/A
$CF_m$	The conversion factor to be used if the units of the activity level do not match those of the emission factor for transport mode $m$ . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A
$j$	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
$t$	The reporting period in question, where the value of $t$ indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A
$m$	Transportation mode	N/A

Various approaches are available for selecting emission factors and activity levels for use in Equation 12, ranging from those based on the use of detailed fuel consumption data recording (most accurate) to calculations based on vehicle-specific fuel economy data and route-specific distance data, to calculations based on total amounts of goods transported and generic transportation emission factor per tonne/km transported. These approaches are outlined in various sources, including the TCR General Reporting Methodology and CDM methodology AM0036.

Given that emissions from this SSR are expected to be small relative to other SSRs, detailed approaches such as use of vehicle-specific fuel consumption will not be required. Instead, two options are available:

6. Distance and assumed fuel economy approach

This approach is described in the equation below:

PE3/BE3 distance and fuel economy approach

Equation 13

$$GHG_{j,PE3/BE3,t} = \sum_m [EF_{m,j} \times \sum_g (FE_m \times D_{m,g} \times C_{m,g,t} \div L_{m,g}) \times CF_m] \quad [13]$$

Where:

Parameter	Description	Default Value
GHG <sub>j, PE3/BE3, t</sub>	Emissions of GHG <i>j</i> from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period <i>t</i> . Expressed in <i>t</i> .	N/A
EF <sub>m, j</sub>	The emission factor for GHG <i>j</i> and fuel combusted by transportation mode <i>m</i> (eg, t CO <sub>2</sub> per L diesel). Expressed in <i>t</i> /unit of fuel.	See below under the title “Determining the emission factor” the emission factor requirements
FE <sub>m</sub>	Fuel economy of transportation mode <i>m</i> (eg, L / 100 km). Expressed in unit of fuel/unit of distance for transportation mode <i>m</i> ..	N/A
D <sub>m,g</sub>	Transport distance for material, equipment, input, or personnel <i>g</i> using transport mode <i>m</i> . Expressed in km.	N/A
C <sub>m,g, t</sub>	Total quantity of material, equipment, input, or personnel <i>g</i> transported using transport mode <i>m</i> during reporting period <i>t</i> . Expressed in <i>t</i> or other relevant unit.	N/A
L <sub>m,g</sub>	Cargo load per transport vehicle of mode <i>m</i> . Expressed in <i>t</i> or other relevant unit (same unit as C <sub>m,g,t</sub> )/transport mode.	N/A
CF <sub>m</sub>	The conversion factor to be used if the units of the various parameters do not match (eg, fuel economy in L/100km but distance in km) for a particular transport mode <i>m</i> . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A
<i>m</i>	transportation mode	N/A
<i>g</i>	Transport distance for material, equipment, input, or personnel	N/A

**Determining the emission factor**

The following emission factors, approved by the province of BC, and used in its GHG Emissions Estimator for emissions reporting, may be used for the province of BC:

- Natural Gas – 0.0503 tCO<sub>2</sub>e/gigajoule
- Gasoline – 0.0023 tCO<sub>2</sub>e/litre
- Diesel – 0.0027 tCO<sub>2</sub>e/litre
- Fuel Oil – 0.0027 tCO<sub>2</sub>e/litre
- Propane – 0.0015 tCO<sub>2</sub>e/litre

For project in the province of Quebec, EF published by “*Transition Énergétique Québec (TEQ)*”<sup>61</sup> may be used , as follows:

- Natural Gas – 0.0565 tCO<sub>2</sub>e/gigajoule
- Gasoline – 0.0023 tCO<sub>2</sub>e/litre
- Diesel – 0.0028 tCO<sub>2</sub>e/litre
- Propane – 0.0015 tCO<sub>2</sub>e/litre

For projects in other provinces of Canada, EF published by the provincial government relevant authorities may be used.

**Determining the activity level and other parameters**

The quantity of material, equipment, input, or personnel must be monitored for the project.

Since it is not possible to directly monitor transportation in the baseline, baseline transportation quantities and assumptions must be estimated based on the activities described for the selected baseline scenario and project assumptions where applicable.

Other parameters, such as transport modes used, transport distance by mode, fuel efficiency, and cargo load per transport vehicle must be conservatively determined and justified based on typical distances and types of transport modes used.

7. Amount and distance shipped approach

This approach is described in the equation below:

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<sup>61</sup> See <https://transitionenergetique.gouv.qc.ca/fileadmin/medias/pdf/FacteursEmission.pdf> for further information.



PE3/BE3 amount and distance approach

Equation 14

$$GHG_{j,PE3/BE3,t} = \sum_m [EF_{m,j} \times \sum_g (D_{m,g} \times C_{m,g,t}) \times CF_m] \quad [14]$$

Where:

Parameter	Description	Default Value
GHG <sub>j, PE3/BE3, t</sub>	Emissions of GHG <i>j</i> , from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period <i>t</i> . Expressed in t.	N/A
EF <sub>m, j</sub>	The emission factor for GHG <i>j</i> and the amount and distance shipped by transportation mode <i>m</i> (eg, g CO <sub>2</sub> per tonne-km). Expressed in t/quantity of transported good over a set distance.	See below under the title “Determining the emission factor” the emission factor requirements
D <sub>m, g</sub>	Transport distance for material, equipment, input, or personnel <i>g</i> using transport mode <i>m</i> . Expressed in km.	N/A
C <sub>m, g, t</sub>	Total quantity of material, equipment, input, or personnel <i>g</i> transported the same distance using transport mode <i>m</i> during reporting period <i>t</i> . Where the same type of good is transported different distances to arrive at the project or baseline site, they must be treated as separate goods for the purposes of this calculation. Expressed in t or other relevant unit.	N/A
CF <sub>m</sub>	The conversion factor to be used if the units of the various parameters do not match for a particular transport mode <i>m</i> . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A
<i>m</i>	transportation mode	N/A
<i>g</i>	Transport distance for material, equipment, input, or personnel	N/A

### Determining the emission factor

Transportation emission factors tend to be uncertain, given the range of factors that can influence overall emissions. Emission factors appropriate for the transport modes in question must be selected from the following reference sources in order of preference (where an appropriate factor is not available from a preferred reference source, the next source on the list may be consulted):

- v. The corresponding provincial reporting regulation.
- vi. Latest version of the provincial GHG Inventory Report
- vii. Latest version of Canada's National GHG Inventory Report
- viii. Other recognized, justified reference sources, as federal (Canada) or provincial government institutions, the IPCC or the UNFCCC. With a preference for the corresponding provincial data over national or international level data.

In the case of projects within BC, the following considerations apply:

Truck freight transport emissions: emissions per tonne-km transported taken from the most recent version of the BC Freight Modal Shifting GHG Protocol<sup>62</sup>. In the March 11, 2010 version this information is presented in Section 4.1.1 under the heading B9 Truck Operation. The emission factor provided is 114 g CO<sub>2</sub>e / tonne-km at time of methodology development.

Note: an alternate truck transport emission factor may be used if justified by the proponent.

Rail freight transport emissions: emissions per revenue tonne-km (RTK) transported taken from the most recent version of the Locomotive Emissions Monitoring Program annual report for the most recent data year available<sup>63</sup>. In the 2008 report, this information is presented in Table 9 under the heading "Emissions Intensity – Total Freight (kg / 1,000 RTK)". The emission factors provided are: 15.98 kg CO<sub>2</sub> / 1,000 RTK; 0.02 kg CH<sub>4</sub> / 1,000 RTK; and 2.05 kg N<sub>2</sub>O / 1,000 RTK.

### **Determining the activity level and other parameters**

The quantity of material, equipment, input, or personnel must be monitored for the project.

Since it is not possible to directly monitor transportation in the baseline, baseline transportation quantities as assumptions must be estimated based on the activities described for the selected baseline scenario and project assumptions where applicable.

Transport distance by good and by mode must be conservatively determined and justified based on typical distances and types of transport modes used.

<sup>62</sup> Most recent version available at time of protocol development: The Delphi Group, Freight Modal Shifting GHG Protocol - British Columbia-Specific Version, March 11, 2010, available at <http://www.pacificcarbontrust.com/LinkClick.aspx?fileticket=SyA1NMa6DZw%3d&tabid=81&mid=577>

<sup>63</sup> Most recent version available at time of protocol development: Railway Association of Canada, Locomotive Emissions Monitoring Program 2008, available at [http://www.railcan.ca/documents/publications/2073/2010\\_06\\_03\\_LEM2008\\_en.pdf](http://www.railcan.ca/documents/publications/2073/2010_06_03_LEM2008_en.pdf)

8.1.2.5 PE4/BE4 Emissions from fossil fuel combustion – Vehicles and Equipment

This quantification method is to be applied to both the project and baseline.

Emissions from fossil fuel combustion in on-site vehicles and equipment are to be calculated using the standard emission factor multiplied by the activity level approach described by Equation 6 and restated here:

Equation 15

$$TE_{PE4/BE4,t} = \sum_j (GHG_{j,PE4/BE4,t} \times GWP_j) \quad [15]$$

Where:

Parameter	Description	Default Value
$TE_{PE4/BE4,t}$	Total emissions from fossil fuel combustion in on site vehicles and equipment, during reporting period $t$ . Expressed in $tCO_2e$	
$GHG_{j,PE4/BE4,t}$	Emissions of GHG $j$ , from fossil fuel combustion in on site vehicles and equipment, during reporting period $t$ . Expressed in $t$ GHG $j$ . (see Equation 16)	N/A
$GWP_j$	Global warming potential of GHG $j$ . Dimensionless.	N/A
$j$	The relevant GHGs in this methodology: $CO_2$ , $CH_4$ and $N_2O$	N/A
$t$	The reporting period in question, where the value of $t$ indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 16

$$GHG_{j,PE4/BE4,t} = \sum_f [\sum_e (EF_{f,e,j} \times AL_{f,e,t} \times CF_{f,e})] \quad [16]$$

Where:

Parameter	Description	Default Value
GHG <sub>j, PE4/BE4, t</sub>	Emissions of GHG <i>j</i> , from on-site vehicles and equipment fossil fuel combustion during reporting period <i>t</i> . Expressed in t GHG <i>j</i> .	N/A
EF <sub>f, e, j</sub>	The emission factor for GHG <i>j</i> , fuel type <i>f</i> and equipment/vehicle type <i>e</i> (eg, tonnes CO <sub>2</sub> per L diesel]. Expressed in t/unit of fuel.	See below under the title “Determining the emission factor” the emission factor requirements
AL <sub>f, e, t</sub>	The quantity of fuel of type <i>f</i> combusted in equipment/vehicle type <i>e</i> during reporting period <i>t</i> . Expressed volumetric measure (eg, l, m <sup>3</sup> , etc.) or mass measure (kg, t, etc.) with appropriate conversion.	N/A
CF <sub>f,e</sub>	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular fuel type <i>f</i> and equipment/vehicle type <i>e</i> . Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A
<i>f</i>	Fuel type	N/A
<i>e</i>	Equipment/vehicle type	N/A

### Determining the emission factor

The following emission factors, approved by the Province of BC, and used in its GHG Emissions Estimator for emissions reporting, must be used for projects within the province of BC:

- Natural Gas – 0.0503 tCO<sub>2</sub>e/gigajoule
- Gasoline – 0.0023 tCO<sub>2</sub>e/litre
- Diesel – 0.0027 tCO<sub>2</sub>e/litre
- Fuel Oil – 0.0027 tCO<sub>2</sub>e/litre
- Propane – 0.0015 tCO<sub>2</sub>e/litre

For project in the province of Quebec, EF published by “*Transition Énergétique Québec (TEQ)*” may be used , as follows:

- Natural Gas – 0.0565 tCO<sub>2</sub>e/gigajoule
- Gasoline – 0.0023 tCO<sub>2</sub>e/litre
- Diesel – 0.0028 tCO<sub>2</sub>e/litre
- Propane – 0.0015 tCO<sub>2</sub>e/litre

For projects in other provinces of Canada, EF published by the provincial government relevant authorities may be used.

### **Determining the activity level**

For fuel combustion in equipment and vehicles, the most accurate approach is to use fuel consumption records by type of equipment or vehicle and fuel type.

Where fuel is not tracked by type of equipment or vehicle, but rather only in total for the entire project site, a conservative emission factor must be chosen based on the range of vehicles and equipment that would consume a particular fuel.

Since it is not possible to directly monitor fuel consumption in the baseline, baseline fuel consumption must be estimated based on justified vehicle and equipment usage estimates in the baseline and considering fuel consumption observed during the project period as applicable.

#### **8.1.2.6 PE5/BE5 Emission from fertilizer application**

This quantification method is to be applied to both the project and baseline.

Emissions of N<sub>2</sub>O resulting from fertilizer application cannot be addressed using the standard emission factor multiplied by activity level approach described by equation 6. Instead, the Good Practice Guidance (GPG) of the IPCC was consulted to identify a suitable approach. Chapter 11 of the IPCC 2006 Guidelines for National GHG Inventories and the CDM A/R Methodological Tool “Estimation of direct nitrous oxide emission from nitrogen fertilization” were selected as the primary sources of good practice guidance as they were applicable to the relevant sections of this methodology.

For the development of this methodology, the methodology described in the IPCC and CDM documents were adopted with some small changes to simplify calculations (eg, making the notation consistent between direct and indirect emissions) and introduced the time-dependent parameter *t* to allocate emissions on an annual basis. This last change was necessary since the IPCC Guidelines are designed to calculate annual inventories instead of considering the lifetime of a project activity.

### N<sub>2</sub>O Emissions from Fertilizer Use

The emissions of N<sub>2</sub>O that result from anthropogenic N inputs occur through both a direct pathway (directly from the soil to which N is added) and through two indirect pathways: (i) volatilization and redeposition of nitrogen compounds, and (ii) leaching and runoff of nitrogen compounds, mainly as nitrate (NO<sub>3</sub>). For simplicity, both direct and indirect emissions are quantified for this SSR even though it is listed as a controlled emission source.

The methodology described in this section addresses the following sources of GHG emissions from fertilizer application:

- Synthetic nitrogen fertilizer
- Organic nitrogen applied as fertilizer (eg, manure, compost, and other organic soil additives)

Total N<sub>2</sub>O emissions related to fertilizer use is determined using the following equation:

Equation 17

$$TE_{PE5/BE5,t} = N_2O_{direct,t} + N_2O_{indirect,t} \quad [17]$$

Where:

Parameter	Description	Default Value
TE <sub>PE5/BE5,t</sub>	Total emissions of N <sub>2</sub> O from fertilizer application within the project boundary. Expressed in t N <sub>2</sub> O.	N/A
N <sub>2</sub> O <sub>direct,t</sub>	Direct emissions of N <sub>2</sub> O from fertilizer application within the project boundary. Calculated in Equation 15. Expressed in t N <sub>2</sub> . (See Equation 18).	N/A
N <sub>2</sub> O <sub>indirect,t</sub>	Indirect emissions of N <sub>2</sub> O from fertilizer application within the project boundary. Calculated in Equation 21. Expressed in t N <sub>2</sub> O	N/A

Approaches for determining direct and indirect emissions are described below.

#### 1. Direct N<sub>2</sub>O Emissions

The direct nitrous oxide emissions from nitrogen fertilization can be estimated using the following equations:

Direct fertilizer use emissions

Equation 18

$$N_2O_{\text{direct},t} = (F_{\text{SN},t} + F_{\text{ON},t}) \times EF_1 \times \frac{MW_{N_2O}}{MW_N} \quad [18]$$

Fraction of Nitrogen that volatilizes as NH<sub>3</sub> and NO<sub>x</sub> for synthetic fertilizers

Equation 19

$$F_{\text{SN},t} = \sum_i^I M_{\text{SF}i,t} \times NC_{\text{SF}i} \quad [19]$$

Fraction of Nitrogen that volatilizes as NH<sub>3</sub> and NO<sub>x</sub> for organic fertilizers

Equation 20

$$F_{\text{ON},t} = \sum_j^J M_{\text{OF}j,t} \times NC_{\text{OF}j} \quad [20]$$

Where:

Parameter	Description	Default Value
$N_2O_{\text{direct},t}$	Direct emissions of N <sub>2</sub> O as a result of fertilizer application within the project boundary. Expressed in t N <sub>2</sub> O.	N/A
$F_{\text{SN},t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year <i>t</i> . Expressed in t N (See Equation 19).	N/A
$F_{\text{ON},t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year <i>t</i> . Expressed in t N (See Equation 20).	N/A
$M_{\text{SF}i,t}$	Mass of synthetic fertilizer of type <i>i</i> applied in year <i>t</i> , tonnes. Expressed in t.	N/A
$M_{\text{OF}j,t}$	Mass of organic fertilizer of type <i>j</i> applied in year <i>t</i> , tonnes. Expressed in t.	N/A
$EF_1$	Emission Factor for N additions from fertilizers. Expressed in t N <sub>2</sub> O-N / t N input.	0.01
$MW_{N_2O}$	Molecular weight of N <sub>2</sub> O. Expressed in g/mole (see Equation 18).	44
$MW_N$	Molecular weight of N <sub>2</sub> . Expressed in g/mole.	28
$NC_{\text{SF}i}$	Nitrogen content (mass fraction) of synthetic fertilizer type <i>i</i> applied, as specified by the manufacturer/supplier, or determined by laboratory analysis. Expressed in %.	N/A



NC <sub>OFj</sub>	Nitrogen content (mass fraction) of organic fertilizer type j applied, as specified by the manufacturer/supplier, or determined by laboratory analysis. Expressed in %.	N/A
l	Number of synthetic fertilizer types.	N/A
j	Number of organic fertilizer types.	N/A

IPCC 2006 guidelines establish that the default emission factor for Nitrogen addition from fertilizers (EF<sub>1</sub>) is 0.01 (1.0%) of applied N<sup>64</sup>. The default value for the fraction of synthetic fertilizer volatilized is 0.1 (Frac<sub>GASF</sub>)<sup>65</sup> and the default value for the fraction of organic fertilizer volatilized is 0.2 (Frac<sub>GASM</sub>)<sup>66</sup>. These default values are to be used for quantifications in this methodology, unless provincial / project-specific factors can be identified and justified.

Project proponents must identify the nitrogen content for each synthetic and organic fertilizer applied, as reported by the fertilizer manufacturer or determined by laboratory analysis.

## 2. Indirect N<sub>2</sub>O emissions

Indirect nitrous oxide emissions from nitrogen fertilization can be estimated using the following equations:

Indirect fertilizer use emissions

Equation 21

$$N_2O_{\text{indirect},t} = (N_2O_{(\text{ATD}),t} + N_2O_{(\text{L}),t}) \times \frac{MW_{N_2O}}{MW_N} \quad [21]$$

Amount of N<sub>2</sub>O-N produced from atmospheric deposition of N volatilized

Equation 22

$$N_2O_{(\text{ATD}),t} = [F_{\text{SN},t} \times (\text{Frac}_{\text{GASF}}) + F_{\text{ON},t} \times (\text{Frac}_{\text{GASM}})] \times EF_4 \quad [22]$$

Amount of N<sub>2</sub>O-N produced from leachate and runoff of N

<sup>64</sup> Table 11.1, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

<sup>65</sup> Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

<sup>66</sup> Derived from Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

Equation 23

$$N_2O_{(L),t} = ([F_{SN,t} + F_{ON,t}] \times \text{Frac}_{\text{LEACH-(H)}}) \times EF_5 \quad [23]$$

Where:

Parameter	Description	Default Value
$N_2O_{\text{indirect},t}$	Indirect emissions of $N_2O$ as a result of fertilizer application within the project boundary. Expressed in t $N_2O$ .	N/A
$N_2O_{(ATD),t}$	Amount of $N_2O$ -N produced from atmospheric deposition of N volatilized, in year $t$ . Expressed in t $N_2O$ -N (See Equation 22).	N/A
$N_2O_{(L),t}$	Amount of $N_2O$ -N produced from leachate and runoff of N, in year $t$ . Expressed in t $N_2O$ -N (see Equation 23).	N/A
$MW_{N_2O}$	Molecular weight of $N_2O$ . Expressed in g/mole.	44
$MW_N$	Molecular weight of $N_2$ . Expressed in g/mole.	28
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied in year $t$ . Unit of measure: tN.	N/A
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied in year $t$ . Unit of measure: tN.	N/A
$EF_4$	Emission Factor for $N_2O$ emissions from atmospheric deposition of N on soils and water surfaces. Expressed in t $N_2O$ -N / (t $NH_3$ -N + t $NO_x$ -N volatilised).	0.01
$\text{Frac}_{\text{GASF}}$	Fraction of Nitrogen that volatilizes as $NH_3$ and $NO_x$ for synthetic fertilizers. Expressed in (t $NH_3$ -N + t $NO_x$ -N volatilised)/t N applied	0.1
$\text{Frac}_{\text{GASM}}$	Fraction of Nitrogen that volatilizes as $NH_3$ and $NO_x$ for organic fertilizers. Expressed in (t $NH_3$ -N + t $NO_x$ -N volatilised)/t N applied	0.2
$\text{Frac}_{\text{LEACH-(H)}}$	Fraction of N lost by leaching and runoff. Expressed in t N/t N added or deposited by grazing animals.	0.30 / 0 (see note)
$EF_5$	Emission factor for $N_2O$ -N emissions from N leaching and runoff. Expressed in t $N_2O$ -N / t N in leaching or runoff.	0.0075
I	Number of synthetic fertilizer types.	N/A
J	Number of organic fertilizer types.	N/A

IPCC 2006 guidelines establish that the default emission factor for N<sub>2</sub>O emissions from atmospheric deposition of nitrogen (EF<sub>4</sub>) is 0.010 (of applied N)<sup>67</sup>. The default value for the emission factor for N<sub>2</sub>O emissions from leaching and runoff (EF<sub>5</sub>) is 0.0075.

The default value for the fraction of synthetic fertilizer volatilized is 0.1 (Frac<sub>GASF</sub>)<sup>68</sup> and the default value for the fraction of organic fertilizer volatilized is 0.2 (Frac<sub>GASM</sub>)<sup>69</sup>.

The fraction of nitrogen lost by leaching and runoff (Frac<sub>LEACH-H</sub>) applies only in those cases where soil water-holding capacity is exceeded as a result of precipitation or irrigation (ie, precipitation is greater than evapotranspiration). Where this condition exists, the default value for Frac<sub>LEACH-H</sub> = 0.30<sup>70</sup>. Where evapotranspiration is greater than precipitation, the value for this parameter is zero. The choice of factor used in the calculations must be justified by the proponent.

Project proponents must identify the nitrogen content for each synthetic and organic fertilizer applied, as reported by the fertilizer manufacturer or determined by laboratory analysis.

Table 12: Assessment of Uncertainty for Direct and Indirect N<sub>2</sub>O Emissions

Factor	Default Value	Uncertainty Range
EF <sub>1</sub> , Emission Factor for N additions from fertilizers, tonne N <sub>2</sub> O-N / tonne N input.	0.010	0.003 – 0.03
EF <sub>4</sub> , Emission Factor for N <sub>2</sub> O emissions from atmospheric deposition of N on soils and water surfaces, tonne N <sub>2</sub> O-N / tonne N input.	0.010	0.002 – 0.05
EF <sub>5</sub> , Emission factor for N <sub>2</sub> O emissions from N leaching and runoff, tonne N <sub>2</sub> O / tonne N input.	0.0075	0.0005 – 0.025
Frac <sub>GASF</sub> , Fraction of Nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> for synthetic fertilizers.	0.10	0.03 – 0.3
Frac <sub>GASM</sub> , Fraction of Nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> for organic fertilizers.	0.20	0.05 – 0.5
Frac <sub>LEACH-(H)</sub> , Fraction of N lost by leaching and runoff.	0.3	0.1 – 0.8

<sup>67</sup> Derived from table 12, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

<sup>68</sup> Derived from Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

<sup>69</sup> Derived from Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

<sup>70</sup> Derived from Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

Uncertainties in estimates of direct and indirect N<sub>2</sub>O emissions from fertilizer are mainly due to uncertainties in emission factors. These factors are constantly being reassessed, and are related to conditions such as temperature, partitioning factors, activity data, and lack of information on specific practices and site characteristics. In general, the reliability of activity data (eg, mass of fertilizer applied) will be greater than that of emission, volatilization and leaching factors. The IPCC suggests utilizing region-specific data whenever possible, but these are not widely available. Additional uncertainties are introduced when values used are not representative of the conditions, but uncertainties in emission factors are likely to dominate.

**8.1.2.7 PE6/BE6 Emissions from biomass burning**

This quantification method must be applied to both the project and baseline.

Note that for this SSP, only CH<sub>4</sub> and N<sub>2</sub>O are to be reported as CO<sub>2</sub> is being monitored as part of the forest carbon pools.

Emissions from controlled burning of biomass on-site, including burning of wood residuals and controlled burning for land clearing, etc., must be calculated using the standard emission factor multiplied by the activity level approach described by Equation 6 and restated here:

Total emission from biomass burning

Equation 24

$$TE_{PE6/BE6,t} = \sum_j (GHG_{j,PE6/BE6,t} \times GWP_j) \quad [24]$$

Where:

Parameter	Description	Default Value
TE <sub>PE6/BE6,t</sub>	Total emissions from biomass burning, during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e	
GHG <sub>j,PE6/BE6,t</sub>	Emissions of GHG <i>j</i> , from biomass burning, during reporting period <i>t</i> . Expressed in t GHG <i>j</i> (See Equation 25).	N/A
GWP <sub>j</sub>	Global warming potential of GHG <i>j</i> . Dimensionless.	N/A
<i>j</i>	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
<i>t</i>	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 25

$$GHG_{j,PE6/BE6,t} = \sum_b EF_{b,j} \times AL_{b,t} \times CF_b \quad [25]$$

Where:

Parameter	Description	Default Value
GHG <sub>j, PE6/BE6, t</sub>	Emissions of GHG <i>j</i> , from biomass burning onsite during reporting period <i>t</i> .. Expressed in t.	N/A
EF <sub>b, j</sub>	Emission factor for GHG <i>j</i> and biomass type <i>b</i> (eg, tonnes CH <sub>4</sub> per tonne of brush burned). Expressed in t / t of biomass.	See below under the title “Determining the emission factor” the emission factor requirements
AL <sub>b, t</sub>	Amount of biomass of type <i>b</i> combusted during reporting period <i>t</i> . Expressed in t of biomass.	N/A
CF <sub>b</sub>	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular biomass type <i>b</i> . Note, special care must be taken to ensure that if the emission factor and activity level do not assume the same moisture content of biomass (often dry mass is assumed for emission factors), an appropriate conversion factor is used based on measured or conservatively assumed biomass moisture content. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: t.	N/A

### Determining the emission factor

Biomass combustion emission factors may be obtained from:

1. The corresponding provincial reporting regulation
2. The latest version of the provincial GHG Inventory Report
3. The latest version of Canada’s National GHG Inventory Report
4. Other recognized, justified reference sources, such as federal (Canadian) or provincial government institutions, the IPCC or the UNFCCC, with a preference for the corresponding provincial data over national or international level data

Emission factors must be used so long as the emission factor selected is appropriate for the type of biomass and conditions under which it is being combusted. Otherwise, emission factors found in peer reviewed sources relevant to the project site conditions may be used. Where site specific data is not available, values from the IPCC GPG LULUCF (Table 3A.1.16) may be used. Where figures from Table 3A.1.16 are used, they must be divided by 1000, to adjust the results from units of g/kg to units of t/t.

**Determining the activity level**

Project proponents must propose and justify an approach for determining the total mass of biomass combusted during controlled burning events during a reporting period. The guidance given in Approach B in the *VCS Module VMD0031, Estimation of Emissions from Burning* may be used as a basis for developing a method. It is expected that such a method will be tailored to the standard operating practices of the proponent, though in all cases it must be possible to verifiably demonstrate that the method results in a conservative estimate of associated project emissions as compared to baseline emissions. Wherever possible, measured amounts of biomass may be used (eg, mass or volume of biomass combusted), though it is recognized that in many cases (eg, land clearing) such a measurement may not be possible, and estimates based on site observations will be necessary.

**8.1.2.8 PE7/BE7 Emissions from forest fires**

This quantification method is to be applied to both the project and baseline.

Note that for this SSR, only CH<sub>4</sub> and N<sub>2</sub>O are to be reported, as CO<sub>2</sub> is tracked as part of forest carbon pools.

Emissions from forest fires are to be calculated using the standard emission factor multiplied by the activity level approach described by Equation 6 and restated here:

Equation 26

$$TE_{PE7/BE7,t} = \sum_j (GHG_{j,PE7/BE7,t} \times GWP_j) \quad [26]$$

Where:

Parameter	Description	Default Value
TE <sub>PE7/BE7,t</sub>	Total emissions from forest fires, during reporting period <i>t</i> . Expressed in tCO <sub>2e</sub>	
GHG <sub>j,PE7/BE7,t</sub>	Emissions of GHG <i>j</i> , from forest fires, during reporting period <i>t</i> . Expressed in t GHG <i>j</i> (See Equation 27).	N/A
GWP <sub>j</sub>	Global warming potential of GHG <i>j</i> . Dimensionless.	N/A
J	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
T	The reporting period in question, where the value of <i>t</i> indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

Equation 27

$$GHG_{j,PE7/BE7,t} = EF_{ff,j} \times AL_{ff,t} \times CF \quad [27]$$

Where:

Parameter	Description	Default Value
GHG <sub>j, PE7/BE7, t</sub>	Emissions of GHG <i>j</i> , from forest fires during reporting period <i>t</i> . Expressed in t.	N/A
EF <sub>ff, j</sub>	The emission factor for GHG <i>j</i> applicable to forest fires. Expressed in t GHG <i>j</i> / t of forest biomass burned.	See below under the title “Determining the emission factor” the emission factor requirements
AL <sub>ff, t</sub>	The quantity of forest biomass combusted during forest fires occurring during reporting period, from both anticipated disturbance events that have been modelled in the project and baseline and unanticipated loss events that are monitored. Expressed in t.	N/A
CF	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular biomass type <i>b</i> . Note, special care must be taken to ensure that if the emission factor and activity level do not assume the same moisture content of biomass (often dry mass is assumed for emission factors), an appropriate conversion factor is used based on measured or conservatively assumed biomass moisture content. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Dimensionless.	N/A

**Determining the emission factor**

Guidance with respect to combustion emission factors for forest fires may be sought from

1. The provincial reporting regulation, corresponding to the province where the project is developed.
2. Latest version of the provincial GHG Inventory Report, corresponding to the province where the project is developed.
3. Latest version of Canada’s National GHG Inventory Report
4. Other recognized sources, including federal (Canada) or provincial government institutions (corresponding to the province where the project is developed), the IPCC or the UNFCCC, with a preference to provincial data over national or international level data.



In the absence of specific guidance, the emission factors from the IPCC GPG LULUCF Table 3A.1.16 may be used. Where figures from Table 3A.1.16 are used, they must be divided by 1000, to adjust the results from units of g/kg to units of t/t.

### **Determining the activity level**

The quantity of forest biomass combusted in forest fires will be calculated as part of assessing the impact of loss events, as described in Section 8.1.1.1.5. Proponents must utilize the guidance given for Approach B in VCS module VMD0031 *Estimation of Emissions from Burning* to make these estimations. The amount of biomass combusted during forest fires may be based on both significant loss events as well as more predictable fire disturbances that have been factored into the emissions modeling for project and baseline.

#### **8.1.2.9 PE8/BE8 Emissions from harvested wood transport**

This quantification method is to be applied to both the project and baseline.

An approach identical to that described for SSR PE3/BE3 is to be used to calculate emissions from SSR PE8/BE8, except that  $C_{m,g,t}$  will refer to the total quantity of harvested wood transported. Amounts and distances transported must be estimated for two stages in the HWP lifecycle:

- Transport of logs to the site of primary production.
- Transport of primary HWPs to the location of use.

It will be assumed that HWPs are disposed of very close to their point of use, and that associated emissions are very small compared to other sources.

### **Determining the emission factor**

Emission factors will be determined in an identical manner to that described for PE3BE3.

### **Determining the activity level and other parameters**

Quantity of harvested wood sent to primary production will be monitored by the project. Quantities of primary HWPs produced must be based on the assumptions used for calculating HWP storage in Section 8.1.1.2.

Distance to the location of primary production must be based on actual locations where project harvested wood is sent, or conservative estimates of distance. Distance from the site of primary production to end use must be estimated based on reasonable, conservative estimates of the locations of final markets.

Since it is not possible to directly monitor the quantity of harvested wood in the baseline, quantities must be estimated based on the activities described for the selected baseline scenario and any available, relevant information from the project period.

All other required parameters must be determined in an identical manner to that described for PE9/BE9.

**8.1.2.10 PE9/BE9 Emissions from harvested wood processing**

This quantification method is to be applied to both the project and baseline.

Emissions from primary processing of harvested wood are to be calculated using standardized emission factors<sup>71</sup> multiplied by the activity level approach described before.

Total emissions from harvested wood processing

Equation 28

$$TE_{PE9/BE9,t} = \sum_j (GHG_{j,PE9/BE9,t} \times GWP_j) \quad [28]$$

Where:

Parameter	Description	Default Value
$TE_{PE9/BE9,t}$	Total emissions from harvested wood processing, during reporting period $t$ . Expressed in tCO <sub>2</sub> e	
$GHG_{j,PE9/BE9,t}$	Emissions of GHG $j$ , from harvested wood processing, during reporting period $t$ . Expressed in t GHG $j$ .	N/A
$GWP_j$	Global warming potential of GHG $j$ . Dimensionless.	N/A
$j$	The relevant GHGs in this methodology: CO <sub>2</sub> , CH <sub>4</sub> and N <sub>2</sub> O	N/A
$t$	The reporting period in question, where the value of $t$ indicates the number of reporting periods that have occurred since the start of the project up to the reporting period in question.	N/A

<sup>71</sup> Refer to “Determining the emission factor” text below in this section

Equation 29

$$GHG_{j,PE9/BE9,t} = \sum_H EF_{H,j} \times AL_{H,t} \times CF_H \quad [29]$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE9/BE9, t}$	Emissions of GHG $j$ from harvested wood processing from wood harvested during reporting period $t$ . Expressed in tonnes of GHG $j$ .	N/A
$EF_{H,j}$	The emission factor for GHG $j$ and harvested wood product $H$ produced (eg, CO <sub>2</sub> per unit of harvested wood converted to wood product $H$ ). Note: for processes that rely solely on electricity, $EF_{H,j}$ is assumed to be zero for projects within BC due to BC's stated goal of net zero GHG emission electricity generation in this province and that the vast majority of BC harvested wood is processed in-province. Expressed in tGHG $j$ /unit of HWP $H$ .	N/A
$AL_{H, t}$	The quantity of harvested wood product $H$ produced from wood harvested during reporting period $t$ . Expressed in t, or other unit with appropriate conversion factor to $t$ .	N/A
$CF_H$	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a particular HWP $H$ . Care must be taken to ensure that the emission factor and the activity level both refer to the same quantity (either amount of HWP produced, or amount of harvested wood processed). If not, then an appropriate conversion factor must be selected. Where both the activity level and emission factor are expressed in the same units, $CF$ would be set to 1. Dimensionless.	N/A

**Determining the emission factor**

Where available, project proponents may use provincially or nationally-approved emission factors relevant for the harvested wood products produced from project and baseline harvested wood. Such factors may be tailored to the province specific circumstances accordingly if possible, including appropriate reflection of the carbon intensity of grid electricity generation in the respective province (which may be assumed to be zero in the case of projects within BC for processes that rely solely on electricity).

If such factors are not available, project proponents must develop factors based on information on energy consumption from production facilities to which project and baseline harvested wood is shipped. Such an approach will need to consider amounts of energy / fuel of different types consumed in producing a given quantity of a particular HWP, and appropriate fuel combustion

emission factors. Such fuel combustion emission factors must be sourced in a manner identical to that described for SSR PE3/BE3 Emissions from fossil fuel combustion – Vehicles and Equipment.

### **Determining the activity level**

Project proponents must use the same monitored log production data used to determine the production of HWP in Section 8.1.1.2.

Since it is not possible to directly monitor the quantity of harvested wood in the baseline, quantities must be estimated based on the activities described for the selected baseline scenario.

#### **8.1.2.11 PE10/BE10 Emissions from harvested wood products and residuals anaerobic decay**

As described in Figure 2, the degradable portion of HWPs in landfill will decay over time to produce CO<sub>2</sub> and CH<sub>4</sub>. This method focuses on determining the total amount of emissions that would result from HWPs decaying in landfills over the post-harvest period that HWP storage is assessed in this methodology. Depending on if the default or optional advanced approach to HWP quantification is taken in Section 8.1.1.2, calculations will either be for a default blend of mill types and uses (default approach), or for a blend of mill types and uses determined and demonstrated by the user (optional advanced approach). Use of this optional advanced approach requires the availability of good historical data on wood delivery by mill type (for North American use) or wood product end use (for offshore use) for wood sourced from within the project area, as well as validatable projections of future wood product processing and end use. This data is more likely to be available for North American markets than for offshore markets, and it is permissible to use this approach for wood used in North America only, while using the default approach for wood used offshore.

Since carbon lost as CO<sub>2</sub> is accounted for as part of SSRs PP8/BP8 and PP9/BP9, PE10/BE10 focuses only on CH<sub>4</sub>.

### **Default Approach**

Using these two sources, quantification of the harvested wood product pool using the default approach is calculated using the following steps:

1. Calculate or estimate volume of roundwood delivered to the mill (or exported), from the project area, by species, year and wood product destination (NA or offshore). Harvest flow for both project and baseline must be developed in accordance with the requirements stipulated in Section 8.1.1.1.3. Volumes must be for wood only (not including bark).
2. For each year, and location of use, convert volumes to tonnes of dry biomass, using Equation 2, and the standard wood density figures given in Table 8A for projects within the province of BC and Table 8B for projects within the province of QC. In the case of

projects within other provinces, the project developer must develop a corresponding table to be validated during the validation process.

3. Tonnes of dry biomass in delivered roundwood per year, by wood product destination will be calculated with the Equation 2.

Calculate the total CH<sub>4</sub> emissions (accounted as tonnes CO<sub>2</sub>e), from wood products in landfills using Equation 30.

Total CH<sub>4</sub> emissions (in tonnes CO<sub>2</sub>e) from landfilled HWPs derived from the project area up to time t

Equation 30

$$GHG_{CH_4 PE10/BE10,t} = \sum_{y \leq t} RWbiomass_{y,NA} * HWPCH4f_{NA,t-y} + RWbiomass_{y,O} * HWPCH4f_{O,t-y} \quad [30]$$

Where:

Parameter	Description	Default Value
GHG <sub>CH<sub>4</sub>PE10/BE10,t</sub>	Mass of CH <sub>4</sub> emitted by the project or baseline HWPs in landfills up to year t. Expressed in tCO <sub>2</sub> e.	N/A
RWbiomass <sub>y,NA</sub>	The dry mass of the delivered roundwood extracted from the project area in year y, used in wood products within North America. Expressed in t.	N/A
RWbiomass <sub>y,O</sub>	The dry mass of the delivered roundwood extracted from the project area in year y, used in wood products offshore. Expressed in t.	N/A
HWPCH4f <sub>NA,t-y</sub>	The factor, derived from table 14, for the amount of CH <sub>4</sub> (accounted as CO <sub>2</sub> e) emitted in a given year, equal to the number of years between harvest and time t, for products used in North America. Expressed in tCO <sub>2</sub> e / t wood biomass delivered.	Table 14
HWPCH4f <sub>O,t-y</sub>	The factor, derived from table 14, for the amount of CH <sub>4</sub> (accounted as CO <sub>2</sub> e) emitted in a given year, equal to the number of years between harvest and time t, for products used outside of North America. Expressed in tCO <sub>2</sub> e / t wood biomass delivered	Table 14

Table 14: CH<sub>4</sub> emissions by year, in CO<sub>2</sub>e, as a percentage of the total wood biomass delivered, by use area – Derivation detailed in Appendix F<sup>72</sup>

	BC		QC	
	North America	Offshore	North America	Offshore
0	0.001%	0.001%	0.001%	0.001%
1	0.020%	0.000%	0.015%	0.000%
2	0.067%	0.100%	0.080%	0.100%
3	0.108%	0.096%	0.136%	0.096%
4	0.141%	0.092%	0.182%	0.092%
5	0.169%	0.118%	0.221%	0.118%
6	0.193%	0.140%	0.254%	0.140%
7	0.212%	0.159%	0.281%	0.159%
8	0.228%	0.175%	0.302%	0.175%
9	0.242%	0.189%	0.320%	0.189%
10	0.252%	0.200%	0.334%	0.200%
11	0.261%	0.210%	0.345%	0.210%
12	0.268%	0.218%	0.354%	0.218%
13	0.273%	0.225%	0.361%	0.225%
14	0.277%	0.230%	0.364%	0.230%
15	0.279%	0.234%	0.367%	0.234%
16	0.281%	0.237%	0.369%	0.237%
17	0.282%	0.239%	0.369%	0.239%
18	0.282%	0.240%	0.368%	0.240%
19	0.282%	0.240%	0.366%	0.240%
20	0.281%	0.240%	0.364%	0.240%
25	0.272%	0.232%	0.346%	0.232%
30	0.258%	0.216%	0.321%	0.216%

<sup>72</sup> Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998, and K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)

35	0.244%	0.198%	0.296%	0.198%
40	0.230%	0.179%	0.272%	0.179%
45	0.217%	0.161%	0.250%	0.161%
50	0.205%	0.145%	0.230%	0.145%
55	0.195%	0.130%	0.212%	0.130%
60	0.185%	0.116%	0.197%	0.116%
65	0.177%	0.105%	0.183%	0.105%
70	0.169%	0.094%	0.171%	0.094%
75	0.163%	0.085%	0.160%	0.085%
80	0.156%	0.076%	0.150%	0.076%
85	0.151%	0.069%	0.141%	0.069%
90	0.146%	0.062%	0.134%	0.062%
95	0.141%	0.057%	0.127%	0.057%
100	0.137%	0.051%	0.121%	0.051%

Proponents must be aware that the data contained in Table 14 are subject to periodic re-assessment, as provided in the most recent version of the VCS document Methodology Approval Process (Section 10.3.1 in version V4.0). Proponents must ensure that they include in their project calculations any changes, which may have been made to these values as a result of this re-assessment.

**Advanced approach**

If the advanced approach is used for North American or offshore products, or both, the same steps will be used as for the default approach, except that at each step either the deliveries of roundwood by mill type (for North American use) or product types (for offshore use) will be accounted separately. The types to be used are shown in Table 15.

**Table 15:** Mill/Product categories for North America and offshore

North America
Lumber mills
Plywood mills
Panel mills (all non-ply panel products)
Pulp and paper

Offshore
Lumber
Panel (including plywood)
Other industrial roundwood
Paper and paperboard

In step 3, the mill type or use categories are calculated separately, using the values given in Table 16.



**Table 16:** CH<sub>4</sub> emissions by year, in CO<sub>2</sub>e, as a percentage of the total wood biomass delivered, by mill or product type and use area – Derivation detailed in Appendix F. <sup>73</sup>

Year	North America - by primary processing facility				Offshore - by end product			Paper/ paperboard
	Lumber mills	Plywood mills	Panel mills	Chip/block mills	Sawnwood	Wood panels	Other industrial roundwood	
0	0.001%	0.000%	0.000%	0.001%	0.001%	0.001%	0.001%	0.001%
1	0.021%	0.018%	0.022%	0.003%	0.001%	0.001%	0.000%	0.000%
2	0.068%	0.050%	0.028%	0.113%	0.038%	0.019%	0.057%	0.315%
3	0.107%	0.078%	0.033%	0.206%	0.037%	0.019%	0.056%	0.301%
4	0.140%	0.101%	0.038%	0.285%	0.037%	0.018%	0.055%	0.287%
5	0.168%	0.121%	0.043%	0.350%	0.041%	0.030%	0.073%	0.367%
6	0.191%	0.138%	0.048%	0.404%	0.046%	0.041%	0.089%	0.435%
7	0.210%	0.152%	0.053%	0.448%	0.050%	0.051%	0.104%	0.492%
8	0.225%	0.164%	0.057%	0.484%	0.054%	0.060%	0.117%	0.539%
9	0.238%	0.174%	0.061%	0.513%	0.058%	0.069%	0.128%	0.577%
10	0.249%	0.183%	0.065%	0.535%	0.062%	0.077%	0.138%	0.608%
11	0.257%	0.190%	0.069%	0.553%	0.066%	0.085%	0.147%	0.631%
12	0.264%	0.196%	0.073%	0.566%	0.069%	0.092%	0.155%	0.649%
13	0.269%	0.201%	0.077%	0.575%	0.072%	0.098%	0.162%	0.661%
14	0.272%	0.205%	0.081%	0.580%	0.075%	0.104%	0.168%	0.669%
15	0.275%	0.208%	0.085%	0.583%	0.078%	0.110%	0.173%	0.673%
16	0.277%	0.211%	0.088%	0.583%	0.081%	0.115%	0.177%	0.673%
17	0.277%	0.213%	0.092%	0.582%	0.083%	0.119%	0.181%	0.670%
18	0.278%	0.214%	0.095%	0.578%	0.086%	0.124%	0.183%	0.665%
19	0.277%	0.215%	0.098%	0.573%	0.088%	0.127%	0.186%	0.657%
20	0.277%	0.216%	0.101%	0.567%	0.090%	0.131%	0.187%	0.648%
25	0.268%	0.216%	0.116%	0.525%	0.099%	0.144%	0.189%	0.582%
30	0.254%	0.212%	0.130%	0.474%	0.104%	0.150%	0.184%	0.503%
35	0.240%	0.208%	0.141%	0.422%	0.108%	0.151%	0.174%	0.422%
40	0.227%	0.203%	0.151%	0.374%	0.110%	0.149%	0.162%	0.349%

<sup>73</sup> Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998, and K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)

45	0.214%	0.198%	0.160%	0.329%	0.110%	0.144%	0.148%	0.285%
50	0.203%	0.194%	0.168%	0.289%	0.109%	0.138%	0.135%	0.230%
55	0.192%	0.190%	0.174%	0.254%	0.106%	0.131%	0.122%	0.185%
60	0.183%	0.186%	0.180%	0.223%	0.104%	0.122%	0.110%	0.148%
65	0.175%	0.183%	0.184%	0.196%	0.100%	0.114%	0.099%	0.118%
70	0.168%	0.180%	0.188%	0.172%	0.096%	0.106%	0.088%	0.094%
75	0.161%	0.177%	0.191%	0.151%	0.092%	0.097%	0.079%	0.074%
80	0.155%	0.174%	0.193%	0.132%	0.088%	0.089%	0.070%	0.059%
85	0.149%	0.172%	0.195%	0.116%	0.084%	0.082%	0.063%	0.046%
90	0.144%	0.170%	0.196%	0.102%	0.079%	0.074%	0.056%	0.037%
95	0.140%	0.167%	0.197%	0.089%	0.075%	0.067%	0.050%	0.029%
100	0.136%	0.165%	0.197%	0.078%	0.070%	0.061%	0.044%	0.023%

Proponents must be aware that the data contained in Table 16 is subject to periodic re-assessment, as provided in the most recent version of the VCS document Methodology Approval Process (Section 10.3.1 in version V4.0). Proponents must ensure that they include in their project calculations any changes which may have been made to this data as a result of this re-assessment.

## 8.2 Baseline Emissions

Total baseline emissions by sources and removals by pools are calculated using equations Equation 31, Equation 32, and Equation 33 .

Total baseline emissions are calculated using the following equation:

Equation 31

$$TBE_t = \Delta TR_{BP,t} + \Delta TE_{BS,t} \quad [31]$$

Where:

Parameter	Description	Default value
TBE <sub>t</sub>	The total baseline emissions reductions and removal enhancements, considering all pools and sources during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	N/A

$\Delta TR_{BP,t}$	The net incremental GHG removals by baseline pools achieved by the baseline during reporting period t. A net increase in total removals is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A
$\Delta TE_{BS,t}$	The net incremental GHG emission reductions by baseline sources of emissions achieved by the baseline during reporting period t. A net increase in total emission reductions is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A

Net incremental baseline GHG removals

Equation 32

$$\Delta TR_{BP,t} = \sum_i (TR_{BPi,t} - TR_{BPi,t-1}) \quad [32]$$

Net incremental baseline emissions reductions

Equation 33

$$\Delta TE_{BS,t} = \sum_j (TE_{BSj,t} - TE_{BSj,t-1}) \quad [33]$$

Where:

Parameter	Description	Default Value
$\Delta TR_{BP,t}$	The net incremental GHG removals by baseline pools achieved by the baseline during reporting period t. A net increase in total removals is expressed as a negative number. Expressed in tonnes of CO <sub>2</sub> e	N/A
$\Delta TE_{BS,t}$	The net incremental GHG emission reductions by baseline sources of emissions achieved by the baseline during reporting period t. A net increase in total emission reductions is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A
$TR_{BPi,t}$	The total GHG removals by pool i, under the baseline scenario during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	
$TR_{BPi,t-1}$	The total GHG removals by pool i, under the baseline scenario during reporting period t-1. Expressed in tonnes of CO <sub>2</sub> e	
$TE_{BSj,t}$	The total GHG emissions by source j, under the baseline scenario during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	

TE <sub>BSj,t-1</sub>	The total GHG emissions by source j, under the baseline scenario during reporting period t-1. Expressed in tonnes of CO <sub>2</sub> e	
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### 8.3 Project Emissions

Total project emissions reductions and removals enhancements are calculated using equations 34, 35 and 36.

Equation 34

$$TPE_t = \Delta TR_{PP,t} + \Delta TE_{PS,t} \quad [34]$$

Where:

Parameter	Description	Default value
TPE <sub>t</sub>	The total project emissions reductions and removal enhancements, considering all pools and sources during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	N/A
ΔTR <sub>PP,t</sub>	The net incremental GHG removals by project pools achieved by the project during reporting period t. A net increase in total removals is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A
ΔTE <sub>PS,t</sub>	The net incremental GHG emission reductions by project sources of emissions achieved by the project during reporting period t. A net increase in total emission reductions is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A

Net incremental project GHG removals Equation 35

$$\Delta TR_{PP,t} = \sum_i (TR_{PPi,t} - TR_{PPi,t-1}) \quad [35]$$

Net incremental project emissions reductions Equation 36

$$\Delta TE_{PS,t} = \sum_j (TE_{PSj,t} - TE_{PSj,t-1}) \quad [36]$$

Where:

Parameter	Description	Default Value
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$\Delta TR_{PP,t}$	The net incremental GHG removals by project pools achieved by the project during reporting period t. A net increase in total removals is expressed as a negative number. Expressed in tonnes of CO <sub>2</sub> e	N/A
$\Delta TE_{PS,t}$	The net incremental GHG emission reductions by project sources of emissions achieved by the project during reporting period t. A net increase in total emission reductions is expressed as a positive number. Expressed in tonnes of CO <sub>2</sub> e	N/A
$TR_{PPI,t}$	The total GHG removals by pool i, under the project scenario during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	
$TR_{PPI,t-1}$	The total GHG removals by pool i, under the project scenario during reporting period t-1. Expressed in tonnes of CO <sub>2</sub> e	
$TE_{PSj,t}$	The total GHG emissions by source j, under the project scenario during reporting period t. Expressed in tonnes of CO <sub>2</sub> e	
$TE_{PSj,t-1}$	The total GHG emissions by source j, under the project scenario during reporting period t-1. Expressed in tonnes of CO <sub>2</sub> e	

## 8.4 Leakage

Leakage occurs when net increases in GHG emissions occur outside the project area, as a result of the project activity.

Where a risk of leakage exists, project proponents may undertake leakage mitigation measures to reduce leakage. If any significant increase in emissions occurs as a result of these measures, the resulting emissions must be accounted using the methods given in section 8.2 for the appropriate emission source.

### 8.4.1 Types of Leakage

There are two potentially relevant forms of leakage that must be assessed for forest projects:

- Activity shifting leakage.** Activity shifting leakage occurs when there is an increase in GHG emissions from areas outside the project area, which is caused by the project activity, and which occurs when the actual agent of deforestation and/or degradation moves to or undertakes activities in an area outside of the project area and continues their deforesting and/or degrading activities in that location. For instance, if a project involves purchasing an area of land from a developer to preserve the forest on it, the developer might use the money to purchase another forested area of land for development.
- Market leakage.** Market leakage occurs when there is an increase in GHG emissions from areas outside the project area, which occurs as a result of the project significantly

reducing the production of a commodity, causing a change in the supply and market demand equilibrium, which results in a shift of production elsewhere to make up for the lost supply.

Leakage emissions are calculated using Equation 37:

PE16 Leakage

Equation 37

$$LE_{PE16,t} = LE_{AS,t} + LE_{M,t} \quad [37]$$

Parameter	Description	Default Value
LE <sub>PE16, t</sub>	Leakage during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>AS,t</sub>	Leakage due to activity shifting during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>M,t</sub>	Market leakage during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A

Accounting of leakage may be omitted where project proponents can demonstrate and document that:

- No internal activity shifting leakage has occurred, as detailed in 8.4.1.1 Step 1 below, and;
- There is no risk of other activity shifting leakage, because it can be demonstrated that any agents whose activities are reduced or eliminated by the project do not have the ability to increase the amount of those activities taking place elsewhere, and;
- Calculation of market leakage using the methods given below shows that market leakage, (together with any other excluded emissions or pools) meets the definition for being *de minimis*.

#### 8.4.1.1 Activity Shifting Leakage

Activity Shifting Leakage is to be addressed by the proponent as follows:

1. **Demonstrate that there is no internal activity shifting leakage.** Project proponents must demonstrate that there is no leakage to areas that are outside the project area but within project proponents’s operations, such as areas where project proponents has ownership of, management of, or legally sanctioned rights to use forest land within the country. It must be demonstrated that the management plans and/or land-use designations of all other lands owned, managed or operated by project proponents (which must be identified by location) have not materially changed as a result of the

project activity (eg, harvest rates have not been increased or land has not been cleared that would otherwise have been set aside). Where project proponents is an entity with a conservation mission, it may be demonstrated that there have been no material changes to other lands managed or owned by project proponents by providing documented evidence that it is against the policy of the organization to change the land use of other owned and/or managed lands including evidence that such policy has historically been followed.<sup>74</sup>

- 2. Determine whether the specific leakage agent can be identified.** If the agent (person, organization or entity) whose activities have been curtailed within the project area can be identified, quantification of activity shifting leakage must be undertaken using the methods given in step 4, below. Where the agent cannot be identified, quantification must be undertaken using the methods given in step 5.

For instance, if the land within the project area was owned by a developer, and has been bought by a conservation organization, the developer would be identified as the potential leakage agent, as that developer might now undertake additional deforestation on another piece of land.

However, if the land was owned by a forest company, who intended to sell it to a developer, but a conservation organization stepped in and bought the land instead, the specific agent of deforestation would not be known, since it would be unclear which developer might have bought the land in the absence of the project occurring.

- 3. Assess the impacts of leakage mitigation measures.** If it can be verifiably shown that demand for the baseline activity is satisfied or removed in some way by or due to leakage mitigation measures undertaken by project proponents that do not involve deforestation outside of the project area, then activity shifting leakage can be assumed to be zero for the remainder of the project (it is possible that a proponent will not be able to demonstrate this initially but may be able to do so at some point during the project).

Examples of situations in which demand could potentially be shown to be satisfied or removed include, but are not necessarily limited to:

- Where a project proponent undertakes a development project on forest lands but increases the density of the development over what would have occurred in the baseline case such that land use demand (eg, residential or commercial ft<sup>2</sup> or other appropriate metric) can be satisfied with less deforestation than in the baseline.
- Where the nature of the baseline land use demand is particular to the specific project site (eg, due to site characteristics, etc.) and that there are no other suitable areas within an appropriately established leakage zone surrounding the

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<sup>74</sup> Requirements sourced from VCS AFOLU Requirements section 4.6.13

project area that would satisfy the land use demand, and thus the demand for land will remain unfilled, and will cause no leakage.

- Project proponents undertakes other activities that can be verifiably demonstrated to satisfy demand for the baseline land use without deforestation and that would not have occurred in the baseline, such as making available for development / use marginal non-forest lands that would not have been suitable for accommodating the baseline land use without the intervention of project proponents.

4. **Estimate emissions due to activity shifting leakage where the agent can be identified.** If the agent can be identified, activity shifting leakage must be quantified by monitoring the actual activities of the agent over a five year period, as compared with the planned activities of that agent prior to the commencement of the project. Quantification must be undertaken using the following steps:

- a. Document the plans of the agent

Prior to project commencement, the plans of the identified agent to undertake activities over the next five years must be documented. The documentation must identify what the agent plans to do, how and where they plan to do it, and when the activities are expected to take place. The plans must identify the specific pieces of land on which activities are forecast to take place, if this is possible, and must be specific enough to allow estimation of the GHG emissions which will occur as the plan is implemented.

- b. Determine if the plans of the agent have materially changed

Five years after project commencement, determine whether the plans of the identified agent have been carried out without substantial changes. If they have been carried out, no further quantification is required. If the actual activities of the agent have varied substantially from the planned activities, quantification must be undertaken using the methods given in step c below.

- c. Quantify the GHG emissions resulting from the changes.

Based on the actual activities undertaken by the agent, and using the methods given in Section 8 of this methodology to quantify specific pools and emissions, determine what the total emissions resulting from the activities of the agent have been. If these emissions are less than those forecast under the original plan for the agent's activities, no leakage has occurred. If the actual emissions are greater than the forecast emissions, the amount of leakage will be the difference between the actual emissions and the forecast emissions for the agent.



5. **Estimate emissions due to activity shifting leakage where the agent cannot be identified.** If the agent cannot be identified, and leakage mitigation measures have not satisfied the demand for the baseline activity, project proponents must undertake a land use analysis for the baseline land use activity in a leakage zone surrounding the project area, in order to assess the extent to which land use shifting to other forest lands would occur as a result of the project, using the following steps:

- a. Identify the leakage zone

The leakage zone is an area or areas in the region of, but outside of, the project area where activities could be undertaken which are similar to those undertaken within the project area under the baseline scenario. For example, if the baseline activity was conversion of private forest land to pasture, the leakage zone will consist of a specific area around the project area where significant amounts of private land with potential for conversion to pasture exist. The leakage zone must be defined based on an analysis of the surrounding area to determine where there are opportunities to undertake the baseline activity. Leakage zones may consist of one or more continuous areas, and may or may not directly adjoin the project area. Typically, leakage zones will be in the range of 2 to not more than 20 times the size of the project area, but could be smaller where opportunity to undertake baseline activities is rare. Leakage zones extending over a broad geographic area (eg, all of BC) will not be appropriate for assessing leakage, as it is unlikely that similar drivers and opportunities exist over that wide an area.

- b. Assess the agents and circumstances for activity shifting leakage within the leakage zone

Such an assessment must consider at minimum the following:

- Who would have undertaken the activity (the class of agents). For instance, if the activity being shifted is clearance of land for development, what class of developers would have undertaken the activity.
- What the class of agents would have done with the land. For instance, if the agents are developers, what type of development would have occurred?
- All local zoning bylaws and other restrictions on land development such as covenants, easements, and existing right of ways;
- Availability of forest land (private, municipal, Crown-owned, First Nations, Indian Reserves, or other) that might be suitable for the baseline land use, subject to the above assessment of zoning, plans and strategies, but with consideration of the potential for zoning changes to occur that

might permit additional forest lands to be eligible for deforestation and conversion to the baseline land use type.

c. Quantify activity shifting leakage

Based on the assessment of the agents and circumstances of activity shifting leakage within the leakage zone, activity shifting leakage must be quantified based upon the difference between historic and with-project rates of activity by the identified class of agents within the region. Project proponents must undertake the following quantification steps

- i. Identify and justify the leakage zone
- ii. Model the expected occurrence of the activity within the leakage zone over the next five years, not including the baseline activity in the project area. If the activity was development, for instance, the rate might be X ha per year. This modelling must be based on an assessment of factors such as:
  - Historic trends
  - Drivers of the activity (population change, economic factors, etc.)
  - Limits to the activity (zoning restrictions, etc.)

Project proponents must document and justify all of the assumptions used in developing this model.

- iii. Model the average GHG output per unit area from the activity within the leakage zone. For instance, if the activity is development, what is the average net GHG emission from the accounted pools for each hectare developed. Accounted pools will include the HWP pool where the activity results in the production of harvested wood products. Quantification of the carbon densities of pools on these lands must be undertaken using the appropriate models and methods discussed for the pools in section 8.
- iv. At the end of the five year period, assess the actual amount of the activity that has taken place within the leakage zone. For instance, quantify the total number of hectares developed. If the actual amount of the activity that has taken place is greater than that projected in step b, the amount of leakage area is the actual amount of the activity, less the modeled amount of the activity, to a maximum of the amount of activity that would have taken place within the project area. As an example:
  - The project area is 40 hectares, and under the baseline this would have been developed.

- Based on the modelling, 180 hectares were expected to be developed in the leakage zone over the five years after project commencement, not counting the project area.
  - After 5 years, 240 hectares have been developed. Thus the actual number of hectares developed is 60 hectares greater than expected. However, since the project area was only 40 hectares, the leakage area is 40 hectares.
- v. Multiply the leakage area by the average GHG output per unit area, calculated in step c, to determine the total activity shifting leakage. Note that the average output is used for the calculation, rather than the output from any specific area, since it is impossible to say which of the areas actually developed represents the leakage. Thus even a project in which the leakage area is equal in size to the project area may have GHG benefits. For instance, if the project saves 40 hectares of old growth forest, but most of the development in the area takes place on low quality agricultural land, shifting development from the old growth to the low quality agricultural land will have significant GHG benefits.

#### 8.4.1.2 Market Leakage

Market leakage may occur where a project involves changing the amount of harvesting that occurs in the project area relative to the baseline. In such a case managers of other forest lands may adjust their levels of harvest in response to increases in price or increased opportunity to sell forest products, which may partially or fully negate the project GHG benefits.

Market leakage must only be assessed in a given reporting period where project HWP production, in terms of amount of carbon or carbon dioxide stored, is less than baseline HWP production. Where baseline HWP production is zero (eg, typically in ARR projects), market leakage would be zero. Note that in REDD projects, the baseline may include harvesting until such time as the baseline lands have been fully developed and further deforestation ceases.

Note: for projects with the potential for both activity shifting and market leakage, market leakage is to be assessed based only on the amount of decreased project harvesting relative to the baseline that is not already compensated for by activity shifting leakage. For example, if half of the baseline deforestation avoided by a project at the project site is determined to shift to other areas outside of the project due to activity shifting leakage, market leakage would only be assessed on the portion of avoided deforestation (ie, avoided harvesting) that would not have directly shifted to other areas due to activity shifting leakage.

Market leakage can be calculated using one of three methods

- Method 1: Total difference in all carbon pools. This method assumes that all of the difference between the carbon content of the carbon pools within the project area under

the project scenario, as compared with the baseline scenario, is attributable to the project actions which are causing the market leakage. For instance, this method must be used if the only project activity is preservation of forests as a result of reductions in harvest. This method is typically easy to calculate, since the total difference in carbon contained in carbon pools within the project area between the baseline and project scenarios is calculated using the sampling and modeling methods given in section 8 above. However, it may significantly over-estimate leakage where multiple project actions are being taken to increase the total carbon in carbon pools within the project area.

- Method 2: Total difference in carbon content of carbon pools within the project area resulting from harvest. This method calculates market leakage based only on changes in carbon pools within the project area as a result of harvest. The method must be used where the project also undertakes other activities which increase the carbon content of carbon pools within the project area, in addition to reductions in harvest. For instance, if a project includes both harvest reduction and enhanced silviculture activities, market leakage would be calculated based only on the reduction in harvest. Note that in cases where the only project activity is reduction in harvest, Methods 1 and 2 will calculate the same amount of leakage.
- Method 3: Project proponents must use the most current market leakage discount factors provided in the latest version of the VCS Standard.

#### 8.4.1.2.1 Market leakage (Method 1)

Market leakage – Method 1

Equation 38

$$LE_{M,t} = \max \{0, (\Delta TR_{PP,t} - \Delta TR_{BP,t}) + \Delta GHG_{CO2,HWP,t} - LE_{AS,t}\} \times LEF_M \quad [38]$$

Where:

Parameter	Description	Default Value
LEM,t	Total increase in project emissions due to market leakage from all affected carbon pools and sources during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
ΔTR <sub>PP,t</sub> - ΔTR <sub>BP,t</sub>	The net incremental amount of carbon stored by the project in forest carbon pools (excluding HWP) during reporting period <i>t</i> as compared to the baseline. Expressed in tCO <sub>2</sub> e.	N/A
ΔGHG <sub>CO<sub>2</sub>, HWP, t</sub>	The net incremental amount of carbon stored in project HWPs harvested during reporting period <i>t</i> <sup>75</sup> as compared to the baseline. Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>AS,t</sub>	Total increase in project emissions due to activity shifting (AS) leakage from all affected carbon pools during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>F<sub>M</sub></sub>	Market leakage factor (LE <sub>F<sub>M</sub></sub> ), expressing the percentage of the total increase in project emissions due to market leakage during reporting period <i>t</i> , Expressed in%.	N/A

#### 8.4.1.2.2 Market leakage (Method 2)

Equation 39

$$LE_{M,t} = \max\{0, \Delta TE_{Harv,t} + GHG_{CO_2,HWPPools,t} - LE_{AS,t}\} \times LE_{F_M} \quad [39]$$

Where:

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<sup>75</sup> Difference of mass of CO<sub>2</sub> in project or baseline HWPs as calculated in the Equation 4 for times *t* and *t-1*

Parameter	Description	Default Value
LE <sub>M,t</sub>	Total increase in project emissions due to market leakage from all affected carbon pools and sources during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
ΔTE <sub>Harv,t</sub>	The net incremental amount of carbon removed from the project forest during reporting period <i>t</i> as compared to the baseline, via the following mechanisms: <ul style="list-style-type: none"> <li>Physical removal of harvested wood from the project forest</li> <li>Harvesting-related losses that occur within the forest (eg, lost branches, tops, etc.) that are assumed to rapidly decay and release CO<sub>2</sub> to the atmosphere.</li> </ul> Expressed in tCO <sub>2</sub> e.	N/A
ΔGHG <sub>CO<sub>2</sub>, HWP Pools, t</sub>	The net incremental amount of carbon stored in project HWPs harvested during reporting period <i>t</i> as compared to the baseline. Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>AS,t</sub>	Total increase in project emissions due to activity shifting leakage (AS) from all affected carbon pools during reporting period <i>t</i> . Expressed in tCO <sub>2</sub> e.	N/A
LE <sub>F<sub>M</sub></sub>	Market leakage factor, expressing the percentage of the total increase in emissions due to market leakage during reporting period <i>t</i> . Expressed in %.	N/A

#### 8.4.1.2.2.1. Estimating harvesting impacts for Method 2

Harvest impacts must be estimated using Equation 40.

Harvesting impacts

Equation 40

$$\Delta TE_{Harv,t} = \left[ \sum_s m_{s,t,baseline} * (ms_s/mh_s) - \sum_s m_{s,t,project} * (ms_s/mh_s) \right] * f_{c,wood} * 44/12$$

Where:

Parameter	Description	Default Value
$\Delta TE_{Harv,t}$	<p>The net incremental amount of carbon removed from the project forest during reporting period <math>t</math> as compared to the baseline, via the following mechanisms:</p> <ul style="list-style-type: none"> <li>Physical removal of harvested wood from the project forest</li> <li>Harvesting-related losses that occur within the forest (eg, lost branches, tops, etc.) that are assumed to rapidly decay and release CO<sub>2</sub> to the atmosphere.</li> </ul> <p>Expressed in tCO<sub>2</sub>e.</p>	N/A
$m_{s,t, baseline}$	<p>Dry mass, in tonnes, of harvested wood, minus bark, harvested in the baseline in reporting period <math>t</math> that will be processed into HWP <math>k</math>. This value is determined in a manner analogous to <math>Rw_{biomass_{y,d}}</math> in Equation 2, Section 8.1.1.2, except that this mass is determined by species or group of species rather than by HWP type. Expressed in tonnes.</p>	N/A
$ms_s$	<p>Average total mass of a standing tree of species or group of species <math>s</math> prior to harvest. Expressed in tonnes.</p>	See endnote below the table
$mh_s$	<p>Average mass of the harvested wood, minus bark, of a tree of species or groups of species <math>s</math>. Expressed in tonnes.</p>	See endnote below the table
$m_{s,t, project}$	<p>Dry mass, in tonnes, of harvested wood, minus bark, harvested in the project in reporting period <math>t</math> that will be processed into HWP <math>k</math>. This value is determined in a manner analogous to <math>Rw_{biomass_{y,d}}</math> in Section 8.1.1.2, except that this mass is determined by species or group of species rather than by HWP type. Expressed in tonnes.</p>	N/A
$f_{c, wood}$	<p>The fraction of the dry mass of wood, excluding bark, that is carbon. Dimensionless</p>	Assumed to be 50% for all wood species. <sup>76</sup>
S	<p>Relevant tree species or group of species types being harvested in the project and baseline area.</p>	N/A

Project proponents will be responsible for justifying total mass and harvested mass appropriate for the project and baseline, considering tree species involved, typical age of trees at harvest, and any other relevant factors. A proponent may also choose to use a single value applicable to all

<sup>76</sup> IPCC GPG for LULUCF equation 3.2.3

species, rather than one for each relevant species, as long as the approach is demonstrated to be conservative (ie, does not under-estimate leakage). The preferred method for deriving  $ms_s$  is to run an appropriate stand model, taking into account species, age and density, and divide the live biomass stock output by the modeled number of remaining live trees per hectare at the stand age.

### 8.4.1.2.3 Determining Percent Market Leakage

Project proponents may undertake this step using project specific data combined with existing results from studies of market leakage effects, summarized for regions of BC under Option 1, below, or through developing their own refined market leakage estimates based on principles discussed under Option 2. In either case, market leakage estimates must be based on an analysis of forests containing the same or substitutable commercial species as compared to the forest in the project area, and must be consistent with methods for quantifying leakage found in scientific peer-reviewed journal sources. Also included is Option 3 which is the VCS leakage discount method.

1. Provincial estimates of  $LEF_M$  (Option 1)

Project proponents within BC can use a BC provincial leakage rate estimate from Table 17 below for the factor  $LEF_M$  in calculating their project leakage estimate. Proponents that choose to use a provincial leakage estimate as their project leakage factors can do so provided that it is supported by a statement of acceptance that the project is representative of average timber commodities and the proponent has no reason to believe leakage would be higher than the provincial base case leakage estimate.

Table 17: BC provincial leakage estimates for projects resulting in reduced harvest in BC

Geographic Area	Estimated Leakage
Northern Interior	65.2%
Southern Interior	63.6%
Coast	55.3%

The leakage factors referenced in the above table have been derived using the project-specific approach (Option 2) described below based on the average mix of tree species in the total harvest of each respective geographic area applicable to the province of BC (see Appendix A for further details on how the base case values were determined). There are certain tree species in specific regions of British Columbia which are less substitutable in terms of developing certain wood products than others. The substitutability of wood products has a significant effect on the ultimate leakage estimate. Project proponents must use the provincial leakage estimates as a guide. When project areas have proportions of tree species that differ from the regional averages and perhaps



higher proportions of tree species with low or moderate substitutability than what is reflected in the estimated leakage rate for the project's region, or in the case of projects within provinces other than BC, it is recommended that project proponents utilize the guidance given in this document and tailor/refine the leakage estimates to reflect these project specifics accordingly. This is particularly the case for the coastal region and southern interior region of British Columbia.

The provincial leakage factors will be reviewed periodically and updated as required. Any changes will be applicable to existing projects and must be incorporated into the next project verification that follows the date new values are published.

2. Project-specific estimates of  $LEF_M$  (Option 2)

Project proponents are free to estimate their own project specific market leakage factor provided that they use the methodology described below. Any proposed project-specific leakage parameters used in preparing the project-specific market leakage factor must be supported by an adequate rationale.

The recommended approach for determining market leakage factor resulting from a project with a reduced harvest utilizes a formula proposed by Murray et al<sup>77</sup> as shown in Equation 41.

% leakage from external harvest shifting

Equation 41

$$LEF_M = \frac{(100 \times e \times \gamma \times C_N)}{([e - E \times (1 + \gamma * \Phi)] \times C_R)} \quad [41]$$

Where:

Parameter	Description	Default Value
$LEF_M$	Market leakage factor ( $LEF_M$ ), % leakage from external harvest shifting	
$e$	Supply price elasticity.	

<sup>77</sup> Murray, B., et al. 2004. "Estimating Leakage from Forest Carbon Sequestration Programs". Land Economics 80(1): 109-124.

E	Demand price elasticity.	See Tables 18 and 19 Below
C <sub>N</sub>	Carbon sequestration reversal per unit of harvest from the non-reserved forest. Expressed in tC.	
C <sub>R</sub>	Carbon sequestration per unit of (forgone) harvest gained by preserving the reserved forest. Expressed in tC.	
Φ	The “preservation” parameter. This is the ratio of timber supply being set aside for the offset project (quantity Q <sub>R</sub> ) to the timber supply outside the offset area (quantity Q <sub>N</sub> ). The ratio can be represented as $\frac{Q_R}{Q_N}$ and can be thought of as the market share of the timber in the offset project.	
Γ	The “substitution” parameter. A parameter introduced into the referenced leakage equation to take into account specialty woods (ie, the degree to which a particular HWP can be substituted for another).	

When using this equation to derive project-specific leakage estimates, it is recommended that project proponents within the province of BC base their calculations on the variable values shown in the Provincial Base Case Approach for Estimating Leakage (Appendix A) for supply price elasticity (e), demand price elasticity (E), and the carbon sequestration values (C<sub>N</sub> and C<sub>R</sub>) (shown below in Table 18). The sources for these values are shown in Appendix A.

**Table 18:** Recommended Values for Estimating Project Specific Leakage

Variable description	Base Case Equation Values	Rationale
Supply price elasticity.	$e = 0.342$	Market supply and demand elasticities are very difficult to estimate and require considerable amounts of relevant and credible background data. For the majority of cases, project proponents will be extremely challenged to compile the data required to estimate appropriate elasticities. In addition there is a risk the elasticities developed or referenced by a proponent could be either derived and/ or applied inappropriately (ie, elasticities that do not adequately represent the market(s) associated with the offset project). The elasticities used in the BC Provincial Base Case approach, and given here, are considered the best representation of current market
Demand price elasticity	$E = -0.181$	

		conditions and are based on statistically significant results from long-run data sets. The derivation of these variables are predicated more on total/ overall market supply and demand factors, and less on project specific factors. As a result, in terms of applying a consistent approach and to streamline validation requirements it is recommended that the referenced elasticities are used
Carbon sequestration per unit of (forgone) harvest gained by preserving the reserved forest.	$C_R = 1$	This is a conservative assumption. In favourable growing conditions $C_R$ would not be unreasonable to assume that $C_R > C_N$ . As the gap between $C_R$ and $C_N$ increases in favour of $C_R$ leakage will decrease.
Carbon sequestration reversal per unit of harvest from the non-reserved forest.	$C_N = 1$	However it is difficult/ impossible to predict the area of North America the leakage will be in, and therefore just as difficult to define a $C_N$ value.

In order to tailor leakage estimates to reflect a specific project market leakage case, it is recommended that proponents focus on developing their own project specific parameters to reflect the preservation parameter ( $\Phi$ ) and the substitutability parameter ( $\gamma$ ).

Table 19: Variables Recommended to be Developed by Project Proponents for Estimating Project Specific Leakage Estimates

Variable description	Equation Variable	Rationale
<p>Preservation parameter –</p> <p>The ratio of timber supply being set aside for the offset project to the timber supply outside the offset area and can be thought of as the market share of the timber in the offset project.</p>	$\Phi$	<p>As projects will vary in size and correspondingly to the market share of timber in the offset area, the preservation parameter can be derived to reflect the specific size of a project. This co-efficient has a minimal effect in the leakage equation but if estimated appropriately can offer a more specific overall leakage estimate for any given project.</p>
<p>Substitution Parameter –</p> <p>A parameter introduced into the referenced leakage equation to take into account specialty woods.</p>	$\gamma$	<p>For specialty woods with few substitutes, such as cedar, leakage is likely lower than for other readily substitutable woods.</p> <p>Proponents who can demonstrate that specialty woods are prevalent in their project area can utilize the substitutability parameter to reflect this and develop a more project specific leakage estimate. Otherwise, the default values provided in Appendix A: A Provincial BC Base Case Approach For</p>

		Addressing Leakage from Forest Carbon Projects must be utilized, considering projects located within the province of BC.
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Method for deriving a preservation parameter ( $\Phi$ )

The preservation parameter ( $\Phi$ ) represents the ratio of timber set aside for the offset project (quantity  $Q_R$ ) to the timber supply outside the offset area (quantity  $Q_N$ ). The ratio can be represented as  $\frac{Q_R}{Q_N}$  and can be thought of as the market share of the timber in the offset project.

The purpose of this ratio is to determine how difficult it will be to replace the preserved timber. Small amounts of preserved timber are easier to replace than large amounts.

A 1% (.01) preservation parameter has been used in the BC provincial base cases. This is in line with Murray et al.'s general calculations. This value is used since it is unlikely that any project will alter harvest rates by more than 1% of the total North American market for the specific commodity. Furthermore, this value has minimal impact on the leakage calculation. As such, a preservation parameter of 1% is adequate for the leakage calculations, and proponents can use this value.

Proponents are free to calculate their own preservation parameter, if they choose. To do this calculation the quantity of preserved lumber ( $Q_R$ ) will be equal to the amount of harvestable timber ( $m^3$ ) being claimed on the proponent's project verification. The remaining supply of timber ( $Q_N$ ) will be the five year average annual total timber harvest in North America for the most recent period.

Preservation parameter

Equation 42

$$\Phi = \frac{Q_R}{Q_N} \quad [42]$$

Where:

Parameter	Description	Default Value
$\Phi$	The "preservation" parameter. This is the ratio of timber supply being set aside for the offset project (quantity $Q_R$ ) to the timber supply outside the offset area (quantity $Q_N$ ). The ratio can be represented as $\frac{Q_R}{Q_N}$ and can be thought of as the market share of the timber in the offset project.	N/A

Q <sub>R</sub>	Quantity of harvestable timber to be claimed on upcoming project verification. Expressed in m <sup>3</sup> .	N/A
Q <sub>N</sub>	Quantity of harvestable timber supply remaining in the market. Expressed in m <sup>3</sup> .	N/A

Method for deriving a substitutability parameter (γ)

There are two key factors to consider when determining the substitutability parameter. The first is the tree species breakdown of the project area, and the second is cross-species product substitutability of each given species.<sup>78</sup> For example, how many cedar products can be replaced with pine products?

A project proponent must use a representative and validated sample of tree species harvest makeup for their project area. If a substitution parameter is then calculated for this representative sample, on average it is going to be accurate (representative) of a project in this area. When utilizing this approach, we are mainly concerned with “specialty woods” that are more difficult to substitute; such as cedar or cypress. The contribution to total harvest of these specialty woods is combined with species specific substitutability to create a weighted average for the substitutability parameter. The weighted average is then applied to the leakage equation, reducing leakage from a project by the weighted average (represented as a percentage) of its original level.

Weighted Substitution Parameter

Equation 43

$$\gamma = \sum_{i=1}^n T_i \times S_i \quad [43]$$

Where:

Parameter	Description	Default Value
γ	Substitution Parameter – A parameter introduced into the referenced leakage equation to take into account specialty woods.	N/A
i	A specific tree type	N/A
n	Number of tree types within the project. Dimensionless.	N/A
T <sub>i</sub>	Tree type <i>i</i> 's share of project's total marketable tree volume. Expressed in %.	N/A
S <sub>i</sub>	Substitutability of tree type <i>i</i>	N/A

<sup>78</sup> Refer to Provincial Base Case Approach for the Coastal Market for an example of the application of the substitutability parameter.

Additional requirements for proponents wishing to estimate their own project specific leakage

Where a project-specific approach is taken for deriving any of the parameters noted above, the additional requirements detailed in Table 20 must also be satisfied.

Table 20: Additional Requirements for Using Coefficients in the Leakage Equation

Variable	Comments
<p>Supply (e) and Demand (E) Elasticities</p>	<p>North American market data must be used when estimating elasticities for the purpose of determining leakage.</p> <p>The price elasticity of total demand of North American must be used if available, otherwise, the price elasticity of total demand (including both domestic demand and import demand) of US must be used as US demand represents the majority of North American demand.</p> <p>The price elasticity of total supply of North American market must be used if available; otherwise an export supply elasticity from Canada to the U.S. may be acceptable.</p> <p>Elasticity estimates used by a project proponent for both supply and demand must be derived from the same data sets and information/ study in order to ensure consistency in derivation and validate their application for estimating project leakage.</p> <p>Both market supply and market demand elasticities used in the leakage methodology must be long-run elasticity estimates.</p>
<p>Carbon sequestration values (<math>C_N</math> and <math>C_R</math>)</p>	<p>It is difficult/ impossible to predict where exactly <math>C_N</math> occurs in North America and what the justified value would be.</p> <p>Using 1:1 ratio is a conservative approach. Proponents choosing to develop their own leakage value must use a value of 1 for <math>C_N</math> and <math>C_R</math> in the leakage formula.</p>
<p>Preservation Parameter (<math>\Phi</math>)</p>	<p>As projects will vary in size and correspondingly to the market share of timber in the offset area, the preservation parameter can be derived to reflect the specific size of a project.</p> <p>This co-efficient has a minimal effect in the leakage equation but if estimated appropriately can offer a more specific overall leakage estimate for any given project.</p> <p>Proponents wishing to estimate this parameter must demonstrate the harvest potential (or forgone harvest since the last verification period) that their respective project has in terms of total North American timber sales over the previous year.</p>

<p>Substitutability Parameter (γ)</p>	<p>Proponents must follow the substitution guidelines given above when calculating their own substitution parameter.</p> <p>Proponents must demonstrate the tree species contribution/makeup within their project area.</p> <p>Proponents must demonstrate the substitutability of tree species in terms of potential wood products.</p> <p>Proponents must apply long-run, own- and cross-price elasticities of demand for substitutable wood products in North American market to derive the substitutability parameters.</p>
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Market leakage (Option 3)

When using Option 3, project proponents must provide justification and evidence of how the leakage discount factor is determined.

The outcome of the VCS Leakage Discount Factor determination, provided in the Table 2 of the *VCS Methodology Requirements* document, will be equal to the value for  $LEF_M$  in the following equation. Table 2 is only eligible for IFM activities.

Equation 44

$$LE_{M,t} = \max\{0, LEF_M \times TPE_t\} \quad [44]$$

Where:

Parameter	Description	Default Value
$LE_{M,t}$	Total increase in project emissions due to market leakage from all affected carbon pools and sources during reporting period $t$ . Expressed in tCO <sub>2</sub> e.	N/A
$LEF_M$	Market leakage factor, expressing the percentage of the total increase in project emissions due to market leakage during reporting period $t$ . Expressed in %.	N/A
$TPE_t$	The total project emissions reductions, considering all pools and sources during reporting period $t$ . Expressed in tCO <sub>2</sub> e. See Equation 34.	N/A

## 8.5 Net GHG Emission Reductions and Removals

The equations for calculating total project and baseline emission reductions and/or removals are given in section 8 above. The net GHG emission reductions and removal calculation is shown in Equation 45 below.

Equation 45

$$NPE_t = TPE_t - TBE_t - LE_{PE16,t} \quad [45]$$

Where:

Parameter	Description	Default Value
$NPE_t$	Net GHG emissions reductions and removals of the project during reporting period t. Expressed in tCO <sub>2</sub> e.	N/A
$TPE_t$	The total project emissions reductions, considering all pools and sources during reporting period t. Expressed in tCO <sub>2</sub> e.	N/A
$TBE_t$	The total baseline emissions reductions, considering all pools and sources during reporting period t. Expressed in tCO <sub>2</sub> e	N/A
$LE_{PE16,t}$	The amount of GHG, emitted from Leakage affected carbon pools during reporting period t. Only relevant for CO <sub>2</sub> ; otherwise, set to zero. Expressed in tCO <sub>2</sub> e.	N/A

### 8.5.1 Net change in carbon stocks

For quantifying the number of buffer credits to be withheld in the AFOLU pooled buffer account, net change in carbon stocks must be calculated using Equation 46.

Equation 46

$$NTR_t = \Delta TR_{PP,t} - \Delta TR_{BP,t} \quad [46]$$

Where:

Parameter	Description	Default Value
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NTR <sub>t</sub>	Net change in carbon stocks during reporting period . Expressed in tCO <sub>2</sub> e.	N/A
ΔTR <sub>PP,t</sub>	The net incremental GHG removals by project pools achieved by the project during reporting period t. A net increase in total removals is expressed as a positive number. Expressed in tCO <sub>2</sub> e.	N/A
ΔTR <sub>BP,t</sub>	The net incremental GHG removals by baseline pools achieved by the baseline during reporting period t. A net increase in total removals is expressed as a positive number. Expressed in tCO <sub>2</sub> e.	N/A

### 8.5.2 Long Term Averaging

Where ARR or IFM projects are to be validated with the VCS Program, and where the project scenario includes harvesting, the maximum number of GHG credits available to the project must not exceed the long term average GHG benefit<sup>79</sup>. Under these conditions, proponents must therefore use the methods set out in this methodology to estimate the expected total GHG benefit of the project for each year of a time period identified following the guidance given in the VCS *AFOLU Requirements*. Specifically, the period over which the long term GHG benefit must be calculated must be established, noting the following:

- For ARR or IFM projects undertaking even-aged management, the time period over which the long term GHG benefit is calculated must include at minimum one full harvesting/cutting cycle, including the last harvest/cut in the cycle.
- For ARR projects under conservation easements with no intention to harvest after the project crediting period, or for selectively cut IFM projects, the time period over which the long-term average is calculated must be the length of the project crediting period.

Equation 47 below, will then be used to calculate the average *GHG* benefit.

Equation 47

$$LA = \sum_{t=0}^n NPE_t/n \quad [47]$$

Where:

Parameter	Description	Default Value
LA	The long term average GHG benefit. Expressed in tCO <sub>2</sub> e.	N/A

<sup>79</sup> See section 3.2.20 of the VCS Standard v4.0 for further details

NPE <sub>t</sub>	Net GHG emissions reductions and removals of the project during reporting period <i>t</i> . Expressed in tCO <sub>2e</sub> .	N/A
n	Total number of years in the established time period	N/A

**8.5.3 VCUs Eligible for Issuance**

The quantity of VCUs eligible for issuance must be determined using Equation 48.

Equation 48

$$\text{Credits}_t = \text{Min} (\text{LA}, \text{NPE}_t) - \text{Risk} \times \text{NTR}_t \quad [48]$$

Where:

Parameter	Description	Default Value
Credits <sub>t</sub>	Total amount of credits available for reporting period <i>t</i> .	N/A
LA	The long term average GHG benefit. Expressed in tCO <sub>2e</sub> .	N/A
NPE <sub>t</sub>	Net change in GHG emissions reductions and/or removals for reporting period <i>t</i> . Expressed in tCO <sub>2e</sub> .	N/A
Risk	Non-permanence risk rating as determined using the AFOLU Non-Permanence Risk Tool.	N/A
NTR <sub>t</sub>	Net change in carbon stocks for reporting period <i>t</i> . Expressed in tCO <sub>2e</sub> .	N/A

Note that where the project is a REDD project, or where ARR or IFM project scenario does not include harvesting, long term averaging will not apply, and therefore the equation will read:

Equation 49

$$\text{Credits}_t = \text{NPE}_t - (\text{Risk} \times \text{NTR}_t) \quad [49]$$

Parameter	Description	Default Value
Credits <sub>t</sub>	Total amount of credits available for reporting period <i>t</i> .	N/A
NPE <sub>t</sub>	Net change in GHG emissions reductions and/or removals for reporting period <i>t</i> . Expressed in tCO <sub>2e</sub> .	N/A

Risk	Non-permanence risk rating as determined using the AFOLU Non-Permanence Risk Tool.	N/A
$NTR_t$	Net change in carbon stocks for reporting period $t$ . Expressed in $tCO_2e$ .	N/A

9 MONITORING

9.1 Data and Parameters Available at Validation

Data / Parameter	LEF <sub>M</sub>
Data unit	%
Description	Market leakage factor, expressing the percentage of the total increase in project emissions due to market leakage during reporting period t.
Equations	Eq. 38, 39 and 41
Source of data	In the case of equations 38 or 39, LEF <sub>M</sub> data for the province of BC is provided by the BC Provincial Leakage Base Case (See Appendix A). In the case of other provinces, project proponents must use the guidance of Appendix A to tailor project specific LEF <sub>M</sub> values. In the case of equation 41, LEF <sub>M</sub> equals the value of the VCS Leakage Discount Factor provided on the <i>VCS AFOLU Requirements</i> document.
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	For option 1 , projects located in BC province may use default values from table 17. For option 2, project developer must use values resulting from Equation 40. For option 3, project developers must use default values from Table 2 of the VCS VCS Methodology Requirements V4.0.
Purpose of data	Calculation of leakage
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	C <sub>R</sub> & C <sub>N</sub>
Data unit	tC
Description	Carbon sequestration per unit of forest
Equations	Eq. 41
Source of data	Conservative estimate based on generally higher productivity of Canada forests, and the unknown location of market leakage.
Value applied	1

Justification of choice of data or description of measurement methods and procedures applied	Conservative estimate based on the generally higher productivity of Canada 's forests, and the unknown location of market leakage.
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	$dq_x, q_x$
Data unit	Factor
Description	Own and cross price elasticities of demand for softwood lumber prices
Equations	Appendix B
Source of data:	Nagubadi, R.V., Zhang, D., Prestemon, J.P., and Wear, D.N. 2004. "Softwood Lumber Products in the United States: Substitutes, Complements, or Unrelated?". Forest Science 51(4):416-426. and Hseu, J-S., and Buongiorno, J. 1993. "Price elasticities of substitution between species in the demand of US softwood lumber imports from Canada". Canadian Journal of Forest Research 23:591-597.
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	The Nagubandi et. al. paper is a peer reviewed, widely cited study of price elasticities in the US market for broad classes of softwood lumber, and was the most appropriate reference found for these variables
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	e
Data unit	%
Description	Supply price elasticity
Equations	Eq.41
Source of data	Song, N., et al., 2011. "U.S. softwood lumber demand and supply estimation using cointegration in dynamic equations". Journal of Forest Economics.

Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	Song et.al was identified as the most recent, appropriate paper for determining elasticities for BC forest products in the NA market.
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	E
Data unit	%
Description	Demand price elasticity
Equations	Eq.41
Source of data	Song, N., et al., 2011. "U.S. softwood lumber demand and supply estimation using cointegration in dynamic equations". Journal of Forest Economics.
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	Song et.al was identified as the most recent, appropriate paper for determining elasticities for Canada forest products in the NA market.
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	EF <sub>1</sub>
Data unit	Tonne N <sub>2</sub> O-N / tonne N input
Description	Emission Factor for N additions from fertilizers,
Equations	Eq. 17
Source of data	Table 11.1, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.01
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines

Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	EF <sub>4</sub>
Data unit	tN <sub>2</sub> O-N / (tNH <sub>3</sub> -N + tNO <sub>x</sub> -N volatilised).
Description	Emission Factor for N <sub>2</sub> O emissions from atmospheric deposition of N on soils and water surfaces, tonne N <sub>2</sub> O-N / tonne N input
Equations	Eq. 21
Source of data	Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.01
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	EF <sub>5</sub>
Data unit	tN <sub>2</sub> O-N / tN in leaching or runoff.
Description	Emission factor for N <sub>2</sub> O-N emissions from N leaching and runoff, tonne N <sub>2</sub> O / tonne N input
Equations	Eq. 22
Source of data	Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.0075
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	f <sub>C, wood</sub>
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Data unit	Tonne / tonne
Description	The fraction of the dry mass of wood, excluding bark, that is carbon.
Equations	Eq. 40
Source of data	IPCC GPG for LULUCF Equation 3.2.3
Value applied	0.5
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	Frac <sub>GASF</sub>
Data unit	(tNH <sub>3</sub> -N + tNO <sub>x</sub> -N volatilised)/tN applied
Description	Fraction of Nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> for synthetic fertilizers
Equations	Eq. 21
Source of data:	Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.1
Justification of choice of data or description of measurement methods and procedures applied:	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	Frac <sub>GASM</sub>
Data unit	(tNH <sub>3</sub> -N + tNO <sub>x</sub> -N volatilised)/tN applied
Description	Fraction of Nitrogen that volatilizes as NH <sub>3</sub> and NO <sub>x</sub> for organic fertilizers
Equations	Eq. 21



Source of data	Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.2
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	Frac <sub>LEACH-(H)</sub>
Data unit	tN/tN added or deposited by grazing animals.
Description	Fraction of N lost by leaching and runoff.
Equations	Eq. 22
Source of data	Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories
Value applied	0.3 (if soil water holding capacity is exceeded) or 0
Justification of choice of data or description of measurement methods and procedures applied	Default factor given for this variable in the IPCC Guidelines
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	GWP <sub>j</sub>
Data unit	Dimensionless
Description	Global warming potential of gas j
Equations	Eq. 5
Source of data	IPCC
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	Values found in Table 4 (p.22) of The Science of Climate Change, Contribution of Working Group 1 to the Second Assessment Report of the IPCC must be used (time horizon - 100 years).

Purpose of data	Calculation of baseline and project emissions, and leakage
Comments	None

Data / Parameter	$HWPCH4f_{X,t,y}$
Data unit	tCO <sub>2e</sub> / t wood biomass delivered
Description	The factor for the amount of CH <sub>4</sub> (accounted as CO <sub>2e</sub> ) emitted in a given year, equal to the number of years between harvest and time t, for products used in area X, where X is either North America (NA) or offshore (O)
Equations	Eq. 30
Source of data	Values given in tables 14 and 15, derived from Dymond 2012 and Winjum et al 1998
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	The Dymond paper represents the most recent, BC focussed assessment of C storage in HWP for North American markets, while the Winjum et.al. paper is the best available source for offshore markets. For other provinces, default values must be calculated according Dymond procedures. Other models may also be suitable to determine HWP default value. If other models are used, VVA must be justified by considering the appropriateness of the selected models.
Purpose of data	Calculation of baseline and project emissions.
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	$HWPf_{NA,t,y}$
Data unit	%
Description	The factor for the percentage of CO <sub>2</sub> remaining after the number of years between harvest and time t, for products used in North America
Equations	Eq. 4
Source of data	Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, and K.E. Skog, Sequestration of

	carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	The Dymond paper represents the most recent, BC focussed assessment of C storage in HWP for North American markets. For other provinces, default values must be calculated according Dymond procedures. Other models may also be suitable to determine HWP default value. If other models are used, VVA must be justified by considering the appropriateness of the selected models.
Purpose of data	Calculation of baseline and project emissions.
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	$HWP_{f_{0,t-y}}$
Data unit	%
Description	The factor for the percentage of CO <sub>2</sub> remaining after the number of years between harvest and time t, for products used offshore
Equations	Eq. 4
Source of data	Derived from Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia's harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998 and K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58(6):56-72. (2008)
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied:	The Dymond (2012) paper represents the most recent, BC focussed assessment of C storage in HWP for North American markets, while the Winjum et.al. paper is the best available source for key factors for offshore markets. For other provinces, default values must be calculated following the procedures proposed by the Dymond (2012) paper. Other models may also be used to determine HWP default values, following conditions mentioned on section 8.1.1.2.

Purpose of data	Calculation of baseline and project emissions.
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	$T_x$
Data unit	%
Description	Timber harvesting volume proportion for species x by region for BC
Equations	Appendix A
Source of data	BC Government data on timber harvest by region
Value applied	Values given in Appendix E in the case of BC. For option 2 of how to calculate $LEF_M\%$ when project areas have proportions of tree species that differ from the regional averages (established in Appendix E) or when areas in other provinces other than BC, it is recommended that project proponents utilize the guidance given in this document (Appendix A) and tailor/refine the leakage updating timber harvesting volume proportion for specie x by project's region according to scientific available data.
Justification of choice of data or description of measurement methods and procedures applied	BC government data provides the definitive record of harvest activities within the province. For projects in other provinces, project developer must use data of recor of harvest activities in the project area or region. This, demostrating that the data is reliable and from relevant peer reviewed literature to ascertain its validity.
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	$wdf_s$
Data unit	$t/m^3$
Description	Wood density for species or groups of species s
Equations	Eq. 2
Source of data	J.S. Gonzalez. Wood density of Canadian tree species. Edmonton: Forestry Canada, Northwest Region, Northern Forestry Centre, 1990, Inform. Rept. NOR-X-315
Value applied	Various

Justification of choice of data or description of measurement methods and procedures applied	The Gonzalez study is a published meta-study reviewing a wide range of research results for wood densities.
Purpose of data	Calculation of baseline and project emissions, and leakage
Comments	None

**9.1.1: Default Factors Subject to Periodic Re-Assessment**

For projects within the province of BC, a number of default factors are given for use various equations. The default factors shown in Table 21, below, are specific to this methodology, and are subject to periodic re-assessment, as laid out in the most recent version of the VCS document “Methodology Approval Process”.

Table 21: Default Factors Subject to Periodic Re-Assessment

Variable	Description	Equation
HWPf	Percentage of CO <sub>2</sub> remaining in use and landfill in wood products	5
HWPC <sub>H4ft</sub>	CH <sub>4</sub> emissions from landfills	30
LEF <sub>M</sub>	Provincial leakage estimates	38

For these factors, updated peer reviewed sources of information or methods used in the derivation of the factor may become available.

9.2 Data and Parameters Monitored

Data / Parameter	$AL_{b,t}$
Data unit	Tonnes of biomass.
Description	The quantity of biomass of type b combusted during reporting period t.
Equations	Eq. 25
Source of data	Field measurement
Description of measurement methods and procedures to be applied	Project proponents must propose and justify an approach for determining the total mass of biomass combusted during controlled burning events during a reporting period. The approach must be based on the guidance given for Approach B in VCS module VMD0031 Estimation of Emissions from Burning.
Frequency of monitoring/recording	For each combustion event.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation Method	See VCS module VMD0031 Estimation of Emissions from Burning.
Comments	

Data / Parameter	$AL_{f,t}$
Data unit	Tonnes
Description	The quantity of fertilizer of type f applied during period t
Equations	Eq. 8
Source of data	Fertilizer purchase and inventory records
Description of measurement methods and procedures to be applied	Standard accounting practices: inventory at beginning of the period plus purchases during the period less inventory at the end of the period
Frequency of monitoring/recording	Annually or every reporting period, whichever is longer.

QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation of purchases plus inventory of fertilizer type f at the beginning of the period, less inventory at the end of the period, or other appropriate accounting method.
Comments	

Data / Parameter	$AL_{f,e,t}$
Data unit	Volumetric measure (eg, l, m <sup>3</sup> , etc.) or mass measure (kg, t, etc.) with appropriate conversion
Description	The quantity of fuel of type f combusted in equipment/vehicle type e during reporting period t.
Equations	Eq. 16
Source of data	Monitoring of fuel consumption
Description of measurement methods and procedures to be applied	Fuel consumption records by type of equipment or vehicle and fuel type. Alternatively, records by fuel type only may be used. Records may be in various forms, as long as they directly relate to amount of fuel consumed and are not estimates.
Frequency of monitoring/recording	Continuous
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	None
Comments	

Data / Parameter	$AL_{ff,t}$
Data unit	Tonnes
Description	The quantity of forest biomass combusted during forest fires occurring during reporting period, from both anticipated disturbance events that have been modeled in the project and baseline and unanticipated loss events that are monitored.

Equations	Eq.27
Source of data	Calculation based on measurement or modelling of key factors.
Description of measurement methods and procedures to be applied	Measurement of area impacted and estimation of biomass quantities in the area prior to the fire event from forest inventories. Measured or modeled percentage of biomass consumed in fire event. Proponents must utilize the guidance given for Approach B in VCS module VMD0031: Estimation of Emissions from Burning to make these estimations.
Frequency of monitoring/recording	For each combustion event.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	See VCS module VMD0031 Estimation of Emissions from Burning.
Comments	

Data / Parameter	$AL_{H,t}$
Data unit	t, or other unit with appropriate conversion factor to t
Description	The quantity of harvested wood product H produced from wood harvested during reporting period t.
Equations	Eq. 29
Source of data	Harvest monitoring
Description of measurement methods and procedures to be applied	Derived from scaling records. Standard scaling methods consistent with or comparable to those contained in the BC Scaling Manual must be used.
Frequency of monitoring/recording	Every time harvesting is conducted.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation of data from scaling records
Comments	



Data / Parameter	$AL_{m,t}$
Data unit	Persons, items or tonnes, as appropriate
Description	The quantity of materials, equipment, inputs, and personnel transported by mode m during reporting period t.
Equations	Eq. 12
Source of data	Monitoring of proponent activities
Description of measurement methods and procedures to be applied	Data sourced from management records of project proponents for transportation by the proponent or contractors working within the project area. Includes transportation outside of the project area where used to access the project area.
Frequency of monitoring/recording	Continuous tracking
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation from management records
Comments	

Data / Parameter	$C_{m,g,t}$
Data unit	Tonnes
Description	Total quantity of material, equipment, input, or personnel g transported using transport mode m during reporting period t.
Equations	Eq. 13, 14
Source of data	Purchase and personnel records (both proponent and subcontractors).
Description of measurement methods and procedures to be applied	Based on sales invoices, personnel records. Where the same type of good is transported different distances to arrive at the project or baseline site, they must be treated as separate goods for the purposes of this calculation.
Frequency of monitoring/recording	Continuous (as sales invoices are received)

QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation from management records
Comments	

Data / Parameter	$D_{m,g}$
Data unit	Kilometers
Description	Transport distance for material, equipment, input, or personnel g using transport mode m.
Equations	Eq. 13, 14
Source of data	Routing information from shippers or drivers, estimation from shipping estimates or maps.
Description of measurement methods and procedures to be applied	Estimate based on shipping routes and route distance tools (eg, internet-based maps, etc.)
Frequency of monitoring/recording	Annually or every reporting period, whichever is longer.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	None
Comments	

Data / Parameter	$EF_{b,j}$
Data unit	t / t of biomass
Description	The emission factor for GHG j and biomass type b (eg, tonnes CH <sub>4</sub> per tonne of brush burned).
Equations	Eq. 25
Source of data	BC Reporting Regulation, National Inventory Reports, or other peer reviewed sources relevant to the project site conditions. Where more site specific data is not available, values from the IPCC GPG LULUCF (Table 3A.1.16) may be used.

Description of measurement methods and procedures to be applied	Monitored from identified external sources. See section 8.1.2.6 for more detail.
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$EF_{f,j}$
Data unit	t / t
Description	The emission factor for GHG j and fertilizer type f. Note: it is likely that fertilizer production emission factors may only be available in units of CO <sub>2</sub> e.
Equations	Eq. 8
Source of data	Various potential sources, as described in section 8.2.2.3
Description of measurement methods and procedures to be applied	Monitored from identified external sources. See section 8.1.2.2 for more detail
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$EF_{f,e,j}$
Data unit	t / unit of fuel
Description	The emission factor for GHG j, fuel type f and equipment/vehicle type e (eg, tonnes CO <sub>2</sub> per L diesel).

Equations	Eq. 16
Source of data	Emission factors approved for use in BC, shown in section 8.1.2.5 above.
Description of measurement methods and procedures to be applied	Monitored from identified external sources. See section 8.1.2.5 for more detail
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$EF_{ff,j}$
Data unit	t / t
Description	The emission factor for GHG j applicable to forest fires.
Equations	Eq. 27
Source of data	BC Reporting Regulation, National Inventory Reports, or other peer reviewed sources. In the absence of such guidance, the emission factors from the IPCC GPG LULUCF Table 3A.1.16 may be used
Description of measurement methods and procedures to be applied	Monitored from identified external sources. See section 8.1.2.8 for more detail
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	Ef <sub>H,j</sub>
Data unit	t / t
Description	The emission factor for GHG j and harvested wood product H produced (eg, CO <sub>2</sub> per quantity of raw harvested wood converted to wood product H)
Equations	Eq. 29
Source of data	Standardized emission factors or monitoring of production facilities
Description of measurement methods and procedures to be applied	Where production facilities are under the control of project proponents, monitored emissions from these facilities must be used. In other cases, provincially or nationally approved standardized emission factors may be used. See section 8.1.2.10 for more detail
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	Ef <sub>m,j</sub>
Data unit	t / unit
Description	The emission factor for GHG j and transportation mode m
Equations	Eq. 12, 13, 14
Source of data	Emission factors approved for use in BC, shown in section 8.1.2.4 above.
Description of measurement methods and procedures to be applied	Emission factors approved for use in BC, shown in section 8.1.2.4 above.
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional

Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$FE_m$
Data unit	unit of fuel per distance (eg, l diesel / 100 km).
Description	Fuel economy of transportation mode m
Equations	Eq. 13
Source of data	Vehicle records, or fuel consumption data by vehicle type from recognized sources.
Description of measurement methods and procedures to be applied	Based on monitored fuel consumption for vehicles controlled by the proponent, or vehicle specifications or default assumptions for the types of vehicles used for vehicles controlled by others.
Frequency of monitoring/recording	Review every five years or every reporting period, whichever is longer.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	None, or ratio of amount of fuel used to distance traveled, depending on data source.
Comments	

Data / Parameter	$\Delta TR_{BP,t}$
Data unit	tCO <sub>2</sub> e
Description	The net incremental GHG removals by pools achieved by the baseline during reporting period t.
Equations	Eq. 32
Source of data	Calculated from sampling, or modelled

Description of measurement methods and procedures to be applied	Determined using the methods given under either Option A or Option B in Section 8.1.1.1. The chosen Option and methods must be used consistently for both project emissions, as calculated in Section 8.2, and baseline emissions, as calculated in section 8.2, noting that if Option A is chosen, methods from Option B will also be used to determine $GHG_j, \text{ Baseline Forest Pools}, t$ for times $t > 0$ . Only relevant for $j = \text{CO}_2$ ; otherwise, set to zero.
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Estimation of baseline emissions.
Calculation method	Given in Section 8 – depends on the Option chosen and pools accounted.
Comments	

Data / Parameter	$\Delta TR_{PP,t}$
Data unit	tCO <sub>2</sub> e
Description	The net incremental GHG removals by project pools achieved by the project during reporting period t.
Equations	Eq. 34
Source of data	Calculated from sampling, or modelled
Description of measurement methods and procedures to be applied	Determined using the methods given under either Option A or Option B in Section 8.1.1.1. The chosen Option and methods must be used consistently for both project emissions, as calculated in Section 8.2, and baseline emissions, as calculated in section 8.2, noting that if Option A is chosen, methods from Option B will also be used to determine $GHG_j, \text{ Baseline Forest Pools}, t$ for times $t > 0$ . Only relevant for $j = \text{CO}_2$ ; otherwise, set to zero.
Frequency of monitoring/recording	Every reporting period
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions.
Calculation method	Given in Section 8 – depends on the Option chosen and pools accounted.

Comments	
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Data / Parameter	$L_{m,g}$
Data unit	Unit of quantity per vehicle
Description	Cargo load per transport vehicle of mode m.
Equations	Eq. 13
Source of data	Industry average loading for identified mode of transportation
Description of measurement methods and procedures to be applied	Data sourced from transport operator, or transport industry averages where project proponents does not have a direct relationship with the transport contractor.
Frequency of monitoring/recording	Review every five years or every reporting period, whichever is longer.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$m_h_s$
Data unit	Tonnes
Description	Average mass of the harvested wood, minus bark, of a tree of species s
Equations	Eq. 40
Source of data	Sampling of harvested trees of each species.
Description of measurement methods and procedures to be applied	Sampling will typically be of per tree volumes, as part of routine scaling operations. Sampling must be undertaken to BC Government scaling standards, consistent with BC Scaling Manual.
Frequency of monitoring/recording	At project commencement, and thereafter where average harvest parameters change
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional



Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Averaging from sampled trees.
Comments	

Data / Parameter	$M_{OF,j,t}$
Data unit	Tonnes
Description	Mass of organic fertilizer of type j applied in year t, tonnes.
Equations	Eq. 20
Source of data	Fertilizer purchase and inventory records
Description of measurement methods and procedures to be applied	Standard accounting practices: inventory at beginning of the period plus purchases during the period less inventory at the end of the period
Frequency of monitoring/recording	Annually or every reporting period, whichever is longer.
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation of purchases plus inventory of organic fertilizer type i at the beginning of the period, less inventory at the end of the period, or other appropriate accounting method.
Comments	

Data / Parameter	$M_{SF,i,t}$
Data unit	Tonnes
Description	Mass of synthetic fertilizer of type j applied in year t, tonnes.
Equations	Eq. 19
Source of data	Fertilizer purchase and inventory records
Description of measurement methods and procedures to be applied	Standard accounting practices: inventory at beginning of the period plus purchases during the period less inventory at the end of the period
Frequency of monitoring/recording	Annually or every reporting period, whichever is longer.

QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation of purchases plus inventory of fertilizer type f at the beginning of the period, less inventory at the end of the period, or other appropriate accounting method.
Comments	

Data / Parameter	NC <sub>oFj</sub>
Data unit	% (Mass fraction)
Description	Nitrogen content of organic fertilizer type j applied as specified by the manufacturer/supplier, or determined by laboratory analysis.
Equations	Eq.20
Source of data	Estimated
Description of measurement methods and procedures to be applied	Derived from manufacturer specifications
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	NC <sub>sFi</sub>
Data unit	% (Mass fraction)
Description	Nitrogen content of synthetic fertilizer type i applied as specified by the manufacturer/supplier, or determined by laboratory analysis.
Equations	Eq. 20

Source of data	Estimated
Description of measurement methods and procedures to be applied	Derived from manufacturer specifications
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions, estimation of baseline emissions
Calculation method	None
Comments	

Data / Parameter	$Vol_{s,y,d}$
Data unit	$m^3$
Description:	The volume of delivered roundwood of species s for each wood product destination d, extracted from the project area in year y
Equations	Eq. 2
Source of data	Measured
Description of measurement methods and procedures to be applied	Accounted from roundwood delivery records from the project area, and market breakdowns for customers.
Frequency of monitoring/recording	Continuous
QA/QC procedures to be applied	All data collection and calculation procedures and activities to be reviewed and spot checked by a qualified professional
Purpose of data	Calculation of project emissions. Will be estimated or modeled for estimation of baseline emissions.
Calculation method	Summation from delivery records
Comments	

### 9.3 Monitoring Plan

As part of the GHG project description, the proponent must prepare a monitoring plan which will ensure that the data and parameters used in the quantification of SSRs in Section 8, and listed in

tables in section 9.1 and 9.2 (the “variables”) are monitored to standards required to maintain the integrity of estimates of GHG emissions reductions or removals, that monitoring is fully documented, and that appropriate Quality Assurance and Quality Control (QA/QC) procedures, consistent with those laid out in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, are followed.

Primary monitoring procedures for quantification of each variable are to be based on the relevant quantification and calculation requirements presented in Section 8. As detailed in Section 8, monitoring of variables may include the use of models, physical field sampling, summation of operational records, and monitoring of relevant research, as specified for that specific variable. These standards represent the minimum monitoring requirements for each variable. Note that project proponents is expected to fully document project-specific details of the steps that will be taken to monitor each of the variables (eg, specific type of measurement approach used, specific procedure used where there is a choice, etc.) in the full monitoring plan as part of a Project description developed for a their project.

For instances in which there is a risk that the primary monitoring procedures may not be able to be followed, either temporarily or permanently (eg, due to monitoring equipment failure, loss of comparable satellite remote sensing products due to satellite failure, etc.), it is recommended that the proponent establish in advance and document in the monitoring plan back-up (contingency) procedures for variables where this is a risk, to ensure continuity of verifiable data. Such procedures must meet the requirements specified in applicable quantification methods for the variable, presented in this methodology.

Where standards and factors from outside sources are used to derive GHG emissions estimates, they must if possible meet the following criteria:

- Be publicly available from a reputable and recognized source
- Have been subject to competent peer review prior to being made publicly available
- Be appropriate for the GHG source or sink concerned
- Be current at the time of quantification

When standards or factors have a high degree of uncertainty, conservative values must be selected to ensure that quantification does not lead to an over-estimation of GHG emission reductions or removals.

The Monitoring Plan must detail how the following will be monitored:

- Project implementation
- Accounted pools and emissions, as chosen in section 5.2.2
- Natural disturbance
- Leakage

Prepare a Monitoring Plan describing how these tasks will be implemented. For each task the monitoring plan must include the following sections:

- ix. Purpose of the monitoring
- x. Technical description of the monitoring task.
- xi. Data to be collected.
- xii. Overview of data collection procedures.
- xiii. Frequency of the monitoring
- xiv. Quality control and quality assurance procedure.
- xv. Data archiving.
- xvi. Organization and responsibilities of the parties involved in all the above.

### 9.3.1 Project Implementation Monitoring

The rationale of monitoring project implementation is to document all project activities implemented by the project activity (including leakage prevention measures) that could cause an increase in GHG emissions compared to the baseline scenario.

The monitoring plan must detail procedures to:

- Describe, date, and geo-reference, as necessary, all measures implemented as part of the project activity by project proponents.
- Collect all of the relevant data on the implementation of project activities which is required to estimate carbon stock changes under the project and baseline scenarios, as well as GHG emissions due to leakage prevention measures. Refer to the relevant modules for the variables to be measured.

State whether the measures implemented were anticipated in the project description, and if not, describe the reasons for the deviation from the project description.

### 9.3.2 Monitoring Accounted Pools and Emissions

The monitoring plan must detail:

- The estimation, modeling, measurement or calculation approaches to be used in monitoring each variable used to calculate an accounted pool or emission.
- How methods and procedures consistent with the requirements given in Section 8 of this methodology will be used to estimate the values of monitored variables.

- How a requirement for geographic re-stratification will be identified for monitored variables which vary across the project area, and how the re-stratification will be undertaken.
- The monitoring plan must include the following details:
- The standards to be used for derivation of data from remote sensing, if remote sensing is to be used. The standards given must be consistent with those used during the preparation of ex-ante projections.
- Procedures to be followed in the case that an improvement of the quality of data and data analysis methods becomes available during the crediting period.

### 9.3.3 Monitoring of Natural Disturbances

Natural disturbances such as tsunamis, sea level rise, volcanic eruption, landslide, flooding, permafrost melting, pest, disease, etc. can impact the area, carbon stocks and non-CO<sub>2</sub> GHG emissions of a project. Such changes can be abrupt or gradual and when significant, they must be factored-out from the estimation of ex post net anthropogenic GHG emission reductions. The monitoring plan must detail the steps to be used to monitor natural disturbance impacts, and factor them out, consistent with the following:

- Where natural disturbances reduce the area within which the project activities are undertaken, or within which they have effect, measure the boundary of the polygons lost from the project area and exclude the area within such polygons from the project area in both the baseline and project scenarios.
- Where natural disturbances have an impact on carbon stocks, measure the boundary of the polygons where such changes happened and the change in carbon stock within each polygon. Assume that a similar carbon stock change would have happened in the project area under the baseline case (if the polygon is already deforested in the baseline, assume no carbon stock change in the baseline).

### 9.3.4 Leakage Monitoring

Depending on methods and variables used to estimate sources of leakage in the ex-ante assessment, some variables may be subject to monitoring. The monitoring plan must detail the methods to be used to monitor these variables relevant to leakage.

### 9.3.5 Monitoring, Assessing, and Managing the Risk of Reversal

Proponents must use the latest version of the *VCS AFOLU Non-Permanence Risk Tool*, and the *VCS Non-permanence Risk Report Template*. Buffering of issued credits will take place through the established VCS mechanisms, based on these templates. Additionally, in the case of projects within the province of BC, the BC EOR requires that proponents of projects that involve removals by controlled sinks and avoided emissions from controlled reservoirs / pools prepare a risk

mitigation and contingency plan for the purposes of ensuring that the atmospheric effect of removals and avoided emissions from reservoirs / pools endures for at least 100 years (ie, to manage the risk of a reversal of carbon storage achieved by a project).

While the VCS risk assessment and buffer pool described above will form the basis of ensuring permanence, projects are also expected to prepare a Risk Mitigation and Contingency Plan to reduce the risk or scale of emissions from natural and human caused events.

As policies and legislation related to GHG emission reductions/removals evolve at the provincial and federal levels, the requirements of this section must be reviewed to ensure that risk mitigation planning is sufficient to ensure compliance with the relevant provincial climate change regulation.

#### 9.3.5.1 Risk Mitigation and Contingency Plan

The purpose of the Risk Mitigation and Contingency Plan is to minimize the likelihood that a natural or human-induced reversal event will occur up to 100 years into the future from the time an emission offset is created by the project. The plan must address at least the two core types of potential risks:

1. Natural disturbances

Forests are subject to a variety of natural disturbances that reduce growth and carbon storage. The risk of natural disturbance varies as a result of climate, tree age, tree species, topography and other factors. The exact location and extent of natural disturbances is difficult to predict. Nevertheless, it is possible to estimate the area that may be affected by different types of natural disturbance within a project area. The types of risk of reversal and the risk of each type must be quantified in the Risk Mitigation and Contingency Plan.

The plan must include a discussion of the history and level of risks from natural disturbances, taking into account the specific ecosystems and tree species involved in the project. Consideration must also be given to potential changes in the historical incidence or scale of these risks because of the impacts of climate change, and must identify responses to occurrences of these risks

Types of unavoidable risk of reversal that must be considered are:

- i. Wildfire
- ii. Disease or insect outbreak
- iii. Other episodic catastrophic events (eg, wind-throw from hurricane or other wind event)

The risk mitigation and contingency plan must identify both pro-active measures to minimize the potential emissions from these risks (for instance, fire response capacity and planning), as well as re-active planning (for instance, salvage of wind-throw,

reforestation of burned areas, etc.). The plan must also identify the methods that will be used to monitor the extent and severity of risk events which do occur.

2. Risks arising from human actions

Illegal harvesting must be considered 0% risk for the country. However, other types of human caused risks may include unplanned harvest, mining activity, or land use change.

The risk mitigation plan must address the likelihood of such events, and propose mitigation strategies to minimize the incidence or severity of such events where they are deemed to be possible within the project area.

The proponent must also ensure that the project description, and the ex-ante modelling of the project and baseline scenarios, reasonably reflects both the risks and responses identified in the Risk Mitigation and Contingency Plan. The plan must also identify the monitoring procedures which are to be used to assess the severity of any incidence of human caused risks.



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## APPENDIX A: THE BC PROVINCIAL BASE CASE APPROACH FOR ADDRESSING LEAKAGE FROM FOREST CARBON PROJECTS

Growing conditions, the destinations of wood, and tree type can vary considerably between the interior and coastal regions of British Columbia. In addition, areas in the southern interior of British Columbia can vary considerably from the northern interior. These differences impact the parameters of the leakage equation (Section 8.3.1.2.) and as such we examine base cases for the northern interior, southern interior and coastal regions separately.

Assumptions made for the base cases of both the coast and northern and southern interior reflect what are simple and representative offset projects in each respective region. Assumptions such as tree type, location, and product type can all impact the estimated leakage. As a result these calculations could be modified on a project to project basis by the proponent through using the leakage equation guidelines in FCOP and by referring to the base case scenarios.

A project timeline of 100 years is used since this is what project timelines are compared to in the B.C. Emission Offsets Regulation. To reflect this long-run market elasticities are used instead of short-run elasticities.<sup>80</sup> The market share of the base case offset project is assumed to be 1% ( $\Phi = .01$ )<sup>81</sup> of the total North America market. CR and CN are assumed to be the same and are given values of 1 as a conservative assumption to lower the chance of underestimating leakage.<sup>82</sup>

Proponents must be aware that these base case calculations are subject to periodic re-assessment, as provided in the most recent version of the VCS document Methodology Approval Process (Section 10.3.1 in version V4.0). Proponents must ensure that they include in their project calculations any changes which may have been made to these calculations as a result of this re-assessment.

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<sup>80</sup> A short-run elasticity measures the current month effect of a change in one variable on lumber supply or demand. As such short-run elasticities capture market reactions within the current month. Long-run elasticities are normally more elastic (further from zero) than short-run due to the positive sum effects of lagged dependent variables. In short-run elasticities, demand and supply relations cannot be ensured to be among the estimated co-integration relations. That is to say, consumers may not be able to respond to the changes in market price due to supply and demand shifting right away, there is a lag. Only long-run elasticities can capture the lag. Given the nature of the leakage issue in this case, it is more appropriate to use long-run elasticities.

<sup>81</sup> This is strictly an assumption to show the impact of a small carbon offset project relative to the total market. However, even increasing a projects size to  $\Phi = .1$ , or 10%, only reduces leakage by 2%. Reducing  $\Phi$  further has even less effect. Overall  $\Phi$  has a minimal impact on the equation.

<sup>82</sup> Given the favourable growing conditions throughout much of B.C. in contrast to the rest of North America it would not be unreasonable to assume that  $C_R > C_N$ . As the gap between  $C_R$  and  $C_N$  increases in favour of  $C_R$  leakage will decrease.

**APPENDIX B: EXAMPLE SUBSTITUTABILITY EQUATIONS**

The substitution parameter in Murray *et al.* (2004) measures the rate of response of quantity demanded of product *N* due to the quantity change of product *R*. Hence, in order to get the substitution parameter from cross price elasticity, the following calculation is applied:

Substitution parameter = cross price elasticity for product *R*\* inverse of own price elasticity of product *R*

$$S = \frac{dq_N/q_N}{dq_R/q_R} = \frac{dq_N/q_N}{dp_R/p_R} \times \frac{dp_R/p_R}{dq_R/q_R}$$

The substitutabilities of low/moderately substitutable wood (imperfect substitutes) in this paper are calculated based on the references listed below:

Table 26: Own- And Cross-Price Elasticities Of Demand For Softwood Lumber Products, US: Jan. 1989 To July 2001.\*

Percentage effect on the quantity demanded of	For a 1% change in the price of					
	SPF	SYP-U	SYP-R	DF	WSP	Other
SPF	-0.6196**	0.2365**	0.0015	0.0223	0.2985**	0.0608
	(0.022)	(0.015)	(0.012)	(0.014)	(0.013)	(0.035)
SYP-U	0.3985**	-0.7189*	-0.0420	0.0070	0.3811**	-0.0257
	(0.025)	(0.035)	(0.024)	(0.018)	(0.020)	(0.056)
SYP-R	0.0093	-0.1569	-1.7949**	2.0646**	0.2163	-0.3384
	(0.076)	(0.089)	(0.234)	(0.178)	(0.211)	(0.381)
DF	0.0661	0.0123	0.9707**	-1.6226**	0.3994**	0.1741
	(0.040)	(0.031)	(0.084)	(0.147)	(0.142)	(0.227)
WSP	0.3460**	0.2622**	0.0398	0.1565**	-1.1059**	0.3014**
	(0.015)	(0.013)	(0.039)	(0.056)	(0.072)	(0.101)
Other	0.0837	-0.0210	-0.0740	0.0810	0.3577**	-0.4275*
	(0.048)	(0.045)	(0.083)	(0.105)	(0.120)	(0.192)

\*\* and \* indicate significance at the 1% and 5% levels, respectively. Figures in parentheses are standard errors:  $SE(\eta_{ij}) = SE(\beta_{ij})/m_i$  (Binswanger 1974, Pindyck 1979)

Source: Nagubadi et al. (2004)<sup>83</sup>

Table 27: Long-Term Elasticities Of Demand For US Softwood Lumber Imports From Canada By Species

	Elasticities							
	P <sub>d</sub>	Y	Spruce	Pine	Fir	Hemlock	Red Cedar	Others
Spruce	2.33*	0.63*	-2.76*	0.16	0.20	0.13	0.11	0.20
	(0.76)	(0.07)	(0.57)	(0.10)	(0.13)	(0.08)	(0.07)	(0.13)
Pine	2.33*	0.63*	2.73*	-6.33*	0.53*	0.33*	0.29*	0.53*
	(0.76)	(0.07)	(0.74)	(0.95)	(0.14)	(0.09)	(0.08)	(0.14)
Fir	2.33*	0.63*	-1.07*	-1.17*	-0.31	-0.13*	-0.11*	-0.21*
	(0.76)	(0.07)	(0.48)	(0.08)	(0.32)	(0.06)	(0.05)	(0.09)
Hemlock	2.33*	0.63*	1.14	0.18	0.22	-3.83*	0.12*	0.22
	(0.76)	(0.07)	(0.62)	(0.10)	(0.12)	(0.71)	(0.06)	(0.12)
Red Cedar	2.33*	0.63*	-0.57	-0.09	-0.11	-0.07	-1.03*	-0.11
	(0.76)	(0.07)	(0.45)	(0.07)	(0.09)	(0.05)	(0.15)	(0.09)
Others	2.33*	0.63*	-0.62	-0.10	-0.12	-0.08	-0.07	-1.01*
	(0.76)	(0.07)	(0.45)	(0.07)	(0.09)	(0.06)	(0.05)	(0.20)

NOTE: Numbers in parentheses are approximate standard errors that ignore possible correlation between the import shares and elasticities. Elasticity values indicate the price of imports of various species.

\*Significantly different from zero at the 5% significance level using a two-tailed test.

Source: Hseu and Buongiorno (1993)<sup>84</sup>

<sup>83</sup> Nagubadi, R.V., Zhang, D., Prestemon, J.P., and Wear, D.N. 2004. "Softwood Lumber Products in the United States: Substitutes, Complements, or Unrelated?". *Forest Science* 51(4):416-426.

<sup>84</sup> Hseu, J-S., and Buongiorno, J. 1993. "Price elasticities of substitution between species in the demand of US softwood lumber imports from Canada". *Canadian Journal of Forest Research* 23:591-597.

Only substitutable woods with the price elasticities that are higher than 5% significance level are considered in calculating the substitution parameters. For example, to calculate the substitution parameter for red cedar, we use the table from Hseu and Buongiorno (1993):

$$S_{red\ cedar} = \frac{E_{pine}}{E_{red\ cedar}} + \frac{E_{hemlock}}{E_{red\ cedar}} = \frac{.29}{-1.03} + \frac{.12}{-1.03} = -40\%$$

To calculate the substitution parameter for larch, the table from Nagubadi *et al.* (2004) is used:

$$S_{larch} = \frac{E_{wsp}}{E_{other}} = \frac{.3014}{-.4275} = -70\%$$

Note that the price elasticities of larch, ponderosa pine, redwood, white pine and other lumber were grouped together in the "Other" group in this reference.

**APPENDIX C: SUBSTITUTABILITY ESTIMATES FOR COMMERCIAL TREE SPECIES IN BRITISH COLUMBIA**

Please find the values for substitutability estimates for commercial tree species in BC in Table 28 below.

Table 28: Low And Moderately Substitutable Woods In BC<sup>85</sup>

Tree Species	Region	Substitutability
Red Cedar	Mostly Coast and Southern Interior	40%
Cypress/ Yellow Cedar	Mostly Coast and Southern Interior	40%
Ponderosa Pine	Mostly Southern Interior	70%
White Pine	Mostly Southern Interior	70%
Larch	Mostly Southern Interior	70%
Note: All other tree species are considered perfectly substitutable (100%)		

<sup>85</sup> For guidance on the derivation of these numbers, see the example given for Red Cedar in Appendix B.

## APPENDIX D: DERIVATION OF WOOD DENSITY FACTORS

Wood density factors for BC and Quebec timber species are given in Tables 8A and 8B of the methodology. The values given are for oven dry density per green volume ( $t/m^3$ ), and are derived from data found in the reference “J.S. Gonzalez. Wood density of Canadian tree species. Edmonton: Forestry Canada, Northwest Region, Northern Forestry Centre, 1990, Inform. Rept. NOR-X-315.” The Gonzalez study is a meta-study summarizing research into wood densities for Canadian timber species.

The values given in Tables 8A, and 8B are the averages of the green volume values measured for trees grown in BC and QC, with the following adjustments:

1. Trembling Aspen. For this species values from across Canada were used, since only one value was available for BC, and this value was excluded as discussed in point 2 below.
2. Exclusion of outliers. After review of the data, the decision was made to exclude the values derived from the study undertaken by Standish (Standish, J.T. 1983. Development of a system to estimate quality of biomass following logging in British Columbia forests to specified recovery criteria. Report prepared for the Canadian Forestry Service, Ottawa, Ontario.), and included in the Gonzalez paper. The Standish values were consistently higher than those found by other researchers, and were felt to be outlier values, probably due to the techniques used by that researcher.



**APPENDIX E: BC TIMBER HARVESTING VOLUME BY SPECIES AND REGION**

Please find the values for timber harvest volume by species and region in Table 29 below.

Table 29: Timber Harvesting Volume Proportion Five-Year Average (2006-2010)<sup>86</sup>

Coast	
Alder	0.6%
Balsam	9.3%
Cedar	22.4%
Cottonwood	0.3%
Cypress	2.9%
Fir	30.1%
Hemlock	32.3%
Lodgepole Pine	0.2%
Maple	0.1%
Spruce	1.6%
White Pine	0.1%
Northern Interior	
Aspen	7.0%
Balsam	5.9%
Birch	0.1%
Cedar	0.5%
Cottonwood	1.1%
Fir	0.7%
Hemlock	2.4%
Lodgepole Pine	61.7%
Spruce	20.6%
Southern Interior	
Aspen	0.3%
Balsam	4.6%

<sup>86</sup> Information derived from the Harvest Billing System (HBS) for British Columbia, which is managed by the Ministry of Forests, Lands and Natural Resource Operations. (<https://www.for.gov.bc.ca/hva/hbs/>)

Birch	0.1%
Cedar	2.9%
Fir	9.6%
Hemlock	1.7%
Larch	1.5%
Lodgepole Pine	62.6%
Spruce	16.2%
White Pine	0.2%
Yellow/Ponderosa Pine	0.3%

**APPENDIX F: DERIVATION OF HWP RETENTION FACTORS, AND DISCARDED HWP CH<sub>4</sub> EMISSION FACTORS**

HWP retention factors were derived for the provinces of BC and Quebec, and are given in Tables 9 and 11 of the methodology, while CH<sub>4</sub> emission factors for discarded HWP are given in Tables 14 and 16.

The factors contained in these tables were generated by a model based on work on HWP retention and emissions contained in three papers:

1. Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012
2. Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998
3. K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.

Using these papers, a model was built which projected HWP retention and emissions from discarded HWP for both North American markets, and overseas markets. The model used the following data and assumptions:

**North American markets**

1. Distribution of delivered log volumes to product categories. Figures used were taken from the Dymond<sup>87</sup> paper, and are shown in Table 30. Figures for the percentage of total harvest for the province of Quebec were taken from official data generated by the government of Quebec<sup>88</sup>.

**Table 30:** Distribution Of Delivered Wood Volumes To Product Categories For North American Markets

First processing facility	% of total harvest (BC)	% of total harvest (QC)	lumber	ply	panels	chips / blocks	Fuel	landfill	Total
Lumber mills	84.0%	53.4%	47.0%			35.0%	17.9%	0.1%	100.0%

<sup>87</sup> Table 3, Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012

<sup>88</sup> Percentages were calculated based on data from the table “*Intrants et extrants de l’industrie québécoise de transformation primaire du bois de 2008 à 2015*” of Gouvernement du Québec (2016). Ressources et industries forestières portrait statistique. Ministère des Forêts, de la Faune et des Parcs, 2016

Chip mills	5.0%	35.5%				96.3%	3.2%	0.5%	100.0%
Ply mills	8.0%	0.5%		51.0%	16.0%	24.0%	8.5%	0.5%	100.0%
panel mills	3.0%	8.7%			84.0%		15.5%	0.5%	100.0%
Net for BC			39.5%	4.1%	3.8%	36.1%	16.3%	0.2%	
Net for QC			26.0%	0.2%	7.4%	53.7%	12.4%	0.3%	

- Distribution of pulpwood to product categories by pulping method. Figures used were taken from the Dymond<sup>89</sup> paper, and are shown in Table 31

**Table 31:** Distribution Of Pulpwood To Product Categories By Pulping Method

	% of total input (BC)	% of total input (QC) <sup>90</sup>	paper	combustion	effluent
mechanical	12.0%	27.8%	93.0%	6.9%	0.1%
chemical	88.0%	72.2%	45.0%	53.9%	1.1%

- Distribution of products to uses. Figures used were taken from the Dymond<sup>91</sup> paper, and are shown in Table 32. Note that the “Other” category includes recycled materials.

**Table 32:** Distribution Of Products To Uses

Total products (BC)	Total products (QC)	Single family	Multi family	Com.	Other building	Furniture	Shipping	Landfill	C	
lumber	39.5%	26%	25.0%	1.5%	7.0%	25.0%	10.0%	10.0%	7.5%	1
ply	4.1%	0.2%	41.0%	3.0%	9.0%	25.5%	7.5%	2.0%	4.0%	8
panel	3.8%	7.4%	15.0%	2.0%	6.0%	16.0%	36.0%	1.0%	4.0%	2

<sup>89</sup> Table 5, Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012

<sup>90</sup> Calculated from data of Portrait statistique du Quebec (2015). Pag 69. Table where is described the number of facilities per paper fabrication industry subgroups.

<sup>91</sup> Table 7, Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012

paper	18.3%	31.3%							
fuel	33.9%	34.3%							
landfill	0.2%	0.3%							
effluent	0.4%	0.4%							
	100.00%	100%							

- Destiny of discarded wood products. Figures used were taken from the Skog<sup>92</sup> and Dymond<sup>93</sup> papers, and are shown in Table 33 below. Recycled solid wood products were modeled as recycling to the “Other” category shown in Table 32 above, except shipping, which recycled to itself. Data for paper was derived from Skog Table 6b. Because the total values in the Skog table added up to 101%, the value for paper was reduced to 34% (30% from Skog, plus a 4% adjustment to reflect the Dymond data), rather than 35%.

**Table 33: Destiny Of Discarded Wood Products**

	Burned	Recycled	Composted	Landfill	Dump	Total
Wood	14.0%	9.0%	8.0%	67.0%	2.0%	100.0%
Paper	14.0%	46.0%	5.0%	34.0%	1.0%	100.0%
Net of recycling						
Wood	15.38%		8.79%	73.63%	2.20%	100.0%
Paper	25.93%		9.26%	62.96%	1.85%	100.0%

<sup>92</sup> Tables 6a and 6b, K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.

<sup>93</sup> Page 5, Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012

- Decay parameters in landfills and dumps. Values used were derived from the Dymond<sup>94</sup> and Skog<sup>95</sup> papers, and are shown in Table 34 below.

**Table 34:** Decay Parameters In Landfills And Dumps

Landfills			Dumps	
% decaying	Half life	%CH4	Half life	%CH4 to CO2 through capture
23.0%	29	50%	16.5	85%
56%	14.5	50%	8.25	85%

**Overseas Markets**

- Amount of wood waste generated in developing country processing facilities. Based on the Winjum paper, 24% of wood was assumed to become waste during processing.
- Product outputs from delivered roundwood, based on inside bark volumes. These values were derived from the Winjum et. al.<sup>96</sup> paper, and are shown in Table 35.

<sup>94</sup> Page 7 and Table 9, Table 7, Caren C. Dymond, Forest carbon in North America: annual storage and emissions from British Columbia’s harvest 1965 - 2065, Carbon Balance and Management 7:8, 2012

<sup>95</sup> Table 7, K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.

<sup>96</sup> Table 5, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998

**Table 35: Product Outputs From Delivered Roundwood**

			% of products	% of delivered roundwood
% Production	sawnwood	26	38.24%	29.06%
	wood panels	6	8.82%	6.71%
	other roundwood	22	32.35%	24.59%
	Paper/paperboard	14	20.59%	15.65%

3. Fraction of total HWP by type falling into the “short-lived” category. Values for this variable were derived from the Winjum et. al.<sup>97</sup> paper by subtracting the percentage noted in the paper as going into long term products from the total (100%) Because the VCS accounts “short-lived” as less than or equal to 3 years, while the Winjum et. al. paper uses 5 years, the resulting values were multiplied by 3/5. This approach has commonly been used in developing VCS estimates based on the Winjum paper. The results are shown in Table 36.

**Table 36: “Short-Lived” HWP By Category**

		Fraction of total HWP by category
Short lived	sawnwood	12%
	wood panels	6%
	other roundwood	18%
	Paper/paperboard	24%

4. Fraction of remaining HWP falling into the “medium-lived” category. The percentage of HWP remaining after elimination of the “short-lived” fraction which fall into the “medium-lived” category are shown in Table 37. The data used for this value was derived from the Winjum et. al paper by determining the amount expected to be remaining after 100 years, and calculating the equivalent half life. Because the majority of BC and QC overseas wood was expected to go to tropical or

<sup>97</sup> Page 276, Step 3, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998

subtropical destinations (southern China, south east Asia, etc.), the values given in Winjum et. al.<sup>98</sup> for tropical use were used.

**Table 37:** Fraction Of Remaining HWP In The “Medium-Lived” Category.

	Fraction of non- short-lived HWP by category	Half life
Sawnwood	86%	34
Woodbase panels	98%	17
Other roundwood	99%	9
Paper	99%	7

5. Destiny of discarded wood products, and decay parameter. The same figures were used as those used for North American HWP, shown in Tables 33 and 34 above. Research indicated that recycling and disposal practices in major overseas markets were either already the same as those in North America, or were rapidly moving in that direction.

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<sup>98</sup> Table 2, Jack K. Winjum, Sandra Brown and Bernhard Schlamadinger, Forest Harvests and Wood Products: Sources and Sinks of Atmospheric Carbon Dioxide, Forest Science 44:2, 1998



**APPENDIX G: FOREST DISTRICTS BY REGION IN THE PROVINCE OF BC**

Forest Districts in the province of BC, used for identifying average tree species mix for the northern interior, southern interior and coastal regions of this province.

Table 38: BC Forest Districts by Region

Coast
Chilliwack
Campbell River
North Coast
North Island
Queen Charlotte Islands
Sunshine Coast
South Island
Squamish
Northern Interior
Fort Nelson
Fort St James
Kalum
MacKenzie
Nadina
Peace
Prince George
Skeena Stikine
Vanderhoof
Southern Interior
Arrow Boundary
Central Cariboo
Chilcotin
Columbia
Cascades
Headwaters
Kamloops

Kootenay Lake
100 Mile
Okanagan Shuswap
Quesnel
Rocky Mountain

**DOCUMENT HISTORY**

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