VCS Methodology

VM0034

British Columbia Forest Carbon Offset Methodology

Version 1.0

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Sectoral Scope 14

Methodology developed by:

Climate Action Secretariat

Ministry of Environment, Province of British Columbia

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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[1]
- CDM Tool 02 *Combined tool to identify the baseline scenario and demonstrate additionality*
- IPCC 2003 GPG for LULUCF
- ISO 14064-2[2]
- IPCC Guidelines for National GHG Inventories (2006)
- System of Measurement and Reporting for Technologies[3]
- *VCS Program Definitions*
- *VCS Program Guide*
- WRI / WBCSD GHG Protocol for Project Accounting[4]

1.2 Forestry-Specific Guidance and Methodologies

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

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[1] Turning the Corner, Canada's Offset System for GHG Guide for Protocol Developers, Draft for Consultation, Environment Canada (2008).

[2] 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).

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

[4] World Resources Institute / World Business Council for Sustainable Development, The GHG Protocol for Project Accounting, November, 2005.

[5] 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.

[6] British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009

[7] Climate Action Reserve, Forest Project Protocol Version 3.2, August 31, 2010

- Draft North American Forest Carbon Standard[8]
- IPCC 2006 Guidelines for Forest Land[9]
- VCS *Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*

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 the province of British Columbia (BC), Canada. The methodology's approach to quantification of carbon in forest carbon pools is based on the extensive scientific knowledge base which exists regarding the dynamics of BC forests. As such, it 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 BC. These models and protocols are well calibrated for the range of forest ecosystems in BC, and are consistent with national and Intergovernmental Panel on Climate Change (IPCC) standards.

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-specific project description.

The steps to be undertaken in developing a project under FCOP 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 or not 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

[8] For more information, see http://forestcarbonstandards.org/home.html

[9] IPCC, 2006 IPCC Guidelines for National GHG Inventories, Volume 4, Chapter 4: Forest Land, 2006

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. GHS sources are described in Table 1 below.

Table 1: GHG Sources included in this Methodology

GHG	Source/Sink	Included?	Explanation
CO_2	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_4	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_2O	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 offset 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)**. If 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**. FCOP 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 proponentss 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 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 EOR, or to avoid confusion with standard BC practices or usages. In these cases the definitions given in this methodology must be used.

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)[10]
Activities that increase carbon stocks in woody biomass (and in some cases soils) by establishing, increasing and/or restoring vegetative cover through the planting, sowing, and/or human-assisted natural regeneration of woody vegetation[11]. For the purposes of this methodology, ARR activities must take place on land that has not been Forest Land for at least

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[10] The term "afforestation" is used interchangeably with ARR within this methodology because "afforestation" is a defined term within British Columbia's Forest Inventory legislation.

[11] This definition is as given in the VCS Program Definitions v3.5. The most recent definition given by the VCS should be used.

20 years[12] prior to project commencement. (Note that to be considered “afforestation” the land must have been deforested for at least 50 years.)

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

CO_2 equivalent (CO_2e)
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
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.*[13] 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 (eg, tonnes of fuel consumed, tonnes of product produced)

Ex-ante
An analysis or quantification of future events or conditions

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[12] A 20 year period was selected as a timeframe that is long enough not to overlap with typical commercial reforestation / natural regeneration timelines (which could exceed 10 years in some cases) without being so long as to be prohibitively restrictive.

[13] This definition is as given in the VCS Program Definitions v3.5. The most recent definition given by the VCS should be used.

Ex-post
An analysis or quantification of past events or conditions

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 proponentss 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[14]:

An area:

- 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 Methodology: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6)

Harvested wood products
Equivalent to "wood products" as defined in the VCS *Program Definitions*

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

[14] http://cfs.nrcan.gc.ca/pages/97

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*. 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

REDD (Reduced Emissions from Deforestation and Degradation) (equivalent to Conservation / Avoided Deforestation)
Activities that reduce GHG emissions by slowing or stopping the conversion of forest land to non-forest land.[15] Logging as part of forest management is not included as a potential conversion /

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[15] This definition is as given in the VCS Program Definitions v3.5. The most recent definition given by the VCS should be used.

deforestation activity that may be avoided under this definition. However, REDD projects are not prevented from including a planned harvest cycle as part of the project activity.

Registered professional
An applied scientist who is:

- Registered and in good standing in British Columbia with an appropriate professional organization constituted under an Act, acting under the association's code of ethics and subject to disciplinary action by that association, 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 the Province of British Columbia, Canada.
2. The project start date must be after November 29, 2007.
3. Project activities must comply with the BC EOR.
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, and is required to apply the BC Chief Forester's Standards for Seed Use[16].
6. This methodology applies to the following VCS project categories:
    - Afforestation, Reforestation and Revegetation (ARR)

[16] Available at http://www.for.gov.bc.ca/code/cfstandards/

- 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 stated applicability conditions:
   - ARR
     a) Project proponents must demonstrate that the project area has not been forest land for at least 20 years prior to project commencement.
   - IFM
     a) Project area must be forest land at the time of project commencement.
   - REDD
     a) 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, as per the latest version of the BC EOR.[17] 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.

[17] The relevant information was contained in section 3(2)(f) of the BC EOR as it existed on Dec. 6 2010.

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
    - Watercourses in area[18]

In addition to the above, project proponents 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:

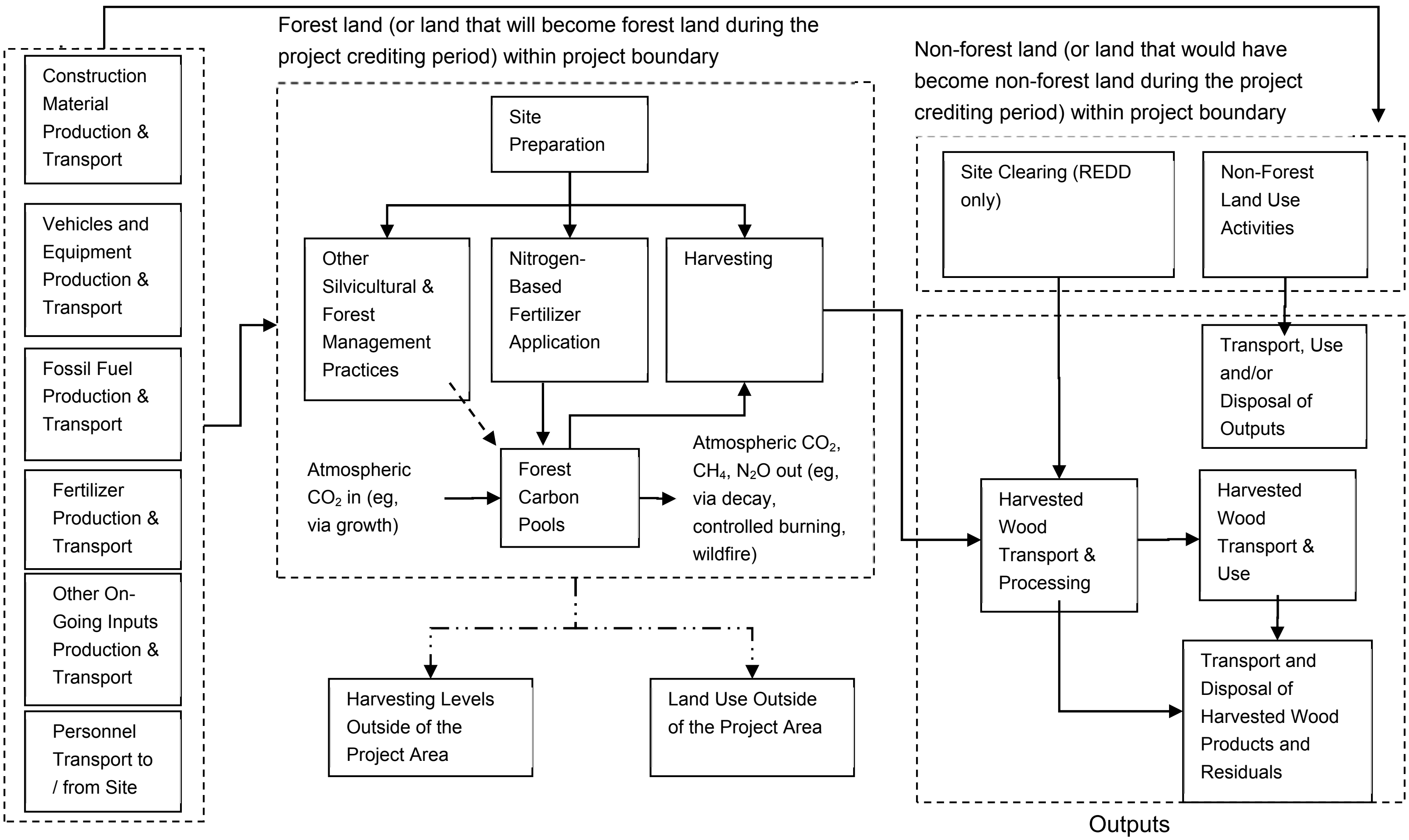
- For Crown lands:
    - Evidence that the area is licensed for timber production by the Crown
- For private lands
    - Registration under the Private Managed Forest Lands Act
    - Zoning as forestry land, or agricultural land based on the production of timber from a stand of trees meeting the national definition of a forest, for tax purposes

[18] 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.

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.

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, related or affected (C/R/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 Carbon Pools

On-site Controlled Carbon Pools			
PP1 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
PP2 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
PP3 Live Roots	Carbon pool	Portions of living trees, shrubs or herbaceous biomass located below-ground, principally roots.	Controlled
PP4 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
PP5 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
PP6 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
PP7 Soil	Carbon pool	Belowground carbon not included in other pools, to a depth appropriate considering the full project-specific	Controlled

		soil profile and potential project effects on soils.	
PP8 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[19]
PP9 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

[19] 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 Emission Sources

Name	Source	Description	Accounted GHGs	Controlled, related or affected
Upstream Related Emission Sources				
PE3 Fossil Fuel Production	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_2, CH_4, and N_2O	Related
PE4 Fertilizer Production	Source	Emissions resulting from raw material extraction through to final production of fertilizers that are used throughout the project.	CO_2, CH_4, and N_2O	Related
PE6 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_2, CH_4, and N_2O	Related
On-site Controlled Emission Sources				
PE7 Fossil Fuel Combustion – Vehicles and Equipment	Source	Emissions from vehicles and equipment which burn fossil fuels.	CO_2, CH_4, and N_2O	Controlled
PE8 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_4, and N_2O	Controlled
PE9 Fertilizer Use	Source	Emissions of N_2O resulting from fertilizer application.	N_2O	Controlled

Emissions				
PE10 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_4, and N_2O	Controlled
Downstream Related Emission Sources				
PE11 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_2, CH_4, and N_2O	Related
PE12 Harvested Wood Processing	Source	Emissions resulting from energy used to process wood from raw logs to finished product.	CO_2, CH_4, and N_2O	Related
PE13 Harvested Wood Combustion	Source	Emissions resulting from the combustion of harvested wood for energy.	CH_4, and N_2O	Related
PE15 Harvested Wood Products and Residuals Anaerobic Decay	Source	Emissions of methane resulting from the decomposition of wood product under anaerobic conditions in landfills.	CH_4	Related

Table 4: Affected Project SSPs

Name	Source	Description	Controlled, related or affected
Affected SSPs			
PE16 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 (PP 1)	Y	Y	Y	Y	Y	Y	Y	Y	Y
Above-ground non-tree biomass (PP 2)	S	N	N	N	N	N	O	O	O
Below ground biomass (Live roots) (PP 3)	S	O	O	O	O	O	O	O	Y
Litter and forest floor (PP 6)	S	S (Note 1)	S (Note 1)	S (Note 1)	S (Note 1)	S (Note 1)	N	N	O
Dead wood (standing PP 4 and lying PP 5)	S	Y	Y	Y	O	O	O	O	Y
Soil (PP 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 8 and in landfill PP 9)	Y	Y	Y	Y	Y	Y	Y	Y	Y

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 overstimation 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 fuels and fertilizers (PE 3 and PE 4)	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 power equipment and transport (PE 6 and PE 7)	Y	S (Note 3)	S (Note 3)	S (Note 3)	S (Note 3)	Y	S	S	S
Emissions from fertilizer application (PE 9)	Y	N	N	N	N	Y	N	N	N

Emissions from biomass burning and forest fires (PE 8 and PE 10)	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 11)	S (Note 3)	Y	Y	Y	Y	S (Note 3)	Y	Y	Y
Harvested wood processing (PE 12)	S (Note 3)	Y	Y	Y	Y	S (Note 3)	Y	Y	Y
Harvested wood products and residuals anaerobic decay (PE 15)	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 overstimation 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

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*[20]

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.

[20] 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:
    i. 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 should be identified separately. Plausible combinations of these should 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 should 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 a BC context.
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:

1. 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;
2. 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;

3. 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;
4. A government/officially approved financial benchmark where it can be demonstrated that such financial benchmarks are used for investment decisions;
5. 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, than 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:

    ii. existing or proposed regulatory requirements relevant to any aspect of the baseline scenario;

    iii. provincial or federal incentives relevant to any aspect of the baseline scenario, including tax incentives or grants that may be available;

    iv. the financial implications of carrying out a course of action referred to in the baseline scenario, and

    v. 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 project report is prepared by project proponents to calculate the net change in emissions and removals that have occurred since the previous project 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:

Net project emission reductions and removal enhancements in CO_2e

$$\Delta CO_2e_{net,t} = \sum_j \left(\Delta GHG_{j,net,t} \times GWP_j\right) \quad (1)$$

Where:

Parameter	Description	Default Value
$\Delta CO_2e_{net,t}$	The net emission reductions and removal enhancements, accounted as tonnes of CO_2e, achieved by the project during reporting period *t* as compared to the baseline. A net increase in emission reductions and removal enhancements is expressed as a positive number. Unit of measure: tCO_2e.	N/A
$\Delta GHG_{j,net,t}$	The net incremental emission reductions and removal enhancements of GHG *j*, in tonnes, achieved by the project during reporting period *t* as compared to the baseline. A net increase in emission reductions and removal enhancements is expressed as a positive number. Calculated in Equation 2. Unit of measure: t.	N/A

GWP_j	The global warming potential specified by the BC government for GHG *j*. Where projects are validated under VCS, the IPCC 100 year GWP factors given in the Second Assessment Report must be used[21]. Unit of measure: tCO_2e/t gas j	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

$\Delta GHG_{j,\,net,\,t}$ from Equation 1 is determined for each relevant GHG_j as follows:

Net project emission reductions and removal enhancements by GHG

$$\Delta GHG_{j,net,t} = \Delta GHG_{j,Project,t} - \Delta GHG_{j,Baseline,t} \qquad (2)$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{j,\,net,\,t}$	The net incremental emission reductions and removal enhancements of GHG *j*, in tonnes, achieved by the project during reporting period *t* as compared to the baseline. A net increase in emission reductions and removal enhancements is expressed as a positive number. Unit of measure: t.	N/A
$\Delta GHG_{j,\,Project,,\,t}$	The total emissions or removals of GHG *j*, in tonnes, occurring in the project during reporting period *t*. Calculated Using Equation 27, found in Section 8.2. Unit of measure: t.	N/A
$\Delta GHG_{j,\,Baseline,\,t}$	The total emissions or removals of GHG *j*, in tonnes, occurring in the baseline during reporting period *t*. Calculated using Equation 25. Unit of measure: t.	N/A

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.

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[21] As of Sept 2014 the appropriate values are 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. These values were re-iterated in the Fourth Assessment Report. The Fifth Assessment Report, page 714, contains alternative values based on assumptions about climate-carbon feedbacks, but notes that the uncertainties related to these effects are high. Therefore at this time the values contained in the Second Assessment Report must be used.

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 Standing Live Trees
- PP2/BP2 Shrubs and Herbaceous Understory
- PP3/BP3 Live Roots
- PP4/BP4 Standing Dead Trees
- PP5/BP5 Lying Dead Wood
- PP6/BP6 Litter & Forest Floor
- PP7/BP7 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 the baseline 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[22] or NFI[23] 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.
- 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.).

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[22] 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

[23] Canada's National Forest Inventory National Standard for Establishment of Ground Plots.

When sampling is conducted, results must be used to re-calibrate modeling outputs.[24]

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.

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)

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[24] 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.

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).

VRI data, and statistically valid ground sample data, will be used as the base inventory for project development. 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 VRI 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.[25]

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 7 are commonly used in British Columbia and are recommended for use by project proponents:

   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 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 7: Commonly Used Growth and Yield Models in BC

Model name	Range of applicability	
	Geographic/biogeoclimatic area*	Stand types
TASS[26]	Province-wide	Second growth, simple stands
TIPSY[27]	Province-wide	Second growth, simple stands
VDYP[28]	Province-wide	Natural stands
PrognosisBC[29]	IDF, ICH, ESSF, MS	Existing mixed species, complex stands

[25] 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.

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

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

[28] Variable Density Yield Prediction. See http://www.for.gov.bc.ca/hts/vdyp/ for further details.

[29] See http://www.for.gov.bc.ca/hre/gymodels/progbc/ for further details

Sortie-ND[30]	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

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 include FSSAM[31], FSOS[32], FSSIM[33], Patchworks[34], SELES-STSM[35], CASH6[36], Woodstock/Stanley[37], and LANDIS-II[38].

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)[39] and FORECAST (Kimmins et al., 1999)[40]. 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

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[30] See http://www.bvcentre.ca/sortie-nd for further details.
[31] Forest Service Spatial Analysis Model: http://www.barrodale.com/bcs/index.php/timber-supply-model
[32] Forest Simulation and Optimization System: http://www.forestecosystem.ca/technology_fsos.html
[33] Forest Service Simulator: http://www.cortex.org/case-mana-case17b.html
[34] http://www.spatial.ca/
[35] Spatially Explicit Landscape Event Simulator: http://www.seles.info/index.php/Main_Page
[36] Critical Analysis by Simulation of Harvesting version 6.21, Timberline Natural Resource Group Ltd.
[37] http://www.remsoft.com/
[38] See http://www.landis-ii.org/ for further details.
[39] 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.
[40] See http://www.forestry.ubc.ca/ecomodels/moddev/forecast/forecast.htm for further details.

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 the model. Plot or other data for calibration must be gathered using sound and reliable measurement methods consistent with VRI[41] or NFI[42] standards, or methods contained in validated VCS modules. In cases where model calibration has been completed, but confidence intervals are still wide (>+/- 10% 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. 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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[41] 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

[42] 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 audior:

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)[43].

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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[43] 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

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 BC. 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 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 methodologys, such as CAR v3.2 and the draft NAFCS, 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 current version of FCOP recognizes that significant portions of BC 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.

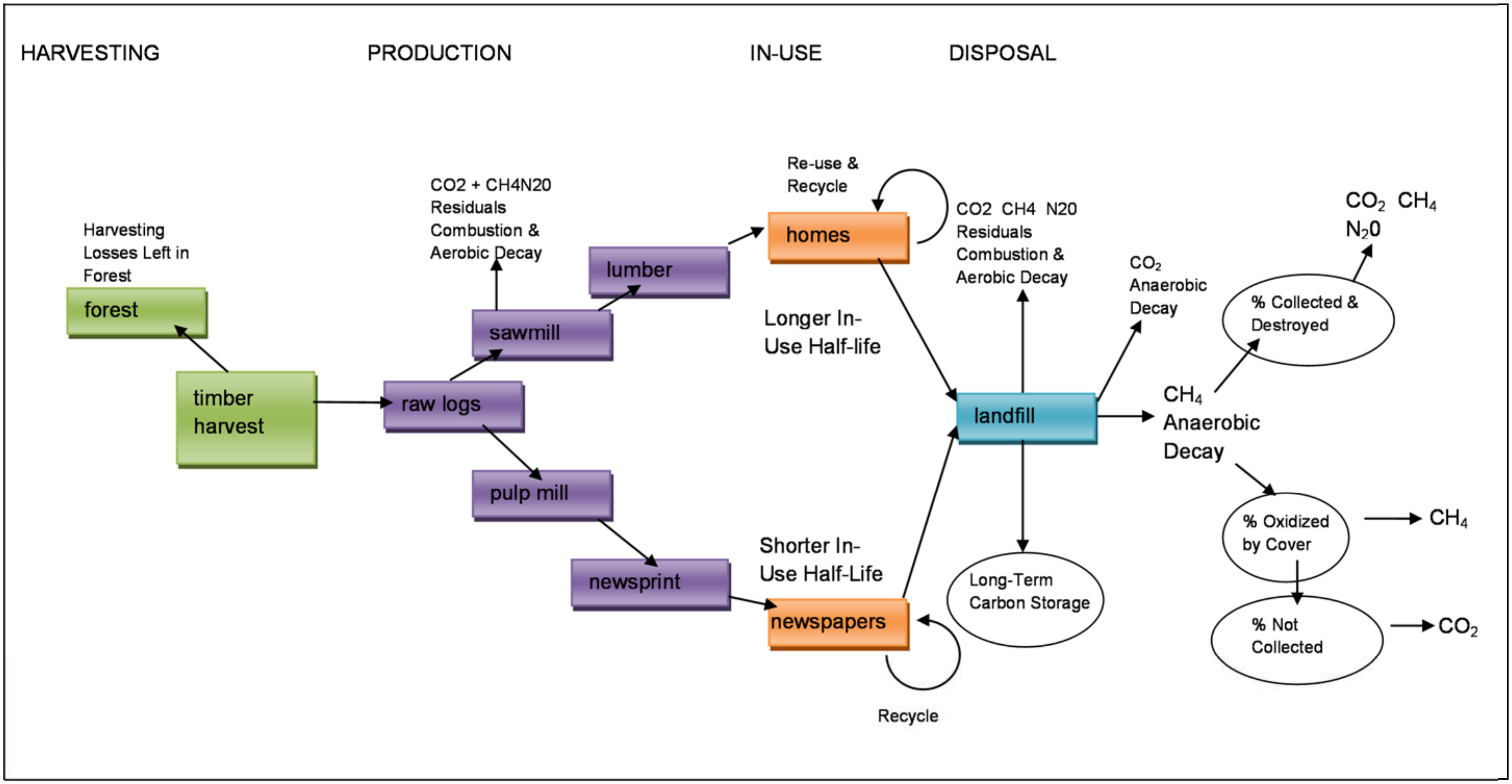
The proponent may choose one of the following two approaches for quantifying HWP storage:

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 then 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_2 with minor amounts of CH_4 and N_2O) and/or otherwise aerobically lost to the atmosphere as CO_2;

   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_2 with minor amounts of CH_4 and N_2O) and/or otherwise aerobically lost to the atmosphere as CO_2, 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_2 and CH_4 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[44], quantifying carbon storage in HWPs in use, and in landfills and dumps, for British Columbia forest products .

For HWP in use offshore, Winjum et al[45] provides general use and decay factors for developing world markets.

These two sources have been used to develop the figures given in Tables 9 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 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 3, and the standard wood density figures given in Table 8

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

$$RWbiomass_{y,d} = \sum_{s} vol_{s,y,d} \cdot wdf_s \qquad (3)$$

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). Unit of measure: t.	N/A
$Vol_{s,y,d}$	The volume of delivered roundwood of species *s* for each wood product destination *d*, extracted from the project area in year *y*, Unit of measure: m^3	N/A
wdf_s	The wood density factor for species *s*, from table 8. Unit of measure: t/m^3	Given in table 8

[44] 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.
[45] 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 8: BC-specific wood density factors (wdf) for oven-dry stemwood 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[46] ($t\ m^{-3}$)
Red alder (Alnus rubra)	0.37
Trembling aspen (Populus tremuloides)	0.38
Western red cedar (Thuja plicata)	0.32
Yellow cypress (Chamaecyparis nootkatensis)	0.42
Douglas-fir (Pseudotsuga menziesii)	0.44
True firs (Abies spp.)[47]	0.35
Western hemlock (Tsuga heterophylla)	0.42
Western larch (Larix occidentalis)	0.50
Lodgepole pine (Pinus contorta)	0.41
Ponderosa pine (Pinus ponderosa)	0.41
Spruce (Picea spp.)[48]	0.36
Sitka spruce (Picea sitchensis)	0.35

3. Convert tonnes of biomass to tonnes of CO_2,for each year, using equation 4.

Tonnes of CO_2 in delivered roundwood for year y

$$GrossHWPCO2_{y,d} = RWbiomass_{y,d} \cdot 22/12 \quad (4)$$

Where:

Parameter	Description	Default Value
$GrossHWPCO2_{y,d}$	The mass of CO_2 equivalent in delivered roundwood extracted from the project area in year *y*, for each wood product destination *d* (North America or offshore). Unit of measure: tCO_2e	N/A

[46] 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.
[47] The trees known in BC as “balsam” are true firs
[48] Spruce includes Engelmann Spruce, White Spruce, and Hybrid Spruce.

$RWbiomass_{y,d}$	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). Unit of measure: t.	N/A
22/12	The conversion factor from tonnes of biomass to tonnes of CO_2. Unit of measure: tCO_2e/t.	22/12[49]

4. Calculate the total GHGs (in tonnes CO_2), remaining in HWPs in use and in landfills, at a given time t, using equation 5.

Total GHGs remaining in HWPs derived from the project area up to time t (5)

$$GHG_{CO2,HWP,t} = \sum_{y<=t} (GrossHWPCO2_{y,NA} \cdot HWPfact_{NA,t-y} + GrossHWPCO2_{y,O} \cdot HWPfact_{O,t-y})$$

Where:

Parameter	Description	Default Value
$GHG_{CO2, HWP, t}$	Mass of carbon dioxide stored in project or baseline HWPs up to time *t*. Unit of measure: tCO2e	N/A
$GrossHWPCO2_{y,NA}$	The mass of CO_2 equivalent in delivered roundwood extracted from the project area in year *y*, destined for use in North America, in tonnes Unit of measure: tCO2e	N/A
$GrossHWPCO2_{y,O}$	The mass of CO_2 equivalent in delivered roundwood extracted from the project area in year *y*, destined for use outside of North America, in tonnes Unit of measure: tCO2e	N/A
$HWPfact_{NA,t-y}$	The factor, derived from table 9, for the percentage of CO_2 remaining after the number of years between harvest and time *t*, for products used in North America. Unit of measure: %.	Table 9
$HWPfact_{O,t-y}$	The factor, derived from table 9, for the percentage of CO_2 remaining after the number of years between harvest and time *t*, for products used outside of North America. Unit of measure: %.	Table 9

[49] Factor is derived from 44/12 (Conversion factor from C to CO_2) times 0.5 (% of biomass dry weight that is carbon)

Table 9: Fraction of CO_2 remaining in-use and in landfill per year – Derivation detailed in Appendix F[50]

Year	Products used in North America - % of total delivered C stored after y years	Products used offshore - % of total delivered C stored after y years
0	65.9%	76.0%
1	64.6%	72.7%
2	63.5%	72.4%
3	62.5%	72.1%
4	61.6%	71.0%
5	60.7%	69.8%
6	59.9%	68.6%
7	59.2%	67.4%
8	58.5%	66.2%
9	57.8%	65.1%
10	57.2%	63.9%
11	56.6%	62.8%
12	56.0%	61.6%
13	55.5%	60.5%
14	54.9%	59.4%
15	54.4%	58.3%
16	53.9%	57.3%
17	53.4%	56.2%
18	53.0%	55.2%
19	52.5%	54.2%
20	52.1%	53.2%
25	50.0%	48.4%

[50] 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)

30	48.1%	44.0%
35	46.4%	40.1%
40	44.8%	36.5%
45	43.4%	33.2%
50	42.0%	30.2%
55	40.7%	27.5%
60	39.5%	25.1%
65	38.3%	22.9%
70	37.2%	20.8%
75	36.2%	19.0%
80	35.2%	17.3%
85	34.2%	15.8%
90	33.3%	14.4%
95	32.4%	13.1%
100	31.6%	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_2 remaining in-use and in landfill per year, by product category – Derivation detailed in Appendix F[51]

	Products used in Canada - % of total delivered C stored after y years				Products used offshore - % of total delivered C stored after y years			
Year	Lumber mills	Plywood mills	Panel mills	Pulp/ Paper	Lumber	Wood panel	Other roundwood	Paper
0	64.9%	79.7%	84.5%	49.4%	76.0%	76.0%	76.0%	76.0%
1	63.6%	78.8%	84.1%	47.1%	73.8%	74.9%	72.7%	69.6%
2	62.5%	78.1%	83.8%	45.1%	73.6%	74.8%	72.4%	69.0%
3	61.5%	77.3%	83.5%	43.1%	73.5%	74.7%	72.2%	68.5%
4	60.6%	76.6%	83.1%	41.4%	73.0%	74.0%	70.8%	66.1%
5	59.7%	76.0%	82.8%	39.7%	72.5%	73.2%	69.5%	63.7%
6	59.0%	75.4%	82.5%	38.2%	72.0%	72.4%	68.1%	61.3%
7	58.2%	74.8%	82.1%	36.8%	71.4%	71.5%	66.8%	59.0%
8	57.5%	74.2%	81.8%	35.4%	70.9%	70.7%	65.5%	56.8%
9	56.9%	73.6%	81.5%	34.2%	70.4%	69.8%	64.2%	54.6%
10	56.3%	73.1%	81.2%	33.0%	69.8%	68.9%	62.9%	52.4%
11	55.7%	72.6%	80.8%	31.9%	69.2%	68.1%	61.6%	50.4%
12	55.1%	72.1%	80.5%	30.8%	68.7%	67.2%	60.3%	48.4%
13	54.6%	71.6%	80.2%	29.8%	68.1%	66.3%	59.0%	46.4%
14	54.0%	71.2%	79.9%	28.9%	67.5%	65.3%	57.8%	44.5%
15	53.5%	70.7%	79.5%	28.0%	66.9%	64.4%	56.6%	42.7%
16	53.0%	70.3%	79.2%	27.1%	66.3%	63.5%	55.4%	40.9%
17	52.6%	69.8%	78.9%	26.3%	65.7%	62.6%	54.2%	39.2%
18	52.1%	69.4%	78.6%	25.5%	65.1%	61.7%	53.0%	37.5%

[51] 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)

19	51.7%	69.0%	78.3%	24.7%	64.4%	60.7%	51.8%	35.9%
20	51.2%	68.6%	77.9%	24.0%	63.8%	59.8%	50.7%	34.4%
25	49.2%	66.6%	76.3%	20.8%	60.6%	55.2%	45.3%	27.6%
30	47.4%	64.8%	74.7%	18.1%	57.4%	50.7%	40.4%	22.0%
35	45.7%	63.1%	73.1%	15.8%	54.2%	46.4%	36.0%	17.5%
40	44.1%	61.5%	71.6%	13.8%	51.1%	42.3%	32.0%	13.9%
45	42.7%	59.9%	70.0%	12.1%	48.0%	38.5%	28.5%	11.0%
50	41.3%	58.4%	68.5%	10.7%	45.0%	34.9%	25.3%	8.7%
55	40.1%	57.0%	67.0%	9.4%	42.1%	31.6%	22.4%	6.8%
60	38.9%	55.6%	65.5%	8.2%	39.3%	28.5%	19.9%	5.4%
65	37.7%	54.3%	64.0%	7.2%	36.6%	25.7%	17.7%	4.3%
70	36.7%	53.0%	62.6%	6.4%	34.1%	23.1%	15.7%	3.4%
75	35.6%	51.8%	61.1%	5.6%	31.7%	20.8%	13.9%	2.6%
80	34.6%	50.6%	59.7%	4.9%	29.4%	18.7%	12.3%	2.1%
85	33.7%	49.4%	58.4%	4.4%	27.3%	16.7%	10.9%	1.6%
90	32.8%	48.3%	57.0%	3.9%	25.3%	15.0%	9.7%	1.3%
95	31.9%	47.2%	55.7%	3.4%	23.4%	13.4%	8.6%	1.0%
100	31.1%	46.1%	54.4%	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 BC Reporting Regulation, the quantification methodology, including relevant sampling, analysis and measurement requirements, may be used[52]. 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 emissions, as follows:

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[52] 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

General (emission factor) X (activity level) calculation

$$GHG_{j,Emission\ Source_i,t} = EF_{i,j} \times AL_i \times CF \quad (6)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ Emission\ Source,t}$	Emissions of GHG *j*, from Emission Source *i* during reporting period *t.* Unit of measure: t.	N/A
$EF_{i,j}$	The emission factor for GHG *j* and Emission Source *i*. Unit of measure: tonne CO_2/unit of activity or input/output	N/A
AL_i	The quantity of input/output or "activity level" for Emission Source *i* (eg, volume of fuel combusted, amount of fertilizer applied, etc.). Unit of measure: unit of activity or input/output.	N/A
CF	The 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. Unit of measure: ratio.	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 BC GHG Inventory should 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 PE3/BE3 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 X activity level approach described by Equation 6 and restated here:

PE3/BE3 fossil fuel production emissions

$$GHG_{j,PE3/BE3,t} = \sum_f EF_{fu,j} \times AL_{fu,t} \times CF_{fu} \quad (7)$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE3/BE3, t}$	Emissions of GHG *j*, from production of fossil fuels consumed by on-site vehicles and equipment during reporting period *t*. Unit of measure: t.	N/A
$EF_{fu, j}$	The emission factor for GHG *j* and fuel type *fu*. Note: it is likely that fuel production emission factors may only be available in units of CO_2e. Unit of measure ; t/unit of fuel	See below
$AL_{fu, t}$	The quantity of fuel of type *f* consumed by on-site vehicles and equipment during reporting period *t.* Unit of measure: Volumetric measure (eg, l, m^3, etc.) or mass measure (kg, t, etc.) with appropriate conversion	N/A
CF_{fu}	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 *f*. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: ratio.	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 should be consulted):

1. The BC Reporting Regulation
2. Latest version of the BC GHG Inventory Report
3. Latest version of Canada's National GHG Inventory Report
4. Latest version of the GHGenius transportation fuel lifecycle assessment model[53]

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_2e per GJ (HHV) of fuel.

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

[53] Available at http://www.ghgenius.ca/

5. 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 PE4/BE4 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 X activity level approach described by Equation 6 and restated here:

PE4/BE4 fertilizer production emissions

$$GHG_{j,PE4/BE4,t} = \sum_f EF_{f,j} \times AL_{f,t} \times CF_f \qquad (8)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE4/BE4,\ t}$	Emissions of GHG *j*, from fertilizer production applied during reporting period *t*. Unit of measure: t.	N/A
$EF_{f,\ j}$	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_2e. Unit of measure: t/t	See below
$AL_{f,\ t}$	The quantity of fertilizer of type *f* applied during reporting period *t.* Unit of measure: t, or other mass unit with appropriate conversion factor.	N/A
CF_f	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 *f.* Where both the activity level and emission factor are expressed in the same units, CF would be set to 1.	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 should be consulted):

1. The BC Reporting Regulation
2. Latest version of the BC GHG Inventory Report
3. Latest version of Canada's National GHG Inventory Report
4. Latest version of the GHGenius transportation fuel lifecycle assessment model

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_2e per kg of nitrogen-based fertilizer produced (not per kg of nitrogen). The emission factor provided is 2,792 g CO_2e / 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.

5. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data.

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 PE6/BE6 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 X activity level approach described by Equation 6 and restated here:

PE6/BE6 transport of material, equipment, inputs, and personnel to site emissions

$$GHG_{j,PE6/BE6,t} = \sum_m EF_{m,j} \times AL_{m,t} \times CF_m \quad (9)$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE6/BE6, t}$	Emissions of GHG *j*, from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*. Unit of measure: t.	N/A
$EF_{m, j}$	The emission factor for GHG *j* and transportation mode *m*. Unit of measure: t/unit of transported material.	N/A
$AL_{m, t}$	The quantity of materials, equipment, inputs, and personnel transported by mode *m* during reporting period *t.* Unit of measure: unit 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 a particular transport mode *m*. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: ratio.	N/A

Various approaches are available for selecting emission factors and activity levels for use in Equation 9, 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:

1. Distance and assumed fuel economy approach

This approach is described in the equation below:

PE6/BE6 distance and fuel economy approach

$$GHG_{j,PE6/BE6,t} = \sum_m \left[EF_{m,j} \times \sum_g \left(FE_m \times D_{m,g} \times C_{m,g,t} \div L_{m,g} \right) \times CF_m \right] \quad (10)$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE6/BE6, t}$	Emissions of GHG *j* from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*. Unit of measure: t.	N/A

$EF_{m,j}$	The emission factor for GHG *j* and fuel combusted by transportation mode *m* (eg, t CO_2 per L diesel). Unit of measure: t/unit of fuel.	See below
FE_m	Fuel economy of transportation mode *m* (eg, L / 100 km). Unit of measure: unit of fuel/unit of distance for a vehicle.	N/A
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport mode *m*. Unit of measure: kilometers	N/A
$C_{m,g,t}$	Total quantity of material, equipment, input, or personnel *g* transported using transport mode *m* during reporting period *t*. Unit of measure: Tonnes (or volume or other relevant units converted to tonnes).	N/A
$L_{m,g}$	Cargo load per transport vehicle of mode *m.* Unit of measure: Unit of quantity/vehicle.	N/A
CF_m	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 *m*. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: ratio.	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, should be used:

- Natural Gas – 0.0503 tCO_2e/gigajoule
- Gasoline – 0.002341 tCO_2e/litre
- Diesel – 0.002691 tCO_2e/litre
- Fuel Oil – 0.002735 tCO_2e/litre
- Propane – 0.001544 tCO_2e/litre

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.

2. Amount and distance shipped approach

This approach is described in the equation below:

PE6/BE6 amount and distance approach

$$GHG_{j,PE6/BE6,t} = \sum_m \left[EF_{m,j} \times \sum_g \left(D_{m,g} \times C_{m,g,t} \right) \times CF_m \right] \quad (11)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE6/BE6,\ t}$	Emissions of GHG *j*, from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*. Unit of measure: t.	N/A
$EF_{m,\ j}$	The emission factor for GHG *j* and the amount and distance shipped by transportation mode *m* (eg, g CO_2 per tonne-km). Unit of measure: t/quantity of transported good over a set distance.	See below
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport mode *m*. Unit of measure: kilometers	N/A
$C_{m,g,\ t}$	Total quantity of material, equipment, input, or personnel *g* transported the same distance using transport mode *m* during reporting period *t*. 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. Unit of measure: Tonnes (or volume or other relevant units converted to tonnes).	N/A
CF_m	The conversion factor to be used if the units of the various parameters do not match for a particular transport mode *m*. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: ratio.	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 should be consulted):

i. The BC Reporting Regulation

ii. Latest version of the BC GHG Inventory Report

iii. Latest version of Canada's National GHG Inventory Report

Truck freight transport emissions: emissions per tonne-km transported taken from the most recent version of the BC Freight Modal Shifting GHG Protocol[54]. 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_2e / 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[55]. 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_2 / 1,000 RTK; 0.02 kg CH_4 / 1,000 RTK; and 2.05 kg N_2O / 1,000 RTK.

iv. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data.

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.

8.1.2.5 PE7/BE7 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 by the activity level approach described by Equation 6 and restated here:

PE7/BE7 fossil fuel combustion – vehicles and equipment emissions

$$GHG_{j,PE7/BE7,t} = \sum_f \left[\sum_e \left(EF_{f,e,j} \times AL_{f,e,t} \times CF_{f,e} \right) \right] \quad (12)$$

Where:

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[54] 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

[55] 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

Parameter	Description	Default Value
$GHG_{j, PE7/BE7, t}$	Emissions of GHG *j*, from on-site vehicle and equipment fuel combustion during reporting period *t*. Unit of measure: t.	N/A
$EF_{f, e, j}$	The emission factor for GHG *j*, fuel type *f* and equipment/vehicle type *e* (eg, tonnes CO_2 per L diesel]. Unit of measure: t/unit of fuel.	See below
$AL_{f, e, t}$	The quantity of fuel of type *f* combusted in equipment/vehicle type *e* during reporting period *t*. Unit of measure: Volumetric measure (eg, l, m^3, etc.) or mass measure (kg, t, etc.) with appropriate conversion	N/A
$CF_{f,e}$	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 f and equipment/vehicle type *e*. Where both the activity level and emission factor are expressed in the same units, CF would be set to 1. Unit of measure: ratio.	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:

- Natural Gas – 0.0503 tCO_2e/gigajoule
- Gasoline – 0.002341 tCO_2e/litre
- Diesel – 0.002691 tCO_2e/litre
- Fuel Oil – 0.002735 tCO_2e/litre
- Propane – 0.001544 tCO_2e/litre

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 PE8/BE8 Biomass Combustion

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

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 X activity level approach described by Equation 6 and restated here:

PE8/BE8 biomass combustion emissions

$$GHG_{j,PE8/BE8,t} = \sum_b EF_{b,j} \times AL_{b,t} \times CF_b \quad (13)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE8/BE8,\ t}$	Emissions of GHG *j*, from biomass burning onsite during reporting period *t*. Note that for this SSP only CH_4 and N_2O are to be reported, as CO_2 is tracked as part of forest carbon pools. Unit of measure: t.	N/A
$EF_{b,\ j}$	The emission factor for GHG *j* and biomass type *b* (eg, tonnes CH_4 per tonne of brush burned). Unit of measure: t/t of biomass.	See below
$AL_{b,\ t}$	The quantity of biomass of type b combusted during reporting period *t.* Unit of measure: t of biomass, or other unit with appropriate conversion factor to t	N/A
CF_b	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 b. 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

Some biomass combustion emission factors are available in the BC Reporting Regulation, or BC or National Inventory Reports (in that order of preference, though note that at the time of methodology development such factors were not included in the BC inventory), and 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 more 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* should 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 should 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.

8.1.2.7 PE9/BE9 Fertilizer Use Emissions

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

Emissions of N_2O resulting from fertilizer application cannot be addressed using the standard emission factor X activity level approach described by Equation 6. Instead, good practice guidance (GPG) 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_2O Emissions from Fertilizer Use

The emissions of N_2O 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_3). 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 GHGes emissions from fertilizer application:

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

Total N_2O emissions related to fertilizer use is determined using the following equation:

PE9/BE9 fertilizer use emissions

$$GHG_{N2O,PE9/BE9,t} = N_2O_{direct,t} + N_2O_{indirect,t} \tag{14}$$

Where:

Parameter	Description	Default Value
$GHG_{N2O,PE9/BE9,t}$	Total emissions of N_2O as a result of nitrogen application within the project boundary. Unit of measure: tN_2O.	N/A
$N_2O_{direct,t}$	Direct emissions of N_2O as a result of nitrogen application within the project boundary. Calculated in Equation 15. Unit of measure: tN_2O.	N/A
$N_2O_{indirect,t}$	Indirect emissions of N_2O as a result of nitrogen application within the project boundary. Calculated in Equation 18. Unit of measure: tN_2O.	N/A

Approaches to determining direct and indirect emissions are described below.

1. Direct N_2O Emissions

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

Direct fertilizer use emissions

$$N_2O_{direct,t} = \left(F_{SN,t} + F_{ON,t}\right) \times EF_1 \times \frac{MW_{N_2O}}{MW_N} \tag{15}$$

Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers

$$F_{SN,t} = \sum_i^I M_{SFi,t} \times NC_{SFi} \tag{16}$$

Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers

$$F_{ON,t} = \sum_j^J M_{OFj,t} \times NC_{OFj} \tag{17}$$

Where:

Parameter	Description	Default Value
$N_2O_{direct,t}$	Direct emissions of N_2O as a result of nitrogen application within the project boundary. Unit of measure: tN_2O.	N/A
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year *t.* Unit of measure: tN.	N/A
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year *t.* Unit of measure: tN.	N/A
$M_{SFi,t}$	Mass of synthetic fertilizer of type *i* applied in year *t*, tonnes. Unit of measure: t.	N/A
$M_{OFj,t}$	Mass of organic fertilizer of type *j* applied in year *t*, tonnes. Unit of measure: t.	N/A
EF_1	Emission Factor for N additions from fertilizers. Unit of measure: tN_2O-N / tN input.	0.010
MW_{N_2O}	Molecular weight of N_2O. Unit of measure: g/mole.	44 g/mole
MW_N	Molecular weight of N_2. Unit of measure: g/mole.	28 g/mole
NC_{SFi}	Nitrogen content (mass fraction) of synthetic fertilizer type i applied, as specified by the manufacturer/supplier, or determined by laboratory analysis. Unit of measure: %.	N/A
NC_{OFj}	Nitrogen content (mass fraction) of organic fertilizer type j applied, as specified by the manufacturer/supplier,or determined by laboratory analysis. Unit of measure: %.	N/A
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 Nitrogen addition from fertilizers (EF_1) is 0.010 (1.0%) of applied N [56]. The default value for the fraction of synthetic fertilizer volatilized is 0.1 ($Frac_{GASF}$) and the default value for the fraction of organic fertilizer volatilized is 0.2 ($Frac_{GASM}$). These default values are to be used for quantifications in this methodology, unless BC / 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_2O Emissions

[56] Table 11.1, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

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

Indirect fertilizer use emissions

$$N_2O_{indirect,t} = \left(N_2O_{(ATD),t} + N_2O_{(L),t}\right) \times \frac{MW_{N_2O}}{MW_N} \quad (18)$$

Amount of N₂O-N produced from atmospheric deposition of N volatilized

$$N_2O_{(ATD),t} = [F_{SN,t} \times (Frac_{GASF}) + F_{ON,t} \times (Frac_{GASM})] \times EF_4 \quad (19)$$

Amount of N₂O-N produced from leachate and runoff of N

$$N_2O_{(L),t} = \left([F_{SN,t} + F_{ON,t}\right) \times Frac_{LEACH-(H)} \times EF_5 \quad (20)$$

Where:

Parameter	Description	Default Value
$N_2O_{indirect,t}$	Indirect emissions of N_2O as a result of nitrogen application within the project boundary. Unit of measure: tN_2O.	N/A
$N_2O_{(ATD),t}$	Amount of N_2O-N produced from atmospheric deposition of N volatilized, tonnes of NO_2 in year *t*. Unit of measure: tN_2O-N.	N/A
$N_2O_{(L),t}$	Amount of N_2O-N produced from leachate and runoff of N, tonnes of NO_2 in year *t*. Unit of measure: tN_2O-N.	N/A
MW_{N_2O}	Molecular weight of N_2O Unit of measure: g/mole.	44 g/mole
MW_N	Molecular weight of N_2 Unit of measure: g/mole.	28 g/mole
$F_{SN,t}$	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. Unit of measure: tN_2O-N / (tNH_3-N + tNO_x-N volatilised).	0.01
$Frac_{GASF}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers. Unit of measure: (tNH_3-N + tNO_x-N volatilised)/tN applied	0.1
$Frac_{GASM}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers. Unit of measure: (tNH_3-N + tNO_x-N volatilised)/tN applied	0.2

Parameter	Description	Default Value
$Frac_{LEACH-(H)}$	Fraction of N lost by leaching and runoff. Unit of measure: tN/tN 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. Unit of measure: tN_2O-N / tN 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_2O emissions from atmospheric deposition of nitrogen (EF_4) is 0.010 (of applied N)[57]. The default value for the emission factor for N_2O emissions from leaching and runoff (EF_5) is 0.0075.

The default value for the fraction of synthetic fertilizer volatilized is 0.1 ($Frac_{GASF}$) and the default value for the fraction of organic fertilizer volatilized is 0.2 ($Frac_{GASM}$).

The fraction of nitrogen lost by leaching and runoff ($Frac_{LEACH-H}$) 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 $Frac_{LEACH-H}$ = 0.30. 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_2O Emissions

Factor	Default Value	Uncertainty Range
EF_1, Emission Factor for N additions from fertilizers, tonne N_2O-N / tonne N input.	0.010	0.003 – 0.03
EF_4, Emission Factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, tonne N_2O-N / tonne N input.	0.010	0.002 – 0.05
EF_5, Emission factor for N_2O emissions from N leaching and runoff, tonne N_2O / tonne N input.	0.0075	0.0005 – 0.025
$Frac_{GASF}$, Fraction of Nitrogen that volatilizes as NH_3 and NO_x for	0.10	0.03 – 0.3

[57] Table 12, EF4, EF5, $Frac_{Gasm}$, $Frac_{Gasf}$ and $Frac_{Leach-(H)}$ are derived from Table 11.3, Chapter 11, Volume 4, 2006 IPCC Guidelines for National GHG Inventories

synthetic fertilizers.		
$Frac_{GASM}$, Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers.	0.20	0.05 – 0.5
$Frac_{LEACH-(H)}$, Fraction of N lost by leaching and runoff.	0.3	0.1 – 0.8

Uncertainties in estimates of direct and indirect N_2O 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.

8.1.2.8 PE10/BE10 Forest Fire Emissions

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

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

PE10/BE10 forest fire emissions

$$GHG_{j,PE10/BE10,t} = EF_{ff,j} \times AL_{ff,t} \times CF \qquad (21)$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE10/BE10, t}$	Emissions of GHG *j*, from forest fires during reporting period *t*. Note that for this SSR, only CH_4 and N_2O are to be reported, as CO_2 is tracked as part of forest carbon pools. Unit of measure: t.	N/A
$EF_{ff, j}$	The emission factor for GHG *j* applicable to forest fires. Unit of measure: t/t.	See below
$AL_{ff,t}$	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. Unit of measure: t,or other unit with appropriate conversion factor to 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 b. 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: ratio.	N/A

Determining the emission factor

Guidance with respect to combustion emission factors for forest fires should be sought from the BC Reporting Regulation, or BC or National Inventory Reports (in that order of preference, though note that at the time of methodology development such guidance was not included in the BC inventory). In the absence of such 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 should 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 PE11/BE11 Harvested Wood Transport

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

An approach identical to that described for SSR PE6/BE6 is to be used to calculate emissions from SSR PE11/BE11, 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 PE6/BE6.

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 PE6/BE6.

8.1.2.10 PE12/BE12 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 the standard emission factor X activity level approach described by Equation 6 and restated here:

PE12/BE12 harvested wood processing

$$GHG_{j,PE4/BE4,t} = \sum_H EF_{H,j} \times AL_{H,t} \times CF_H \quad (22)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE12/BE12,\ t}$	Emissions of GHG *j* from production of primary harvested wood products from wood harvested during reporting period *t*. Unit of measure: t.	N/A
$EF_{H,\ j}$	The emission factor for GHG *j* and harvested wood product *H* produced (eg, CO_2 per quantity of raw harvested wood converted to wood product H). Note: for processes that rely solely on electricity, $EF_{H,\ j}$ is assumed to be zero due to BC's stated goal of net zero GHG emission electricity generation in the province and that the vast majority of BC harvested wood is processed in-province. Unit of measure: t/t.	N/A

$AL_{H,t}$	The quantity of harvested wood product *H* produced from wood harvested during reporting period t. Unit of measure: 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. Unit of measure: ratio.	N/A

Determining the emission factor

Where available, project proponents may use provincially or nationally approved standardized emission factors relevant for the harvested wood products produced from project and baseline harvested wood. Such factors should be tailored to BC-specific circumstances if possible, including appropriate reflection of the low carbon intensity of grid electricity generation in the province (which may be assumed to be zero for the purposes of this methodology).

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 PE7/BE7 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 PE15/BE15 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_2 and CH_4. This method focuses on determining the total amount of emissions that would result from HWPs decaying in landfill 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 then 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_2 is accounted for as part of SSRs PP8/BP8 and PP9/BP9, PE15/BE15 focuses only on CH_4.

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 23, and the standard wood density figures given in Table 13.

Tonnes of dry biomass in delivered roundwood per year, by wood product destination (23)

$$RWbiomass_{y,d} = \sum_{s} vol_{s,y,d} \cdot wdf_s$$

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). Unit of measure: t.	N/A
$Vol_{s,y,d}$	The volume of delivered roundwood of species *s* for each wood product destination *d*, extracted from the project area in year *y*. Unit of measure: m^3	N/A
wdf_s	The wood density factor for species *s*, from table 13. Unit of measure: t/m^3.	Given in table 13

Table 13: BC-Specific Wood Density Factors (Wdf) for Oven-Dry Stemwood to Convert from Inside-Bark Harvested Volume (M^3) to Mass – Derivation Detailed in Appendix D.

BC Species or genus	Wood density to

	2 significant figures[58] (t m^{-3})
Red alder (Alnus rubra)	0.37
Trembling aspen (Populus tremuloides)	0.38
Western red cedar (Thuja plicata)	0.32
Yellow cypress (Chamaecyparis nootkatensis)	0.42
Douglas-fir (Pseudotsuga menziesii)	0.44
True firs (Abies spp.)[59]	0.35
Western hemlock (Tsuga heterophylla)	0.42
Western larch (Larix occidentalis)	0.50
Lodgepole pine (Pinus contorta)	0.41
Ponderosa pine (Pinus Ponderosa)	0.41
Spruce (Picea spp.)[60]	0.36
Sitka spruce (Picea sitchensis)	0.35

3. Calculate the total CH_4 emissions (accounted as tonnes CO_2e), from wood products in landfills using equation 24

Total CH_4 emissions (in tonnes CO_2e) from landfilled HWPs derived from the project area up to time t (24)

$$GHG_{CH4PE15/BE15,t} = \sum_{y<=t} (RWbiomass_{y,NA} \cdot HWPCh4\,fact_{NA,t-y} + RWbiomass_{y,O} \cdot HWPCH4\,fact_{O,t-y})$$

Where:

Parameter	Description	Default Value
$GHG_{CH4PE15BE15,t}$	Mass of CH_4 emitted by the project or baseline HWPs in landfills up to year *t*. Unit of measure: tCO_2e.	N/A

[58] 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.
[59] The trees known in BC as “balsam” are true firs
[60] Spruce includes Engelmann Spruce, White Spruce, and Hybrid Spruce.

$RWbiomass_{y,NA}$	The dry mass of the delivered roundwood extracted from the project area in year *y,* used in wood products within North America. Unit of measure: t.	N/A
$RWbiomass_{y,O}$	The dry mass of the delivered roundwood extracted from the project area in year *y,* used in wood products offshore. Unit of measure: t.	N/A
$HWPCH4fact_{NA,t-y}$	The factor, derived from table 14, for the amount of CH_4 (accounted as CO_2e) emitted in a given year, equal to the number of years between harvest and time *t*, for products used in North America. Unit of measure: tCO_2e/ t wood biomass delivered	Table 14
$HWPCH4fact_{O,t-y}$	The factor, derived from table 14, for the amount of CH_4 (accounted as CO_2e) emitted in a given year, equal to the number of years between harvest and time *t*, for products used outside of North America. Unit of measure: tCO_2e/ t wood biomass delivered	Table 14

Table 14: CH_4 emissions by year, in CO_2e, as a percentage of the total wood biomass delivered, by use area – Derivation detailed in Appendix F[61]

	North America	Offshore
0	0.001%	0.001%
1	0.020%	0.000%
2	0.067%	0.100%
3	0.108%	0.096%
4	0.141%	0.092%
5	0.169%	0.118%
6	0.193%	0.140%
7	0.212%	0.159%
8	0.228%	0.175%
9	0.242%	0.189%
10	0.252%	0.200%

[61] 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)

11	0.261%	0.210%
12	0.268%	0.218%
13	0.273%	0.225%
14	0.277%	0.230%
15	0.279%	0.234%
16	0.281%	0.237%
17	0.282%	0.239%
18	0.282%	0.240%
19	0.282%	0.240%
20	0.281%	0.240%
25	0.272%	0.232%
30	0.258%	0.216%
35	0.244%	0.198%
40	0.230%	0.179%
45	0.217%	0.161%
50	0.205%	0.145%
55	0.195%	0.130%
60	0.185%	0.116%
65	0.177%	0.105%
70	0.169%	0.094%
75	0.163%	0.085%
80	0.156%	0.076%
85	0.151%	0.069%
90	0.146%	0.062%
95	0.141%	0.057%
100	0.137%	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 V3.5). 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_4 emissions by year, in CO_2e, as a percentage of the total wood biomass delivered, by mill or product type and use area – Derivation detailed in Appendix F. [62]

	North America - by primary processing facility				Offshore - by end product			
Year	Lumber mills	Plywood mills	Panel mills	Chip/block mills	Sawnwood	Wood panels	Other industrial roundwood	Paper/ paperboard
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%

[62] 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)

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%
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 V3.5). 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 or removals are calculated using equations 25 and 26.

Total baseline emissions or removals by GHG (25)

$$\Delta GHG_{j,Baseline,t} = \left(GHG_{j,Baseline\ Forest\ Pools,t} - GHG_{j,Baseline\ Forest\ Pools,t-1}\right) + GHG_{CO2,Baseline\ HWP,t} - GHG_{j,Baseline\ Emission\ Sources,t}$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{j,\ Baseline,\ t}$	The total emissions or removals of GHG *j*, in tonnes, occurring in the baseline during reporting period *t* as compared to the baseline. Removals area expressed as a negative number, and emissions as	N/A

	a positive number. Unit of measure: tCO_2	
$GHG_{j, Baseline\ Forest\ Pools,\ t}$	The mass of GHG *j*, in tonnes, stored in baseline forest carbon pools (excluding HWPs) at the end of reporting period *t*. 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 baseline emissions, as calculated in this section, and project emissions, as calculated in section 8.2, noting that when using Option A, determination of $GHG_{j,\ Baseline\ Forest\ Pools,\ t}$ for times t>0 will require the use of modelling methods discussed under Option B. Only relevant for j = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{j, Baseline\ Forest\ Pools,\ t-1}$	The mass of GHG *j*, in tonnes, stored in baseline forest carbon pools (excluding HWPs) at the end of reporting period *t-1* (equivalent to the beginning of reporting period *t*). Determined using the same methods as those used for $GHG_{j,\ Baseline\ Forest\ Pools,\ t}$. Only relevant for j = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{CO2, Baseline\ HWP,\ t}$	The mass of GHG *j*, in tonnes, transferred to and stored in baseline HWP carbon pools during reporting period *t*. Determined using methods in Section 8.1.1.2,, with $GHG_{j,\ Baseline\ HWP,\ t} = GHG_{CO2,\ HWP,\ t}$ as calculated in equation 5, for the baseline scenario. Only relevant for j = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{j, Baseline\ Emission\ Sources,\ t}$	The mass of GHG *j*, in tonnes, emitted by the baseline during reporting period *t*. Calculated in Equation 26. Unit of measure: t.	N/A

$GHG_{j,\ Baseline\ Emission\ Sources,\ t}$ is determined for each relevant GHG *j* as follows:

Emissions from baseline sources

$$GHG_{j,Baseline\ Emission\ Sources,t} = \sum_i GHG_{j,BE_i,t} \quad (26)$$

Where:

Parameter	Description	Default Value
$GHG_{j, Baseline\ Emission\ Sources,\ t}$	The mass of GHG *j* emitted by the baseline during reporting period *t*. Unit of measure: t.	N/A
$GHG_{j,\ BE_i,t}$	Baseline emissions of GHG *j*, in tonnes, from SSR BE_i during reporting period *t*. BE_i must only include emissions sources deemed relevant based on the requirements of Section 5.3. Unit of measure: t.	N/A

8.3 Project Emissions

Total project emissions must be calculated using equations 27 and 28 below

Total project emissions or removals by GHG (27)

$$\Delta GHG_{j,Project,t} = \left(GHG_{j,Project\ Forest\ Pools,t} - GHG_{j,Project\ Forest\ Pools,t-1}\right) + GHG_{CO2,Project\ HWP,t} - GHG_{j,Project\ Emission\ Sources,t} - GHG_{j,Leakage,t}$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{j, Project, t}$	The total emissions or removals of GHG *j*, in tonnes, occurring in the project during reporting period *t*. Removals area expressed as a negative number, and emissions as a positive number. Unit of measure: tCO_2.	N/A
$GHG_{j, Project Forest Pools, t}$	The mass of GHG *j*, in tonnes, stored in project forest carbon pools (excluding HWPs) at the end of reporting period *t*. 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 this section, 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 $GHG_{j, Baseline Forest Pools, t}$ for times t>0. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{j, Project Forest Pools, t-1}$	The mass of GHG *j*, in tonnes, stored in project forest carbon pools (excluding HWPs) at the end of reporting period *t-1* (equivalent to the beginning of reporting period *t*). Determined using the same methods as those used for $GHG_{j, Project Forest Pools, t}$. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{CO2, Project HWP, t}$	The mass of GHG *j*, in tonnes, transferred to and stored in project HWP carbon pools during reporting period *t.* Determined using methods in Section 8.1.1.2,, with $GHG_{j, Project HWP, t} = GHG_{CO2, HWP, t}$ as calculated in equation 5, for the project scenario. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: t.	N/A
$GHG_{j, Project Emission Sources, t}$	The mass of GHG *j*, in tonnes, emitted by the project during reporting period *t* as compared to the baseline. Calculated in Equation 28 Unit of measure: t.	N/A
$GHG_{j, Leakage, t}$	The mass of GHG *j*, in tonnes, emitted from affected carbon pools during reporting period *t.* Determined in Section 8.3 Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: t.	N/A

$GHG_{j,\ Project\ Emission\ Sources,\ t}$ is determined for each relevant GHG *j* as follows:

Emissions from project sources

$$GHG_{j,Project\ Emission\ Sources,t} = \sum_i GHG_{j,PE_i,t} \qquad (28)$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ Project\ Emission\ Sources,\ t}$	The mass of GHG *j*, in tonnes, emitted by the project during reporting period *t*. Unit of measure: t.	N/A
$GHG_{j,\ PE_i,t}$	Project emissions of GHG *j*, in tonnes, from SSR PE_i during reporting period *t*. PE_i must only include emissions sources deemed relevant based on the requirements of Section 5.2. PE_i must be calculated based on the requirements of Section 8.1. Unit of measure: t.	N/A

8.3.1 Summing Carbon Pools within the Project Area

The total carbon in the carbon pools within the project area at a given time *t* for the project scenario must be estimated using Equation 29.

Summing Carbon Pools

$$C_{ProjectForestPools,t} = \sum_{ap} C_{ap,t} \qquad (29)$$

Where

Parameter	Description	Default Value
$C_{ProjectForestPools,t}$	Total carbon contained in forest carbon pools under the project scenario, at time *t*. Equal to $GHG_{j,\ Project\ Forest\ Pools,\ t}$, where j=$CO_2$, times 12 and divided by 44, to convert from CO2 to C. Unit of measure: tC.	N/A
$C_{ap,t}$	The carbon in an accounted pool within the project area at time *t,* as derived from the appropriate measurement or model output, as discussed in section 8.1.1.1. The precise measurement or modeling approach used will depend on the Option chosen, as described in that section. Methods used must be the same as those used to determine $GHG_{j,\ Project\ Forest\ Pools,\ t}$ in section 8.2. Unit of measure: tC.	N/A
ap	The accounted carbon pools for the project, as determined following the guidance given in section 5.	N/A

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** (called land use shifting leakage in earlier versions of FCOP). 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** (called harvest shifting leakage in earlier versions of FCOP). 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 30:

PE16 Leakage

$$GHG_{CO2,Leakage,t} = GHG_{CO2,\mathrm{PE16},t} = GHG_{CO2,Activity\ Shifting,t} + GHG_{CO2,Market,t} \qquad (30)$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,Leakage,t}$; $GHG_{CO2,\ PE16,\ t}$	The mass of GHG *j*, in tonnes, emitted from affected carbon pools during reporting period *t*. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: tCO_2e.	N/A
$GHG_{CO2,\ Activity\ Shifting,\ t}$	Total increase in project emissions due to activity shifting leakage from all affected carbon pools during reporting period *t*. See Section 8.3.1.1 for details. Unit of measure: tCO_2e.	N/A

$GHG_{CO2, Market, t}$	Total increase in project emissions due to market leakage from all affected carbon pools during reporting period *t*. See Section 8.3.1.2 for details. Unit of measure: tCO_2e.	N/A

If project proponents can demonstrate and document that:

- No internal activity shifting leakage has occurred, as detailed in 8.3.1.1 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*, then accounting of leakage may be omitted.

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.[63]
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.

[63] Requirements sourced from VCS AFOLU Requirements section 4.6.13

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^2 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 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 proponentss 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 two 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.

8.4.1.2.1 Market leakage (Method 1)

Market leakage – Method 1 **(31)**

$$GHG_{CO2,Market,t} = \max\{0, \Delta GHG_{CO2,ForestCarbonPools,t} + GHG_{CO2,HWPPools,t} - GHG_{CO2,ActivityShifting,t}\} \times \%Leakage_{Market}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ Market,\ t}$	Total increase in project emissions due to market leakage from all affected carbon pools during reporting period *t.* Unit of measure: tCO_2e.	N/A
$\Delta GHG_{CO2,\ Forest\ Carbon\ Pools,\ t}$	The net incremental mass of carbon dioxide, in tonnes, stored by the project in forest carbon pools (excluding HWPs) during reporting period *t* as compared to the baseline. Unit of measure: tCO_2e.	N/A
$\Delta GHG_{CO2,\ HWP\ Pools,\ t}$	The net incremental mass of carbon dioxide, in tonnes, stored in project HWPs harvested during reporting period *t* as compared to the baseline. Unit of measure: tCO_2e.	N/A
$GHG_{CO2,\ Activity\ Shifting,\ t}$	Total increase in project emissions due to activity shifting leakage from all affected carbon pools during reporting period *t.* Unit of measure: tCO_2e.	N/A
$\%Leakage_{Market}$	Total increase in project emissions due to market leakage during reporting period *t*, expressed as a percentage of the net removals to be achieved by the project from forest and HWP carbon pools relative to the baseline over the reporting period. Unit of measure: %.	N/A

8.4.1.2.2 Market leakage (Method 2)

$$GHG_{CO2,Market,t} = \max\{0, \Delta GHG_{CO2,Harvesting,t} + GHG_{CO2,HWPPools,t} - GHG_{CO2,ActivityShifting,t}\} \times \%Leakage_{Market} \quad \textbf{(32)}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ Market,\ t}$	Total increase in project emissions due to market leakage from all affected carbon pools during reporting period *t.* Unit of measure: tCO_2e.	N/A

$\Delta GHG_{CO2, Harvesting, t}$	The net incremental mass of carbon dioxide, in tonnes, removed from the project forest during reporting period *t* as compared to the baseline, via the following mechanisms: Physical removal of harvested wood from the project forest Harvesting-related losses that occur within the forest (eg, lost branches, tops, etc.) that are assumed to rapidly decay and release CO_2 to the atmosphere. Unit of measure: tCO_2e.	N/A
$\Delta GHG_{CO2, HWP Pools, t}$	The net incremental mass of carbon dioxide, in tonnes, stored in project HWPs harvested during reporting period *t* that will endure for a period of 100 years as compared to the baseline. Unit of measure: tCO_2e.	N/A
$GHG_{CO2, Activity Shifting, t}$	Total increase in project emissions due to activity shifting leakage from all affected carbon pools during reporting period *t*. . Unit of measure: tCO_2e.	N/A
$\%Leakage_{Market}$	Percentage increase in emissions due to market leakage during reporting period *t*, expressed as a percentage of the reduction in emissions due to harvest relative to the baseline over the reporting period. Unit of measure: %.	N/A

8.4.1.2.2.1. Estimating harvesting impacts for Method 2

Harvest impacts must be estimated using equation 33.

Harvesting impacts **(33)**

$$\Delta GHG_{CO2,Harvesting,t} = [\sum_s m_{s,t,Baseline} \times (ms_s / mh_s) - \sum_s m_{s,t,Project} \times (ms_s / mh_s)] \times f_{C,wood} \times \frac{MW_{CO2}}{MW_C}$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{CO2, Harvesting, t}$	The net incremental mass of carbon dioxide, in tonnes, removed from the project forest during reporting period *t* as compared to the baseline, via the following mechanisms: Physical removal of harvested wood from the project forest Harvesting-related losses that occur within the forest (eg, lost branches, tops, etc.) that are assumed to rapidly decay and release CO_2 to the atmosphere. Unit of measure: tCO_2e.	N/A

$m_{s,\ t,\ baseline}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in the baseline in reporting period *t* that will be processed into HWP *k*. This value is determined in a manner analogous to $Rwbiomass_{y,d}$ in Equation 3, Section 8.1.1.2, except that this mass is determined by species rather than by HWP type. Unit of measure: t.	N/A
ms_s	Average total mass of a standing tree of species *s* prior to harvest. Unit of measure: t.	See below
mh_s	Average mass of the harvested wood, minus bark, of a tree of species *s.* Unit of measure: t.	See below
$m_{s,\ t,\ project}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in the project in reporting period *t* that will be processed into HWP *k*. This value is determined in a manner analogous to $Rwbiomass_{y,d}$ in Section 8.1.1.2, except that this mass is determined by species rather than by HWP type. Unit of measure: t.	N/A
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon. Unit of measure: t/t.	Assumed to be 50% for all wood species.[64]
MW_{CO_2}	Molecular weight of CO_2. Unit of measure: g/mole.	44 g/mole
MW_C	Molecular weight of carbon. Unit of measure: g/mole.	12 g/mole
s	Relevant tree species types being harvested in the project and baseline area.	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 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 prefered method for deriving ms_s is to run an appropriate TIPSY 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.

8.3.1.2.3 Determining Percent Market Leakage

[64] IPCC GPG for LULUCF equation 3.2.3

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.

1. Provincial estimates of $\%Leakage_{Market}$ (Option 1)

   Project proponents can use a provincial leakage rate estimate from Table 17 below for the factor $\%Leakage_{Market}$ 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: 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 (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, 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 *%Leakage*$_{Market}$ (Option 2)

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

   The recommended approach for determining market leakage rates resulting from a project with a reduced harvest utilizes a formula proposed by Murray et al[65] as shown in Equation 34.

% leakage from external harvest shifting

$$\%Leakage_{Market} = \frac{(100*e*\gamma*C_N)}{([e-E*(1+\gamma*\Phi)]*C_R)} \quad (34)$$

Where:

Parameter	Description	Default Value
e	Supply price elasticity.	See Tables 18 and 19 Below
E	Demand price elasticity.	
C_N	Carbon sequestration reversal per unit of harvest from the non-reserved forest. Unit of measure: tC.	
C_R	Carbon sequestration per unit of (forgone) harvest gained by preserving the reserved forest. Unit of measure: tC.	
Φ	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.	
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 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

[65] Murray, B., et al. 2004. "Estimating Leakage from Forest Carbon Sequestration Programs". Land Economics 80(1): 109-124.

elasticity (E), and the carbon sequestration values (C_N and C_R) (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 Provincial Base Case Approach, and given here, are considered the best representation of current market 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
Demand price elasticity	E = -0.181	
Carbon sequestration per unit of (forgone) harvest gained by preserving the reserved forest.	C_R = 1	This is a conservative assumption. 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. 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.
Carbon sequestration reversal per unit of harvest from the non-reserved forest.	C_N = 1	

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 (Φ) and the substitutability parameter (γ).

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

Variable description	Equation Variable	Rationale
Preservation parameter – 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.	Φ	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.
Substitution Parameter – A parameter introduced into the referenced leakage equation to take into account specialty woods.	γ	For specialty woods with few substitutes, such as cedar, leakage is likely lower than for other readily substitutable woods. 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 Base Case Approach For Addressing Leakage from Forest Carbon Projects must be utilized, considering the location of the project.

Method for deriving a preservation parameter (Φ)

The preservation parameter (Φ) 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 provincial base cases. This is in line with Murray et al.'s general calculations. This value is used since it is unlikely 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

$$\Phi = \frac{Q_R}{Q_N} \quad (35)$$

Where:

Parameter	Description	Default Value
Q_R	Quantity of harvestable timber to be claimed on upcoming project verification. Unit of measure: m^3.	N/A
Q_N	Quantity of harvestable timber supply remaining in the market. Unit of measure: m^3.	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.[66] 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

$$\gamma = \sum_{i=1}^{n} T_i * S_i \quad (36)$$

Where:

Parameter	Description	Default Value
i	A specific tree type	N/A

[66] Refer to Provincial Base Case Approach for the Coastal Market for an example of the application of the substitutability parameter.

n	Number of tree types within the project Unit of measure: number.	N/A
T_i	Tree type *i*'s share of project's total marketable tree volume Unit of measure:%.	N/A
S_i	Substitutability of tree type *i*	N/A

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
Supply (e) and Demand (E) Elasticities	North American market data must be used when estimating elasticities for the purpose of determining leakage from projects in BC. 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. 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. This is to ensure B.C. is captured as the reference point The uniqueness of B.C. forests, and therefore a B.C. based project, will be captured by the substitution parameter. 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. Both market supply and market demand elasticities used in the FCOP leakage methodology must be long-run elasticity estimates.
Carbon sequestration values (C_N and C_R)	It is difficult/ impossible to predict where exactly C_N occurs in North America and what the justified value would be. Using 1:1 ratio is a conservative approach. Proponents choosing to develop their own leakage value must use a value of 1 for C_N and C_R in the leakage formula.

Preservation Parameter (Φ)	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. 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.
Substitutability Parameter (γ)	Proponents must follow the substitution guidelines given above when calculating their own substitution parameter. Proponents must demonstrate the tree species contribution/makeup within their project area. Proponents must demonstrate the substitutability of tree species in terms of potential wood products. 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.

8.5 Net GHG Emission Reductions and Removals

The equations for calculating total GHG emission reductions and/or removals are given in section 8 above. An alternative form of the final calculations is shown in equation 37 below.

Summation of GHG emission reductions and/or removals

$$\Delta CO_2e_{net,t} = \sum_j (\Delta GHG_{j,Baseline,t} \cdot GWP_j) - \sum_j (\Delta GHG_{j,Project,t} \cdot GWP_j) \qquad (37)$$

Where:

Parameter	Description	Default Value
$\Delta CO_2e_{net,t}$	Net *GHG* emissions reductions and/or removals in the period beginning at time *t-1* and ending at time *t*. Unit of measure: tCO_2e.	N/A
$\Delta GHG_{j,Baseline,t}$	Baseline emissions of GHG *j* in the period beginning at time *t-1* and ending at time *t*. Unit of measure: t.	N/A
$\Delta GHG_{j,Project,t}$	Project emissions of GHG *j* in the period beginning at time *t-1* and ending at time *t*, including leakage. Unit of measure: t.	N/A
GWP_j	The global warming potential of GHG *j*. Unit of measure: tCO_2e/t.	N/A

8.5.1 Net change in carbon stocks

For the purpose of quantifying the number of buffer credits withheld in the AFOLU buffer account, net change in carbon stocks must be calculated using equation 38.

Net change in carbon stocks

$$\Delta CO_2e_{net,stocks,t} = GHG_{j,ProjectForestPools,t} - GHG_{j,BaselineForestPools,t} \quad (38)$$

Where:

Parameter	Description	Default Value
$\Delta CO_2e_{net,stocks,t}$	Net change in carbon stocks at time *t* Unit of measure: tCO_2e.	N/A
$GHG_{j, Project Forest Pools, t}$	The mass of GHG *j*, in tonnes, stored in project forest carbon pools (excluding HWPs) at the end of reporting period *t*. Determined in Section 8.2. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: tCO_2e.	N/A
$GHG_{j, Baseline Forest Pools, t}$	The mass of GHG_j, in tonnes, stored in baseline forest carbon pools (excluding HWPs) at the end of reporting period *t*. Determined in Section 8.2. Only relevant for *j* = CO_2; otherwise, set to zero. Unit of measure: tCO_2e.	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. 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 39, below, will then be used to calculate the average *GHG* benefit.

Long term averaging of GHG benefit

$$LA = (\sum_{t=0}^{n}(\sum_{j}(\Delta GHG_{j,Baseline,t} \cdot GWP_j) - \sum_{j}(\Delta GHG_{j,Project,t} \cdot GWP_j))) \cdot n^{-1} \quad (39)$$

Where:

Parameter	Description	Default Value
LA	The long term average GHG benefit. Unit of measure: tCO_2e.	N/A
$\Delta GHG_{j,Baseline,t}$	Baseline emissions of GHG *j* n the period beginning at time *t-1* and ending at time *t.* Unit of measure: t.	N/A
$\Delta GHG_{j,Project,t}$	Project emissions of GHG *j* in the period beginning at time *t-1* and ending at time *t*, including leakage. Unit of measure: t.	N/A
GWP_j	The global warming potential of GHG *j.* Unit of measure: tCO_2e/t.	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 shall be determined using equation 40.

$$Credits_t = Min(LA, \Delta CO_2e_{net,t}) - Risk \cdot \Delta CO_2e_{net,stocks,t} \quad (40)$$

Where:

Parameter	Description	Default Value
$Credits_t$	Total credits available to time *t.* Unit of measure: tCO_2e.	N/A
LA	The long term average GHG benefit. Unit of measure: tCO_2e.	N/A
$\Delta CO_2e_{net,t}$	Net GHG emissions reductions and/or removals in the period beginning at time *t-1* and ending at time *t.* Unit of measure: tCO_2e.	N/A
Risk	Non-permanence risk rating as determined using the AFOLU Non-Permanence Risk Tool.	N/A
$\Delta CO_2e_{net,stocks,t}$	Net change in carbon stocks at time *t.* Unit of measure: tCO_2e.	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:

$$Credits_t = \Delta CO_2e_{net,t} - Risk \cdot \Delta CO_2e_{net,stocks,t}$$

9 MONITORING

9.1 Data and Parameters Available at Validation

Data / Parameter	$\%Leakage_{Market}$
Data unit	%
Description	Total increase in project emissions due to market leakage, expressed as a percentage of the net removals to be achieved by the project from forest and HWP carbon pools relative to the baseline over the reporting period.
Equations	Eq. 31
Source of data	From Provincial Leakage Base Case (See Appendix A)
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	Established by the provincial government based on an analysis of leakage for BC forest products
Purpose of data	Calculation of leakage
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	C_R & C_N
Data unit	tC
Description	Carbon sequestration per unit of forest
Equations	Eq. 34
Source of data	Conservative estimate based on the generally higher productivity of BC's 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 BC'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.34
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.34
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, approriate paper for determining elasticities for BC forest products in the NA market.
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	EF_1
Data unit	Tonne N_2O-N / tonne N input
Description	Emission Factor for N additions from fertilizers,
Equations	Eq. 15
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_4
Data unit	tN_2O-N / (tNH_3-N + tNO_x-N volatilised).
Description	Emission Factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces, tonne N_2O-N / tonne N input

Equations	Eq. 19
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_5
Data unit	tN_2O-N / tN in leaching or runoff.
Description	Emission factor for N_2O-N emissions from N leaching and runoff, tonne N_2O / tonne N input
Equations	Eq. 20
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	$f_{C, wood}$
Data unit	Tonne / tonne
Description	The fraction of the dry mass of wood, excluding bark, that is carbon.
Equations	Eq. 33
Source of data	IPCC GPG for LULUCF Equation 3.2.3
Value applied	0.5
Justification of choice of data or description of	Default factor given for this variable in the IPCC Guidelines

measurement methods and procedures applied	
Purpose of data	Calculation of baseline and project emissions.
Comments	None

Data / Parameter	$Frac_{GASF}$
Data unit	(tNH_3-N + tNO_x-N volatilised)/tN applied
Description	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers
Equations	Eq. 15, 19
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	$Frac_{GASM}$
Data unit	(tNH_3-N + tNO_x-N volatilised)/tN applied
Description	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers
Equations	Eq. 15, 19
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	$Frac_{LEACH-(H)}$
Data unit	tN/tN added or deposited by grazing animals.
Description	Fraction of N lost by leaching and runoff.
Equations	Eq. 20
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_j
Data unit	tCO_2e / tGasj
Description	Global warming potential of gas j
Equations	Eq. 1
Source of data	BC Government or IPCC
Value applied	Various
Justification of choice of data or description of measurement methods and procedures applied	The global warming potential specified by the BC Government for GHG j. Where projects are validating under VCS the 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.
Purpose of data	Calculation of baseline and project emissions, and leakage
Comments	None

Data / Parameter	$HWPCH4fact_{X,t-y}$
Data unit	tCO_2e / t wood biomass delivered
Description	The factor for the amount of CH_4 (accounted as CO_2e) 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. 24
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.
Purpose of data	Calculation of baseline and project emissions.
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	$HWPfact_{NA,t-y}$
Data unit	%
Description	The factor for the percentage of CO_2 remaining after the number of years between harvest and time t, for products used in North America
Equations	Eq. 5
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.
Purpose of data	Calculation of baseline and project emissions.
Comments	Default factors for this variable may be subject to periodic re-assessment

Data / Parameter	$HWPfact_{O,t-y}$
Data unit	%

Description	The factor for the percentage of CO_2 remaining after the number of years between harvest and time t, for products used offshore
Equations	Eq. 5
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 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.
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
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
Purpose of data	Calculation of leakage
Comments	None

Data / Parameter	wdf_s

Data unit	t/m^3
Description	Wood density factor for species s
Equations	Eq. 3 & 23
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

A number of default factors are given in FCOP 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
HWPfact	Percentage of CO_2 remaining in use and landfill in wood products	5
HWPCH4fact	CH_4 emissions from landfills	24
$\%Leakage_{Market}$	Provincial leakage estimates	31

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 fuel combusted, or other unit with appropriate conversion factor to t
Description	The quantity of biomass of type b combusted during reporting period t.
Equations	Eq. 13
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	t, or other mass unit with appropriate conversion factor.
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	Annually or every reporting period, whichever is longer.

monitoring/recording	
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	$AL_{f,e,t}$ & $AL_{fu,t}$
Data unit	Volumetric measure (eg, l, m^3, 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. 7 & 12
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	t of forest biomass combusted, or other unit with appropriate conversion factor to t.

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.21
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. 22
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	$AI_{m,t}$
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. 9
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	$C_{ap,t}$
Data unit	tC
Description	The carbon in an accounted pool within the project area at time t
Equations	Eq. 29
Source of data	Calculated from sampling, or modelled
Description of measurement methods and procedures to be applied	The carbon in an accounted pool within the project area at time t, as derived from the appropriate measurement or model output, as discussed in section 8.1.1.1. The precise measurement or modeling approach used will depend on the Option chosen, as described in that section. Methods used must be the same as those used to determine $GHG_{j,\ Project\ Forest}$

	$_{Pools,\, t}$ in section 8.2.
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	Calculation methods are given in section 8, and depend on Option chosen and pools accounted.
Comments	

Data / Parameter	$C_{m,g,\, t}$
Data unit	Tonnes (or volume or other relevant units converted to tonnes).
Description	Total quantity of material, equipment, input, or personnel g transported using transport mode m during reporting period t.
Equations	Eq. 10, 11
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. 10, 11

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_4 per tonne of brush burned).
Equations	Eq. 13
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_2e.
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_2 per L diesel].
Equations	Eq. 12
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. 21
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	$Ef_{fu,j}$
Data unit	t / unit of fuel
Description	The emission factor for GHG j and fuel type fu. Note: it is likely that fuel production emission factors may only be available in units of CO_2e.
Equations	Eq. 7
Source of data	BC Reporting Regulation, National Inventory Reports, or other peer reviewed sources
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	$Ef_{H,j}$
Data unit	t / t
Description	The emission factor for GHG j and harvested wood product H produced (eg, CO_2 per quantity of raw harvested wood converted to wood product H)
Equations	Eq. 22
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	$Ef_{m,j}$
Data unit	t / unit
Description	The emission factor for GHG j and transportation mode m
Equations	Eq. 9, 10, 11
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. 10, 11
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	$GHG_{j,\ Baseline\ Forest\ Pools,\ t}$
Data unit	tCO_2
Description	The mass of GHG j, in tonnes, stored in baseline forest carbon pools (excluding HWPs) at the end of reporting period t.

Equations	Eq. 25
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 $GHG_{j,\ Baseline\ Forest\ Pools,\ t}$ for times >t=0. Only relevant for j = 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	$GHG_{j,\ Project\ Forest\ Pools,\ t}$
Data unit	tCO_2
Description	The mass of GHG j, in tonnes, stored in project forest carbon pools (excluding HWPs) at the end of reporting period t.
Equations	Eq. 27
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 $GHG_{j,\ Baseline\ Forest\ Pools,\ t}$ for times >t=0. Only relevant for j = 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	

Data / Parameter	$L_{m,g}$
Data unit	Unit of quantity per vehicle
Description	Cargo load per transport vehicle of mode m.
Equations	Eq. 10, 11
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	mh_s
Data unit	Tonnes
Description	Average mass of the harvested wood, minus bark, of a tree of species s
Equations	Eq. 33
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	$M_{OFj,t}$
Data unit	Tonnes of nitrogen-based organic fertilizer
Description	Mass of organic fertilizer of type i applied in year t, tonnes.
Equations	Eq. 17
Source of dat	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	$M_{SFi,t}$
Data unit	Tonnes of nitrogen-based synthetic fertilizer
Description	Mass of synthetic fertilizer of type i applied in year t, tonnes.
Equations	Eq. 16
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_{OFj}
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. . 17
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_{SFi}
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. 16

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. 3, 23
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 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 Module 3
- 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:

i. Purpose of the monitoring

ii. Technical description of the monitoring task.

iii. Data to be collected.

iv. Overview of data collection procedures.

v. Frequency of the monitoring

vi. Quality control and quality assurance procedure.

vii. Data archiving.

viii. 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 tsunami, sea level rise, volcanic eruption, landslide, flooding, permafrost melting, pest, disease, etc. can impact the area, carbon stocks and non-CO_2 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, The BC Emission Offset Regulation 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 in British Columbia, the requirements of this section must be reviewed to ensure that risk mitigation planning is sufficient to ensure compliance with the BC EOR.

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 BC. 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.

10 REFERENCES

AFOLU Non-Permanence Risk Tool v3.2. Verified Carbon Standard (2012)

A/R Methodological Tool “Estimation of direct nitrous oxide emission from nitrogen fertilization”. UNFCCC CDM EB, (2007).

BC Vegetation Resource Inventory Standards http://www.for.gov.bc.ca/hts/vri/index.html

British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, (2009)

Canada’s National Forest Inventory Ground Sampling Guidelines, Canadian Forest Inventory Committee, (2004)

“CBM-CFS3: A model of carbon-dynamics in forestry and land-use change implementing IPCC standards”. 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, Ecological Modelling 220: 480–504. (2009)

Change Monitoring Inventory Ground Sampling Quality Assurance Standards V2.2 BC Ministry of Forests, Lands and Natural Resource Operations, (2012)

Climate Action Reserve, Forest Project Protocol Version 3.2, (2010)

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

Freight Modal Shifting GHG Protocol - British Columbia-Specific Version. The Delphi Group, (2010).

General Technical Report NE-343 Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the United States, USDA Forest Service, April 2006

US DOE, Technical Guidelines for Voluntary Reporting of GHG Program, June 2006.

The GHG Protocol for Project Accounting. World Resources Institute / World Business Council for Sustainable Development, November, (2005)

Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration on U.S. Timberland. American Carbon Registry / Finite Carbon, (2010).

IPCC Guidelines for National GHG Inventories. IPCC, (2006)

ISO 14064-2:2006, GHGes - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of GHG emission reductions or removal enhancements. International Standards Organization, (2006)

Locomotive Emissions Monitoring Program. Railway Association of Canada, (2008).

“Price elasticities of substitution between species in the demand of US softwood lumber imports from Canada”. Hseu, J-S., and Buongiorno, J., Canadian Journal of Forest Research 23:591-597. (1993)

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

Turning the Corner, Canada’s Offset System for GHGes Guide for Protocol Developers, Draft for Consultation, Environment Canada (2008)

Wood density of Canadian tree species. J.S. Gonzalez., Forestry Canada, Northwest Region, Northern Forestry Centre, (1990)

Sequestration of carbon in harvested wood products for the United States. Skog, K.E., Forest Products Journal 58(6):56-72. (2008)

APPENDIX A: THE 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.[67] The market share of the base case offset project is assumed to be 1% (Φ = .01)[68] 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.[69]

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 V3.5). 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.

Northern Interior British Columbia Base Case:

In this guideline, the northern interior region of British Columbia is generally referred to as the northern part of the province that contains pine and spruce trees as the dominant leading species.[70] Since approximately 60% of total Canadian softwood lumber production (m^3) was exported from 2007-2009,

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[67] 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.

[68] 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 Φ = .1, or 10%, only reduces leakage by 2%. Reducing Φ further has even less effect. Overall Φ has a minimal impact on the equation.

[69] 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.

[70] Refer to Appendix G for the BC Forest Districts Used to delineate the regions used in the base cases.

and lumber is a major use of B.C.'s northern interior wood, a lumber export market has been chosen for the market setting of the northern interior.[71] In particular we examine the Canadian export market to the U.S. As such, supply price elasticity represents the export supply from all of Canada to the U.S. and the demand price elasticity represents U.S. demand for softwood lumber.

Base case leakage is estimated via using export supply price elasticity (e) of .342, and a demand price elasticity (E) of -.181 (Song et al., 2011)[72]. Song et al. uses monthly U.S. data from 1990-2006 for the elasticity calculations. The elasticity of demand calculated by Song et al. is for the entire U.S. lumber demand. In addition the elasticities offered by Song et al. are statistically significant.

Song et al. elasticities offer a representative leakage estimate for the North American lumber market, and are appropriate for this case due to the fact that the majority of BC products export to the United States (the bulk of the North American market place). Furthermore, Song et. al. elasticities are appropriate for this application because the research they are derived from uses recent data, examines a long period of time, has statistically significant results, and focuses on the much larger U.S. market in its entirety. When examining the market for Canadian softwood lumber exports to the U.S. using Song et al. the leakage estimate is 65%, as seen in Table 22 below:

Table 22: Northern Interior Leakage Estimation

Factor	Default
e	0.342
E	-0.181
C_R	1
C_N	1
Φ	0.01
γ	1
L	65.2%

For the northern interior base case, it is assumed that the wood supplied from this geographic area can be substituted with any number of other wood alternatives (harvested in BC or elsewhere) to generate the same product lines.[73] Tree species that have a high number of alternative species, in terms of the

[71] British Columbia's total softwood lumber exports accounted for approximately 63%, 65% and 69% of total softwood lumber exports for 2007, 2008, and 2009 respectively. Source: Natural Resources Canada, "Canada's Forests, Statistical Data". Last modified on December 3rd, 2010. Accessed on January 26th, 2011. <http://canadaforests.nrcan.gc.ca/statsprofile>.
[72] Song, N., et al., 2011. "U.S. softwood lumber demand and supply estimation using cointegration in dynamic equations". Journal of Forest Economics.
[73] For example pulp products can be manufactured out of a number of harvested tree species across Canada, North America and beyond. Highly substitutable wood is identified as 100% substitutable in this guideline (also referred to as perfectly substitutable).

product lines they are geared for are referred to as highly substitutable.[74] This is generally the case for species such as pine and spruce which are the leading commercial timber species in the northern interior.

There may be instances where project proponents have other species of commercially harvestable timber within their project area. If project proponents can demonstrate that these commercial tree species have low or moderate substitutability, it is recommended that project proponents utilize the methodology applied in the coastal and southern interior base cases to refine/ tailor the northern interior base case to reflect their specific project dynamics.

Coastal British Columbia Base Case:

This base case represents an offset project in coastal British Columbia instead of in the northern interior. Good growing conditions for trees on the coast, allowing trees to become larger more quickly than other areas of the province, make coastal areas desirable for offset projects.

The North American lumber market is largely based on highly substitutable wood species. Since the value and uses of highly substitutable woods are generally the same if not identical for the coast and interior, the market supply and demand equilibrium of the coastal and interior woods can also be considered the same. This is to say that the market supply and demand elasticities referenced in the base case are still appropriate and a good representation of coastal market supply and demand dynamics.[75]

However, for regions that grow certain woods that have few substitutes for their product lines, such as cedar on the coast, leakage is likely lower. This is simply due to the fact that the constrained supply is not replaced, or less easily replaced by the supply of another wood species. There is a supply constraint and less likelihood of harvest shifting relieving that constraint. Therefore coastal projects (or projects in areas containing woods with low substitutability) warrant lower leakages.

Applying the substitutability parameter to reflect low substitutability woods on the coast indicates the leakage estimate is reduced to 55% for the coastal base case as indicated in Table 23 below. It is important to note that the base case for the coast represents the average mix of tree species in the total harvest area of the coastal region. Leakage estimates for projects on the coast can vary according to species composition and the proportion of low substitutability species to high substitutable species in the project area.

Table 23: Coastal Leakage Estimation

Factor	Default
e	0.342

[74] Wood substitution is generally a function of product line. Wood can also be substituted with other materials such as vinyl, steel or manmade fibers depending on the intended product lines. In this analysis we only consider substitution between different tree species as any consideration of substitution with other materials would necessitate incorporation of a number of different variables for supply and demand.
[75] Elasticities appropriate for determining leakage are long-run supply and demand elasticities for the total North American market.

E	-0.181
C_R	1
C_N	1
Φ	0.01
γ	0.8479
L	55.3%

For the coastal base case the average tree species mix for the entire coastal harvest region was used. To derive a substitutability parameter (γ) for a specific project, a proponent needs to ascertain the representative tree species mix for their specific project area (in place of the average tree species mix for the coastal harvest area).[76] For the coastal base case red cedar and cypress are identified as low substitutability woods, white pine is identified as moderately substitutable.[77] Substitutability values for these species are given in Appendix C. All other commercially harvested trees in the coastal region are assumed to be perfectly substitutable (100% substitutability).[78]

A total of 25.3% of wood (cedar and cypress) has 40% substitutability. White Pine, making up 0.1%, is 70% substitutable. The remaining 74.6% of the wood is 100% substitutable; this means that all products from a tree in this category can be replaced by the same or similar products of other trees.

Therefore the substitutability parameter is (0.253 * .4) + (0.001 * .7) + (0.746 * 1) = 0.8479. This weight is then applied to the leakage equation, reducing leakage from the 'perfectly substitutable' base case (the northern interior base case) to approximately 85% of its original level and is now representative of the total average coastal market.

[76] The tree species composition of the project area would need to be verified.
[77] Refer to Equations for calculation on how to derive substitutability estimates for tree species.
[78] Hemlock, Balsam, Douglas Fir and Grand Fir are all assumed to be 100% substitutable. Sitka Spruce is also assumed to be 100% substitutable; however there may be cases where a proponent can demonstrate that Sitka Spruce has lower substitutability as research compiled to date for Sitka Spruce products is lacking. Proponents must use methodology identified in Appendix B, Example Substitutability Equations for deriving wood substitutability estimates.

Table 24: Low And Moderately Substitutability Wood As A Contribution Of Total Coastal Harvest

	Cedar	Cypress	White Pine[79]	Other	Total
Harvest Contribution (T)	22.4%	2.9%	0.1%	74.6%	100%
Substitution (S)[80]	40%	40%	70%	100%	84.79%

Coastal Substitution Calculation:

$$\gamma_{Coast} = T_{cedar} * S_{cedar} + T_{cypress} * S_{cypress} + T_{white\ pine} * S_{white\ pine} + T_{other} * S_{other}$$

$$\gamma_{Coast} = .224 * .4 + .029 * .4 + .001 * .7 + .746 * 1 = .8479$$

Southern Interior British Columbia Base Case

The southern interior base case represents the general geographic extent of cedar trees (a low substitutability wood) in the interior of British Columbia.[81] The southern interior of British Columbia has a diversity of tree species and growing sites. Project areas could be highly variable and it may be appropriate to derive a substitution parameter specific to individual projects.

The methodology for estimating leakage for the southern interior base case follows that of the coastal base case. In this base case a substitutability parameter is derived to reflect the average tree species mix for the total southern interior harvest region.

Table 25: Low and Moderately Substitutable Wood as Contribution of Total Southern Interior Harvest

	Cedar	Larch, Yellow & White Pine[82]	Other	Total
Harvest	2.9%	2.0%	95.1%	100%

[79] Larch, yellow pine, and white pine were grouped together, along with redwood, and other lumber under the "other" category in the price elasticities referenced on [Nagubadi et al. (2004)]. The substitution derived from the elasticities is a grouped substitution. A single tree species substitution is not available for larch, yellow pine, or white pine due to data limitation. This figure can be modified if the cross- and own-price elasticities of these species become available in future research. Currently the 70% figure is the best representative estimate.
[80] See Appendix B for the methodology, source, and an example of the substitution calculation for low/ moderate wood substitutes. All tree types with 100% substitution have simply been listed together.
[81] Refer to Region for the BC Forest Districts Used to delineate the regions used in the base cases.
[82] Larch, yellow pine, and white pine were grouped together, along with redwood, and other lumber under the "other" category in the price elasticities we referenced on (Nagubadi et al. (2004)). Therefore the substitution derived from the elasticities is a grouped substitution. A single tree species substitution is not available for larch, yellow pine, or white pine due to data limitation. This figure can be modified if the cross- and own-price elasticities of these species become available in future research. Currently the 70% figure is the best representative estimate.

Contribution				
Substitution	40%	70%	100%	97.66%

Southern Interior Substitution Calculation:

$$\gamma_{South} = T_{cedar} * S_{cedar} + T_{larch} * S_{larch} + T_{other} * S_{other}$$

$$\gamma_{South} = .029 * .4 + .02 * .7 + .951 * 1 = .9766$$

As with the coastal case, to derive a substitutability parameter (γ) for a specific project in the southern interior, a proponent needs to ascertain the representative tree species mix for their specific project area and reflect that in the calculation with the respective substitutability of those tree species.

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*

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

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)[83]

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

	Elasticities							
	P_d	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)[84]

[83] 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.

[84] 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[85]

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%)		

[85] 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 timber species are given in Tables 8 and 13 of the FCOP. 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 8 and 13 are the averages of the green volume values measured for trees grown in BC, 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 be species and region in Table 29 below.

Table 29: Timber Harvesting Volume Proportion Five-Year Average (2006-2010)[86]

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%
Birch	0.1%

[86] 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/)

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_4 EMISSION FACTORS

HWP retention factors were derived for BC, and are given in Tables 9 and 11 of the FCOP, while CH_4 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[87] paper, and are shown in Table 30.

Table 30: Distribution Of Delivered Wood Volumes To Product Categories For North American Markets

First processing facility	% of total harvest	lumber	ply	panels	chips / blocks	Fuel	landfill	Total
Lumber mills	84%	47.0%			35.0%	17.9%	0.1%	100.0%
Chip mills	5%				96.3%	3.2%	0.5%	100.0%
Ply mills	8%		51.0%	16.0%	24.0%	8.5%	0.5%	100.0%
panel mills	3%			84.0%		15.5%	0.5%	100.0%
Net		39.48%	4.08%	3.80%	36.14%	16.34%	0.16%	

[87] 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

2. Distribution of pulpwood to product categories by pulping method. Figures used were taken from the Dymond[88] paper, and are shown in Table 31

Table 31: Distribution Of Pulpwood To Product Categories By Pulping Method

	% of total input	paper	combustion	effluent
mechanical	12.0%	93.0%	6.9%	0.1%
chemical	88.0%	45.0%	53.9%	1.1%

3. Distribution of products to uses. Figures used were taken from the Dymond[89] paper, and are shown in Table 32. Note that the "Other" category includes recycled materials.

Table 32: Distribution Of Products To Uses

Total products		Single family	Multi family	Com.	Other building	Furniture	Shipping	Landfill	Other
lumber	39.48%	25.0%	1.5%	7.0%	25.0%	10.0%	10.0%	7.5%	14.0%
ply	4.08%	41.0%	3.0%	9.0%	25.5%	7.5%	2.0%	4.0%	8.0%
panel	3.80%	15.0%	2.0%	6.0%	16.0%	36.0%	1.0%	4.0%	20.0%
paper	18.34%								
fuel	33.78%								
landfill	0.16%								
effluent	0.35%								
	100.00%								

[88] 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

[89] 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

4. Destiny of discarded wood products. Figures used were taken from the Skog[90] and Dymond[91] 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%

5. Decay parameters in landfills and dumps. Values used were derived from the Dymond[92] and Skog[93] 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

1. 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.

[90] Tables 6a and 6b, K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.
[91] 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
[92] 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
[93] Table 7, K.E. Skog, Sequestration of carbon in harvested wood products for the United States, Forest Products Journal 58:6, 2008.

2. Product outputs from delivered roundwood, based on inside bark volumes. These values were derived from the Winjum et. al.[94] paper, and are shown in Table 35.

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%
				100.00%

3. Fraction of total HWP by type falling into the "short-lived" category. Values for this variable were derived from the Winjum et. al.[95] 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

[94] 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

[95] 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

determining the amount expected to be remaining after 100 years, and calculating the equivalent half life.Because the majority of BC overseas wood was expected to go to tropical or subtropical destinations (southern China, south east Asia, etc.), the values given in Winjum et. al.[96] 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.

[96] 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: BC FOREST DISTRICTS BY REGION

Forest Districts used for identifying average tree species mix for the northern interior, southern interior and coastal regions of BC.

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

Version	Date	Comment
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