PROTOCOL FOR THE CREATION OF FOREST CARBON OFFSETS IN BRITISH COLUMBIA (FCOP)

BRITISH COLUMBIA

Pacific Carbon Trust

Document Prepared by Pacific Carbon Trust

Title	Protocol for the Creation of Forest Carbon Offsets in British Columbia (FCOP)
Version	Version1
Date of Issue	October 25, 2011
Type	Methodology
Sectoral Scope	AFOLU Applicable project categories ARR, IFM, REDD Applicable project types include Reduced Impact Logging (RIL), Logged to Protected Forests (LtPF), Extended Rotation Age / Cutting Cycle (ERA), Low Productive to High Productive Forest (LtHP), Avoiding Planned Deforestation (APD),
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Reference Number	

Relationship to Approved or Pending Methodologies

Note: The methodology as submitted for public review has been altered from FCOP version 1.0 as the first step of alignment with VCSA standards. Changes have been made to sections 8.1.1.1a, and 8.1.1.1b, as noted in footnotes.

This protocol focuses on enhancing sequestration (removal[1]) 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. This protocol is compliant with the BC Emission Offset Regulation and is intended for use within BC on both private and Crown land

At the time of writing the following methodologies are approved for use under the VCS program

VM0003 Methodology for Improved Forest Management through Extension of Rotation Age v1.0

VM0004 Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests v1.0

VM0005 Methodology for Conversion of Low-productive Forests to Hgh-productive Forests. v 1.1

VM0006 Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and degradation v 1.0

VM0007 REDD Methodology Modules (REDD-MF) v1.1

VM0009 Methodology for Avoided Mosaic Deforestation of Tropical forests v 1.0

VM0010 Methodology for Improved Forest Management: conversion from Logged to Protected Forest v1.0

VM00011 Methodology for Calculating GHG Benefits from Preventing Planned degradation v 1.0

VM0012 Improved Forest Management on Privately Owned Properties in Temperate and Boreal Forests (LtPF) v1.0

VM0015 Methodology for Avoided Unplanned Deforestation

At the time of writing, there are also several AFOLU Methodologies under development in the VCS program. However, none of the approved Methodologies or the methodologies under development allow for multiple forest and carbon management activities as part of a single projec urthermore, there are no other AFOLU methodologies that have been developed to meet the requirements of the BC Emission Offsets Regulation.

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1.0 SOURCES

In developing this offset protocol, 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 includes, but was not limited to, the following (note: guidance provided by experts is discussed in Section 01.3 Stakeholder Consultation Summary):

1.1 General GHG Quantification Guidance

- ISO 14064-2[2]
- WRI / WBCSD GHG Protocol for Project Accounting[3]
- Canada's Offset System for Greenhouse Gases Guide for Protocol Developers, Draft for Consultation, 2008[4]
- System of Measurement and Reporting for Technologies[5]

1.2 Forestry-Specific Guidance and Methodologies

- British Columbia Forest Offset Guide Version 1.0[6]
- Climate Action Reserve Forest Project Protocol Version 3.2[7]
- Voluntary Carbon Standard: Tool for AFOLU Methodological Issues[8]; and Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination (including September 2010 update)[9]
- Draft North American Forest Carbon Standard[10]
- IPCC 2006 Guidelines for Forest Land[11]
- American Carbon Registry Improved Forest Management Methodology September 2010[12]

1.3 Stakeholder Consultation Summary

The process to develop the forest carbon offset protocol has benefited from professional advice and regular feedback through the consultation approach designed into the protocol building program. A technical working group of experienced professionals in forest management, forest carbon and carbon offsets was invited to provide expert advice in a collaborative manner as the writing of the protocol was progressing, and to comment on draft protocol content as it emerged. The technical working group and the protocol development team used an on-line document collaboration site that allowed members to submit comments, pose questions, and recommend solutions and specific wording with all content available to each member. While the technical working group was an important element in the formation of the draft protocol, the province of BC acknowledges that participation by the expert advisors on the technical working group does not constitute endorsement by those expert advisors of either the draft protocol or the final Forest Carbon Offset Protocol that may be approved by government.

In addition to the group of expert advisors working with the protocol development team, the province offered a series of information webinars for people and organizations interested in, or affected by, the protocol. The webinars enabled participants to be informed of both the protocol development process and emerging protocol content. The webinars have been both open sessions for all to participate, and sector briefings where the protocol development team reached out to First Nations, the forest industry, the carbon industry and environmental organizations in an effort to communicate with those groups most directly affected by the protocol. Each of the webinars provided an opportunity for both a presentation and a question/answer session with key members of the protocol development team. Individual meetings with key sectors and organizations also took place over the project term to allow groups to submit specific feedback to the protocol development team.

Once the draft protocol was developed, a nine week public review and comment period was initiated. The draft protocol was posted on the BC Ministry of Environment website, with an open invitation for the public to read, analyze and submit comments on the protocol content. Another public webinar was hosted to explain the structure and content of the draft document and a web-based template was provided to assist the public in providing feedback. In addition, members of the protocol development team were available to meet with interested groups to provide information about the proposed approach and receive input directly from groups. Upon conclusion of the public review period, submissions were reviewed to determine the appropriate protocol refinements. A summary of the public submissions will be posted on the BC Ministry of Environment website at the time the final Forest Carbon Offset Protocol is approved for implementatio

2.0 SUMMARY DESCRIPTION OF THE METHODOLOGY

2.1 List of GHG(S) That Will Be Reduced

This protocol focuses on enhancing sequestration (removal[13]) 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 emission of methane and nitrous oxide may also be realized by eligible projects. No relevant changes in other GHGs (PFCs, HFCs, or SF_6) are anticipated

2.2 Description of How Real Reductions Will Be Achieved

Real GHG emission reductions, removal enhancements, and increased forest carbon sequestration and maintenance relative to appropriately selected baseline scenarios will be achieved by undertaking the various eligible project activities described in this protocol.

Appropriate quantification of real emission reductions has been ensured through development of this protocol and will be ensured through development of subsequent GHG project plans in accordance with ISO 14064-2[14], the BC Emissions Offset Regulation, and other relevant requirements and good practice guidanc

2.3 Protocol Flexibility

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

1. **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 protocol.

2. **Baseline scenario selection approach**. For some project types, flexibility is given in the protocol with respect to the baseline scenario selection approach used.

3. **Exclusion of sources, sinks and pools (SSPs).** If justified based on project and baseline-specific details, the project proponent may exclude some additional SSPs from quantification beyond those excluded by default in the protocol. 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 immaterial based on a materiality threshold of 5%.

4. **Forest carbon quantification approaches.** The proponent is free to choose appropriate forest carbon pool inventory, modeling, and/or other related approaches, subject to the requirements stipulated in this protocol. This protocol does not prescribe on specific approach that must be used.
5. **Emission source quantification methods**. For some emission sources, more than one option is provided for quantification, with the proponent being free to choose the method most suited to available data.
6. **Project-specific emission factors and assumptions.** Where justified, appropriately documented, and permitted by the quantification methodologies provided in this protocol, project-specific emission factors and assumptions may be used instead of default references sources and/or factors noted in the protocol.
7. **Assessing leakage.** Various options are presented for project proponents to address land use shifting and/or harvest shifting leakage, as appropriate, for their projects.
8. **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 protocol.
9. **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 protocol does not prescribe specific data quality management approaches that must be followed.
10. **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 protocol.

2.4 List of Relevant Federal and BC legal requirements and climate-change incentives

Legal requirements and climate change incentives listed in this section shall be considered by project proponents when determining and justifying that the project is surplus / additional, and that the project conforms to the requirements of the BC Emission Offset Regulation. These legal requirements often necessitate the inclusion, direction or sign off of professionals such as Registered Professional Foresters, Professional Engineers and Geologists, or Registered Professional Biologists and nothing in this protocol or the Act reduced those requirements. It is anticipated that a Registered Professional Forester will be involved in most projects carried out under this protocol.

Potentially Relevant Legal Requirements

While not exhaustive, the following table[15] includes a list of key applicable legislation and regulations that apply to forest offset projects in B.C. at the time that this version of the protocol was finalized. These are provided for reference only, and project proponents are responsible for ensuring that they have an up-to-date understanding of applicable legislation.

Table 1: Applicable Legislation

Applicable legislation	Land base	Relevance
Forest and Range Practices Act (FRPA) and regulations	Crown*	Forest and range practices
Private Managed Forest Land Act	Private	Forest practices
Federal Fisheries Act	All	In-stream and streamside practices
Wildlife Act	All	Practices to protect/manage wildlife
Water Act	All	Practices to sustain water resources
Drinking Water Protection Act	All	Practices to protect drinking water
Chief Forester's Standards for Seed Use	Crown*	Tree seed use
Foresters Act	All	Prescription, monitoring, measurement, verification

*FRPA and its regulations and standards apply to Crown lands primarily, but also to private lands within tree farm licenses, woodlot licenses, and community forests.

Other applicable legal requirements

Forest offset projects must also comply with all other municipal, provincial and Federal laws that apply to the project area and activity. These are not itemized here.

Potentially Relevant Climate-Change Incentives

Climate change incentives, including tax incentives or grants that may be available, will be relevant to determining the additionality of the project. However, given their variability they are not itemized here. Project proponents are responsible for identifying climate change incentives that apply to their project in their GHG project plan.

3.0 DEFINITIONS

Aboveground Biomass: All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.[16]

Additionality: The concept that a project's emission reductions and removal enhancements must go beyond (i.e. be additional to) what would have occurred in the absence of the GHG offset project. In the BC Emission Offset Regulation, projects are deemed additional where they can demonstrate that the incentive of having a greenhouse gas reduction recognized as an emission offset overcomes or partially overcomes financial, technological or other obstacles to carrying out the project.

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.

Carbon Pool: A carbon pool is defined as a physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate carbon from the atmosphere by a greenhouse gas sink or carbon captured from a greenhouse gas source through a physical, chemical or biological process. Equivalent to the ISO 14064 term “reservoir”.

CO_2 equivalent (CO_2e): The universal unit of measurement to indicate the global warming potential (GWP) of each of the six greenhouse gases, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate releasing (or avoiding releasing) different greenhouse gases against a common basis.

Controlled SSP: A GHG source, sink, or carbon pool whose operation is under the direction and influence of the proponent through financial, policy, management or other instruments.

Dead Wood: Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps.[17]

Emission factor: A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions.

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 gas emission: the release of greenhouse gases to the atmosphere, by a GHG source (e.g. fossil fuel combustion).

Greenhouse gas removal: a removal of greenhouse gases from the atmosphere, by a GHG sink (e.g. growing trees).

Greenhouse gases (GHG): GHGs are the six gases listed in the Kyoto Protocol: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6).

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

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

Soil Organic Matter: Includes organic carbon in mineral and organic soils (including peat) through the full soil profile and applied consistently through the time series. Live fine roots are included with soil organic matter where they cannot be distinguished from it empirically.[18]

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.

World Resources Institute (WRI): WRI is an environmental think tank founded in 1982 based in Washington, D.C. in the United States. WRI is an independent, non-partisan and nonprofit organization with the intention of protecting the Earth and improving people's lives. WRI organizes its work around four key goals: Climate, energy & transport, Governance & access, Markets & enterprise and People & ecosystem.

World Business Council for Sustainable Development (WBCSD): The World Business Council for Sustainable Development (WBCSD) is a CEO-led, global association of some 200 companies dealing exclusively with business and sustainable development. The Council provides a platform for companies to explore sustainable development, share knowledge, experiences and best practices, and to advocate business positions on these issues in a variety of forums, working with governments, non-governmental and intergovernmental organizations.

4.0 APPLICABILITY CONDITIONS

Please note that this section of the protocol focuses solely on clearly identifying the project types for which GHG quantification methods have been developed and presented elsewhere in this protocol, and thus the project types to which this protocol applies. These eligibility requirements are designed to be as broad and non-restrictive as possible, while still ensuring that projects with relevant aspects not covered by the provided quantification methodologies are clearly identified as being not eligible to use this version of the protocol. Such non-eligible project types could become eligible at a later date through revision of protocol methodologies.

This section of the protocol makes no attempt to judge eligible project types with regards to GHG emission reduction potential or any potential non-GHG impacts, positive or negative. An eligible project will be required, through the preparation and implementation of a GHG project plan according to the requirements of this protocol and the BC Emission Offset Regulation (BC EOR), to assess and report on the GHG emission reductions achieved in a manner that complies with the BC EOR and associated normative references, such as ISO 14064-2. This also includes ensuring that emission reductions are conservatively stated, considering the associated uncertainties of relevant Sources, Sinks and Pools (SSPs)[19] and quantification approaches.

With respect to potential non-GHG project impacts, this protocol is intended for application in the Province of British Columbia, where a strong framework of forest management, environmental, and other laws and mandatory requirements are in place to manage non-GHG aspects of undertakings, whether GHG offset projects or not. Appropriate government ministries and departments with the mandate to set the requirements regarding such potential non-GHG impacts must be contacted for any related approvals, licenses and permits. This protocol is concerned with GHG accounting related to GHG offset projects. The Province of British Columbia supports sustainable forestry management including the Future Forest Ecosystems Initiative and adapting BC's forest and range management framework so that it continues to maintain and enhance the resilience and productivity of BC's ecosystems as our climate changes. The Province also supports Preparing for Climate Change: British Columbia's Adaptation Strategy, which recognizes that adaptation is an important part of addressing climate change, and that provincial investments (such as enabling forest carbon offset projects on Crown Land) aim to build a green economy and infrastructure are resilient to climate change impacts.

4.1 Description of Eligible project types

This protocol may be applied to forestry projects that:

- comply with all of the applicable requirements of the BC Emissions Offset Regulation[20];
- meet the general forest project eligibility criteria specified below; and
- fall into one or more of the forestry project types described later in this section, including meeting any project type-specific eligibility criteria noted.

In considering the eligibility criteria below, the following definition of “Forest Land”, consistent with BC and Canadian GHG Inventory definitions, shall be used.

Forest Land: an area:

- that is greater than or equal to one hectare in size measured tree-base to tree-base (stump to stump); 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.

General Forest Project Eligibility Criteria:

- All projects must follow applicable legislation and regulations for forest and land management in BC.
- Where a project involves planting, the project must use genetically diverse and productive seed stock, and is expected to apply the BC Chief Forester’s Standards for Seed Use[21], which prohibit the use of genetically modified trees and limit the use of species collected outside of BC. The standards also establish criteria for the registration of seedlots and vegetative lots, and regulate storage, selection and use, and transfer of registered lots.

Note: Harvested wood products may be counted as long term carbon pools in this protocol only under specific situations described more fully elsewhere in this protocol. In particular, where wood is harvested for use as biofuel or where the creation of specific kinds of HWPs cannot be verifiably demonstrated, the associated carbon is assumed lost to the atmosphere. Projects that harvest wood primarily to create biofuel are not explicitly excluded from using this protocol, though it is likely that such projects will not be able to show a net emission reduction / removal enhancement according to the quantification methods included in this protocol.

4.1.1 Afforestation

Project Type Definition:

Afforestation means the direct human-induced conversion of land that has not been Forest Land for at least 20 years prior to project commencement to Forest Land through planting, seeding and/or human-induced promotion of natural seed sources[23].

Areas that may be suitable for afforestation projects include, but are not limited to:

- marginal productivity land;
- urban land; or
- degraded industrial lands such as mine sites[24].

Specific Eligibility Criteria:

- In assessing whether land is capable of achieving the height and crown cover criteria specified in the Forest Land definition, above, the assessment must be made considering what the land is capable of achieving in the absence of a change in current (i.e. pre-project) management practice. Clearly, a viable afforestation project will be capable of achieving these criteria in the future and becoming Forest Land, but only as the result of a change in management practice, including site development, planting activities, etc.
- There must be evidence to demonstrate that the project lands have not been Forest Land for at least 20 years prior to project commencement. Where satisfactory evidence is not available, the project could instead be treated as a reforestation project if all reforestation project eligibility requirements are met.

4.1.2 Reforestation

Project Type Definition:

Reforestation means the re-establishment of trees on land through planting, seeding and/or human-induced promotion of natural seed sources.

Specific Eligibility Criteria:

- The project lands must have been forest land in the recent past (i.e. within the last 20 years; otherwise, see the afforestation project definition) or must still be Forest Land, and must have reduced tree cover as a result of significant natural disturbance or harvesting.
- There are no legal requirements to reforest the project lands.
- Planting activities are the only activities to be undertaken on the lands other than the continuation of management practices that were being undertaken prior to project commencement. Where the project also involves improved forest management on project lands that are being reforested, all activities, including reforestation, must be treated as an improved forest management project according to the requirements of this protocol and not a reforestation project, except that where a requirement for a reforestation project is more stringent than for an improved forest management project (e.g. for determination of relevant versus optional or not relevant SSPs), the more stringent requirement is to be applied.

4.1.3 Improved Forest Management

Project Type Definition:

Improved Forest Management means a system of practices for stewardship and use of forest land, which may include production of harvest wood products, which reduces GHG emissions and/or increases GHG sinks / carbon pools.

Eligible management activities may include one or more of a variety of approaches, including but not limited to those that:

- increase sequestration rates (e.g. through fertilization, improving stocking, reducing regeneration delays, use of faster growing trees/seed, thinning, diseased and suppressed trees, managing competing brush and short-lived forest species, etc.);
- reduce emissions (e.g. through capturing mortality, reducing natural disturbances, reducing burning, reducing new road widths, etc.); and
- increase long-term carbon storage in forests and wood products (e.g. through conservation areas, reduced harvesting through forest cover constraints, increasing rotation age, increasing

proportion of long lived harvested wood products in conjunction with other changes in forest management, etc.).

Specific Eligibility Criteria:

- Project lands must meet the definition of 'Forest Land' immediately prior to project commencement.

4.1.4 Conservation / Avoided Deforestation

Project Type Definition:

Conservation / Avoided Deforestation means preventing the direct human-induced conversion of Forest Land to a non-forest land use. Logging as part of forest management is not included as a potential conversion / deforestation activity that may be avoided under this definition.

Note: That conservation / avoided deforestation projects are not prevented from including a planned harvest cycle.

Avoided land-uses could include, but are not necessarily limited to, residential, commercial, industrial, and agricultural.

Specific Eligibility Criteria:

- Project lands must meet the definition of 'Forest Land' immediately prior to project commencement, in order to be able to justify that the project avoids the deforestation of Forest Land.
- The project proponent must demonstrate that there is a significant threat of conversion of project land to a non-forest land use, according to the baseline selection requirements in this protocol.

4.2 Description of any project-specific technology

A wide range of practices and technologies are available for use in forest projects; this protocol will not attempt to describe them here or restrict the applicability of the protocol to specific practices or technologies. Instead, project proponents shall clearly describe their project and associated practices and technologies in a project-specific greenhouse gas project plan.

5.0 PROJECT BOUNDARY

5.1 Identification of the Project Area

A forest offset project proponent 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, as per section 3(2)(f) of the BC EOR. The project can be contiguous or separated into tracts.

This information must include a geo-referenced map that shows the project area. 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 (e.g., 1:20 000 or larger, though in some cases a smaller scale map might be appropriate), and include sufficient features, place names and administrative boundaries to enable field interpretation and positive identification of the project site.

The following information must be provided on the map:

- Forest ownership and project boundaries
- Size of forest ownership 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[25]

In addition to the above, the project proponent must also provide other project identification and description information as required by the BC EOR.

5.2 Identification of Project SSPs

5.2.1 Selection of Criteria and Procedures for Identifying SSPs for the Project

There is general consensus among relevant GHG quantification good practice guidance that a systematic, lifecycle assessment-based approach should be used to completely and transparently identify relevant SSPs for a GHG project. Such an approach would consider both 'on-site' SSPs directly owned/controlled by the project proponent as well as related/affected SSPs upstream and downstream of owned/controlled SSPs, including those that occur on an on-going basis as well as only once. Guidance considered in making this assessment included:

- Annex A of ISO 14064-2
- WRI/WBCSD GHG Protocol
- Federal Draft Guide for Protocol Developers[26]
- The System of Measurement and Reporting for Technologies (SMART)[27]
- Numerous protocols and project based quantifications prepared for government funding agencies, the Alberta Offset System, etc.

As a result, the following lifecycle assessment-based approach was selected for use in identifying SSPs for the project in this protocol. This procedure draws heavily on procedures developed for preparation of GHG project plans based on SMART for projects funded by Natural Resources Canada's Technology

Early Action Measures program, which in turn draw upon approaches codified in the ISO 14040 series of lifecycle assessment standards[28]. Please note that the use of a lifecycle assessment-based approach at this stage does not necessarily mean that all SSPs included in the full lifecycle (e.g. upstream, downstream) will be deemed to be relevant to the quantification – this determination, considering BC Offset System-specific or other relevant criteria, will be made at a later stage in this protocol.

5.2.2 Procedure to Identify Relevant SSPs for the Project

The following seven-step procedure was used to identify potentially relevant SSPs for projects eligible for quantification using this protocol.

1. Identify the project model based on the processes and activities included in the project.
2. Identification of all SSPs controlled or owned by the project proponent relevant to the primary project activities.
3. Identification of all SSPs physically related to the primary project activities, by tracing products, materials and energy inputs/outputs upstream to origins in natural resources and downstream along their life-cycles. For example: electricity production, fossil fuel production, etc.
4. Identification of all SSPs affected by the project through consideration of the economic and social consequences of the project. This was achieved by looking for activities, market effects, and social changes that result from or are associated with the project activity, and documenting the associated GHG emissions.
5. Classify SSPs as owned and/or controlled by the project; related to the project, or affected by the project, as defined by ISO 14064-2.
6. Identify the GHG inputs and outputs for each SSP, and identify the parameters required to estimate or measure GHGs.
7. Review all SSPs and material and energy flows to ensure that relevant SSPs have been completely identified.

5.2.3 Identification of Relevant SSPs For The Project

To assist with identifying SSPs, a project model consisting of key activities and associated material and energy flows was developed. Given the similarities between all eligible forestry project types included in this protocol, as well as their associated baselines, a single overall model was developed to encompass all project types and their baselines. This model is presented as Figure 1.

In the model, similar activities were grouped together wherever possible, based on considerations of potential associated emission sources as well as the activities' interaction with other activities and SSPs via material and energy flows. For example, Nitrogen-Based Fertilizer Application was identified as a distinct activity due to associated N_2O emissions particular to fertilizer application, whereas all "Other Silvicultural & Forest Management Practices" (with the exception of Harvesting) were grouped together as a single activity since the only anticipated emission sources were fossil fuel combustion in vehicles and equipment (aside from controlled burning / wildfire emissions which have been associated in the Figure with Forest Carbon Pools).

Based on the model, the SSP identification procedure described previously was applied to identify project SSPs. Given the similarities between eligible project types, all project types were considered together. The result is a single set of potentially relevant SSPs that cover all eligible project types (illustrated in Figure 2, and described in detail in Table 2 through Table 4), though which SSPs are ultimately deemed to be relevant for a particular project will depend on the forestry project type to which the protocol is being applied.

In developing the project and baseline model and identifying SSPs, SSP identification provided in existing forestry project GHG methodologies and protocols was considered, including the CAR Forest Project Protocol Version 3.2[29], the Voluntary Carbon Standard Tool for AFOLU Methodological Issues[30], and the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[31]. In particular, these sources of good practice guidance provide lists of recognized forest carbon pools, which are generally consistent between the different source documents though some references provide more subdivisions than others. The SSPs identified in this protocol are consistent with these sources of good practice guidance.

5.2.4 Tracking Carbon Pools vs. Sources and Sinks

There are two fundamentally distinct approaches that can be taken to track carbon in a carbon pool:

1) assess the amount of carbon stored in the carbon pool at different times, and the difference equals the increase or decrease in carbon stored in the pool over that time; or

2) track the emissions from all sources, removals from all sinks, and transfers to and from all carbon pools associated with the carbon pool, and the difference between the sum of all inputs and the sum of all outputs equals the increase or decrease in carbon stored in the pool over time.

Since the quantification approaches presented in this protocol envision the assessment of the carbon stored in forest carbon pools at different times (option 1, above), rather than the tracking of individual sources, sinks and transfers (option 2, above), a complimentary approach has been taken in identifying SSPs. Thus, in developing Figure 2, the following approach was taken:

- Where forest or wood product carbon pools were identified, the associated CO_2 sources and sinks (and transfers) were not identified. Such carbon pools are labeled using a PP1, PP2, … , PPn convention, where PP denotes 'project pool'.

- For emission sources that do not have an associated carbon pool (e.g. fossil fuel combustion, fertilizer emissions, etc.) or for non-CO_2 emissions from combustion or decay of biomass/wood products, these emission sources are explicitly identified. Such emission sources are labeled using a PE1, PE2, …, PEn convention, where PE denotes 'project emission source'.

- Note that no stand-alone sink processes were identified (i.e. all sinks had an associated carbon pool, and thus did not need to be identified).

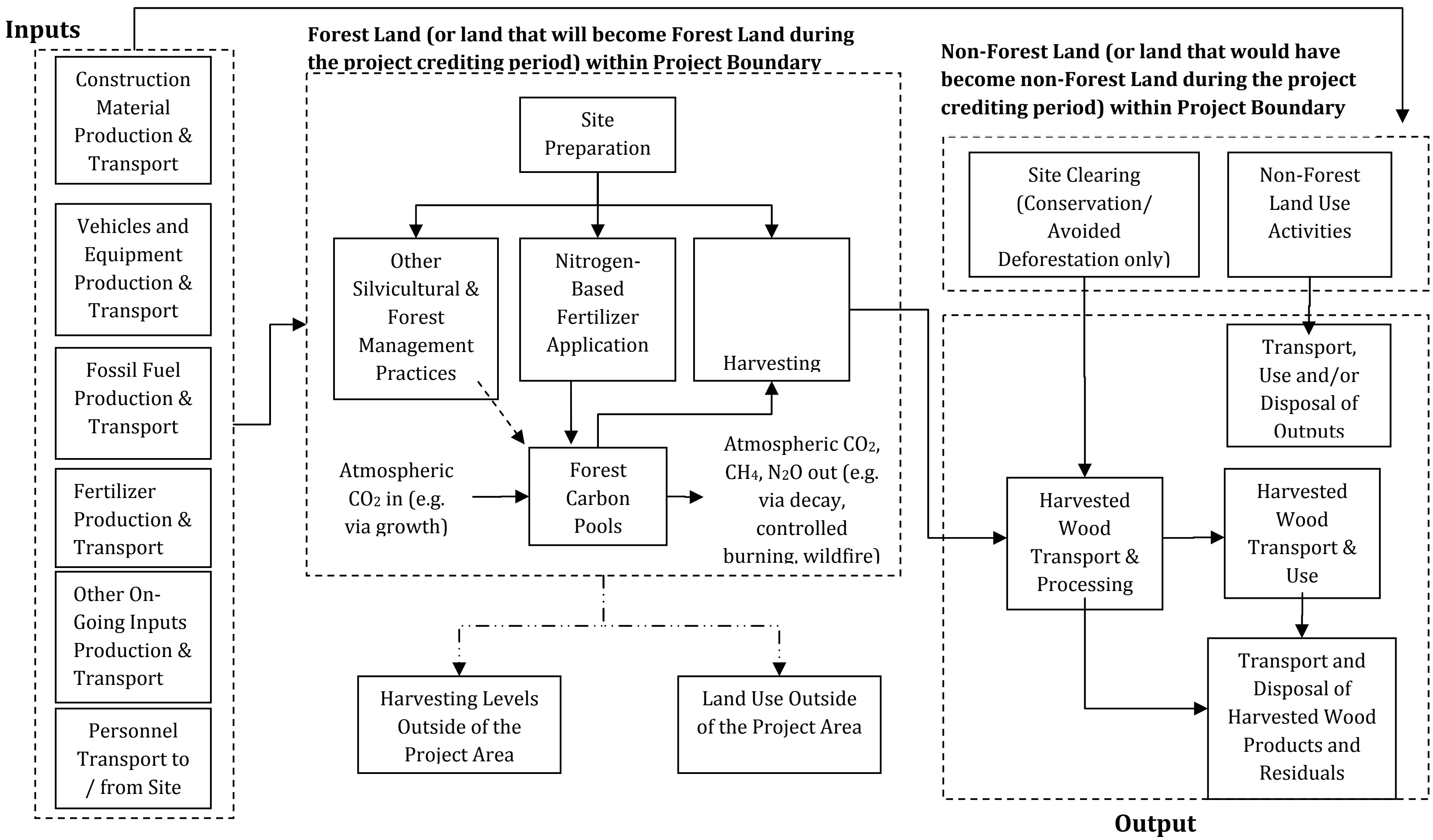
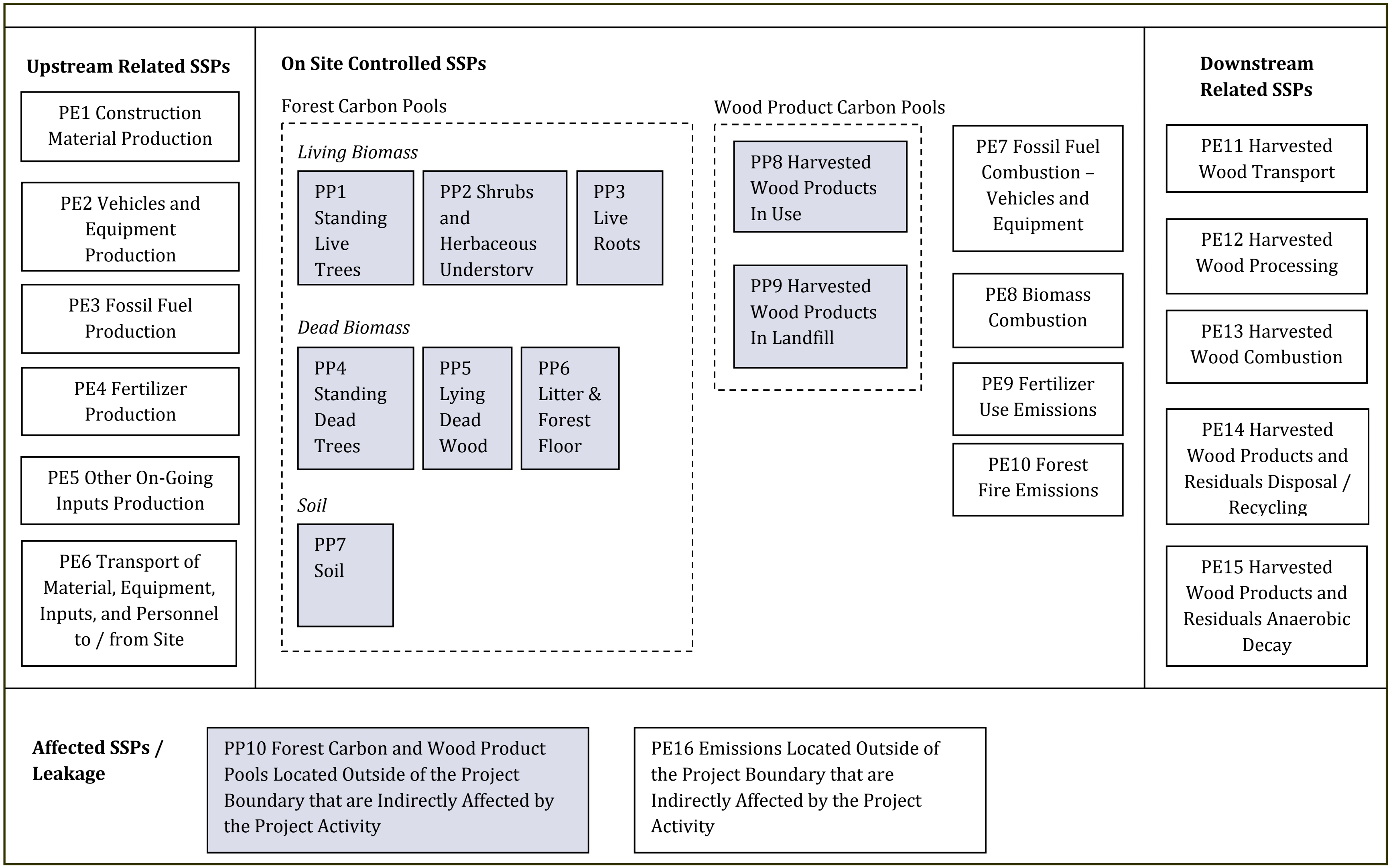


Figure 1: Project and Baseline Model – All Eligible Project Types



Note: Carbon pools are shaded light blue to distinguish them from emission sources.

Figure 2: Project SSPs – All Eligible Project Types

5.2.5 Description of project SSPs

Project SSPs, as identified in Figure 2, are described in Table 2 (controlled carbon pools),

Table 3 (controlled and related emission sources), and Table 4 (affected SSPs). Note that carbon pools are shaded light blue to further distinguish them from emission sources.

Table 2: Controlled Project Carbon Pools

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
On-site Controlled Carbon Pools					
PP1 Standing Live Trees	Carbon pool	Standing live trees include the stem, branches, and leaves or needles of all above ground live biomass, regardless of species.[32] Stores carbon by incorporating atmospheric CO_2 into its biomass (a sink process) via photosynthesis. A minimum diameter at breast height threshold may be justified by the project proponent based on the requirements of models and field sampling techniques used.	• Carbon via growth	• Carbon via respiration, fire, transfer to dead wood and HWP carbon pools	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. Stores carbon by incorporating atmospheric CO_2 into its biomass (a sink process) via photosynthesis.	• Carbon via growth	• Carbon via respiration, fire, transfer to dead wood carbon pools	Controlled

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
PP3 Live Roots	Carbon pool	Portions of living trees, shrubs or herbaceous biomass located below-ground, principally roots. Stores carbon by incorporating atmospheric CO_2 into its biomass (a sink process) via photosynthesis that occurs above ground.	• Carbon via growth	• Carbon via transfer to soil carbon pools	Controlled
PP4 Standing Dead Trees	Carbon pool	Standing dead trees include the stem, branches, roots, or section thereof, regardless of species. Stumps[33] are not considered standing dead stocks.[34] A minimum diameter at breast height threshold may be justified by the project proponent based on the requirements of models and field sampling techniques used.	• Carbon via transfer from live biomass	• Carbon via decay, transfer to other dead wood and HWP carbon pools	Controlled
PP5 Lying Dead Wood	Carbon pool	Any piece(s) of dead woody material from a tree, e.g. dead boles, limbs, and large root masses, on the ground in forest stands. Lying dead wood is all dead tree material with a minimum average diameter of 12.5cm and a minimum length of 2.4m. Anything not meeting the measurement criteria for lying dead wood will be considered litter. Stumps are not considered lying dead wood.[35]	• Carbon via transfer from live biomass and standing dead biomass	• Carbon via decay, transfer to other dead wood carbon pools	Controlled
PP6 Litter & Forest Floor	Carbon pool	Any piece(s) of dead woody material from a tree, e.g. dead boles, limbs, and large root masses, on the ground in forest stands that is smaller than material identified as lying dead wood.[36]	• Carbon via transfer from live biomass and other dead biomass	• Carbon via decay, transfer to soil carbon pool	Controlled

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
PP7Soil	Carbon pool	Belowground carbon not included in other pools, to a depth appropriate considering the full project-specific soil profile. Can be a net sink or emission source depending on the circumstances.	• Carbon via transfer from live roots and dead biomass	• Carbon via soil respiration, leaching and growth	Controlled
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 (i.e., has not been burned, disposed of, etc.).	• Carbon via transfer from live and dead standing trees	• Carbon via transfer to landfill or via aerobic decay	Controlled[37]
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.	• Carbon via transfer from harvested wood in-use or residuals	• Carbon via anaerobic decay	Controlled

Table 3: Controlled and Related Project Emission Sources

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
Upstream Related Emission Sources					
PE1 Construction Material Production	Source	Raw material extraction through to final production of any construction materials used for the project. Results in CO_2, CH_4, and N_2O emissions.	• Raw materials • Energy	• Products • Emissions	Related
PE2 Vehicles and Equipment Production	Source	Raw material extraction through to final production of any vehicles, equipment, and associated parts and supplies, tools, etc. that are used throughout the project. Results in CO_2, CH_4, and N_2O emissions.	• Raw materials • Energy	• Products • Emissions	Related
PE3 Fossil Fuel Production	Source	Extraction and production / refining of the fuel used to operate vehicles and equipment throughout the project, including for both site development activities (e.g. site clearing, road construction, etc.) and on-going silvicultural and other forest management activities. Results in CO_2, CH_4, and N_2O emissions.	• Raw materials • Energy	• Fossil Fuel • Emissions	Related
PE4 Fertilizer Production	Source	Raw material extraction through to final production of fertilizers that are used throughout the project. Results in CO_2, CH_4, and N_2O emissions.	• Raw materials • Energy	• Fertilizer • Emissions	Related
PE5 Other On-Going Inputs Production	Source	Raw material extraction through to final production of any other inputs that are used throughout the project, such as seedlings or chemical inputs (other than	• Raw materials • Energy	• Products • Emissions	Related

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		fertilizer). Results in CO_2, CH_4, and N_2O emissions.			
PE6 Transport of Material, Equipment, Inputs, and Personnel to Site	Source	Transportation of all construction materials, equipment, inputs, and personnel to the project site as required during the project. Typically conducted by various fossil fuel-burning modes of transportation (truck, rail, etc.). Results in CO_2, CH_4, and N_2O emissions.	• Freight and personnel • Fuel	• Freight and personnel • Emissions	Related
On-site Controlled Emission Sources					
PE7 Fossil Fuel Combustion – Vehicles and Equipment	Source	On-site vehicles and equipment may burn fossil fuels. Such vehicles and equipment include, but are not limited to: • Trucks and other small cargo / passenger vehicles • Harvesting equipment • Skidders • Loaders • Processors • Heaters (e.g. for any on-site buildings) • Portable generators • Aircraft Results in CO_2, CH_4, and N_2O emissions.	• Fossil Fuel	• Energy • Emissions	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. Results in CO_2, CH_4, and N_2O	• Biomass	• Energy • Emissions	Controlled

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		emissions, though CO_2 need not be tracked here as it is already tracked as part of other carbon pools.			
PE9 Fertilizer Use Emissions	Source	Application of nitrogen-based fertilizers and associated N_2O emission pathways, including emission from soil, volatilization, and leaching and runoff.	• Fertilizer	• N_2O emissions	Controlled
PE10 Forest Fire Emissions	Source	Combustion of forest carbon pools in place due to natural fire events as well as human induced fire events (e.g. accident, arson, etc.). Results in CO_2, CH_4, and N_2O emissions, though CO_2 need not be tracked here as it is already tracked as part of other carbon pools.	• Forest carbon biomass	• Emissions	Controlled
Downstream Related Emission Sources					
PE11 Harvested Wood Transport	Source	Transport of harvested wood will occur at various points in the lifecycle of the wood, including but not limited to: • Transport from the forest to one or more processing and manufacturing locations (e.g. sawmills, lumber yards, finished goods manufacturers, etc.) • Transport of wood products to end users • Transport of residuals from processing / manufacturing to end-use / disposal / recycling locations (e.g. landfills, places where residuals sold for mulch, etc.)	• Harvested Wood • Fuel	• Harvested Wood • Emissions	Related

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		• Transport of wood products to disposal / recycling locations at end of life Results in CO_2, CH_4, and N_2O emissions			
PE12 Harvested Wood Processing	Source	Raw harvested wood will be processed in some fashion off-site post harvesting, unless all required processing (e.g. chipping) is completed at the forest site (in which case, emissions from such activities would be captured under P6). Processing could include but is not limited to: • Chipping • Milling • Manufacture into finished wood products (e.g. paper, furniture, etc.) Processing would require energy that may be provided by fossil fuel combustion or use of electricity generated using fossil fuels. Results in CO_2, CH_4, and N_2O emissions.	• Harvested Wood • Energy	• Processed Harvested Wood • Emissions	Related
PE13 Harvested Wood Combustion	Source	Harvested wood may be combusted for energy. Results in CO_2, CH_4, and N_2O emissions, though CO_2 emissions are tracked as part of the	• Harvested Wood	• Energy • Emissions	Related

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		Harvested Wood Products In Use carbon pool.			
PE14 Harvested Wood Products and Residuals Disposal / Recycling	Source	Wood residuals and wood products at the end of their useful lives will be disposed of or recycled. Disposal / recycling may require energy inputs to operate associated on-site equipment and vehicles.	• Harvested Wood • Energy	• Emissions	Related
PE15 Harvested Wood Products and Residuals Anaerobic Decay	Source	A portion of harvested wood products and residuals will decay under anaerobic conditions, such as in a managed landfill, to CO_2 and CH_4. While CO_2 emissions are tracked as part of the Harvested Wood Products in Landfill carbon pool, CH_4 emissions would need to be tracked here. Actual CH_4 emissions would vary depending on the extent to which landfill sites employed landfill gas capture systems. CH_4 that was captured and flared or otherwise combusted would not need to be considered here as emissions would largely be CO_2 and thus tracked by the previously noted carbon pool.	• Harvested Wood	• Emissions	Related

Table 4: Affected Project SSPs (Leakage)

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
Affected SSPs					
PP8 Forest Carbon and Wood Product Pools Located Outside of the Project Boundary that are Indirectly Affected by the Project Activity	Carbon pool	Project activities that result in the change in the level of a service (e.g. land use of a given type, amount of wood products produced) provided from within the project boundary may result in changes in the level of those services provided outside the project area, including areas within BC as well as outside of BC, due to market forces / activity shifting. Such changes, which are often referred to as 'leakage', may result in changes in the amount of carbon stored in forest and/or wood product carbon pools located outside of the project boundary, but that are nonetheless affected by the project activity and that might serve to cancel out to some degree emission reductions or enhanced sequestration achieved by the project within the project boundary	• Various	• Various	Affected
PE16 Emissions Located Outside of the Project Boundary that are Indirectly Affected by the Project Activity	Source	Project activities that result in the change in the level of a service (e.g. land use of a given type, amount of wood products produced) provided from within the project boundary may result in changes in the level of those services provided outside the project area, including areas within BC as well as outside of BC, due to market forces / activity shifting.	• Various	• Various	Affected

Name	Source, sink or carbon pool	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		Such changes, which are often referred to as 'leakage', may result in changes in the amount of emissions occurring outside of the project boundary (e.g. due to fossil fuel combustion, fertilizer application, etc. associated with shifted land use or harvesting, or with production of wood product alternatives) but that are nonetheless affected by the project activity and that might serve to cancel out to some degree emission reductions or enhanced sequestration achieved by the project within the project boundary.			

Explanation of SSPs Categorization

All SSPs were categorized as controlled, related or affected (C/R/A) based on their relation to the project proponent, where the project proponent 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.

5.3 Identification of Baseline SSPs

As per ISO14064-2 requirements baseline SSPs were identified using the same criteria and procedures as for identification of project SSPs. No additional criteria were used.

As noted previously, a combined project and baseline model was prepared and provided as Figure 1. In a manner analogous to the project case, and with a large number of resulting similarities, the SSP identification procedure described previously was applied to identify baseline SSPs based on the model. Given the similarities between eligible project types and associated potential baselines, baselines for all project types were considered together. The result is a single set of potentially relevant SSPs that cover all potential baseline activities (illustrated in Figure 3, and described in detail in Table 5), though which SSPs are ultimately deemed to be relevant for a particular baseline will depend on the forestry project type to which the protocol is being applied.

5.3.1 Tracking Carbon Pools vs. Sources and Sinks

There are two fundamentally distinct approaches that can be taken to track carbon in a carbon pool:

1) Assess the amount of carbon stored in the carbon pool at different times, and the difference equals the change in carbon in the carbon pool; or

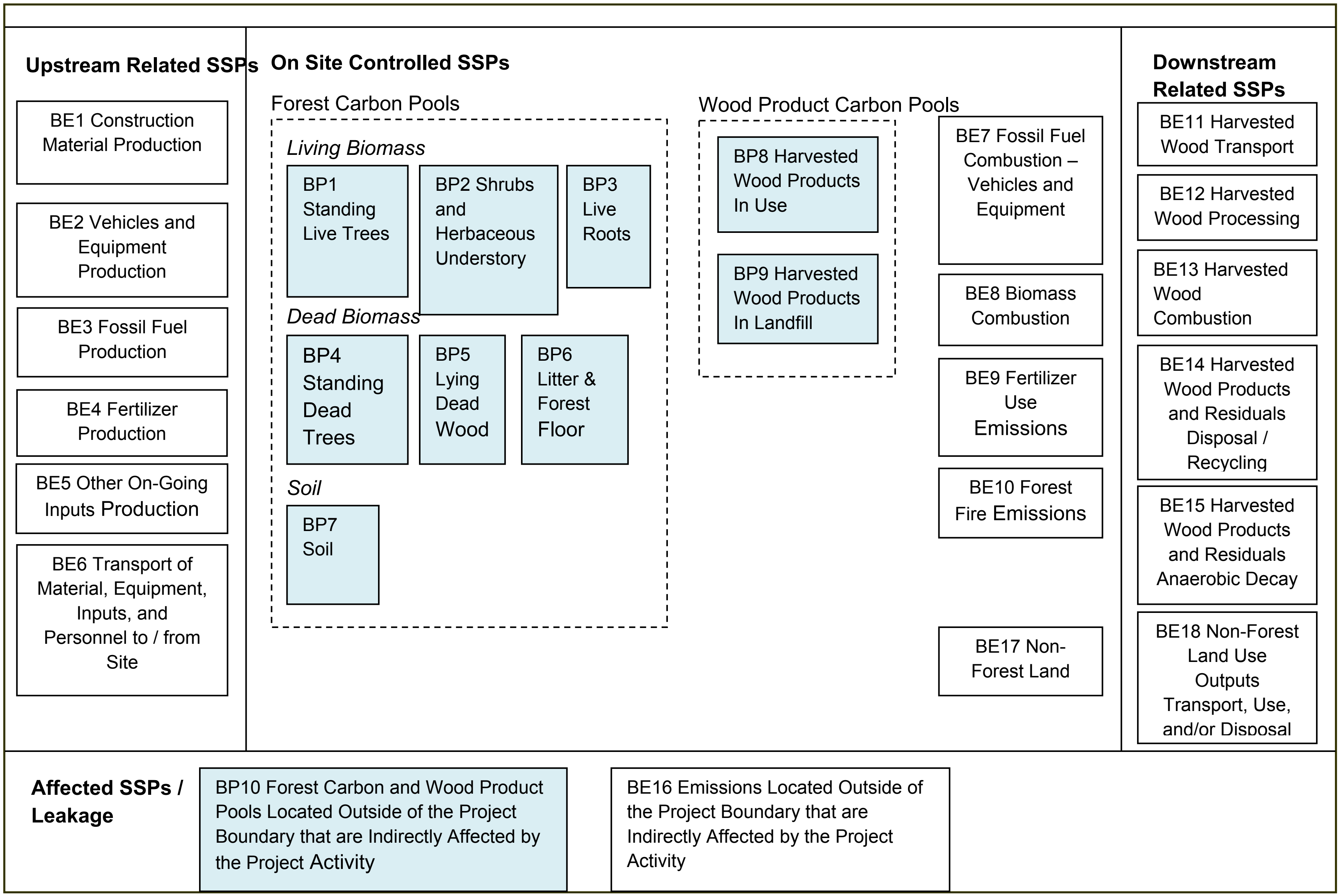
2) Track the emissions from all sources, removals from all sinks, and transfers to and from all carbon pools associated with the carbon pool, and the difference between the sum of all inputs and the sum of all outputs equals the change in carbon stored in the carbon pool over time.

Since the quantification approaches presented in this protocol envision the assessment of the carbon stored in forest carbon pools at different times (option 1, above), rather than the tracking of individual sources, sinks and transfers (option 2, above), a complimentary approach has been taken in identifying SSPs. Thus, in developing Figure 3 the following approach was taken:

- Where forest or wood product carbon pools were identified, the associated CO_2 sources and sinks (and transfers) were not identified. Such carbon pools are labeled using a BP1, BP2, … , BPn convention, where BP denotes ‘baseline pool’

- For emission sources that do not have an associated carbon pool (e.g. fossil fuel combustion, fertilizer emissions, etc.) or for non-CO_2 emissions from combustion or decay of biomass/wood products, these emission sources are explicitly identified. Such emission sources are labeled using a BE1, BE2, … , BEn convention, where BE denotes ‘baseline emission source’

- Note that no stand-alone sink processes were identified (i.e. all sinks had an associated carbon pool, and thus did not need to be identified).



Note: Carbon pools are shaded light blue to distinguish them from emission sources.

Figure 3: Baseline SSPs – All Eligible Project Types

5.3.2 Description of baseline SSPs

Baseline SSPs as identified in Figure 3 are described in Table 5. Since identified baseline SSPs include all identified project SSPs plus two other SSPs not found in the project, for enhanced clarity, only those SSPs not present in the project case are described here. All other SSPs have the same description as corresponding project SSPs as presented in Table 2 through Table 4, except that the word "project" should be replaced with the word "baseline" in those descriptions.

Table 5: List of Baseline SSPs Not Present in the Project.

Name	Source, sink or carbon pool (SSP)	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
Upstream Related SSPs					
On-site Controlled SSPs					
BE17 Non-Forest Land Use	Source	Applicable to afforestation, conservation / avoided deforestation projects, and potentially reforestation projects. Emissions related to non-forest land use activities (e.g. residential, commercial, industrial, agricultural, etc.) occurring at the baseline site, which could include, but are not limited to: • Fossil fuel combustion emissions for space heating, electricity, process heat, etc. • Industrial process emissions • Agricultural methane and nitrous oxide emissions	• Various	• Various • Emissions	Controlled

Name	Source, sink or carbon pool (SSP)	Description	Inputs	Outputs	Controlled (C), related (R) or affected (A)
		• Methane emissions from anaerobic decay			
Downstream Related SSPs					
B18 Non-Forest Land Use Outputs Transport, Use, and/or Disposal	Source	Applicable to afforestation, conservation / avoided deforestation projects, and potentially reforestation. Where non-forest baseline land use results in the generation of useful products or wastes that are transported, used, and/or disposed of off-site, emissions could result from these transport, use and disposal activities.	• Various Outputs • Energy	• Emissions	Related

5.3.3 Explanation of SSP Categorization

All SSPs were categorized as controlled, related or affected (C/R/A) based on their relation to the project proponent and based on how similar SSPs were categorized in the project case, where the project proponent is assumed to control all on-site SSPs in the project and analogous SSPs in the baseline, whereas upstream and downstream SSPs are assumed to be controlled by others, and thus are related to the project. This categorization is to be reviewed by each user of this protocol and adjusted accordingly based on project-specific circumstances. However, this categorization does not have any impact on other aspects of this protocol, such as calculation methodologies.

5.4 Compare project and baseline SSPs and Select Relevant SSPs

This section includes the following methodological components:

- Compare project SSPs to baseline SSPs (as per section 5.5 c) of ISO 14064-2)
- Identify a final list of relevant project and baseline SSPs
- Select relevant SSPs for either monitoring or estimating GHG emissions and removals

5.4.1 Selection of Criteria and Procedures

While no specific criteria or procedures are required for comparison of project and baseline SSPs according to ISO 14064-2 requirements, criteria and procedures are required to both identify the final set of relevant SSPs as well as to determine whether emissions and removals from each relevant SSP should be monitored or estimated.

With regards to identifying a final set of relevant SSPs, the criteria and procedures identified in ISO 14064-2, the Federal draft Guide for Protocol Developers, and BC-specific offset rules for assessing the relevance of SSPs were considered to be the most relevant and current, and were thus used to identify and compare a final set of relevant project and baseline SSPs from the preliminary lists of SSPs presented above. ISO 14064-2 provides common good practice guidance (in Figure A.2 included within the standard) used to compare and select relevant GHG SSPs for monitoring and estimating.

Additionally, since one-time-only emission sources, such as those associated with construction of project equipment and end-of-life decommissioning, are typically not material to overall GHG emission reduction calculations, these emission sources have not been considered relevant in this protocol. This approach is consistent with the Federal draft Guide for Protocol Developers. However, the Director reserves the right to identify specific one-time-only emission sources that must be quantified, where there is potential for associated emissions to be material to the emission reduction calculation. Finally, BC offset-specific requirements related to emission reductions and removal enhancements occurring within British Columbia from controlled SSPs were also respected.

With regards to selecting relevant SSPs for monitoring vs. estimating, the cost/benefit criteria and procedures described in ISO 14064-2 Annex A, Figure A.2 are considered to be a generally accepted approach, and were used.

5.4.2 Procedures for Selecting Final List of Relevant SSPs and Selecting SSPs for Monitoring or Estimating

5.4.2.1 Selecting Final List of Relevant SSPs

In performing a final assessment of relevance for project and baseline SSPs, the following criteria were used:

- **No change between project and baseline**: if there were no apparent changes in emissions between the project and baseline for an equivalent SSP, then the SSP was excluded from further consideration since it would have no bearing on overall project emission reductions. (as per ISO 14064-2 Figure A.2 No. 6).
- **Emissions greater for baseline than project**: if estimated emissions for a baseline SSP were greater than for an equivalent project SSP, or if there was no equivalent project SSP, then the SSP was considered for exclusion (equivalent to estimating emissions at zero) as it would be conservative to do so. This decision would be made based on a cost-benefit analysis (e.g., it would be excluded where effort required to quantify the emissions were considered prohibitive given the size or uncertainty of the SSPs in question).
    - **Emission Reductions and Removal Enhancements from Controlled SSPs within BC**: where emissions are greater for the baseline than the project (or removals greater for the project than the baseline) for SSPs that are located outside BC or that are not controlled by the project proponent (i.e. related or affected), these SSPs must be excluded as the BC Emissions Offset Regulation only permits emission reductions and removal enhancements to be counted from controlled SSPs within BC. Note: where project emissions are greater than baseline emissions (or baseline removals are greater than the project) this exclusion does not apply.
- **One-Time-Only Upstream or Downstream SSPs**: all one-time-only SSPs that occur either before or after the project, such as construction of project and baseline equipment, end-of-life decommissioning of equipment, etc., are excluded from consideration.

  Emissions so small as to be clearly much less than the 5% materiality threshold, but difficult to estimate: where a clear case can be made for indicating that emission sources are so small as to not be relevant to intended users of the GHG information, they may be excluded.

5.4.2.2 Selecting Relevant SSPs for Monitoring or Estimating

For each relevant SSP, consideration was given with respect to whether or not an SSP could be monitored cost-effectively (e.g. do the potential benefits of monitoring, such as enhanced accuracy and possibly increased potential for emission reductions, out-weigh any increased costs associated with monitoring rather than estimating). Where estimating was selected, explanation for the decision based on cost-benefit criteria is provided.

5.4.2.3 Comparing and Selecting Relevant SSPs

In applying the procedures described above, the relevance of all project and baseline SSPs was assessed. For enhanced clarity, the results of this assessment have been detailed separately for 1) controlled carbon pools, 2) controlled and related emission sources, and 3) affected SSPs, in Table 6, Table 7, and Table 8 respectively. Similar SSPs for the project and baseline are entered on the same row. For each eligible project type, a decision was made regarding 1) is the SSP relevant to the quantification, and 2) if so, should associated emissions and removals be monitored or estimated. Where an SSP was deemed to be not relevant and/or selected for estimating, supporting explanation is provided. No explanation is needed for relevant SSPs selected for monitoring

Table 6: Relevant controlled carbon pools

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
On-site Controlled Carbon Pools					
PP1/BP1 Standing Live Trees	**Relevant**				**Estimate based on monitored field sampling data and models**
PP2/BP2 Shrubs and Herbaceous Understory	**Relevant**	**Relevant**	**Optional** Project proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since this carbon pool is typically very small in established forests and improved forest management projects are not anticipated to have an appreciable effect on this carbon pool relative to the baseline.	**Optional** Project proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since conservation / avoided deforestation projects would be expected to increase carbon stored in the Shrubs and Herbaceous Understory carbon pool relative to the baseline.	**Estimate based on monitored field sampling data and models**

SSP	Relevance				Monitored or Estimated
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**	
PP3/BP3 Live Roots	**Relevant**				**Estimate based on field sampling of above ground biomass and models** Direct monitoring of below ground live biomass is not feasible.
PP4/BP4 Standing Dead Trees	**Relevant**				**Estimate based on monitored field sampling data and models**

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PP5/BP5 Lying Dead Wood	**Optional** Project proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since afforestation projects would increase carbon stored in the Lying Dead Wood carbon pool relative to the baseline.	**Relevant** If it cannot be demonstrated that the project will involve the same or more carbon being stored in the Lying Dead Wood carbon pool than the baseline. **Optional** All other cases.	**Relevant** If it cannot be demonstrated that the project will involve the same or more carbon being stored in the Lying Dead Wood carbon pool than the baseline. **Optional** All other cases.	**Optional** Project proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since conservation / avoided deforestation projects would increase carbon stored in the Lying Dead Wood carbon pool relative to the baseline.	**Estimate based on monitored field sampling data and models**

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PP6/BP6 Litter & Forest Floor	**Optional** Proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since afforestation projects would increase carbon stored in the Litter carbon pool relative to the baseline.	**Relevant** Unless it is demonstrated that the project will involve the same or more carbon being stored in the Litter carbon pool than the baseline, in which case this SSP may be conservatively deemed not relevant.	**Relevant** Unless it can be demonstrated that the project will involve the same or more carbon being stored in the Litter carbon pool than the baseline, in which case this SSP would be conservatively deemed not relevant.	**Optional** Proponent may elect to consider this SSP to be relevant, but explanation is not required to deem this SSP as not relevant, since conservation / avoided deforestation projects would increase carbon stored in the Litter carbon pool relative to the baseline.	**Estimate based on monitored field sampling data and models**

SSP	Relevance				Monitored or Estimated
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**	
PP7/BP7 Soil	**Relevant** If the project exceeds the soil disturbance limits as 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*[38], regardless of whether or not the Regulation would otherwise apply to the project area. Also relevant where the project involves lowering the water table relative to the baseline case through physical alteration of the project site (e.g. trenching). **Optional** All other cases.				**Estimate based on field sampling and models**

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PP8/BP8 Harvested Wood Products In Use	**Relevant**				**Estimate using monitored wood harvesting activity data and assumptions regarding permanence of storage over time.** Direct measurement of carbon stored in harvested wood products over time is not feasible.
PP9/BP9 Harvested Wood Products in Landfill	**Relevant**				**Estimate using monitored wood harvesting activity data and assumptions regarding permanence of storage over time.** Direct measurement of carbon stored in harvested wood products in landfill over time is not feasible.

Table 7: Relevant controlled and related emission sources

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
Upstream Related Emission Sources					
PE1/BE1 Construction Material Production	**Not Relevant** One-time-only emission source.				Not Applicable
PE2/BE2 Vehicles and Equipment Production	**Not Relevant** One-time-only emission source.				Not Applicable

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PE3/BE3 Fossil Fuel Production	**Relevant** If project emissions > baseline emissions **Not Relevant** If project emissions ≤baseline emissions[39].				**Estimate using Standard Emission Factor and Monitored Activity Level** Not possible to monitor as the SSP is not under the control of the proponent.
PE4/BE4 Fertilizer Production	**Relevant** If project emissions > baseline emissions **Not Relevant** If project emissions ≤baseline emissions				**Estimate using Standard Emission Factor and Monitored Activity Level** Not possible to monitor as the SSP is not under the control of the proponent, and not common practice to directly monitor fuel combustion emissions.

SSP	Relevance				Monitored or Estimated
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**	
PE5/BE5 Other On-Going Inputs Production	**Not Relevant** Emissions associated with growing seedlings and producing chemical inputs are expected to be extremely small and not relevant to the quantification. Other potentially significant forest project inputs were not identified. Therefore, this SSP is conservatively deemed not relevant.				Not Applicable
PE6/BE6 Transport of Material, Equipment, Inputs, and Personnel to Site	Only transport of fossil fuels and fertilizer were identified as having the potential to result in material levels of emissions. Transport of seedlings was considered, but one truck is estimated to be able to transport tens of thousands of seedlings and thus associated emissions are very small. Other chemical inputs tend to be minor, and thus associated transport emissions also expected to be not relevant. **Relevant** If project emissions from transport of fossil fuels and fertilizer > baseline emissions **Not Relevant** If project emissions from transport of fossil fuels and fertilizer ≤baseline emissions				**Estimate using Standard Emission Factor and Monitored Activity Level** Not common practice to directly monitor fuel combustion emissions.
On-site Controlled Emission Sources					

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PE7/BE7 Fossil Fuel Combustion – Vehicles and Equipment	**Relevant** If project emissions > baseline emissions **Optional** If project emissions ≤baseline emissions				**Estimate using Standard Emission Factor and Monitored Activity Level** Not common practice to directly monitor fuel combustion emissions.
PE8/BE8 Biomass Combustion	**Relevant – CH_4 and N_2O only** If project emissions > baseline emissions **Optional – CH_4 and N_2O only** If project emissions ≤baseline emissions				**Estimate using Standard Emission Factor and Monitored Activity Level** Not common practice to directly monitor fuel combustion emissions.

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
	Not Relevant – CO_2 CO_2 emissions are not relevant in all cases for this SSP as they are tracked by monitoring changes in stored carbon in relevant carbon pools.				
PE9/BE9 Fertilizer Use Emissions	**Relevant – N_2O only** If project emissions > baseline emissions **Optional – N_2O only** If project emissions ≤baseline emissions **Not Relevant – CO_2 and CH_4** CO_2 and CH_4 emissions are not relevant in all cases since they are not generated during fertilizer application.				**Estimate using monitored quantities of fertilizer and equations modeling the potential for emissions.** Direct measurement of N_2O emissions from fertilizer application is not feasible.

<table>
<tr><th rowspan="2">SSP</th><th colspan="4">Relevance</th><th rowspan="2">Monitored or Estimated</th></tr>
<tr><th>Afforestation</th><th>Reforestation</th><th>Improved Forest Management</th><th>Conservation / Avoided Deforestation</th></tr>
<tr><td>PE10/BE10 Forest Fire Emissions</td><td colspan="4">Relevant – CH_4 and N_2O only

If project emissions > baseline emissions

Optional – CH_4 and N_2O only

If project emissions ≤baseline emissions

Not Relevant – CO_2

CO_2 emissions are not relevant in all cases for this SSP as they are tracked by monitoring changes in stored carbon in relevant carbon pools.</td><td>Estimate using Standard Emission Factor and Monitored Activity Level

Not common practice to directly monitor combustion emissions.</td></tr>
<tr><td>BE17 Non-Forest Land Use</td><td>Not Relevant

While the baseline involves non-forest land use that may result in emissions, these</td><td>Not Relevant

While the baseline may involve non-forest land use that may result in emissions, these</td><td>Not Relevant

Project and baseline do not involve non-forest land use.</td><td>Not Relevant

While the baseline involves non-forest land use that may result in emissions, these</td><td>Not Applicable</td></tr>
</table>

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
	emissions will be conservatively deemed not relevant, given the challenges in accurately assessing these emissions and their likely minimal contribution to overall emissions.	emissions will be conservatively deemed not relevant, given the challenges in accurately assessing these emissions and their likely minimal contribution to overall emissions.		emissions will be conservatively deemed not relevant, given the challenges in accurately assessing these emissions and their likely minimal contribution to overall emissions.	
Downstream Related Emission Sources					
PE11/BE11 Harvested Wood Transport	**Relevant** If project emissions > baseline emissions **Not Relevant** If project emissions ≤baseline emissions				**Estimate using Standard Emission Factor and Monitored Activity Level** Not possible to monitor as the SSP is not under the control of the proponent, and not common practice to directly monitor fuel combustion emissions.
PE12/BE12 Harvested Wood Processing	**Relevant**				**Estimate using Default or Project-Specific Emission Factors and**

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
	If project emissions > baseline emissions **Not Relevant** If project emissions ≤baseline emissions				**Monitored Activity Level.** Not possible to monitor as the SSP is not under the control of the proponent.
PE13/BE13 Harvested Wood Combustion	**Not Relevant** Any associated CO_2 emissions would be addressed within the HWP methodologies (PP8/BP8 & PP9/BP9). CH_4 and N_2O combustion emissions are expected to be very small relative to other carbon pools and emission sources (even were this to be the only emission source for a project, CH_4 and N_2O combustion emissions are typically ≤ 1% of associated CO_2 emissions, and it is expected that far more carbon will be incrementally stored by a project than would be lost due to combustion of harvested wood) and thus not expected to be relevant to intended users of the GHG information (i.e. much less than the 5% materiality threshold).				Not Applicable
PE14/BE14 Harvested Wood Products and Residuals Disposal / Recycling	**Not Relevant** Only potentially relevant for projects that increase the amount of HWPs generated. However, even then, associated emissions (e.g. from operation of landfill equipment) would be very small and not expected to				Not Applicable

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
	be relevant to intended users of the GHG information (i.e. much less than the 5% materiality threshold).				
PE15/BE15 Harvested Wood Products and Residuals Anaerobic Decay	**Relevant – CH_4 only** If project emissions > baseline emissions **Not Relevant – CH_4 only** If project emissions ≤ baseline emissions **Not Relevant – CO_2 and N_2O** Associated CO_2 emissions accounted for as part of SSP PR9/BR9 and N_2O emissions are not emitted by this source. Note: in assessing the potential relevance of this emission source, consideration was given to the degree to which landfills in the future might face mandatory fixed GHG emission caps and/or requirements for the installation of LFG collection and destruction systems.				**Estimate using monitored wood harvesting activity data, assumptions regarding amount of HWP decay in landfill (as per SSP PP9/BP9) and level of landfill gas collection and destruction.** Not possible to monitor as the location of final landfilling for a given HWP is not known and will occur many years into the future.

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
	Based on current and proposed GHG cap & trade approaches in BC and the Western Climate Initiative, as well as the inherent challenges of accurately determining the total amount of CH_4 emitted from a particular landfill over a specified time period, it is not expected that landfills will face site-specific fixed GHG emission caps in the foreseeable future. Instead, it is expected, as described in Appendix B: Determining LFG Collection Efficiency, that the prevalence of mandatory requirements for installation of LFG collection and destruction equipment will increase in North America, and by the time that most HWPs produced today ultimately make it to landfill, it is assumed that all HWPs will be disposed of at landfills with installed LFG collection and destruction systems. As a result, it is assumed that only the portion of CH_4 generated from anaerobic decay of HWPs that is not captured and destroyed or otherwise converted to CO_2 (e.g. via cover oxidation) prior to release to the atmosphere will be deemed relevant, subject to the restriction noted above where project emissions ≤ baseline emissions.				
BE18 Non-Forest Land Use Outputs Transport, Use, and/or Disposal	**Not Relevant** The project will result in fewer emissions than the baseline or in no change, thus this SSP is conservatively deemed not relevant.	**Not Relevant** The project will result in fewer emissions than the baseline or in no change, thus this SSP is conservatively deemed not relevant.	**Not Relevant** Project and baseline do not involve non-forest land use.	**Not Relevant** The project will result in fewer emissions than the baseline or in no change, thus this SSP is conservatively deemed not relevant.	Not Applicable

Table 8: Relevant affected SSPs

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
Affected SSPs					

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PP10/BP10 Forest Carbon and Wood Product Pools Located Outside of the Project Boundary that are Indirectly Affected by the Project Activity	**<u>Land Use Shifting Leakage</u>** **Relevant** In the following situations, as long as project emissions from affected pools are positive: • Conservation / avoided deforestation projects • Afforestation / reforestation projects, where shifting to other lands owned or controlled by the project proponent ("internal leakage") **Not Relevant** If project emissions from affected pools is zero or negative, or in the following situations: • Improved Forest Management projects, since there is no land use change • Afforestation and reforestation projects, where shifting is to lands outside the ownership or control of the project proponent. This type of leakage is not expected to occur for projects in BC since it is not anticipated that an afforestation and reforestation project would occur on land that was being actively and profitably being used for other activities (e.g. farming, grazing, industrial use, etc), given the economics and financial barriers associated with afforestation and reforestation projects. In the CAR Forest Protocol v3.2, which looks at land use shifting leakage for reforestation projects in detail, leakage is only deemed to occur in situations where a project is displacing other commercially viable land uses.				**Estimate using approaches detailed in Section** 4.4.1 Virtually impossible to monitor affected emissions. Use conservative estimates and assumptions instead.

<table>
<tr><th rowspan="2">SSP</th><th colspan="4">Relevance</th><th rowspan="2">Monitored or Estimated</th></tr>
<tr><th>Afforestation</th><th>Reforestation</th><th>Improved Forest Management</th><th>Conservation / Avoided Deforestation</th></tr>
<tr><td></td><td colspan="4">
<u>Harvest Shifting Leakage</u>
Relevant
In the following situations, as long as project emissions from affected pools are positive:
Where the project results in a decrease in HWP production relative to the baseline
Not Relevant
If project emissions from affected pools is zero or negative, or in the following situations:
Where the project results in no change or an increase in harvested wood product production relative to the baseline, including projects where there was no harvesting in the baseline. These situations are considered not relevant based on the following assumptions:

The potential leakage effect of a project increasing HWP production is that Forest Land outside the project area might decrease HWP production depending on the degree of inelasticity of demand (e.g. where demand is very elastic, then no leakage, but where demand is inelastic and relatively fixed, then potential for leakage).
In typical Forest Land in North America (a relevant geographic area given the large percentage of BC HWP production that is exported to the US) that is not employing improved forest management practices, it is assumed that decreasing harvested wood product production will have the net impact of increasing the combined amount of carbon stored in forest and HWP carbon pools (i.e. increases in carbon stored in forest carbon pools is expected to exceed the decrease in carbon stored in HWPs that are no longer produced). Note that this protocol acknowledges the potential for improved forest management projects to result in increases in total stored carbon while also increasing HWP production, but this situation is not considered typical.
Since the leakage effect in this situation is the increase of stored carbon, it is not relevant since the BC Emission Offset Regulation requires that emission reductions and removal enhancements be derived from controlled SSPs only.

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</table>

SSP	Relevance				Monitored or Estimated
	Afforestation	Reforestation	Improved Forest Management	Conservation / Avoided Deforestation	
PE16/BE16 Emissions Located Outside of the Project Boundary that are Indirectly Affected by the Project Activity	**Not Relevant** With respect to emissions associated with shifting of non-forest land use or harvesting outside the project boundary, some fraction of the emissions (not considering any associated changes in sequestration) reduced by the project (e.g. due to avoided harvesting-related fuel consumption; associated with deforesting, developing, or utilizing non-forest land; etc.) would be emitted outside the project boundary based on the extent to which activity shifting occurs. However, since such emission reductions are not accounted for according to the methods in this protocol (they are only counted when the project results in an emissions increase, which is conservative), it is still conservative to deem these emissions to be not relevant, since the net effect still underestimates the emission reductions due to the project since the affected emissions increase will be some fraction of, and thus less than, the emissions that are saved by the project within the project boundary. Emissions associated with changes in the production and use of wood product alternatives outside of the project boundary (due to reduced harvesting associated with a project), could be expected to occur to some degree. However, such impacts will likely be: • minor relative to other relevant SSPs for forest projects • will be extremely difficult to accurately estimate • will represent a net increase in project emissions in some cases (reduced harvesting) whereas will represent a net decrease in project emissions in other cases (increased harvesting) and thus might be expected to balance out over a large number of projects • covered in the near future under a regulated system with fixed emission caps for larger facilities, which would capture most producers of wood alternatives, such as steel, cement, etc. As such, changes in emissions due to the production and use of wood product alternatives are deemed not relevant.				Not Applicable

6.0 PROCEDURE FOR DETERMINING THE BASELINE SCENARIO

6.1 Determining the Baseline Scenario

In order to calculate the net emission reductions and/or removal enhancements that have resulted from a particular project undertaking, it is necessary to first estimate the quantity of emissions and removals that would have occurred had the project not been implemented. To quantify these emissions, it is necessary to identify and select a baseline scenario representing what would have most likely occurred in the absence of the project.

6.1.1 Selection of Criteria and Procedures for Determining the Baseline Scenario

Various approaches exist for both identifying and assessing potential baseline scenarios and justifying the final baseline scenario selected. Good practice guidance reviewed in this regard included:

- WRI/WBCSD GHG Protocol
- Draft Federal Guide for Protocol Developers[40]
- The Alberta Offset System
- Annex A of ISO 14064-2
- Approaches taken in approved forestry methodologies such as CAR Forest Project Protocol Version 3.1 and VCS Forestry Methodologies.

The draft Federal Guide for Protocol Developers was selected as the most relevant and current good practice guidance for this procedure as it is specifically designed for protocol development (versus project-specific GHG project plan development) and is designed to be broadly applicable in the Canadian context. Also, this latest draft method is essentially the same as one presented in 2005/2006, and thus has been subject to significant scrutiny over the past 3-4 years.

While the above noted good practice guidance contains methodologies that provide some level of guidance for identifying baseline alternatives, several key deficiencies prevented them from being used directly in this protocol. The widely used and highly regarded WRI/WBCSD GHG Protocol offers two different approaches for estimating baseline emissions 1) a project-specific barriers test approach and 2) a performance standard approach, both of which were useful when paired with the approaches from the draft Federal Guide for Protocol Developers. The Alberta Offset System utilizes a modified version of the approach contained in the draft Federal Guide for Protocol Developers and thus need not be used directly. ISO 14062-2 provides some specific items for selecting and establishing criteria but it is not prescriptive in its guidance. Approved forestry methodologies such as the CAR Forest Project Protocol tend to proscribe an overall baseline approach and then provide guidance around how to implement it, rather than providing procedures and criteria for how to select the most appropriate baseline scenario.

6.1.2 Identification of Baseline Type

The draft Federal Guide for Protocol Developers requires that specific types of potential baseline approaches be evaluated. Although each approach is defined and explained, the Federal Guide provides very few specific selection criteria for determining when each approach should be used. Thus, this protocol reverts to the requirements and good practice guidance found in ISO 14064-2 (e.g. requirements specified in Section 5.4) for cases where specific criteria are not provided.

The types of baseline scenarios that must be considered according to the draft Federal Guide for Protocol Developers are described below (note: some of these definitions have been modified slightly from what is provided in the Federal Guide to ensure that this process focuses on baseline scenario selection rather than identifying baseline data and quantification approaches).

Note that for all of these baseline types, the Federal Guide also requires that the baseline should be established once at the start of the project (static) or updated periodically during the project (dynamic). Note that a static baseline does not mean that baseline emissions and removals are necessarily fixed at one level for the duration of the project. Instead, baseline emissions and removals may still vary from year to year, but that year-to-year variation is predicted in advance at the beginning of the project in the static case and not adjusted thereafter. For example, predicting at the start of the project the expected future growth and yield in the absence of a project would be an example of a static baseline where baseline carbon levels are different from year to year. In a dynamic baseline, baseline updates would not be predicted in advance, but would instead be updated periodically throughout the project. Updating growth and yield model results on a periodic basis from observed changes in environmental or other relevant parameters during the project period would be an example.

BASELINE TYPES

Historic Benchmark: Assumes that historic practices occurring prior to project commencement would be likely to continue during the project period in the absence of the project. Typically site-specific and can be constructed to reflect reductions in a base period (such as the average emissions of the previous three years). Note that SSPs need not be assumed to be static and fixed at historic levels; instead, if appropriate, expected changes from historic levels over time could be projected once at the beginning of the project (e.g. due to expected baseline growth, harvesting, etc.) and/or could be adjusted dynamically during the project period based on monitored factors that would have affected the baseline (e.g. climate, levels of production, etc.).

Performance Standard: Assumes that a typical emissions profile for the industry or sector is a reasonable representation of the baseline. An assessment of comparable activities within a given industry or sector is necessary.

Comparison-based: Assumes that activities occurring within an appropriately selected control group (such as similar plots of Forest Land) not undertaking the project activities are representative of what would have occurred during the project period in the absence of the project. Emissions or removals from the control group are monitored throughout the project and compared with the emissions from the project site to determine the incremental reductions from the project. Such a control group can be used with more than one project.

Projection-based: Where historic practices are not deemed likely to have continued during the project period in the absence of the project, an alternative site-specific approach is to project forward what would have most likely occurred considering the range of potential activities that could have been conducted. The typical approach in these circumstances is to perform a project-specific barriers test to identify the most likely baseline candidate, as described in the WRI/WBCSD GHG Protocol.

Pre-registered: Baselines that are already approved for use in similar situations.

Other (if appropriate): Protocol developers may have other approaches for developing a baseline that might be suitable if justified.

Normalized Baseline (if appropriate): Where it is clear that a jurisdiction has taken regulatory or other steps to protect the environment that are significantly more advanced of what is happening in most other jurisdictions, the program authority may establish a normalized baseline. In these cases, protocol developers would only need to state that they are using this type of baseline. If a normalized baseline has not been established by the program authority for a project type that is subject to clear differences between jurisdictions, the protocol developer can propose and justify one.

6.1.3 Baseline Selection and Explanation

The suitability of each potential baseline scenario was evaluated for each forest project type, as documented in Table 9, considering the positive and negative aspects of each approach.

Table 9: Potential Baseline Evaluation

Baseline Approach	**Discussion of Suitability**			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
Historic Benchmark	The historic benchmark would be based on the carbon stock levels and activities at the project site prior to project commencement. In the case of an afforestation project, where the project lands have been in a non-forest state for at least 20 years, it is reasonable to expect that the historic non-forest state of the land would continue in the absence of the project. Thus, this approach would give a reasonable and conservative estimate of what would be most likely to	The historic benchmark would be based on the carbon stock levels and activities at the project site prior to project commencement. As long as it can be demonstrated that reforestation of the project area was not required by law (an eligibility requirement for reforestation projects in this protocol), the historic non-reforested state of the land prior to project commencement would be an appropriate foundation on which to build the baseline scenario.	The historic benchmark would be based on the carbon stock levels and activities at the project site prior to project commencement. Where it can be demonstrated that forest management practices in place prior to project commencement would be most likely to continue in the absence of the project, the historic forest management practices would be a suitable basis for the baseline scenario and carbon stock levels existing immediately prior to project commencement would be a suitable starting point for the baseline scenario.	The historic benchmark would be based on the carbon stock levels and activities at the project site prior to project commencement. Since this project type explicitly involves a baseline that does not involve the continuation of historic activities (and in fact, it is the project that continues historic activities), an historic benchmark approach would not be suitable.

Baseline Approach	Discussion of Suitability			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
	occur in the absence of the project. Given that in a non-forest state, it is unlikely that there would be any changes to forest carbon at the site over time during the baseline, a static rather than dynamic baseline would be appropriate.	In many reforestation cases it could be expected that at least some natural regeneration would take place over time, and such regeneration would be affected by various factors including those under the control of forest managers (e.g. the impacts of harvesting and other forest management practices) and those largely outside the control of forest managers (e.g., temperature, precipitation, pests, disease, etc.). Therefore, to ensure consistency and comparability between the project and baseline, the baseline should be developed considering the potential for natural regeneration at the site and dynamically updated during the project period to reflect changes in key factors affecting project and baseline growth.	The forest ecosystem is highly dynamic, and affected by various factors including those under the control of forest managers (e.g. the impacts of harvesting and other forest management practices) and those largely outside the control of forest managers (e.g., temperature, precipitation, pests, disease, etc.). Therefore, to ensure consistency and comparability between the project and baseline, the baseline should be developed considering likely baseline forest growth and other changes during the project period, and dynamically updated during the project period to reflect changes in key factors affecting project and baseline growth.	

Baseline Approach	**Discussion of Suitability**			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
Performance Standard	The pre-project land use scenario and conditions would be project-specific, and a performance standard approach would not be suitable.	The pre-project land use scenario, extent of forest cover, conditions, and potential for baseline regeneration would be project-specific, and a performance standard approach would not be suitable.	A performance standard, such as typical carbon stock level per hectare for different stand types does not exist for B.C. A performance standard approach would involve considerable uncertainty and would need to be established in a way that ensured that emission reductions and removal enhancements were not overstated. Development of such an approach is deemed outside the scope of the current version of this protocol; therefore, this type of baseline is not suitable.	Since the baseline for an conservation / avoided deforestation project is: • a hypothetical situation without recent historic precedent on the project land; where • the lands are converted from a Forest Land to a non-forest land use; and where • the specific details of which may or may not be precisely known; a performance standard approach may be useful in determining the extent of conversion (e.g. change in carbon pool levels) that might have taken place in the baseline, based on the general type of conversion (e.g. residential, industrial, agricultural, etc.) that was expected.

Baseline Approach	Discussion of Suitability			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
				A static performance standard would be appropriate, as the baseline assumes that the process of conversion / deforestation would have begun at the start of the project based on factors at that time, and likely would not be drastically affected by changes in factors over time. A dynamic baseline would not offer significant increased accuracy while increasing project risk. However, a performance standard approach would involve considerable uncertainty and would need to be established in a way that ensured that emission reductions and removal enhancements were not overstated. Development of such an approach is deemed outside the scope of the

Baseline Approach	Discussion of Suitability			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
				current version of this protocol.
Comparison-based	It would be possible to use other non-forest areas with similar land use as the project lands prior to project commencement and subject to similar conditions to the project during the project as a basis for comparison. However, the likelihood of a project area reverting to Forest Land in the baseline case after having been non-forest land for at least 20 years is remote. As such, the effort required for the comparison-based approach would not be warranted over taking an historic benchmark approach.	As long as appropriate control plots can be established (i.e. representative of the project lands prior to reforestation, and subject to similar conditions as the project lands during the project), then a comparison-based approach might be feasible. However, consideration would need to be given to the possibility that a disturbance in the forest (e.g. fire, pest) could have an effect on the control plots that was not representative of the project area as a whole (e.g. a disturbance could eliminate the some or all control plots while the project area is less affected on a relative basis, or the control plots might be unaffected by disturbance while the project area was	As long as appropriate control plots can be established (i.e. representative of the project lands prior to reforestation, and subject to similar conditions as the project lands during the project), then a comparison-based approach might be feasible. However, consideration would need to be given to the possibility that a disturbance in the forest (e.g. fire, pest) could have an effect on the control plots that was not representative of the project area as a whole (e.g. a disturbance could eliminate the some or all control plots while the project area is less affected on a relative basis, or the control plots might be unaffected by disturbance while the project area was	It would be possible to use other forest areas with demand for non-forest lands and associated economic and other relevant factors similar to the project area as the basis for comparison and establishment of the baseline scenario (i.e. baseline rate of conversion / deforestation). However, a sufficient number of comparison areas would be required in order to make the approach statistically valid (especially where lower rates of conversion/deforestation are expected), at which point the approach would become similar to a performance standard. As such, a comparison-based approach is not preferred over a performance standard approach.

Baseline Approach	**Discussion of Suitability**			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
		affected), thereby potentially compromising baseline data for the project from that point forward. The comparison-based approach is by definition a dynamic approach.	affected), thereby potentially compromising baseline data for the project from that point forward. The comparison-based approach is by definition a dynamic approach.	
Projection-based	The projection-based approach would involve considering the range of activities that might be undertaken on the project lands in the absence of the project and selecting the most likely scenario. Since it is reasonable to expect that the historic non-forest state of the project lands would continue in the baseline, use of a projection-based approach is not appropriate.	The projection-based approach would involve considering the range of activities that might be undertaken on the project lands in the absence of the project and selecting the most likely scenario. As long as it can be demonstrated that reforestation of the project area was not required by law (an eligibility requirement for reforestation projects in this protocol), the historic non-reforested state of the land	The projection-based approach would involve considering the range of activities that might be undertaken on the project lands in the absence of the project and selecting the most likely scenario. Where it cannot be demonstrated that forest management practices in place prior to project commencement would be most likely to continue in the absence of the project, a projection-based approach	The projection-based approach would involve considering the range of activities that might be undertaken on the project lands in the absence of the project and selecting the most likely scenario. Since this project type explicitly involves a baseline that does not involve the continuation of historic activities (and in fact, it is the project that continues historic activities), a projection-based approach is an appropriate

Baseline Approach	Discussion of Suitability			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
		prior to project commencement would be an appropriate foundation on which to build the baseline scenario, and a projection-based approach would not be appropriate.	would be appropriate. As with the historic benchmark approach, however, carbon stock levels existing immediately prior to project commencement would be a suitable starting point for the baseline scenario. The forest ecosystem is highly dynamic, and affected by various factors including those under the control of forest managers (e.g. the impacts of harvesting and other forest management practices) and those largely outside the control of forest managers (e.g., temperature, precipitation, pests, disease, etc.). Therefore, to ensure consistency and comparability between the project and baseline, the baseline should be developed considering likely baseline forest growth and other changes during the project period, and	approach for determining the specific type of conversion activity that would have occurred in the baseline and the extent of that conversion. The use of elements of a performance standard may be useful when preparing the projection. Since the conversion is to a non-forest land-use, a static baseline would be appropriate as there would be no need to adjust the baseline from time-to-time based on project-specific conditions (e.g., temperature, precipitation, pests, disease, etc.).

Baseline Approach	**Discussion of Suitability**			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
			dynamically updated during the project period to reflect changes in key factors affecting project and baseline growth.	
Pre-registered	Not Applicable			
Other	Not Applicable			
Normalized Baseline	Not Applicable			
Selected Baseline Approach	A static historic benchmark approach is selected as the most appropriate baseline approach.	A dynamic historic benchmark approach is selected as the most appropriate baseline approach. **Other Options:** Proponents may also choose to use a dynamic comparison-based approach with explanation as to why it is most appropriate.	Where it can be demonstrated that forest management practices in place prior to project commencement would be most likely to continue in the absence of the project, the dynamic historic benchmark approach is selected as the most appropriate baseline approach Otherwise, a dynamic projection-based approach	A static projection-based approach is selected as the most appropriate baseline approach.

Baseline Approach	Discussion of Suitability			
	Afforestation	**Reforestation**	**Improved Forest Management**	**Conservation / Avoided Deforestation**
			would be preferred. **Other Options:** Proponents may also choose to use a dynamic comparison-based approach instead of an historic benchmark or projection-based approach with explanation as to why it is most appropriate.	

6.1.4 Project Type-Specific Baseline Considerations

Note that requirements in this section deal with establishing the baseline scenario (i.e. set of baseline activities and practices), and do not deal with requirements related to quantifying baseline emissions, removals or storage levels in carbon pools. Quantification of baseline SSPs is described in Section 8.0.

6.1.4.1 Afforestation

Establishing a static historic benchmark baseline scenario for an afforestation project requires:

- Confirming that in the absence of the project, the land would most likely not have been afforested, by considering existing or proposed regulatory requirements and provincial or Federal incentives. If this cannot be confirmed, then the baseline is afforestation and the project is not additional.

6.1.4.2 Reforestation

Establishing a dynamic historic benchmark baseline for a reforestation project requires:

- Confirming that in the absence of the project, the land would most likely not have been reforested, by considering existing or proposed regulatory requirements and provincial or Federal incentives. If this cannot be confirmed, then the baseline is reforestation and the project is not additional.

6.1.4.3 Improved Forest Management

Dynamic Historic Benchmark vs. Dynamic Projection-Based Approach

An historic or projection-based baseline would be appropriate, depending on whether or not management practices in place prior to project commencement would be most likely to continue in the absence of the project (see the end of this section for a discussion of the comparison-based approach).

To determine whether or not forest management practices in place prior to project commencement would be most likely to continue in the absence of the project, and thus if an historic benchmark would be appropriate, the project proponent must:

- Prepare a verifiable record of historic forest management practices occurring at the site prior to the project, for a period of at least five years or since the forest area came under management, whichever is lesser;
- Document how the historic forest management practices are not prohibited by law;

- Assess whether or not in the absence of the project, the land would continue to be managed according to historic forest management practices by considering at minimum:
    - existing or proposed regulatory requirements;
    - provincial or Federal incentives;
    - the financial implications of historic forest management practices; and
    - common forest management practices within a geographic region that includes the project, with the size of the region and time period considered to be justified by the proponent.

Since management of a forest area typically involves a variety of activities, the above assessment must consider each type of management activity individually, and what each activity involves, including associated activities, schedules, etc., must be clearly described. For example, if baseline management practices include harvesting, then historic harvesting techniques, schedules, volumes, etc. must be described.

If it cannot be demonstrated that forest management practices in place prior to project commencement would be most likely to continue in the absence of the project, then a projection-based approach would be used instead. Note: where forest management practices include multiple activities, it may be possible to demonstrate that some of the historic activities are the most likely baseline while others are not. A projection-based baseline would only need to be established for those activities where the historic approach could not be shown to be the baseline. This could result in a project having a hybrid historic benchmark / projection-based baseline, but this distinction will disappear once the baseline activities are fully described and selected and baseline quantification begins.

To select a projection-based baseline, the requirements for identifying baseline candidates and selecting a project-specific baseline scenario described in Chapter 7 and Chapter 8 Sections 8.1 and 8.2 of the WRI/WBCSD GHG Protocol November 2005 version are to be used, except that historic practice would not need to be considered as a potential baseline candidate as it would have already been considered and eliminated in making the assessment described above. The final output from this process will be a fully justified and described project-specific baseline scenario.

In addition to / as part of following the stated requirements of the WRI/WBCSD GHG Protocol, the project proponent must:

- Prepare a verifiable record of common forest management practices within a geographic region that includes the project area, with the size of the region and time period considered to be justified by the proponent, and use the record to identify potential baseline candidates.
- Identify forest management practices that are required by law (including regulations, mandatory orders, replanting requirements following harvest, etc. that affect the project site).
- Employ the following barriers, at minimum, when evaluating each baseline candidate:
    - Financial (including consideration of the availability of provincial or Federal incentives)
    - Legal
- Perform the common practice review as described in Section 8.2.3 of the WRI/WBCSD GHG Protocol November 2005 version.

Note that for both the historic benchmark and projection-based approaches the use of the Annual Allowable Cut (AAC) determination is not recommended as the sole means of defining the harvest projection in baselines, since there is no guarantee that the AAC will be fully utilized in a given area.

In addition to considering applicable AACs, baseline harvest projections must take into account the historic harvest statistics (historic benchmark) or typical harvesting statistics (projection-based approach) and possible fluctuations in future harvest levels due to future expected market conditions. The ways in which future market conditions are used to project forward harvesting levels must be explicitly described, and such assumptions must be dynamically updated during the project based on observations of actual conditions (in a manner similar to dynamic updating of baseline growth models based on relevant factors affecting both the project and baseline such as temperature, precipitation, pests, disease, etc.).

Comparison-Based Approach

As an alternative to the historic and projection-based approaches, a project proponent may choose to employ a comparison-based baseline approach. However, in order to select management activities that would be suitable for the comparison area(s), the proponent must still go through the historic / projection-based baseline approach described above. Once the most likely set of baseline forest management activities is identified, then any comparison plots would need to be managed according to those selected baseline activities or according to activities that would result in a more conservative assessment of baseline emission reductions and removal enhancements (i.e. lower baseline emissions / increased removals). Further details on appropriately establishing a comparison-based approach will not be provided here and any such approaches must be successfully justified by a project proponent to a validator on a case-by-case basis.

6.1.4.4 Conservation / Avoided Deforestation

The baseline approach selected for this project type is the projection-based approach. To select the most likely baseline scenario, the generic requirements for identifying baseline candidates and selecting a project-specific baseline scenario described in Chapter 7 and Chapter 8 Sections 8.1 and 8.2 of the WRI/WBCSD GHG Protocol November 2005 version are to be used. The final output from this process will be a fully justified and described project-specific baseline scenario.

In addition to / as part of following the stated requirements of the WRI/WBCSD project-specific barriers test approach, the project proponent must:

- Consider at minimum the following baseline candidates:
    - Maintaining the existing (pre-project) Forest Land state of the project lands;
    - The project scenario (if different from maintaining the pre-project Forest Land state of the project lands);
    - Other baseline candidates identified by considering a range of potential development scenarios that might reasonably be undertaken on the project lands by considering:
        - other recent development activities undertaken within a geographic region that includes the project, with the size of the region and time period considered to be justified by the proponent; and

  - the type of development activities that have been proposed for the project lands (which will define the type of land use that the project would intend to avoid at the project site).

  Baseline candidates must be described in detail, including type of development, intensity of development (e.g. density, etc.) and extent and timing of associated deforestation. Where baseline candidates include maintaining some portion of the project land as Forest Land for at least some part of the project period (e.g. where development is staged and the site will not be fully developed for a number of years) consideration must also be given to potential forest management practices that could be employed in the baseline. Such forest management practices are to be assessed by employing the projection-based barriers test described in this protocol for improved forest management projects.

- Employ the following barriers, at minimum, when evaluating each baseline candidate:
  - Financial (including consideration of the availability of provincial or Federal incentives);
  - Legal, including consideration of zoning by-laws, development permits, tree protection by-laws, riparian regulations, covenants, easements, existing right of ways, and any other relevant project land-specific, local or other legal requirements;
  - Official community development plans;
  - Official regional growth strategies; and
  - Strategic land-use plans and higher-order plans (e.g. as emerge from land and resource management planning processes).

- Perform the common practice review as described in Section 8.2.3 of the WRI/WBCSD GHG Protocol November 2005 version.

As part of completing the above assessment, given the inherent uncertainty associated with conservation / avoided deforestation baselines and the challenges in proving with a high degree of confidence that a particular development scenario would have occurred in the absence of the project, a project proponent must provide clear documentary evidence indicating a high likelihood (i.e. very low barriers) that the selected baseline scenario would have occurred. Such evidence must include:

- an assessment of development practices, including development density, typical development area to meet the stated need, typical extent of deforestation, timing of development, for equivalent land uses to the selected baseline land use that have occurred within a geographic region that includes the project, with the size of the region and time period considered to be justified by the proponent;

- if the baseline is not considered to reflect identified common development practices, then explanation of why the baseline would be different for the particular project site including the identification and explanation of key criteria used to make the assessment;

- where the project does not involve developing the project site in a way that satisfies baseline non-forest land demand, for example where the project involves managing the project area as a forest with no development, or where project development differs from baseline development:

- o An approved development plan / permit for the site issued within two years of project start indicating that the baseline development has been approved; **<u>or</u>**

- o A written offer to purchase the project lands issued within the two years prior to project start, by a developer that is completely independent of the GHG project proponent, and where it can be convincingly demonstrated that the developer would have undertaken the development and deforestation of the project lands according to the selected baseline (including how any identified barriers to the baseline scenario would be overcome); **<u>or</u>**
- o An economic analysis of the selected baseline scenario demonstrating:

  - That the baseline scenario is more financially attractive than maintaining the project lands as Forest Land without development and more financially attractive than the project scenario;

  - That the baseline scenario would exceed the investment thresholds (e.g. internal rate of return, payback period, etc. as appropriate) of the likely developer (which may or may not be the GHG project proponent);

  - That where the project proponent would not develop the site themselves in the baseline, that there is sufficient local demand for development lands similar to the project lands and for the type of development identified in the baseline scenario such that the baseline scenario would be reasonably likely to occur;

  - Why the baseline scenario has not yet occurred (i.e. if it is so likely, what has stopped it from occurring prior to project commencement?);

  - How any identified barriers to the baseline scenario would be overcome in the absence of the project.

Note: Projects that involve developing the project site in a way that satisfies baseline non-forest land demand will likely still need to consider the financial viability of the project as part of the additionality assessment described in Section 7.

If a project is unable to meet the above baseline selection and explanation requirements, then the project must be considered the baseline and thus the project is not additional.

7.0 PROCEDURE FOR DEMONSTRATING ADDITIONALITY

7.1 Project Additionality

In general, the additionality of a project must be established by verifiably demonstrating with explanation that there are financial, technological or other obstacles to carrying out the project that are overcome or partially overcome by the incentive of having a greenhouse gas reduction recognized as an emission offset in British Columbia. Note that project activities that are legally required (i.e. must be conducted in order to meet a legislative requirement) are considered to not face any barriers and thus would be non-additional (also known as 'non-surplus' in the context of legislative additionality). The remainder of this section provides a list of potential ways that additionality may be demonstrated. The particular approach used will depend on project-specific circumstances, and may include approaches not listed below. Note that only one obstacle, or barrier, need be identified for a particular project to demonstrate additionality.

Potential financial barriers include, but are not limited to, the following:

- would not be profitable (i.e. revenues would be less than fixed and variable costs) even taking into account existing government climate change or other incentives, without additional financial support from the sale of offsets;
- is less financially attractive than the proponent's established and documented internal investment hurdle rate without the sale of offsets;
- is less financially attractive without the sale of offsets than a viable alternative to the project;
- faces restrictions on access to capital (e.g. due to high up-front capital costs) that would be overcome at least in part by the potential to generate an offset credit revenue stream.

Non-financial barriers (technological or other) may also be considered. In all cases the proponent must still clearly demonstrate how the incentive of receiving offsets helps to at least partially overcome the identified barriers, though the incentive does not need to be financial. Some examples include:

- An otherwise profitable project faces certain supply chain challenges (e.g. cost effectively getting their product to market cost or delivering an important input to the project site). However, the ability to generate offsets and the associated verified climate change benefits convince companies, local government, etc. in a position to help solve the supply chain challenges to work with the project proponent to reduce these barriers, since supporting such environmentally beneficial initiatives fits within the companies' / government's sustainability and social responsibility goals. As a result, the project is able to proceed.

- The project involves technologies / approaches with which the proponent is not comfortable or experienced (e.g. not a core business of the project proponent). Thus, even if profitable, the proponent would not normally have undertaken the project. However, being able to generate offset credits carries non-financial benefits such as demonstration of environmental stewardship, etc. that are of value to the proponent or their stakeholders (e.g. customers, investors, etc.). As a result, these non-financial benefits of receiving offsets result in the proponent deciding to proceed with the project.

- The project activity faces certain legal barriers that prevent it from being undertaken. However, the potential to generate offsets and the associated verified climate change benefits 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.

Project type-specific requirements related to additionality are described below.

7.1.1 Afforestation

Given the capital-intensive nature of all afforestation projects relative to very limited or no expectations of financial return, at least in the early years of a project (financial barrier), afforestation project proponents need only demonstrate that the afforestation project is not required by law in order to justify that the project is additional.

7.1.2 Reforestation

Reforestation projects on Crown land where there is no legal reforestation obligation will face similar barriers to those described for afforestation projects. As such, these projects need only demonstrate that the reforestation project is not required by law in order to justify that the project is additional.

Reforestation projects on private, municipal, First Nations, Indian Reserves or other land must complete a standard additionality assessment as described in Section 7.1, above.

7.1.3 Improved Forest Management

Improved forest management projects must complete a standard additionality assessment as described in Section 7.1, above.

7.1.4 Conservation / Avoided Deforestation

Conservation / avoided deforestation projects must complete a standard additionality assessment as described in Section 7.1, above.

8.0 OVERVIEW OF QUANTIFICATION APPROACH

QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

Baseline and Project emission quantification are dealt with in a single section below.

Baseline Emissions

Project Emissions

Quantification methods for relevant SSPs are presented below and in the sub sections that follow. These methods would be used each time an emission reduction report is prepared by the project proponent to calculate the net change in emissions and removals that have occurred since the previous emission reduction report was issued (i.e. 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.

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

Equation 1: Net project emission reductions and removal enhancements in CO_2e

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

Where:

Parameter	Description	Default Value
$\Delta CO_2e_{net,\,t}$	The net emission reductions and removal enhancements of CO_2e, 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.	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.	N/A
GWP_j	The global warming potential specified by the BC government for GHG_j	N/A
j	The relevant GHGs in this protocol: 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:

Equation 2: Net project emission reductions and removal enhancements by GHG

$$\Delta GHG_{j,net,t} = \Delta GHG_{j,Project,t} - \Delta GHG_{j,Baseline,t}$$

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.	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 in Equation 3.	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 in Equation 5.	N/A

$\Delta GHG_{j,\ Project,\ t}$ from Equation 2 is determined for each relevant GHG_j as follows:

Equation 3: Total project emissions or removals by GHG

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

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.	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 8.1. Only relevant for j = CO_2; otherwise, set to zero.	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 in Section 8.1. Only relevant for j = CO_2; otherwise, set to zero.	N/A
$GHG_{j,\ Project\ HWP\ Pools,\ t}$	The mass of GHG_j, in tonnes, transferred to and stored in project HWP carbon pools during reporting period *t.* Determined in Section 8.1.2. Only relevant for j = CO_2; otherwise, set to zero.	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 4.	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.	N/A

$GHG_{j,\ Project\ Emission\ Sources,\ t}$ from Equation 3 is determined for each relevant GHG_j as follows:

Equation 4: Emissions from project sources

$$GHG_{j,Project\ Emission\ Sources,t} = \sum_{i} GHG_{j,PE_i,t}$$

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*.	N/A
$GHG_{j,\ PE_i,t}$	Project emissions of GHG_j, in tonnes, from SSP PE_i during reporting period *t*. PE_i shall only include emissions sources deemed relevant based on the requirements of Section 5.2. PE_i shall be calculated based on the requirements of Section 8.2.	N/A

$\Delta GHG_{j,\ Baseline,\ t}$ from Equation 2 is determined for each relevant GHG_j as follows:

Equation 5: Total baseline emissions or removals by GHG

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

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 a positive number.	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 8.1. Only relevant for j = CO_2; otherwise, set to zero.	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 in Section 8.1. Only relevant for j = CO_2; otherwise, set to zero.	N/A
$GHG_{j,\ Baseline\ HWP\ Pools,\ t}$	The mass of GHG_j, in tonnes, transferred to and stored in baseline HWP carbon pools during reporting period *t*. Determined in Section 8.1.2. Only relevant for j = CO_2; otherwise, set to zero.	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 6.	N/A

$GHG_{j,\ Baseline\ Emission\ Sources,\ t}$ from Equation 5 is determined for each relevant GHG_j as follows:

Equation 6: Emissions from baseline sources

$$GHG_{j,Baseline\ Emission\ Sources,t} = \sum_i GHG_{j,BE_i,t}$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ Baseline\ Emission\ Sources,\ t}$	The mass of GHG_j, in tonnes, emitted by the baseline during reporting period *t*.	N/A
$GHG_{j,\ BE_i,t}$	Baseline emissions of GHG_j, in tonnes, from SSP BE_i during reporting period *t*. BE_i shall only include emissions sources deemed relevant based on the requirements of Section 5.3. BE_i shall be calculated based on the requirements of Section 8.2.	N/A

8.1 Quantification Methodologies ‑ Controlled Carbon Pools

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

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

- 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

Which of these pools needs to be quantified depends on which pools are identified by a project proponent 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.

A Note on 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 protocol (i.e. 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 the project proponent, 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 7, this carbon pool should be deemed not relevant.

8.1.1.1 Quantification Approach and Associated Uncertainty

Tracking of carbon pool changes in the project and baseline can be done in two ways:

a) Periodic direct measurement by sampling coupled with assumptions or models used to convert the measured forest biomass into amount of stored carbon; or

b) Projection of study area inventories, disturbance events and stand types using suitable stand level growth and/or carbon models, with some minimum amount of periodic direct observation.

The former approach may provide precision for projects on single stands or simple forest estates, whereas the latter may be more effective for complex forest estates characterized by a diversity of stands, treatments, and disturbances.

a) Field Sampling Method (Direct Measurement):

When using this approach, project proponents must use VRI[41] or NFI[42] standards for conducting field sampling and forest inventories, and this sampling must be supervised by a qualified registered professional. Sample plots must be chosen using a justified statistically valid approach appropriate for the project site (e.g. that reflects any site stratification, etc.).

Results of the sampling would then be converted into amounts of stored carbon in relevant forest carbon pools based on justified assumptions or a forest carbon model (see Section 8.1.1.3). In this way, sampled results replace the results of the growth and yield and forest estate and landscape dynamics models used in Option b), but both options still require the conversion of this forest biomass information into estimates of forest carbon since forest carbon would not be directly measured.

While this approach may be appropriate for the project case, unless a comparison-based baseline approach is being used, direct measurement of baseline forest carbon will not be possible since the project occurs instead of the baseline. In these cases, the baseline will need to be assessed using Option b), but with measured project data used to refine / validate baseline modeling parameters / results to ensure comparability between project and baseline.

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

- 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. A project proponent is permitted to report on and claim offsets from emission reductions and removal enhancements in years where sampling was not conducted (e.g. annual reporting is still permitted) based on modeled results prepared in accordance with Option b). While forest sampling is not strictly required in each reporting period, modelled results must be updated to accurately reflect other activities conducted and monitored during the reporting period (e.g. harvesting activities, fertilizer use, burning, etc.), as well as other relevant factors identified as affecting the project and baseline (e.g. pests, disease, etc.).

  When sampling is conducted, results must be used to re-calibrate model results that may have been prepared[1]

  - 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.

- Instead of specifying a minimum amount of sampling that is required and associated minimum uncertainties, this protocol allows for a more flexible approach where the results of field sampling shall be taken as the lower bound of a two-sided 90% confidence interval for project sampling and the upper bound of a two-sided 90% confidence for baseline sampling (only feasible for comparison-based

[1] 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.

baselines) rather than the mean. 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 should 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 b) (Inventory / Modelling Method) would apply.

b) Inventory / Modelling Method (Indirect Linkage):

While rigorous re-measurement of field conditions typically provides more precision than modeled projections, for large and diverse forest estates (or in some cases small but remote projects) intensive sampling may be prohibitively expensive. For diverse project areas, modelling forest carbon changes for each stand, or for stratified groupings of similar stands, over time with amalgamation of results across the project landbase may provide sufficiently accurate estimates without intensive field sampling. This approach would focus 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 the project proponent (see below for further details)

Vegetation Resource Inventory (VRI) photo-estimates 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 landbase (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 shall 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 shall 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 the project proponent. However, the type and level of measurement shall be reflected in an overall assessment of uncertainty prepared by the project proponent. Such field measurement must be conducted at least once every ten years, to align with the requirements of a) (Field Sampling Method), above.

- In assessing the overall uncertainty of the forest carbon pool quantification approach, the project proponent 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 shall be considered.

- Based on the results of this uncertainty assessment, the proponent shall 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[2]

8.1.1.2 Estimating Harvest Flow

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 project 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.

For non-crown land, proponents must develop and justify an approach appropriate for their project, and subject to requirements detailed elsewhere in this protocol (e.g. Section 6).

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:

a) The long-term level must be sustainable, as indicated by a stable total growing stock;

b) Any declines in harvest levels in the early to mid term must be no more than 10% per decade;

c) Any “dip” in timber supply in the mid-term below that long-term level should be minimized; and

d) Current AAC level should 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 should 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

[2] 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.

mean that the AAC should be used as the sole basis for harvest flow – as detailed in Section 6.0, other information (e.g. 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 both the baseline and the project runs (expect where monitored project data is being used and the baseline is based on estimates), 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).

8.1.1.3 Selection of Appropriate Models

[43]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:

(i) Growth and yield: estimate values for existing and projected tree volume and other characteristics (e.g., diameter at breast height) given starting conditions and site characteristics.

The following growth and yield models are commonly used in British Columbia and are recommended for use by project proponents:

Table 10: Commonly Used Growth and Yield Models in BC

Model name	Range of applicability	
	Geographic/biogeoclimatic area*	Stand types
TASS[44]	Province-wide	Second growth, simple stands
TIPSY[45]	Province-wide	Second growth, simple stands
VDYP[46]	Province-wide	Natural stands
PrognosisBC[47]	IDF, ICH, ESSF, MS	Existing mixed species, complex stands
Sortie-ND[48]	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

The proponent has the option of using the above suggested models 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.

(ii) Forest estate and landscape dynamics: 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 (e.g. 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[49], FSOS[50], FSSIM[51], Patchworks[52], SELES-STSM[53], CASH6[54], Woodstock/Stanley[55], and LANDIS-II[56].

(iii) Ecosystem carbon projection: project changes in carbon stocks in various pools, as well as some emissions sources from forestry operations, over time given initial conditions (e.g. 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)[57] and FORECAST (Kimmins et al., 1999)[58]. CBM-CFS3 is used for national-level and forest management unit-level forest carbon accounting in Canada. FORECAST has also been pre-approved for use in B.C. Both of these models have been parameterized using field data from B.C. forest ecosystems.

In all cases, field measurements may be needed to initially calibrate the model or model inputs (e.g. growth rates for stand growth models, inventory plots to validate air-photo interpreted spatial forest cover data, carbon pool sizes and flux after disturbances).

The above lists of recommended models should be used as a guideline only when deciding which modeling approach to use. Each model has its own advantages and limitations (e.g. 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 (i.e. what information is passed between different models in the overall approach).

Recommendation of models in this protocol does not indicate the assumption of liability by the Government of BC in the case of model errors.

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 has been peer reviewed in a process that: (i) primarily involved reviewers with the necessary technical expertise (e.g., modeling specialists and relevant fields of biology, forestry, ecology, etc.), and (ii) was open and rigorous;
- The model is 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;

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 validator:

1. The amount of peer reviewed empirical data behind the growth and yield 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)[59].

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. Validators and verifiers must ensure the conservative and consistent use of model parameters and assumptions.

8.1.1.4 Quantifying Reversal 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 significant reversals of stored carbon to occur on relatively short timescales. Storage of carbon that is reversed 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 Emission Offset Regulation. Examples include natural reversals due to fire, pest, disease, etc., and human-induced reversals due to legal and illegal harvesting activities, arson, negligence, etc.

For the purposes of this protocol, the term reversal refers to significant disturbances that are not anticipated based on the normal incidence of reversals for the project area. Disturbances and harvesting that are anticipated to occur on a predictable basis for the project area shall 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 the project proponent 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).

The project proponent must monitor for natural and human-induced reversal events, and when detected assess and report on the impact of the event in the next emission reduction report prepared for the project. Assessment of the impact of a reversal should 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 reversal event, one of two approaches is to be taken:

1) For natural reversals that would have also affected the baseline:

   The impact of the reversal 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 afforestation or conservation / avoided deforestation where the baseline is 100% deforestation at the start of the project period). Such modeling must draw on observations of the type and extent of reversal experienced by the project, as well as assumptions regarding the baseline scenario. In preparing this baseline assessment, the project proponent must demonstrate how the assessment is conservative (i.e. does not overstate the impact of the reversal on the baseline) in order to manage the inherent uncertainty of predicting the impact of a particular reversal event on a hypothetical baseline scenario.

   Note that this approach of modeling the impact of reversal events on the baseline is not a common approach taken in existing forest carbon protocols, 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 reversals or natural reversals that would not have affected the baseline:

   The impact of the reversal is to be assessed for the project only. Note that for legal harvesting activities controlled by the project proponent, a portion of the harvested forest carbon may be transferred to HWP pools according to the HWP methodologies described in Section 8.1.2.

Where the net impact of the reversal event and other forest SSPs is that the project emission reductions and removal enhancements are less than baseline emission reductions and removal enhancements for that reporting period, the project proponent must replace a quantity of offsets equal to the difference between the change in project and baseline for the reporting period on a 1:1 basis.

Storage on shorter timescales than 100 years

Storage on shorter timescales than 100 years total may have a benefit on mitigating climate change for the time during which the stored carbon is removed from the atmosphere. The following approach may be used to determine the portion of tonnes of CO_2 emitted during a reversal event that would need to be replaced by the project proponent. The project proponent must include the methodology, research and evidence required to undertake this approach in their GHG Project Plan and third party validation is essential as at the time of publishing this protocol, the Province has not undertaken similar research and no default factors are provided.

1. Assess impact of reversal event on project and baseline storage levels as per normal

It is necessary to have an accurate accounting of the total amount of carbon storage in project and baseline carbon pools at the end of a given reporting period, as those amounts are the basis for determining net changes in storage between the project and baseline for the following reporting period. As such, the approaches described above for quantifying the impacts of natural and human-induced reversals shall be followed.

2. Assess the benefit of carbon storage that has been reversed during the reporting period

The selected approach for assessing the benefits of storage of CO_2 shorter than 100 years in total must ensure that the total number of offsets issued represents an amount of 100 year storage equivalent to the actual storage benefit achieved by the project. Any such method will need to equate the benefit of shorter term storage (e.g. 30 years, 50 years, 80 years, etc.) to equivalent amounts of 100 year storage (e.g. storing 1 tonne of CO_2 for 30 years is equivalent to XX% of the benefit of storing 1 tonne of CO_2 for 100 years, where XX would be justified by the proponent for all relevant shorter-term storage durations). Shorter term storage benefit would need to be assessed for both the project and baseline, and the proponent will need to justify modified, alternative versions of Equation 3 and Equation 5 to account for this benefit while ensuring that the remainder of the 100-year atmospheric benefit not achieved is not credited to the project.

8.1.2 PP8/BP8 & PP9/BP9 Harvested Wood Products In Use and in Landfill

The methodologies 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 protocol 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 overtime, the approach presented here involves assessing the amount of wood product carbon that is lost at various stages along the HWP lifecycle. Since it is extremely difficult to directly monitor the amount of carbon retained in a particular HWP after it moves through this lifecycle after initial production and sale, the approach presented here focuses on estimating the amount of carbon that will be remaining in HWPs, both in-use and in landfill, a certain number of years after harvest.

Note: harvest flow for both project and baseline must be developed in accordance with the requirements stipulated in Section 8.1.1.2.

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

1) Default approach – 100 year storage in HWPs

   In-use and in-landfill storage is based on the amount of carbon that would still be in storage 100 years after harvest. This 100 year period aligns with the BC Emission Offset Regulation requirement that the atmospheric effect of removals endures for at least 100 years.

2) Optional advanced approach – variable length of storage in HWPs

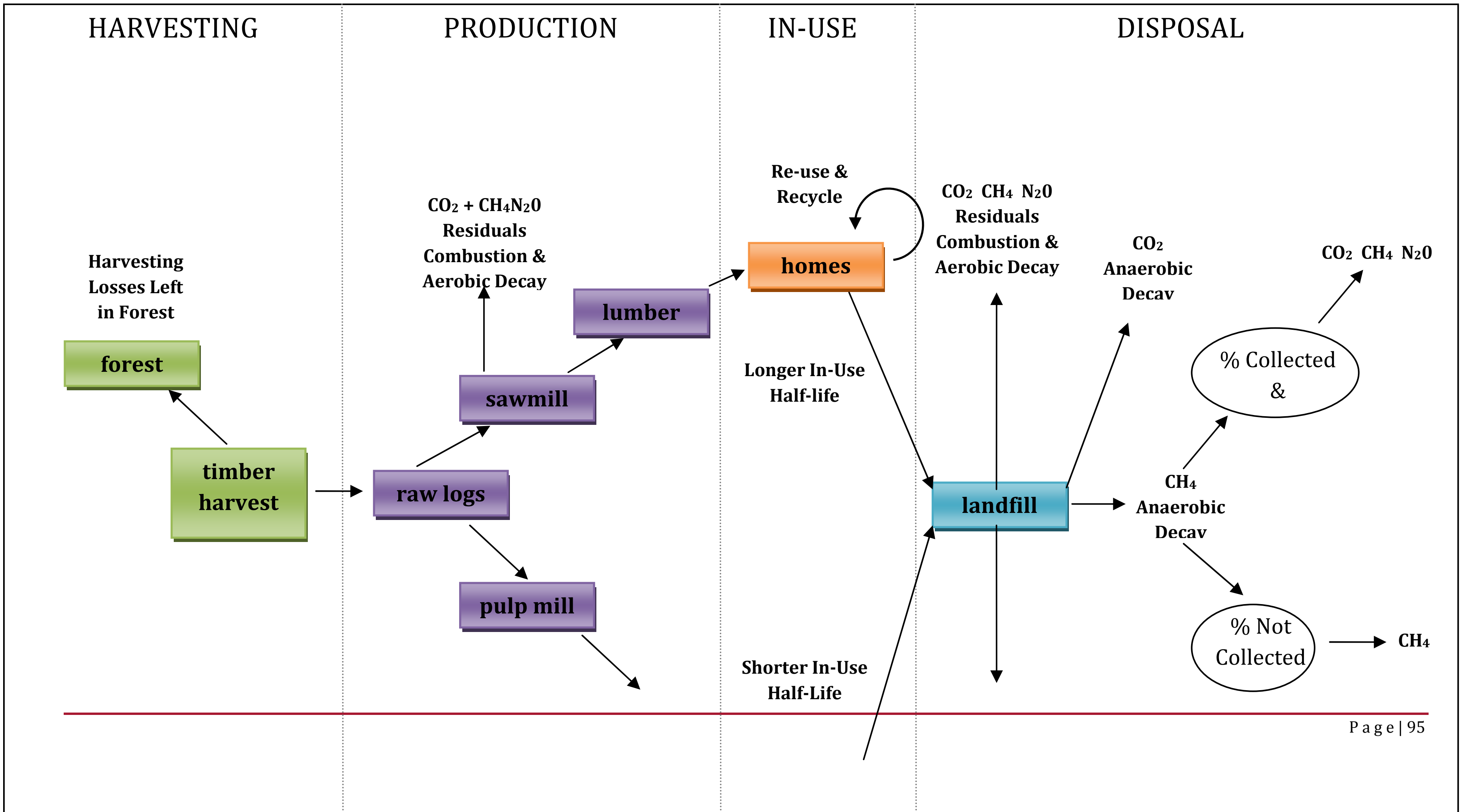
This approach recognizes that it is appropriate to consider the time that carbon spends stored in forest carbon pools after the start of a project but prior to harvesting in determining the length of time that that carbon must subsequently remain in a HWP in order to meet the 100-year permanence requirement. For instance, for an amount of carbon that has been stored for 40 years during a project prior to harvest, it would be appropriate to assess the amount of carbon that would still be in storage in HWPs 60 years after harvest (for total storage of 100 years), rather than the full 100 years assumed in the default approach (which in this example would give a total storage of 140 years). Note that the optional approach requires the use of additional information regarding the wood that is harvested, including the age of the various harvested trees, estimated amounts of tree growth in each year of a tree's life, and more detailed information on the amount of carbon in-use and in-landfill over a range of different timeframes.

The default approach is described in detail below. Aspects of the optional advanced approach that differ from the default approach are then described.

1) Default approach – 100 year storage in HWPs

The lifecycle of HWPs is illustrated in

Figure 4:


HARVESTING
PRODUCTION
IN-USE
DISPOSAL
Harvesting Losses Left in Forest
forest
timber harvest
raw logs
sawmill
lumber
pulp mill
CO_2 + CH_4N_20 Residuals Combustion & Aerobic Decay
Re-use & Recycle
homes
Longer In-Use Half-life
Shorter In-Use Half-Life
CO_2 CH_4 N_20 Residuals Combustion & Aerobic Decay
landfill
CO_2 Anaerobic Decav
CH_4 Anaerobic Decav
% Collected &
% Not Collected
CO_2 CH_4 N_20
CH_4

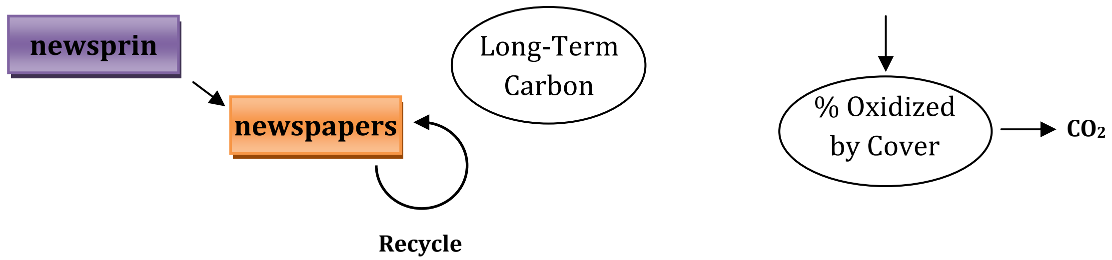


Figure 4: HWP Lifecycle

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:

- Amount of carbon removed from the forest in harvested wood (net of on-site harvesting losses);
- Amount of carbon lost during production of wood products (e.g. 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;
- Amount of carbon in primary HWPs that remains in-use over the 100-year period;
- 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)
        - 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).

The above listed quantities can be very difficult to assess in practice, as they depend on a wide variety of factors including type of wood, type of wood product produced, type of end use, location of production and use (where associated local practices will affect the use and disposal of HWPs), type of disposal practices, etc., which are virtually impossible to track for any specific quantity of harvested wood product.

However, work has been conducted by Smith *et al, 2006*[lx] of the United States Department of Agriculture Forestry Service to estimate many of these quantities for a wide range of harvested wood products produced from across the US. The method used by Smith et al has been adopted by the US Department of Energy in the Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program[lxi] and the CAR Forest Protocol v3.2 (though note that the CAR protocol uses the average of storage fractions from 1 to 100 years, rather than the fraction remaining stored in-use and in landfill after 100 years), and a similar approach has also been used in the draft NAFCS. As result, this method has been also been adopted for use in this protocol.

While the specific details and assumptions of the Smith et al method will not be repeated here, an overview of the method and key assumptions will be provided.

This method assumes as a starting point an amount of primary HWP (e.g. lumber, panels and paper), and associated carbon, net of losses associated with harvesting and production. On a yearly basis for a period of 100 years, the amount of HWP carbon in-use and in landfill for different types of primary wood products is determined based on the following key assumptions:

- Volume to mass conversion factors for various wood products;
- Carbon content of solid wood (50%) and air dry weight paper (45%);
- Fraction of solid wood products used in various applications (see Table D2 in Smith *et al*, 2006 for detailed assumptions);
- In-use half-lives for various solid wood products and paper, where paper also assumes recycling (Smith et al, 2006 have assumed 48% of discarded paper is recycled, and 70% of recycled fibers

are incorporated into new paper products) (see Table D3 in Smith *et al*, 2006 for detailed assumptions);

- First-order decay equation: amount of HWP in use in a particular application in a particular year = (fraction used in the application) × $e^{(-n \times \ln(2)/\text{ in-use half-life of the HWP in the particular application})}$, where n = the number of years since production;
- The change in the amount of HWP in-use between one year and the next is the amount that is discarded in a given year;
- Assumption of the percentage of discarded HWP that is sent to landfill (Smith et al, 2006 have assumed that 67% of discarded solid wood is sent to landfill, and 34% of discarded paper is sent to landfill);
- Portion of HWPs that are degradable in a landfill vs. non-degradable and assumed to remain stored indefinitely (Smith *et al*, 2006 have assumed that 77% of solid wood is non-degradable, and 44% of paper is non-degradable);
- Half-life of degradable portion of HWPs in landfill (Smith *et al*, 2006 have assumed 14 years for both solid wood and paper products); and
- First-order decay equation: fraction of degradable HWP remaining in landfill n years after disposal = $e^{(-n \times \ln(2)/\text{landfill decay half-life})}$.

Note that Smith et al, 2006, makes no assumptions regarding the fate of carbon emitted through decay in landfills (e.g. capture and destruction, oxidation by cover material, emitted to atmosphere, etc.), as once it decays it is assumed to no longer be stored. However, PE15 / BE15 Harvested Wood Products and Residuals Anaerobic Decay accounts for the portion of this decayed HWP carbon that would be emitted to atmosphere as CH_4.

The final result of applying the above methodology is the determination of the fraction of carbon in various HWPs remaining in-use and in-landfill for each year over a 100-year period that starts when the primary wood product is first produced. Final results from the assessment of Smith *et al*, 2006 based on US average data and the assumptions noted above, are presented below.

Table 11: Fraction of Carbon Remaining In-Use and In Landfill after 100 years (Smith *et al*, 2006)

	Softwood Lumber	**Hardwood Lumber**	**Softwood Plywood**	**Oriented Strandboard**	**Non-structural Panels**	**Miscellaneous Products**	**Paper**
Fraction of carbon remaining in-use	0.234	0.064	0.245	0.349	0.138	0.003	0.000
Fraction of carbon remaining in landfill	0.405	0.490	0.400	0.347	0.454	0.0518	0.151

Given that the large majority of BC HWPs are either used in Canada or exported to the US[lxii], and that Canada and the US share similar usage patterns for solid wood and paper HWPs, the above factors are considered suitable for application to BC projects using this protocol. However, project proponents have the option to propose other factors that they feel are more suitable to their project by employing the methodology of Smith et al, 2006 but adjusting the underlying assumptions. The spreadsheets[lxiii] used to prepare the Smith et al analysis will likely prove useful to project proponents in adjusting assumptions, recalculating storage factors, and justifying the adjustments to a validator.

Since the Smith et al, 2006 approach starts with the amount of primary wood products produced, rather than the amount of wood harvested, the net amount of storage in project or baseline (this approach applies equally to project and baseline calculations) HWP pools for wood harvested in a given year is determined as follows (note: Equation 8 is used to calculate storage for SSPs PP8 and BP8, and Equation 9 is used to calculate storage for SSPs PP9 and PB9, with Equation 7 being used to determine overall HWP storage based on results from Equation 8 and Equation 9):

Equation 7: CO_2 storage in HWP pools (Default and Optional Approach)

$$GHG_{CO2,HWP,t} = GHG_{CO2,HWP_{in-use},t} + GHG_{CO2,HWP_{in\ landfill},t}$$

Equation 8: CO_2 storage in the in-use HWP pool (Default Approach)

$$GHG_{CO2,HWP_{in-use},t} = \sum_k \left[m_{k,t} \times f_{C,in-use,k} \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$$

Equation 9: CO_2 storage in the landfill HWP pool (Default Approach)

$$GHG_{CO2,HWP_{in\ landfill},t} = \sum_k \left[m_{k,t} \times f_{C,in\ landfill,k} \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ HWP,\ t}$	Mass of carbon dioxide, in tonnes, stored in project or baseline HWPs harvested during reporting period *t* that will endure for a period of 100 years.	N/A
$GHG_{CO2,\ HWP_{in-use},\ t}$	Mass of carbon dioxide, in tonnes, that remains stored in in-use project or baseline HWPs harvested in reporting period *t*, 100 years after production (note: it is assumed in this protocol that HWPs are produced in the same year that the wood is harvested).	N/A
$GHG_{CO2,\ HWP_{in\ landfill},\ t}$	Mass of carbon dioxide, in tonnes, that remains stored in landfilled project or baseline HWPs harvested in reporting period *t*, 100 years after production.	N/A

$m_{k,t}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in reporting period *t* that will be processed into HWP *k*. Where quantities of harvested wood are available in volume, units, an appropriate wood density for each species *l* must be used and justified by the proponent (see below the table for default values).	N/A
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k.*	N/A
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Assumed to be 50% for all wood species.
$f_{C,\ in\text{-}use,\ k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	Table 11: Fraction of Carbon Remaining In-Use and In Landfill after 100 years (Smith et al, 2006)
$f_{C,\ in\ landfill,\ k}$	The fraction of carbon in HWPs of type *k* that remain in landfill after 100 years.	
MW_{CO_2}	Molecular weight of CO_2.	44 g/mole
MW_C	Molecular weight of carbon.	12 g/mole
k	Relevant HWP types. Using the default Smith et al, 2006 approach, *k* can include, depending on the project, some or all of Softwood Lumber, Hardwood Lumber, Softwood Plywood, Oriented Strandboard, Non-structural Panels, Miscellaneous Products, and Paper. Other HWP types may be justified by the proponent if associated fractions of carbon remaining in-use and in landfill are determined.	N/A

Determining $m_{k,t}$

Where a proponent is determining $m_{k,t}$, using harvested wood volumes, the BC-specific wood density factors for oven-dry stemwood listed in Table 12 shall be used to convert from inside-bark harvested volume (m^3) to mass, unless the proponent can justify alternative values more appropriate for their project and/or baseline.

Table 12: BC-specific wood density factors for oven-dry stemwood to convert from inside-bark harvested volume (m3) to mass

BC Species or genus	Wood density to 2 significant figures[lxiv] (t m^{-3})
Red alder (Alnus rubra)	0.42
Trembling aspen (Populus tremuloides)	0.42
Western red cedar (Thuja plicata)	0.35
Yellow cypress (Chamaecyparis nootkatensis)	0.45
Douglas-fir (Pseudotsuga menziesii)	0.50
True firs (Abies spp.)[lxv]	0.40
Western hemlock (Tsuga heterophylla)	0.47
Western larch (Larix occidentalis)	0.64
Lodgepole pine (Pinus contorta)	0.46
Ponderosa pine (Pinus Ponderosa)	0.46
Spruce (Picea spp.)	0.43
Sitka spruce (Picea sitchensis)	0.41

In determining $m_{k,t}$, for the project, only masses of harvested wood for which there is a verifiable link to the primary HWP produced may be included. Where the primary HWP produced cannot be identified, associated carbon is assumed to be lost to the atmosphere.

In determining $m_{k,t}$, for the baseline, for species that are also harvested in the project, the assumed HWPs produced from a given species must be the same as for the project. For species harvested in the baseline but not the project, the proponent must conservatively select and justify the HWPs produced from those species. Where the primary HWP produced cannot be identified for the baseline, the HWP with the greatest overall storage in-use + in landfill must conservatively be assumed.

Determining $f_{production\ loss,k}$

In determining $f_{production\ loss,k}$, project proponents may justify values appropriate for the HWPs included in the project and baseline, or they may use a BC-specific default factor of 25% for all HWP types[lxvi].

2) Optional advanced approach – variable length of storage in HWPs

The optional approach utilizes the same general approach presented above in the default approach, including the use of the Smith *et al*, 2006, dataset. However, as previously described, instead of estimating storage that would remain in HWPs 100 years after harvest, storage is estimated a number of years after harvest that depends on how long the carbon was stored in the harvested wood prior to harvest. To enable this method, the following two equations are to be used in place of Equation 8 and Equation 9.

Equation 10: CO_2 storage in the in-use HWP pool (Optional Approach)

$$GHG_{CO2,HWP_{in-use},t} = \sum_{k}\left[\sum_{x=0}^{p}\left(m_{k,t,x} \times f_{C,in-use,k,(100-x)}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$$

Equation 11: CO_2 storage in the landfill HWP pool (Optional Approach)

$$GHG_{CO2,HWP_{in\ landfill},t} = \sum_{k}\left[\sum_{x=0}^{p}\left(m_{k,t,x} \times f_{C,in\ landfill,k,(100-x)}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ HWP_{in-use},\ t}$	Mass of carbon dioxide, in tonnes, that remains stored in in-use project or baseline HWPs harvested in reporting period *t*, 100 years after initial sequestration in the tree from which it is derived or after the start of the project, whichever is later.	N/A
$GHG_{CO2,\ HWP_{in\ landfill},\ t}$	Mass of carbon dioxide, in tonnes, that remains stored in in landfill project or baseline HWPs harvested in reporting period *t*, 100 years after initial sequestration in the tree from which it is derived or after the start of the project, whichever is later.	N/A

$m_{k, t, x}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in reporting period *t*, that grew *x* years prior to harvest, and that will be processed into HWP *k*. Note: each tree would be split into annual masses of growth occurring over the life of the tree for the purposes of the calculation. Since tree growth does not occur linearly over time (i.e. a tree does not store the same amount of carbon each year but rather the rate varies over its life), justified tree growth equations must be used to determine $m_{k, t, x}$ based on the age of the tree at harvest. Such equations must be appropriate for the species being harvested and the location of the project. Where quantities of harvested wood are available in non-mass units, an appropriate wood density for each species *l* must be used and justified by the proponent.	N/A
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k.*	N/A
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Assumed to be 50% for all wood species.
$f_{C,\ in\text{-}use,\ k,\ 100\text{-}x}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years.	Consult Table 8 in Smith *et al*, 2006 and spreadsheet provided by Smith *et al*, 2006.
$f_{C,\ in\text{-}landfill,\ k,\ 100\text{-}x}$	The fraction of carbon in HWPs of type *k* that remains in landfill after 100 – *x* years.	Consult Table 8 in Smith *et al*, 2006 and spreadsheet provided by Smith *et al*, 2006.
MW_{CO_2}	Molecular weight of CO_2.	44 g/mole
MW_C	Molecular weight of carbon.	12 g/mole

k	Relevant HWP types. Using the default Smith et al, 2006 approach, *k* can include, depending on the project, some or all of Softwood Lumber, Hardwood Lumber, Softwood Plywood, Oriented Strandboard, Non-structural Panels, Miscellaneous Products, and Paper. Other HWP types may be justified by the proponent if associated fractions of carbon remaining in-use and in landfill are determined.	N/A
x	A number of years prior to the harvest. *x* ranges from 0 (i.e. the year of harvest) to *p*, where *p* represents **the lesser of** the age in years of the oldest tree that is harvested in a given reporting period; and the number of years from project start to the end of reporting period.	N/A

8.2 Quantification Methodologies – Controlled and Related Sources

8.2.1 General Approach for Quantifying Emission sources

For each "relevant" controlled and related emission source identified in **Table 7**, 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, should be used[lxvii]. Deviation from the referenced or directly incorporated methodologies for a parameter requires appropriate explanation from the project proponent.

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

Equation 12: General (emission factor) X (activity level) calculation

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

Where:

Parameter	Description	Default Value
$GHG_{j,\ Emission\ Source_i,\ t}$	Emissions of GHG_j, in tonnes, from Emission Source *i* during reporting period *t.*	N/A
$EF_{i,j}$	The emission factor for GHG j and Emission Source *i* [e.g. tonne CO2/(activity or input/output)]	N/A
AL_i	The quantity of input/output or "activity level" for Emission $Source_i$ (e.g. volume of fuel combusted, amount of fertilizer applied, etc.).	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.	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 8, wherever project emissions are less than baseline emissions for a related SSP, that SSP is deemed not relevant and the net change in emissions between project and baseline set to zero.

8.2.2 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 12 and restated here:

Equation 13: PE3/BE3 fossil fuel production emissions

$$GHG_{j,PE3/BE3,t} = \sum_{f} EF_{f,j} \times AL_{f,t} \times CF_f$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE3/BE3,\ t}$	Emissions of GHG_j, in tonnes, from production of fossil fuels consumed by on-site vehicles and equipment during reporting period *t*.	N/A
$EF_{f,\ j}$	The emission factor for GHG *j* and fuel type f. Note: it is likely that fuel production emission factors may only be available in units of CO_2e.	See below
$AL_{f,\ t}$	The quantity of fuel of type *f* consumed by on-site vehicles and equipment during reporting period *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 fuel 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

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 should 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[lxviii]

   Note: at time of protocol 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.

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

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.

8.2.3 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 12 and restated here:

Equation 14: PE4/BE4 fertilizer production emissions

$$GHG_{j,PE4/BE4,t} = \sum_{f} EF_{f,j} \times AL_{f,t} \times CF_{f}$$

Where:

Parameter	Description	Default Value
$GHG_{j, PE4/BE4, t}$	Emissions of GHG_j, in tonnes, from fertilizer production applied during reporting period *t*.	N/A
$EF_{b, j}$	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.	See below
$AL_{f, t}$	The quantity of fertilizer of type *f* applied during reporting period *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 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 should 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 protocol 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 (e.g. 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.

8.2.4 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 12 and restated here:

Equation 15: PE6/BE6 transport of material, equipment, inputs, and personnel to site emissions

$$GHG_{j,PE6/BE6,t} = \sum_{m} EF_{m,j} \times AL_{m,t} \times CF_m$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE6/BE6,\ t}$	Emissions of GHG *j*, in tonnes, from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*.	N/A
$EF_{m,\ j}$	The emission factor for GHG *j* and transportation mode *m*.	N/A
$AL_{m,\ t}$	The quantity of materials, equipment, inputs, and personnel transported by mode *m* during reporting period *t.*	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.	N/A

Various approaches are available for selecting emission factors and activity levels for use in Equation 15, 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 Protocol and CDM methodology AM0036.

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

Distance and assumed fuel economy approach

This approach is described in the equation below:

Equation 16: PE6/BE6 distance and fuel economy approach

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

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE6/BE6,\ t}$	Emissions of GHG *j*, in tonnes, from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*.	N/A
$EF_{m,\ j}$	The emission factor for GHG *j* and fuel combusted by transportation mode *m* (e.g. g CO_2 per L diesel).	See below
FE_m	Fuel economy of transportation mode *m* (e.g. L / 100 km).	N/A
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport mode *m*.	N/A
$C_{m,g,\ t}$	Total quantity of material, equipment, input, or personnel *g* transported using transport mode *m* during reporting period *t*.	N/A
$L_{m,g}$	Cargo load per transport vehicle of mode *m.*	N/A
CF_m	The conversion factor to be used if the units of the various parameters do not match (e.g. 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.	N/A

Determining the emission factor

Given the range of reasonable, low uncertainty fossil fuel combustion emission factors available for standard fossil fuels (e.g. gasoline, diesel, etc.), an average emission factor from a recognized source such as the BC or National Inventory Reports may be used so long as the emission factor selected is appropriate for the transport mode and fuel used, and separate emission factors for CO_2, CH_4, and N_2O are available. Where different types of vehicles or fuels are used, associated emission calculations must be performed separately for each vehicle and fuel type.

Determining the activity level and other parameters

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.

Amount and distance shipped approach

This approach is described in the equation below:

Equation 17: PE6/BE6 amount and distance approach

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

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE6/BE6,\ t}$	Emissions of GHG *j*, in tonnes, from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*.	N/A
$EF_{m,\ j}$	The emission factor for GHG *j* and the amount and distance shipped by transportation mode *m* (e.g. g CO_2 per tonne-km).	See below
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport mode *m*.	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 should be treated as separate goods for the purposes of this calculation.	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.	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 should 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

   Truck freight transport emissions: emissions per tonne-km transported taken from the most recent version of the BC Freight Modal Shifting GHG Protocol[lxix]. 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 protocol 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[lxx]. 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.

4. 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

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.

8.2.5 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 X activity level approach described by Equation 12 and restated here:

Equation 18: PE7/BE7 fossil fuel combustion – vehicles and equipment emissions

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

Where:

Parameter	Description	Default Value
$GHG_{j,\,PE7/BE7,\,t}$	Emissions of GHG *j*, in tonnes, from on-site vehicle and equipment fuel combustion during reporting period *t.*	N/A
$EF_{f,\,e,\,j}$	The emission factor for GHG *j*, fuel type *f* and equipment/vehicle type *e* (e.g. tonnes CO_2 per L diesel].	See below
$AL_{f,\,e,\,t}$	The quantity of fuel of type *f* combusted in equipment/vehicle type *e* during reporting period *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 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.	N/A

Determining the emission factor

Given the range of reasonable, low uncertainty fossil fuel combustion emission factors available for standard fossil fuels (e.g. gasoline, diesel, etc.), an average emission factor from a recognized source such as the BC Reporting Regulation, or BC or National Inventory Reports may be used so long as the emission factor selected is appropriate for the vehicle or equipment and fuel type used, and separate emission factors for CO_2, CH_4, and N_2O are available. Where different types of vehicles, equipment or fuels are used, associated emission calculations must be performed separately for each vehicle, equipment and fuel type.

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.

8.2.6 PE8/BE8 Biomass Combustion

This quantification method is to 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., are to be calculated using the standard emission factor X activity level approach described by Equation 12 and restated here:

Equation 19: PE8/BE8 biomass combustion emissions

$$GHG_{j,PE8/BE8,t} = \sum_{b} EF_{b,j} \times AL_{b,t} \times CF_b$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE8/BE8,\ t}$	Emissions of GHG *j*, in tonnes, from on-site vehicle and equipment fuel combustion 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.	N/A
$EF_{b,\ j}$	The emission factor for GHG *j* and biomass type b (e.g. tonnes CH_4 per tonne of brush burned).	See below
$AL_{b,\ t}$	The quantity of biomass of type b combusted during reporting period *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.	N/A

Determining the emission factor

Some biomass combustion emission factors are / may be available in the BC Reporting Regulation, or BC or National Inventory Reports (in that order of preference, though note that at the time of protocol development such factors were not included in the BC inventory), and may 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, project proponents will need to justify the use of an adjusted or alternative emission factor based on recognized sources wherever possible.

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. 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 (e.g. mass or volume of biomass combusted), though it is recognized that in many cases (e.g. land clearing) such a measurement may not be possible and estimates based on site observations will be necessary.

8.2.7 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 12. Instead, good practice guidance (GPG) was consulted to identify a suitable approach.

In searching for GPG, various methodologies were reviewed for several jurisdictions. This is a brief summary of the review findings for fertilizer emission:

- British Columbia Forest Offset Protocol mentions it as a GHG source and establishes a quantification method related directly to the IPCC Guidelines.
- The World Resources Institute (WRI) methodology refers directly to the IPCC guidelines.

- Voluntary Carbon Standard has several methodologies under review for Improved Forest Management:
    - *Methodology for Estimating Reductions of GHG Emissions from Mosaic Deforestation* identifies fertilizer as a source of N_2O emissions, and refers to the CDM methodology for quantification.
    - *IFM-Logged to Protected Forest on Fee Simple Forested Properties* mentions fertilizers as a as a source of N_2O, but makes the quantification of this parameter optional as long as this exclusion does not increase the emission reductions in the project.
    - *IFM-Logged to Protected Forest Methodology* explicitly excludes fertilizer use.

  The American Carbon Registry *Methodology for Emission Reductions through Changes in Fertilizer Management* establishes a methodology for calculating N_2O emissions from fertilizer use. This methodology relies on the DNDC model developed by the University of New Hampshire, but it is tailored for crop-growing operations and does not translate easily into forestry applications.

- The UNFCCC CDM executive board has issued a methodological tool denominated *A/R Methodological Tool "Estimation of direct nitrous oxide emission from nitrogen fertilization"*. This document describes a detailed method to quantify the direct nitrous oxide emissions resulting from applying fertilizers as part of a project activity. This tool makes reference to the IPCC 2006 guidelines for the parameters necessary to estimate these emissions.

- The IPCC has issued a series of *Guidelines for National Greenhouse Gas Inventories*. Chapter 11 of the 2006 version establishes the methodological approach and defines the parameters necessary to calculate N_2O emissions from fertilizer use.

While none of the existing protocols or methodologies completely satisfied the needs of a BC Forest Carbon Offset Protocol, Chapter 11 of the IPCC 2006 *Guidelines for National Greenhouse Gas 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 Protocol.

For the development of this methodology, the methodology described in the IPCC and CDM documents were adopted with some small changes to simplify calculations (e.g. 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 SSP even though it is listed as a controlled emission source.

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

- Synthetic nitrogen fertilizer

- Organic nitrogen applied as fertilizer (e.g. manure, compost, and other organic soil additives)

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

Equation 20: PE9/BE9 fertilizer use emissions

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

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.	N/A
$N_2O_{direct,t}$	Direct emissions of N_2O as a result of nitrogen application within the project boundary. Calculated in Equation 21.	N/A
$N_2O_{indirect,t}$	Indirect emissions of N_2O as a result of nitrogen application within the project boundary. Calculated in Equation 24.	N/A

Approaches to determining direct and indirect emissions are described below.

Direct N_2O Emissions

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

Equation 21: Direct fertilizer use emissions

$$N_2O_{direct,t} = [\left(F_{SN,t} \times (1 - Frac_{GASF}) + \ (F_{ON,t} \times (1 - Frac_{GASM})\right)] \ \times \ EF_1 \ \times \frac{MW_{N_2O}}{MW_N}$$

Equation 22: Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers

$$F_{SN,t} = \sum_{i}^{I} M_{SFi,t} \ \times \ NC_{SFi}$$

Equation 23: Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers

$$F_{ON,t} = \sum_{j}^{J} M_{OFj,t} \times NC_{OFj}$$

Where:

Parameter	Description	Default Value
$N_2O_{direct,t}$	Direct emissions of N_2O as a result of nitrogen application within the project boundary.	N/A
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year t.	N/A
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year t.	N/A
$M_{SFi,t}$	Mass of synthetic fertilizer of type i applied in year t, tonnes.	N/A
$M_{OFj,t}$	Mass of organic fertilizer of type i applied in year t, tonnes.	N/A
EF_1	Emission Factor for N additions from fertilizers, tonne N_2O-N / tonne N input.	0.010
$Frac_{GASF}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers.	0.1
$Frac_{GASM}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers.	0.2
MW_{N_2O}	Molecular weight of N_2O.	44 g/mole
MW_N	Molecular weight of N.	14 g/mole
NC_{SFi}	Nitrogen content (mass fraction) of synthetic fertilizer type i applied.	N/A
NC_{OFj}	Nitrogen content (mass fraction) of organic fertilizer type i applied.	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 (1.25%) of applied N. 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 protocol, unless BC / project-specific factors can be identified and justified.

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

Indirect N_2O Emissions

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

Equation 24: Indirect fertilizer use emissions

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

Equation 25: Amount of N_2O-N produced from atmospheric deposition of N volatilized

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

Equation 26: Amount of N_2O-N produced from leachate and runoff of N

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

Where:

Parameter	Description	Default Value
$N_2O_{indirect,t}$	Indirect emissions of N_2O as a result of nitrogen application within the project boundary.	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*.	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*.	N/A
MW_{N_2O}	Molecular weight of N_2O	44 g/mole
MW_N	Molecular weight of N	14 g/mole
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year *t*. Calculated in Equation 22.	N/A

Parameter	Description	Default Value
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year *t*. Calculated in Equation 23.	N/A
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.	0.01
$Frac_{GASF}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers.	0.1
$Frac_{GASM}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers.	0.2
$Frac_{LEACH-(H)}$	Fraction of N lost by leaching and runoff.	0.30 / 0 (see note)
EF_5	Emission factor for N_2O-N emissions from N leaching and runoff, tonne N_2O / tonne N input.	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). 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 (i.e. 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 participants should identify the nitrogen content for each synthetic and organic fertilizer applied, as reported by the fertilizer manufacturer or determined by laboratory analysis.

Assessment of Uncertainty

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 synthetic fertilizers.	0.10	0.03 – 0.3
$Frac_{GASM}$, 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 (e.g. 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.

8.2.8 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 12 and restated here:

Equation 27: PE10/BE10 forest fire emissions

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

Where:

Parameter	Description	Default Value
$GHG_{j, PE10/BE10, t}$	Emissions of GHG *j*, in tonnes, from forest fires 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.	N/A
$EF_{ff, j}$	The emission factor for GHG *j* applicable to forest fires.	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 reversal events that are monitored.	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.	N/A

Determining the emission factor

Guidance with respect to combustion emission factors for forest fires shall 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 protocol development such guidance was not included in the BC inventory). Where appropriate factors are not identified, then project proponents will need to justify the use of an adjusted or alternative emission factor based on recognized sources wherever possible.

Determining the activity level

The quantity of forest biomass combusted in forest fires will be calculated as part of assessing the impact of reversal events, as described in Section 8.1.1.3. The amount of biomass combusted during forest fires shall be based on both significant reversal events as well as more predictable fire disturbances that have been factored into the emissions modeling for project and baseline.

8.2.9 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 SSP PE6/BE6 is to be used to calculate emissions from SSP 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 8.1.2.

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 will be determined in an identical manner to that described for PE6/BE6.

8.2.10 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 12 and restated here:

Equation 28: PE12/BE12 harvested wood processing

$$GHG_{j,PE4/BE4,t} = \sum_{H} EF_{H,j} \times AL_{H,t} \times CF_{H}$$

Where:

Parameter	Description	Default Value
$GHG_{j,\ PE12/BE12,\ t}$	Emissions of GHG *j*, in tonnes, from production of primary harvested wood products from wood harvested during reporting period *t*.	N/A
$EF_{H,\ j}$	The emission factor for GHG *j* and harvested wood product *H* produced (e.g. 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.	N/A
$AL_{f,\ t}$	The quantity of harvested wood product *H* produced from wood harvested during reporting period *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 should 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.	N/A

Determining the emission factor

Where available, the project proponent may use 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 protocol).

If such factors are not available, the project proponent shall develop factors based on information on energy consumption from production facilities to which project and baseline harvested wood is shipped. Such an approach will likely 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 shall be sourced in a manner identical to that described for SSP PE7/BE7 Fossil Fuel Combustion – Vehicles and Equipment.

Determining the activity level

The project proponent may either use monitored data or may estimate the amount of HWP produced using monitored quantities of wood sent to the processing facility and a BC-specific default production loss factor of 25% for all HWP types (as described previously in Section 8.1.2).

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.

8.2.11 PE15/BE15 Harvested Wood Products and Residuals Anaerobic Decay

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

As described in Figure 4, 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 protocol. Depending on if the default or optional advanced approach to HWP quantification is taken in Section 8.1.2, this post-harvest period will either be 100-years (default approach), or a variable period based on the years in which growth occurred as compared to the year of harvest (optional advanced approach).

All such emissions would be accounted for up-front in the reporting period in which a given quantity of wood is harvested and processed into a HWP. Since carbon lost as CO_2 is accounted for as part of SSPs PP8/BP8 and PP9/BP9, PE15/BE15 focuses only on CH_4.

Emissions for this SSP are calculated as follows:

Equation 29: PE15/BE15 harvested wood products and residuals anaerobic decay

$$GHG_{CH4,PE15/BE15,t} = GHG_{CH4,decay,t} \times (1 - \%LFG\ Collection) \times (1 - OX)$$

Where:

Parameter	Description	Default Value
$GHG_{CH4,PE15/BE15,t}$	Emissions of CH_4 from anaerobic decay of landfilled HWPs harvested in year *t* over a 100 year period since the HWP was produced.	N/A
$GHG_{CH4,decay,t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100 year period since the HWP was produced, as determined in Equation 30 or Equation 32, depending on approach used..	N/A
$\%_{LFG\ Collection}$	The % of generated CH_4 that is captured and destroyed by a landfill gas collection system. See Appendix B: Determining LFG Collection Efficiency for additional discussion of this parameter.	Assumed to be 80%.
OX	Oxidation factor for the landfill cover layer, expressed as the percentage of CH_4 that is oxidized to CO_2 as it passes through the cover layer.	For a managed landfill, typically assumed to be 10%[lxxi]

1) Default Approach – 100 year storage in HWPs

$GHG_{CH4,decay,\,t}$ from Equation 29 is determined as follows:

Equation 30: HWP methane generation from decay in landfill (Default Approach)

$$GHG_{CH4,decay,t} = \sum_{k}\left[m_{k,t} \times \left(1 - f_{C,in-use,k} - f_{C,non\ landfill,k} - f_{C,in\ landfill,k}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \%CH_{4,LFG} \times \frac{MW_{CH_4}}{MW_C}$$

Where:

Parameter	Description	Default Value
$GHG_{CH4,decay,\,t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100 year period since the HWP was produced.	N/A
$m_{k,\,t}$	Dry mass, in tonnes, minus bark, harvested in year *t* that will be processed into HWP *k*. Where quantities of harvested wood are available in volume units, an appropriate wood density for each species *l* must be used and justified by the proponent (see Section 8.1.2 for default values).	N/A
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k.*	N/A
$f_{C,\,wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Assumed to be 50% for all wood species.
$f_{C,\,in\text{-}use,\,k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	N/A
$f_{C,\,non\text{-}landfill,\,k}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 years. Calculated in Equation 31, below.	N/A
$f_{C,\,in\ landfill,\,k}$	The fraction of carbon in HWPs of type *k* that remain in landfill after 100 years.	N/A
$\%CH_{4,LFG}$	Molar % CH_4 in landfill gas. Typically, 50% of the anaerobically degraded carbon is assumed to be released as CH_4, with the remainder released as CO_2[lxxii].	50%

MW_{CH_4}	Molecular weight of CH_4.	16 g/mole
MW_C	Molecular weight of carbon.	12 g/mole
k	Relevant HWP types. Using the default Smith et al, 2006 approach, *k* can include, depending on the project, some or all of Softwood Lumber, Hardwood Lumber, Softwood Plywood, Oriented Strandboard, Non-structural Panels, Miscellaneous Products, and Paper. Other HWP types may be justified by the proponent if associated fractions of carbon remaining in-use and in landfill are determined.	N/A
l	Relevant species of wood, based on the species harvested in the project or baseline.	N/A

$f_{C,\ non\text{-}landfill,\ k}$ from Equation 30 is determined as follows:

Equation 31: Fraction of carbon in HWPs that is discarded but not sent to landfill (Default Approach)

$$f_{C,non\ landfill,k} = \left(1 - f_{C,in-use,k}\right) \times f_{Discard\ non\ landfill,k}$$

Where:

Parameter	Description	Default Value
$f_{C,\ non\text{-}landfill,\ k}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 years.	N/A
$f_{C,\ in\text{-}use,\ k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	Table 11: Fraction of Carbon Remaining In-Use and In Landfill after 100 years (Smith *et al*, 2006)

$f_{Discard\ non\ landfill,\ k}$	The mass fraction of HWPs of type *k* that are not sent to landfill when discarded (assumed by Smith et al, 2006 to be (1 – 0.67) = 0.33 for all discarded solid wood HWPs and (1 – 0.34) = 0.66 for discarded paper HWPs).	0.33 for solid wood; 0.66 for paper
k	Relevant HWP types.	N/A

2) Optional Advanced Approach – variable length of storage in HWPs

$GHG_{CH4,decay,\ t}$ from Equation 29 is determined as follows:

Equation 32: HWP methane generation from decay in landfill (Optional Approach)

$$GHG_{CH4,decay,t} = \sum_{k}\left\{\sum_{x=0}^{p}\left[m_{k,t,x} \times \left(1 - f_{C,in-use,k,(100-x)} - f_{C,non\ landfill,k,(100-x)} - f_{C,in\ landfill,k,(100-x)}\right)\right] \times \left(1 - f_{Production\ loss,k}\right)\right\} \times f_{C,wood} \times \%CH_{4,LFG} \times \frac{MW_{CH_4}}{MW_C}$$

Where:

Parameter	Description	Default Value
$GHG_{CH4,decay,\ t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100 – *x* year period since the HWP was produced.	N/A
$m_{k,\ t,\ x}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in reporting period *t*, that grew *x* years prior to harvest, and that will be processed into HWP *k*. Note: each tree would be split into annual masses of growth occurring over the life of the tree for the purposes of the calculation. Since tree growth does not occur linearly over time (i.e. a tree does not store the same amount of carbon each year but rather the rate varies over its life), justified tree growth equations must be used to determine $m_{k,\ t,\ x}$ based on the age of the tree at harvest. Such equations must be appropriate for the species being harvested and the location of the project. Where quantities of harvested wood are available in volume units, an appropriate wood density for each species *l* must be used and justified by the proponent (see Section 8.1.2 for default values).	N/A

$f_{C,\ in\text{-}use,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years.	Consult spreadsheet provided by Smith et al, 2006.
$f_{C,\ non\text{-}landfill,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 – *x* years. Calculated in Equation 33 below.	N/A
$f_{C,\ in\text{-}landfill,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that remains in landfill after 100 – *x* years.	Consult spreadsheet provided by Smith et al, 2006.
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k.*	N/A
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Assumed to be 50% for all wood species.
$\%CH_{4,LFG}$	Molar % CH_4 in landfill gas. Typically, 50% of the anaerobically degraded carbon is assumed to be released as CH_4, with the remainder released as CO_2[lxxiii].	50%
MW_{CH_4}	Molecular weight of CH_4.	16 g/mole
MW_C	Molecular weight of carbon.	12 g/mole
k	Relevant HWP types. Using the default Smith et al, 2006 approach, *k* can include, depending on the project, some or all of Softwood Lumber, Hardwood Lumber, Softwood Plywood, Oriented Strandboard, Non-structural Panels, Miscellaneous Products, and Paper. Other HWP types may be justified by the proponent if associated fractions of carbon remaining in-use and in landfill are determined.	N/A
x	A number of years prior to the harvest. *x* ranges from 0 (i.e. the year of harvest) to *p*, where *p* represents **the lesser of** the age in years of the oldest tree that is harvested in a given reporting period; and the number of years from project start to the end of reporting period.	N/A

$f_{C,\ non\text{-}landfill,\ k,\ 100\text{-}x}$ from Equation 32 is determined as follows:

Equation 33: Fraction of carbon in HWPs that is discarded but not sent to landfill (Optional Approach)

$$f_{C,non\ landfill,k,(100-x)} = \left(1 - f_{C,in-use,k,(100-x)}\right) \times f_{Discard\ non\ landfill,k}$$

Where:

Parameter	Description	Default Value
$f_{C,\ non\text{-}landfill,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 – *x* years.	N/A
$f_{C,\ in\text{-}use,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years. The longer a given mass has been stored in a tree prior to harvest, the greater the value of *x* for that mass of wood, and the lesser the amount of time that must be considered for the in-use phase of its lifecycle.	Consult spreadsheet provided by Smith et al, 2006.
$f_{Discard\ non\ landfill,\ k}$	The mass fraction of HWPs of type *k* that are not sent to landfill when discarded (assumed by Smith et al, 2006 to be (1 – 0.67) = 0.33 for all discarded solid wood HWPs and (1 – 0.34) = 0.66 for discarded paper HWPs).	0.33 for solid wood; 0.66 for paper

8.3 Leakage

In many cases forest based carbon offset projects result in a change in output of certain goods or services from the project area. Reduced supply from the project area can encourage the supply of those goods or services from another area in a manner that increases overall emissions, thus reducing the effect of the original offset project. In this case, it can be said that a portion of the offsets of the project "leaked" out through production in another area. This is referred to as positive leakage.

Conversely, increased supply of a good or service from the project area can encourage reduced supply from another area in a manner that reduces overall emissions. This is referred to as negative leakage. In this protocol, while we assume that some projects have the potential to increase supply of wood products while at the same time increasing overall carbon storage; it is assumed for the forest industry in general that this is not the case. Thus, where an offset project increases the supply of wood products and as a result there is potential for a decrease in supply of wood products from a different area, it is assumed that this decrease in wood product production results in a net increase in stored carbon (net gains in in-forest carbon storage assumed to exceed the net decrease in carbon stored in wood products). According to the requirements of the BC EOR, such increases in sequestration from leakage cannot be counted, as they are not from controlled sources.

Understanding the situations where leakage can occur and defining appropriate methods for quantifying and mitigating leakage is critical to the accuracy of forest carbon offsets.

8.3.1 PP10/BP10 Forest Carbon and Wood Product Pools Located Outside of the Project Boundary that are Indirectly Affected by the Project Activity

There are two potentially relevant forms of leakage that must be assessed for forest projects: land use shifting leakage and harvest shifting leakage. Since these impacts occur, by definition, at locations not directly linked to project activities, but rather through market forces, it is impractical to try to assess project and baseline removals from affected pools individually prior to determining the net change between project and baseline, as is the standard GHG quantification approach in ISO 14064-2.

Instead, the approaches described here focus on assessing the change in key project and baseline activity levels that are under the control of the project proponent, namely harvesting levels and amount of land-use conversion, and then using this change in activity to estimate the reduced removals that would be associated with project activities but that occur at locations outside the project boundary. This calculated amount would be reported for SSP PP10, while setting emissions / removals for BP10 to zero.

The following table lists which project types might need to assess which types of leakage. For detailed instructions on determining whether or not leakage is relevant for a particular project type, see Section 5.4.2.3 Table 8.

Table 13: Summary of potentially relevant leakage types by project type

Project Type	**Leakage Type**	
	Land Use Shifting	**Harvest Shifting**
Afforestation	POTENTIALLY (internal only)	NO
Reforestation	POTENTIALLY (Internal only)	NO
IFM	NO	POTENTIALLY (if project harvesting < baseline harvesting)
Conservation / Avoided Deforestation	YES	YES

Total emissions (i.e. reduced carbon storage) from carbon pools covered by PP10, is to be calculated as follows:

Equation 34: PP10 affected emissions (leakage)

$$GHG_{CO2,Leakage,t} = GHG_{CO2,PP10,t} = GHG_{CO2,Land\ Use\ Shifting,t} + GHG_{CO2,Harvest\ Shifting,t}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,Leakage,t}$; $GHG_{CO2, PP10, t}$	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.	N/A
$GHG_{CO2, Land Use Shifting, t}$	Total increase in project emissions due to land use shifting leakage from all affected carbon pools during reporting period *t*. See Section 8.3.1.1 for details.	N/A
$GHG_{CO2, Harvest Shifting, t}$	Total increase in project emissions due to harvest shifting leakage from all affected carbon pools during reporting period *t*. See Section 8.3.1.2 for details.	N/A

8.3.1.1 Land Use Shifting Leakage

With land use shifting leakage, the concern is that where a given project involves preventing a baseline land use from occurring during the project period, there is potential for that baseline land use to shift to other Forest Land outside of the project area if demand for that baseline land use is not addressed in some way, with associated deforestation-related emissions.

For ease of assessment, land use shifting leakage can be divided into two categories (consistent with the approach taken in the draft NAFCS):

1. **Internal leakage**: shifting to other lands owned or controlled by the project proponent

   Internal leakage is the easiest form of leakage to detect, as all activities fall under the control of the project proponent. Such leakage could occur, for instance, where a project proponent decides to prevent the deforestation of a portion of their lands and establish a conservation / avoided deforestation project on those lands while also deforesting another portion of land that they own, but which is outside the defined project area.

   All project types that involve the potential for shifting baseline non-forest land uses, which includes conservation / avoided deforestation projects as well as afforestation and reforestation projects, must assess internal land use shifting leakage.

   Internal leakage is to be addressed by the proponent as follows:

   i. For afforestation and reforestation projects, if it can be shown that there was no baseline use of the project lands, then internal leakage can be assumed to be zero for the duration of the project.
   ii. For all project types, if it can be shown that::
       a. Lands controlled by the proponent outside the project area are not Forest Land, and then internal leakage can be assumed to be zero.

b. Covenants, easements, existing right of ways, or other restrictions are in place on Forest Land controlled by the proponent outside the project area, then internal leakage can be assumed to be zero for as long as those restrictions remain in place.

c. Demand for the baseline land use is satisfied or removed in some way by or due to the actions of the project proponent, then internal 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). For more details on how to demonstrate this, see the external leakage section below.

iii. Otherwise, justify an appropriate geographic area for assessment of land-use shifting, considering economic and other relevant factors affecting demand for baseline land-use types affected by the project, given that land use demand is typically local in nature (e.g. demand for housing, commercial land, etc.). This will be important for project proponents that own or control large areas of land. A proponent may skip this step by including all land that they own or control within the assessment area.

iv. In each emission reduction report issued during the project, the project proponent must report on any deforestation activities that have occurred within the assessment area where the new land use is equivalent to the project's baseline land use. Where such deforestation is identified, the decrease in stored carbon that occurs as a result of the deforestation, considering decreases in forest carbon pools and increases in HWP pools as appropriate must be assessed using the same methods as for the project. The net decreases associated with that deforestation activity must be recorded as an affected land use shifting emission for the project. Such calculations will be subject to the same validation and verification requirements as the rest of the project calculations. Clearly, a project proponent would be advised to assess the starting carbon levels in any non-project area that is planned for a land use change as noted above, to increase the accuracy of the assessment of lost carbon, which will likely avoid the need to apply conservative factors to the final calculation to manage uncertainty, which could increase the total emissions counted against the project.

Note that should this affected deforestation be substantial and result in the proponent having to replace issued offset credits, the proponent is only responsible for replacing a maximum of the total amount of credits issued.

2. **External leakage**: shifting to other lands outside the ownership or control of the project proponent.

External leakage is harder to assess as the associated activities are not under the control of the project proponent.

External leakage only needs to be addressed for conservation / avoided deforestation projects, and is to be addressed by the proponent as follows:

i. If it can be verifiably shown that demand for the baseline land use is satisfied or removed in some way by or due to the actions of the project proponent that does not involve deforestation outside of the project area, then external 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 (e.g. 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 (e.g. due to site characteristics, etc.) and that there are no other suitable areas within an appropriately established assessment area surrounding the project area that would satisfy the land use demand, and thus the demand for land will remain unfilled without leakage.
- The project proponent undertakes other activities that can be verifiably demonstrated to result in a decrease in demand for the baseline land use such that the reduced demand will completely offset the loss of the baseline land use avoided by the project.
- The project proponent 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 the project proponent.

ii. Otherwise, the project proponent must undertake a land use analysis for the baseline land use type in a geographic area of justified size 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.

Such an assessment must consider at minimum the following:

- The state of supply and demand for the baseline land use type, including historic trends over the past 5 years, the current situation, and a projection forward of anticipated future trends over the project's validation period (typically 10 years as per the BC Emission Offset Regulation requirements);
- All local zoning bylaws and other restrictions on land development such as covenants, easements, and existing right of ways;
- Community development plans and regional growth strategies;
- There are restrictions in place such that there is no opportunity for the baseline land use to shift to other Forest Land within an appropriately established assessment area surrounding the project area, and thus the demand for land will remain unfilled (note, zoning restrictions are likely not sufficient to demonstrate this, as zonings can be changed based on applications by developers, as can land use plans); and
- 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.

Generally speaking, the use of average development rates for lands over a broad geographic area (e.g. all of BC) will not be appropriate for assessing leakage, as by definition, a conservation / avoided deforestation project is occurring in an area of sufficient non-forest land use demand that the deforestation baseline can be justified. In such situations, it is likely that local land use demand will exceed average land use demand across a broader area.

Based on the results of this assessment, the proponent must verifiably provide a conservative assessment of the quantity of emissions that would occur from affected carbon pools, 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 validation period. Since it will likely not be possible accurately determine whether or not, for a particular project, there actually will be leakage and to what extent, the leakage percentage developed should reflect that assessed likelihood / risk that leakage might occur.

Based on the above assessments of internal and external land use shifting leakage, $GHG_{CO2,\ Land\ Use\ Shifting,t}$ from Equation 34 would be calculated as follows:

Equation 35: Land use shifting emissions (leakage)

$$GHG_{CO2,Land\ Use\ Shifting,t} = GHG_{CO2,Internal\ Land\ Use\ Leakage,t} + max\{0, \Delta GHG_{CO2,Forest\ Carbon\ Pools,t} + \Delta GHG_{CO2,HWP\ Pools,t} - GHG_{CO2,Internal\ Land\ Use\ Leakage,t}\} \times \%Leakage_{External\ Land\ Use}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ Land\ Use\ Shifting,\ t}$	Total increase in project emissions due to land use shifting leakage from all affected carbon pools during reporting period *t.*	N/A
$GHG_{CO2,\ Internal\ Land\ Use\ Leakage,\ t}$	Total increase in project emissions due to internal land use shifting leakage during reporting period *t*.	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. Calculated in Equation 36.	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. Calculated in Equation 37.	N/A
$\%Leakage_{External\ Land\ Use}$	Total increase in project emissions due to external land use shifting 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 validation period.	N/A

$\Delta GHG_{CO2\ Forest\ Carbon\ Pools,\ t}$ from Equation 35 is determined as follows:

Equation 36: Net change in forest carbon pools

$$\Delta GHG_{CO2,Forest\ Carbon\ Pools,t} = \left(GHG_{CO2,Project\ Forest\ Pools,t} - GHG_{CO2,Project\ Forest\ Pools,t-1}\right) - \left(GHG_{CO2,Baseline\ Forest\ Pools,t} - GHG_{CO2,Baseline\ Forest\ Pools,t-1}\right)$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{CO2,\ Forest\ Carbon\ Pools,\ t}$	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.	N/A
$GHG_{CO2,\ Project\ Forest\ Pools,\ t}$	The mass of CO2, in tonnes, stored in project forest carbon pools (excluding HWPs) at the end of reporting period *t*. Determined in Section 8.1.	N/A
$GHG_{CO2,\ Project\ Forest\ Pools,\ t-1}$	The mass of CO2, 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*).	N/A
$GHG_{CO2,\ Baseline\ Forest\ Pools,\ t}$	The mass of CO2, in tonnes, stored in baseline forest carbon pools (excluding HWPs) at the end of reporting period *t*. Determined in Section 8.1.	N/A
$GHG_{CO2,\ Baseline\ Forest\ Pools,\ t-1}$	The mass of CO2, 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*).	N/A

$\Delta GHG_{CO2,\ HWP\ Pools,\ t}$ from Equation 35 is determined as follows:

Equation 37: Net change in HWP pools

$$\Delta GHG_{CO2,HWP\ Pools,t} = \left(GHG_{CO2,Project\ HWP\ Pools,t} - GHG_{CO2,Project\ HWP\ Pools,t-1}\right) - \left(GHG_{CO2,Baseline\ HWP\ Pools,t} - GHG_{CO2,Baseline\ HWP\ Pools,t-1}\right)$$

Where:

Parameter	Description	Default Value
$\Delta GHG_{CO2,\ HWP\ Pools,\ t}$	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.	N/A

$GHG_{CO2,\ Project\ HWP\ Pools,\ t}$	The mass of CO_2, in tonnes, stored in project HWP carbon pools at the end of reporting period *t*. Determined in Section 8.1.2.	N/A
$GHG_{CO2,\ Project\ HWP\ Pools,\ t-1}$	The mass of CO_2, in tonnes, stored in project HWP carbon pools at the end of reporting period *t-1* (equivalent to the beginning of reporting period *t*). Determined in Section 8.1.2.	N/A
$GHG_{CO2,\ Baseline\ HWP\ Pools,\ t}$	The mass of CO_2, in tonnes, stored in baseline HWP carbon pools at the end of reporting period *t*. Determined in Section 8.1.2.	N/A
$GHG_{CO2,\ Baseline\ HWP\ Pools,\ t-1}$	The mass of CO_2, in tonnes, stored in baseline HWP carbon pools at the end of reporting period *t-1* (equivalent to the beginning of reporting period *t*). Determined in Section 8.1.2.	N/A

8.3.1.2 Harvest Shifting Leakage

With harvest shifting leakage, the concern is that where a given project involves changing the amount of harvesting that occurs in the project area relative to the baseline, other Forest Lands may adjust their levels of harvest in response, which may partially or fully negate increased removals claimed by the project relative to the baseline.

As discussed in Table 8, harvest shifting 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 (e.g. typically in afforestation projects, reforestation projects), harvest shifting leakage would be zero. Note that in conservation / avoided deforestation projects, the baseline will 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 land use-shifting and harvest shifting leakage (this would only potentially apply to conservation / avoided deforestation projects), harvest-shifting leakage is to be assessed based only on the amount of decreased project harvesting relative to the baseline that is not already represented in the assessed amount of land use 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 non forest land use demand, harvest shifting leakage would only be assessed on the portion of avoided deforestation (i.e. avoided harvesting) that would not have shifted to other areas due to non-forest land use demand. In the case of assessing internal harvest-shifting leakage, this must be factored into the analysis conducted by the project proponent; for external harvest-shifting leakage this has been explicitly factored into the equations provided.

As with land use shifting leakage, harvest shifting leakage can be divided into two categories:

1. **Internal leakage**: shifting to other lands owned or controlled by the project proponent

   Internal leakage is the easiest form of leakage to detect, as all activities fall under the control of the project proponent. Such leakage could occur, for instance, where a project proponent decides to reduce harvesting on a portion of their lands and establish a forest carbon offset project while increasing harvesting on another portion of land that they own, but which is outside the defined project area.

Internal leakage is to be addressed by the proponent in each reporting period as follows:

i. If it can be verifiably shown that demand for harvested wood that is no longer harvested by the project is satisfied or removed in some way by or due to the actions of the project proponent, then internal 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).

ii. Assess the opportunities for increasing harvesting on other lands owned or controlled by the project proponent by:

   a. For Crown land licensed by the project proponent, report on the difference between current harvesting levels and the annual allowable cut in all Timber Supply Areas (TSAs) and Tree Farm Licence (TFL) areas for which the proponent holds a license. Note that in the case of TSAs, this may require the consideration of land not controlled by the proponent but that still falls within a TSA in which the proponent holds a license (for the purposes of this internal leakage assessment, such lands will be considered owned or controlled).

   b. For private land, assess the extent to which other Forest Land owned or controlled by the proponent could be harvested (which could consider the existence of land covenants that would prohibit harvesting).

   If there are no opportunities for further harvesting identified, then internal leakage may be assumed to be zero.

iii. If opportunities for increased harvest are identified, then the proponent has two options:

   a. Expand the project area to encompass areas with additional harvesting potential, thereby bringing all potential sources of internal leakage within the controlled SSPs of the project, and assume internal leakage is zero; or

   b. Prepare a report that assesses the extent to which internal harvest shifting leakage has occurred, by considering historic harvesting amounts per hectare per year on all owned and controlled lands outside of the project area for the 5 years prior to the start of the current emission reduction reporting period and all years within the current reporting period, as well as regional or provincial trends in amounts of harvesting over the same timeframe (with the selected geographic area to be justified by the proponent). Where owned and controlled harvesting trends indicate that harvesting has increased relative to regional or provincial trends, and where these increases cannot be explained by factors independent from the forest carbon offset project, internal leakage is to be assessed as the minimum of:

      i. The difference between owned and controlled harvesting per hectare per year and regional or provincial harvesting per hectare per year multiplied by the total hectares of owned and controlled forest outside of the project area and by the number of years in the reporting period; and

      ii. The maximum potential amount of increased harvesting that could occur over the reporting period based on the assessment described in 1.ii., above.

      iii. The total amount of decreased harvesting that occurred due to the project relative to the baseline during the current reporting period plus decreases in harvesting between the project and baseline for the five years prior to the start of the current reporting period minus any internal harvest shifting leakage assessed against the project due to decreased harvesting in the five years prior to the start of the current reporting period.

2. **External leakage**: shifting to other lands outside the ownership or control of the project proponent.

External harvest shifting is particularly challenging to assess given the large percentage of BC HWPs that are exported outside of the province (principally to the US), and the inherent challenges in assessing the associated economic factors and the potential role that any given project might play on overall supply of wood products. Nonetheless, it is recognized that leakage can occur, and must be considered in order to ensure that project emission reductions and removal enhancements are not overstated.

If it can be verifiably shown that demand for wood products that are no longer produced by the project relative to the baseline during the reporting period is satisfied or removed in some way by or due to the actions of the project proponent that does not involve increasing harvesting outside the project area, then external leakage can be assumed to be zero for that reporting period. Otherwise, external harvest shifting leakage must be assessed.

To assess external harvest shifting leakage, the first step is to determine the percentage of the difference between project and baseline harvesting that is expected to shift to lands outside the ownership or control of the project proponent.

Two options are provided: 1) use of provincial base case leakage estimates, and 2) estimating project-specific leakage.

A project proponent is free to use either approach (subject to any restrictions noted below). However, where a proponent decides part way through the project to change from the use of a project-specific approach to the use of provincial base case estimates and such a change is likely to result in a lower assessed amount of leakage going forward, the proponent must estimate the extent to which the base case is expected to underestimate leakage relative to the project-specific case based on historic project data and provincial base case estimates, and adjust the provincial base case results going forward accordingly to minimize the likelihood of the final leakage assessment underestimate what the project-specific approach would have likely determined. As part of preparing this estimate, the proponent may also consider if and to what degree the historic project-specific approach likely overestimated actual historic leakage based on retroactive market and other data, and adjust the estimate accordingly.

1) Provincial base case external harvest shifting leakage estimates (Option 1

Project proponents can use a provincial base case leakage estimate from Table 14 below for their project leakage estimate. Proponents that choose to use a provincial base case leakage estimate as their project default 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 14: Provincial base case leakage estimates for projects resulting in reduced harvest in BC

Geographic Area	Estimated Leakage
Northern Interior	65%
Southern Interior	63.1%
Coast	55.3%

The base case 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 D 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 should use the provincial base case leakage estimates as a guide. When project areas have proportions of tree species that differ from the base case averages and perhaps higher proportions of tree species with low or moderate substitutability than what is reflected in the base case for the project's region, it is recommended that project proponents utilize the guidance indicated 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 base case leakage values 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 external harvest shifting leakage estimates (Option 2)

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

The recommended approach for determining leakage resulting from a project with a reduced harvest utilizes a formula proposed by Murray *et al*[lxxiv] as shown in Equation 38.

Equation 38: % leakage from external harvest shifting

$$\%Leakage_{External\ Harvest\ Shifting} = \frac{(100 * e * \gamma * C_N)}{([e - E * (1 + \gamma * \Phi)] * C_R)}$$

Where:

Parameter	Description	Default Value
e	Supply price elasticity.	See Below
E	Demand price elasticity.	
C_N	Carbon sequestration reversal per unit of harvest from the non-reserved forest.	
C_R	Carbon sequestration per unit of (forgone) harvest gained by preserving the reserved forest.	
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 (i.e. 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 the variables used in the *Provincial Base Case Approach for Estimating Leakage* provided in Appendix E for supply price elasticity (e), demand price elasticity (E), and the carbon sequestration values (C_N and C_R) as identified in Table 15 below are used for deriving project leakage estimates:

Table 15: 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 (i.e. elasticities that do not adequately represent the market(s) associated with the offset project). The elasticities used in the *Provincial Base Case Approach* 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 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 16: 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 D: A Provincial Base Case Approach For Addressing Leakage from Forest Carbon Projects must be utilized, considering the location of the project.

Methodology 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 be beyond 1% of the market share. 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.

Equation 39: Preservation parameter

$$\Phi = \frac{Q_R}{Q_N}$$

Where:

Parameter	Description	Default Value
Q_R	Quantity of harvestable timber (m^3) to be claimed on upcoming project verification.	N/A
Q_N	Quantity of harvestable timber supply (m^3) remaining in the market.	N/A

Methodology for deriving a substitutability parameter *(γ)*

There are two key factors to consider when determining the substitutability parameter of an offset project. The first is tree species breakdown of the project area, and the second is cross-species product substitutability of each given species.[lxxv] 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.

Equation 40: Weighted Substitution Parameter

$$\gamma = \sum_{i=1}^{n} T_i * S_i$$

Where:

Parameter	Description	Default Value
i	A specific tree type	N/A
n	Number of tree types within the project	N/A
T_i	Tree type *i*'s share of project's total marketable tree volume	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 17 must also be satisfied.

Table 17: Additional Requirements for using coefficients in the leakage equation

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.
	  o The price elasticity of total demand of North American should be used if available, otherwise, the price elasticity of total demand (including both domestic demand and import demand) of US should be used as US demand represents the majority of North American demand.
	  o The price elasticity of total supply of North American market should 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
	  o 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 when calculating their own substitution parameter (see Appendix d: Example Substitutability Equations). • 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.

Based on the above assessments of internal and external harvest shifting leakage, $GHG_{CO2,\ Harvest\ Shifting,\ t}$ from Equation 34 would be calculated using one of the following two approaches.

1) Harvest shifting leakage (Option 1)

This approach uses the total change in forest carbon pools, rather than just the change associated with harvesting, as the basis for the external leakage calculation, and is simpler than Option 2. This approach is most suitable for projects that reduce the amount of harvesting relative to the base case without undertaking any other changes to forest management practices, though for these projects Option 2 should generate similar results. For projects that reduce harvest but also undertake improved forest management practices, Option 1 may result in a larger assessment of leakage than Option 2.

Equation 41: Harvest shifting emissions (leakage) – Option 1

$$GHG_{CO2,Harvest\ Shifting,t} = GHG_{CO2,Internal\ Harvest\ Shifting,t} + max\{0, \Delta GHG_{CO2,Forest\ Carbon\ Pools,t} + \Delta GHG_{CO2,HWP\ Pools,t} - GHG_{CO2,Internal\ Harvest\ Shifting,t} - GHG_{CO2,Land\ Use\ Shifting,t}\} \times \%Leakage_{External\ Harvest\ Shifting}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2,\ Harvest\ Shifting,\ t}$	Total increase in project emissions due to harvest shifting leakage from all affected carbon pools during reporting period *t.*	N/A
$GHG_{CO2,\ Internal\ Harvest\ Shifting,\ t}$	Total increase in project emissions due to internal harvest shifting leakage during reporting period *t*.	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. Calculated in Equation 36.	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. Calculated in Equation 37.	N/A
$GHG_{CO2,\ Land\ Use\ Shifting,\ t}$	Total increase in project emissions due to land use shifting leakage from all affected carbon pools during reporting period *t*. Calculated in Equation 35.	N/A
$\%Leakage_{External\ Harvest\ Shifting}$	Total increase in project emissions due to external harvest shifting 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.	N/A

2) Harvest shifting leakage (Option 2)

This approach, while similar to Option 1, uses changes in forest carbon pools related to harvesting only, rather than the total change in forest carbon pools, as the basis for the external leakage calculation. Option 2 is more complex than Option 2. This approach is most suitable for projects that reduce harvest relative to the base case but also undertake improved forest management practices aimed at increasing sequestration.

Equation 42: Harvest shifting emissions (leakage) – Option 2

$$GHG_{CO2,Harvest\ Shifting,t} = GHG_{CO2,Internal\ Harvest\ Shifting,t} + max\{0, \Delta GHG_{CO2,Harvesting,t} + \Delta GHG_{CO2,HWP\ Pools,t} - GHG_{CO2,Internal\ Harvest\ Shifting,t} - GHG_{CO2,Land\ Use\ Shifting,t}\} \times \%Leakage_{External\ Harvest\ Shifting}$$

Where:

Parameter	Description	Default Value
$GHG_{CO2, Harvest Shifting, t}$	Total increase in project emissions due to harvest shifting leakage from all affected carbon pools during reporting period *t.*	N/A
$GHG_{CO2, Internal Harvest Shifting, t}$	Total increase in project emissions due to internal harvest shifting leakage during reporting period *t*.	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 (e.g. lost branches, tops, etc.) that are assumed to rapidly decay and release CO2 to the atmosphere. Calculated in Equation 43.	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. Calculated in Equation 37.	N/A
$GHG_{CO2, Land Use Shifting, t}$	Total increase in project emissions due to land use shifting leakage from all affected carbon pools during reporting period *t*. Calculated in Equation 35.	N/A
$\%Leakage_{External Harvest Shifting}$	Total increase in project emissions due to external harvest shifting 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.	N/A

Equation 43: In-forest harvesting impacts (for harvest shifting leakage)

$$\Delta GHG_{CO2,Harvesting,t} = \left[\sum_{s}\left(m_{s,t,baseline} \div Harvest\ Efficiency_{s}\right) - \sum_{s}\left(m_{s,t,project} \div Harvest\ Efficiency_{s}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_{C}}$$

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 (e.g. lost branches, tops, etc.) that are assumed to rapidly decay and release CO2 to the atmosphere.	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 $m_{k, t}$ in Section 8.1.2, except that this mass is determined by species rather than by HWP type.	N/A
$Harvest\ Efficiency_s$	The ratio of $m_{s, t,}$, as defined above, to total woody dry mass of a tree of species *s* prior to harvest.	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 $m_{k, t}$ in Section 8.1.2, except that this mass is determined by species rather than by HWP type.	N/A
$f_{C, wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Assumed to be 50% for all wood species.
MW_{CO_2}	Molecular weight of CO_2.	44 g/mole
MW_C	Molecular weight of carbon.	12 g/mole
s	Relevant tree species types being harvested in the project and baseline area.	N/A

Determining $Harvest\ Efficiency_s$

Project proponents will be responsible for justifying Harvesting Efficiencies appropriate for the project and baseline, considering tree species (*s*) involved, typical age of trees at harvest, and any other relevant factors. A proponent may also choose to use a single Harvest Efficiency value, rather than one for each relevant species, as long as the approach is demonstrated to be conservative (i.e. does not under-estimate leakage).

8.4 Summary of GHG Emission Reduction and/or Removals

Describe the procedure for quantifying net GHG emission reductions and/or removals, as a function of baseline emissions, project emissions and leakage, as follows:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_Y = *Net GHG emissions reductions and/or removals in year y*

BE_Y = *Baseline emissions in year y*

PE_y = *Project emissions in year y*

LE_y = *Leakage in year y*

Note in FCOP original this was not included

9.0 MONITORING

Description of the Monitoring Plan

Primary monitoring procedures for quantification of each SSP and parameter, based on the quantification requirements presented in Section 8, have been detailed in Table 18. Only parameters that must be either monitored or estimated for specific SSPs, and associated equations, are noted in this table. Other data and information related to other aspects of complying with this protocol that may require monitoring are not listed here. Note that a project proponent is expected to fully document project-specific details of each of these methodologies (e.g. specific type of measurement approach used, specific procedure used where there is a choice, etc.) in a full monitoring plan as part of a GHG Project Plan developed for a their project.

For instances in which the primary monitoring procedures cannot be followed (e.g. due to monitoring equipment failure, etc.), it is recommended that the proponent establish in advance temporary back-up (contingency) procedures for key data to ensure continuity of verifiable data. Such procedures must meet the requirements specified in applicable quantification methods presented in this protocol, but will not be described further here.

Table 18: Data Monitoring Summary

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
PP1/BP1 – PP7/BP7 Live and Dead Forest Carbon Pools (Excluding Harvested Wood Products)						
Given the dependence of monitoring procedures for live and dead forest carbon pools (excluding HWPs) on the modelling and other approaches chosen based on the requirements and options in Section 8.1, specific monitoring requirements will not be detailed here.						
PP8/BP8 & PP9/BP9 Harvested Wood Products In Use and in Landfill						
Equation 8: $GHG_{CO2,HWP_{in-use},t} = \sum_k [m_{k,t} \times f_{C,in-use,k} \times (1 - f_{Production\ loss,k})] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$						
Equation 9: $GHG_{CO2,HWP_{in\ landfill},t} = \sum_k [m_{k,t} \times f_{C,in\ landfill,k} \times (1 - f_{Production\ loss,k})] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$						
$GHG_{CO2,\ HWP_{in-use},\ t}$	Mass of carbon dioxide that remains stored in in-use project or baseline HWPs harvested in reporting period *t*, 100 years after production.	Tonnes of carbon dioxide.	Calculated	N/A	N/A	N/A
$GHG_{CO2,\ HWP_{in\ landfill},\ t}$	Mass of carbon dioxide that remains stored in landfilled project or baseline HWPs harvested in reporting period *t*, 100 years after production.	Tonnes of carbon dioxide	Calculated	N/A	N/A	N/A
$m_{k,\ t}$	Dry mass, in tonnes, of harvested wood, minus bark, harvested in reporting period *t* that will be processed into HWP type *k*.	Tonnes of harvested wood	Measured	Approach must be of a level of accuracy comparable to what would be used to determine mass (or volume, converted to mass units) of wood for commercial sales purposes.	Every time harvesting is conducted.	Key variable, must be monitored. Commercial transactions tend to demand a high level of accuracy, and it will likely not be practical for proponents to monitor this parameters with even more

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
						accurate methods.
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k*.	Mass fraction	Estimated	Estimated based on the type of wood product produced, and either data from the facilities where the harvested wood will be processed, or default / standardized data that can be shown to be relevant for project-specific circumstances.	Review every five years or every reporting period, whichever is longer.	Since wood product production not controlled by proponent, direct monitoring impractical. These fractions are unlikely to change significantly over time, so less frequent monitoring (i.e. every 5 years vs. every year) is appropriate.
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$f_{C,\ in\text{-}use,\ k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{C,\ in\ landfill,\ k}$	The fraction of carbon in HWPs of type *k* that remain in landfill after 100 years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
MW_{CO_2}	Molecular weight of CO_2.	g/mole	Estimated	Standard default value	N/A	N/A
MW_C	Molecular weight of carbon.	g/mole	Estimated	Standard default value	N/A	N/A
Equation 10: $GHG_{CO2,HWP_{in-use},t} = \sum_k \left[\sum_{x=0}^{p} \left(m_{k,t,x} \times f_{C,in-use,k,(100-x)}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$						
Equation 11: $GHG_{CO2,HWP_{in\ landfill},t} = \sum_k \left[\sum_{x=0}^{p} \left(m_{k,t,x} \times f_{C,in\ landfill,k,(100-x)}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \frac{MW_{CO_2}}{MW_C}$						

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
$GHG_{CO2, HWP_{in-use}, t}$	Mass of carbon dioxide, that remains stored in in-use project or baseline HWPs harvested in reporting period *t*, 100 years after initial sequestration in the tree from which it is derived or after the start of the project, whichever is later.	Tonnes of carbon dioxide.	Calculated	N/A	N/A	N/A
$GHG_{CO2, HWP_{in\ landfill}, t}$	Mass of carbon dioxide, that remains stored in in landfill project or baseline HWPs harvested in reporting period *t*, 100 years after initial sequestration in the tree from which it is derived or after the start of the project, whichever is later.	Tonnes of carbon dioxide	Calculated	N/A	N/A	N/A
$m_{k, t, x}$	Dry mass of harvested wood, minus bark, harvested in reporting period *t*, that grew *x* years prior to harvest, and that will be processed into HWP *k*.	Tonnes of harvested wood	Measured	Approach must be of a level of accuracy comparable to what would be used to determine mass (or volume, converted to mass units) of wood for commercial sales purposes. Assigning mass in a given tree to different ages must be based on justified tree growth equations.	Every time harvesting is conducted.	Key variable, must be monitored. Commercial transactions tend to demand a high level of accuracy, and it will likely not be practical for proponents to monitor this parameters with even more accurate methods. Apportioning of growth to different years necessarily must be done using assumptions / models.
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k*.	Mass fraction	Estimated	Estimated based on the type of wood product produced, and either data from the facilities where the harvested wood will be processed, or default / standardized data that can be shown to be	Review every five years or every reporting period, whichever is longer.	Since wood product production not controlled by proponent, direct monitoring impractical. These fractions are unlikely to change significantly over time, so less frequent monitoring (i.e. every 5 years vs. every year) is

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				relevant for project-specific circumstances.		appropriate.
$f_{C, wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$f_{C, in\text{-}use, k, 100\text{-}x}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{C, in\text{-}landfill, k, 100\text{-}x}$	The fraction of carbon in HWPs of type *k* that remains in landfill after 100 – *x* years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
MW_{CO_2}	Molecular weight of CO_2.	g/mole	Estimated	Standard default value	N/A	N/A
MW_C	Molecular weight of carbon.	g/mole	Estimated	Standard default value	N/A	N/A
PE3/BE3 Fossil Fuel Production						
Equation 13: $GHG_{j,PE3/BE3,t} = \sum_f EF_{f,j} \times AL_{f,t} \times CF_f$						
$GHG_{j, PE3/BE3, t}$	Emissions of GHG_j from production of fossil fuels consumed by on-site vehicles and equipment during reporting period *t*.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{f, j}$	The fuel production emission factor for GHG *j* and fuel type *f*.	Mass of GHG j per volume of fuel produced (e.g. grams CO_2,/ L diesel); or mass of CO_2e per volume of fuel	Estimated	In order of preference: 1. BC Reporting Regulation 2. Latest version of the BC GHG Inventory Report 3. Latest version of Canada's National GHG Inventory Report	Annually or every reporting period, whichever is longer.	Not possible to monitor directly given range of potential production facilities that are not controlled by the proponent. Reference sources should allow for a sufficiently accurate result given that expected magnitude

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				4. Latest version of the GHGenius transportation fuel lifecycle assessment model 5. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data.		of these emissions is small.
$AL_{f,t}$	The quantity of fuel of type *f* consumed by on-site vehicles and equipment during reporting period *t.*	Volumetric measure (e.g. L, m3, etc.)	Measured	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.	Continuous	Key variable. Monitored fuel consumption records should be available.
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 fuel type *f.*	Varies	N/A	Standard default values	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
PE4/BE4 Fertilizer Production						
Equation 14: $GHG_{j,PE4/BE4,t} = \sum_f EF_{f,j} \times AL_{f,t} \times CF_f$						
$GHG_{j,\ PE4/BE4,\ t}$	Emissions of GHG_j from fertilizer production applied during reporting period *t*.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{b,\ j}$	The fertilizer production emission factor for GHG *j* and fertilizer type *f*.	g GHG j per kg of nitrogen-based fertilizer produced or g CO_2e per kg of nitrogen-based fertilizer produced	Estimated	1. 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 5. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data.	Review every five years or every reporting period, whichever is longer.	Since fertilizer production is not controlled by proponent, direct monitoring impractical.
$AL_{f,\ t}$	The quantity of fertilizer of type *f* applied during reporting period *t*.	kg of nitrogen-based fertilizer produced	Measured	Based on sales invoices	Continuous (as sales invoices are received)	Key variable. Monitored fertilizer purchase records should be available.
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 fertilizer type *f*.	Varies	N/A	Standard default values	N/A	N/A
PE6/BE6 Transport Of Material, Equipment, Inputs, and Personnel To Site						

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
One of the following two approaches (Equation 16 OR Equation 17) to be selected:						
Equation 16: $GHG_{j,PE6/BE6,t} = \sum_m [EF_{m,j} \times \sum_g (FE_m \times D_{m,g} \times C_{m,g,t} \div L_{m,g}) \times CF_m]$						
$GHG_{j,\ PE6/BE6,\ t}$	Emissions of GHG_j from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{m,\ j}$	The emission factor for GHG *j* and fuel combusted by transportation mode *m*	Mass of GHG j per volume of fuel (e.g. grams CO_2,/ L diesel)	Estimated	BC Reporting Regulation , or BC or National Inventory Reports, so long as the emission factor selected is appropriate for the transport mode and fuel used, and separate emission factors for CO_2, CH_4, and N_2O are available. Where different types of vehicles or fuels are used, associated emission calculations must be performed separately for each vehicle and fuel type.	Annually or every reporting period, whichever is longer.	Given the range of reasonable, low uncertainty fossil fuel combustion emission factors available for standard fossil fuels (e.g. gasoline, diesel, etc.), an average emission factor from a recognized source such as the BC or National Inventory Report is appropriate.
FE_m	Fuel economy of transportation mode *m*	Volume fuel per distance (e.g. L diesel / 100 km).	Estimated	Based on vehicle specifications or default assumptions for the types of vehicles used.	Review every five years or every reporting period, whichever is longer.	Unlikely that specific vehicles used for shipping can be monitored or tracked individually. Given that expected magnitude of these emissions is small, approach is sufficiently accurate.
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport	Km	Estimated	Estimate based on shipping routes and route distance tools (e.g. internet-based	Annually or every reporting period,	This emission source will likely be very small. An estimation

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
	mode *m*.			maps, etc.)	whichever is longer.	approach is most practical.
$C_{m,g,t}$	Total quantity of material, equipment, input, or personnel *g* transported using transport mode *m* during reporting period *t*.	mass, volume, or other relevant units	Measured	Based on sales invoices	Continuous (as sales invoices are received)	Key variable. Monitored purchase records should be available.
$L_{m,g}$	Cargo load per transport vehicle of mode *m*.	Same units used for $C_{m,g,t}$	Estaimted	Based on vehicle specifications or default assumptions for the types of vehicles used.	Review every five years or every reporting period, whichever is longer.	Based on typical shipping practices not typically controlled by the project proponent. Expected magnitude of these emissions is small.
CF_m	The conversion factor to be used if the units of the various parameters do not match for a particular transport mode *m*.	Varies	N/A	Standard default values	N/A	N/A
Equation 17: $GHG_{j,PE6/BE6,t} = \sum_m [EF_{m,j} \times \sum_g (D_{m,g} \times C_{m,g,t}) \times CF_m]$						
$GHG_{j,PE6/BE6,t}$	Emissions of GHG_j from transportation of materials, equipment, inputs, and personnel to the project / baseline site during reporting period *t*.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{m,j}$	The emission factor for GHG *j* and the amount and distance shipped by transportation mode *m*	Grams GHG j per tonne-km shipped (e.g. g CO_2 per tonne-km).	Estimated	1. BC Reporting Regulation 2. Latest version of the BC GHG Inventory Report 3. Latest version of Canada's National GHG Inventory Report 4. Most recent version of	Annually or every reporting period, whichever is longer.	Provides a range of options for reasonably accurate emission factors, given that expected magnitude of these emissions is small.

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				the BC Freight Modal Shifting GHG Protocol; most recent version of the Locomotive Emissions Monitoring Program annual report for the most recent data year available 5. Other recognized, justified reference sources, with a preference for BC-specific data over national or international level data.		
$D_{m,g}$	Transport distance for material, equipment, input, or personnel *g* using transport mode *m*.	Km	Estimated	Estimate based on shipping routes and route distance tools (e.g. internet-based maps, etc.)	Annually or every reporting period, whichever is longer.	This emission source will likely be very small. An estimation approach is most practical.
$C_{m,g,t}$	Total quantity of material, equipment, input, or personnel *g* transported the same distance using transport mode *m* during reporting period *t*.	Tonnes (or volume or other relevant units converted to tonnes).	Measured	Based on sales invoices. Where the same type of good is transported different distances to arrive at the project or baseline site, they should be treated as separate goods for the purposes of this calculation.	Continuous (as sales invoices are received)	Key variable. Monitored purchase records should be available.
CF_m	The conversion factor to be used if the units of the various parameters do not match for a particular transport mode *m*.	Varies	N/A	Standard default values	N/A	N/A
PE7/BE7 fossil fuel combustion – vehicles and equipment emissions						

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
Equation 18: $GHG_{j,PE7/BE7,t} = \sum_f [\sum_e (EF_{f,e,j} \times AL_{f,e,t} \times CF_{f,e})]$						
$GHG_{j,\ PE7/BE7,\ t}$	Emissions of GHG_j, in tonnes, from on-site vehicle and equipment fuel combustion during reporting period *t*.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O)	Calculated	N/A	N/A	N/A
$EF_{f,\ e,\ j}$	The emission factor for GHG *j*, fuel type *f* and equipment/vehicle type.	Mass CO_2, CH_4, and N_2O per volume of fuel. (e.g.: g CO_2/L, g CH_4/m^3)	Estimated	BC Reporting Regulation , or BC or National Inventory Reports so long as the emission factor selected is appropriate for the vehicle or equipment and fuel type used, and separate emission factors for CO_2, CH_4, and N_2O are available. Where different types of vehicles, equipment or fuels are used, associated emission calculations must be performed separately for each vehicle, equipment and fuel type.	Annually or every reporting period, whichever is longer.	Given the range of reasonable, low uncertainty fossil fuel combustion emission factors available for standard fossil fuels (e.g. gasoline, diesel, etc.), an average emission factor from a recognized source such as the BC or National Inventory Report is appropriate.
$AL_{f,\ e,\ t}$	The quantity of fuel of type *f* combusted in equipment/vehicle type *e* during reporting period *t*.	Volumetric measure (e.g. L, m3, etc.)	Measured	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.	Continuous	Key variable. Monitored fuel consumption records should be available.
CF	The conversion factor to be used if the units of the activity level do not match those of the emission factor for a	Varies	N/A	Standard default values	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
	particular fuel type f and equipment/vehicle type *e*.					
PE8/BE8 biomass combustion emissions						
Equation 19: $GHG_{j,PE8/BE8,t} = \sum_b EF_{b,j} \times AL_{b,t} \times CF_b$						
$GHG_{j,\ PE8/BE8,\ t}$	Emissions of GHG *j*, in tonnes, from on-site vehicle and equipment fuel combustion during reporting period *t*. Note that for this SSP, only CH_4 and N_2O are to be reported, as CO2 is tracked as part of forest carbon pools.	Tonnes of GHG j (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{b,\ j}$	The emission factor for GHG *j* and biomass type b (e.g. tonnes CH_4 per tonne of brush burned).	Mass CO_2, CH_4, and N_2O per mass or volume of biomass fuel.	Estimated	Some biomass combustion emission factors are / may be available in the BC Reporting Regulation , or BC or National Inventory Reports (in that order of preference, though note that at the time of protocol development such factors were not included in the BC inventory), and may 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, project proponents will need to justify the use of an adjusted or alternative emission factor based on	Annually or every reporting period, whichever is longer.	Flexibility must be given to manage the range of biomass fuel types and combustion conditions.

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				recognized sources wherever possible.		
$AL_{b,t}$	The quantity of biomass of type *b* combusted during reporting period *t*.	Mass or volume of biomass fuel	Measured or estimated	Project proponents must propose and justify an approach for determining the total mass of biomass combusted during controlled burning events during a reporting period. Wherever possible, measured amounts of biomass should be used (e.g. mass or volume of biomass combusted), though it is recognized that in many cases (e.g. land clearing) such a measurement may not be possible and estimates based on site observations will be necessary.	For each combustion event.	Flexibility must be given to manage the range of biomass fuel types and combustion situations.
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*.	Varies	N/A	Standard default values	N/A	N/A
PE9/BE9 fertilizer use emissions						
Equation 21: $N_2O_{direct,t} = [\left(F_{SN,t} \times (1 - Frac_{GASF}) + (F_{ON,t} \times (1 - Frac_{GASM})\right)] \times EF_1 \times \frac{MW_{N_2O}}{MW_N}$						
Equation 22: $F_{SN,t} = \sum_i^I M_{SFi,t} \times NC_{SFi}$						

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
Equation 23: $F_{ON,t} = \sum_{j}^{J} M_{OFj,t} \times NC_{OFj}$						
$N_2O_{direct,t}$	Direct emissions of N_2O as a result of nitrogen application within the project boundary	Tonnes of N_2O	Calculated	N/A	N/A	N/A
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year *t*	Tonnes of N	Calculated	N/A	N/A	N/A
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year *t*	Tonnes of N	Calculated	N/A	N/A	N/A
$M_{SFi,t}$	Mass of synthetic fertilizer of type i applied in year *t*, tonnes.	Tonnes of nitrogen-based synthetic fertilizer	Measured	Based on sales invoices	Continuous (as sales invoices are received)	Key variable. Monitored fertilizer purchase records should be available.
$M_{OFj,t}$	Mass of organic fertilizer of type i applied in year *t*, tonnes.	Tonnes of nitrogen-based organic fertilizer	Measured	Based on sales invoices	Continuous (as sales invoices are received)	Key variable. Monitored fertilizer purchase records should be available.
EF_1	Emission Factor for N additions from fertilizers,	Tonne N_2O-N / tonne N input	Estimated	Standard default value	N/A	See detailed quantification method.
$Frac_{GASF}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$Frac_{GASM}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
MW_{N_2O}	Molecular weight of N_2O	g/mole	N/A	Standard default value	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
MW_N	Molecular weight of N	g/mole	N/A	Standard default value	N/A	N/A
NC_{SFi}	Nitrogen content of synthetic fertilizer type i applied.	Mass fraction	Estimated	Manufacturer specifications	annually	Key variable. Manufacturer specifications are accurate and practical to use.
NC_{OFj}	Nitrogen content of organic fertilizer type i applied.	Mass fraction	Estimated	Manufacturer specifications	annually	Key variable. Manufacturer specifications are accurate and practical to use.
Equation 24: $N_2O_{indirect,t} = \left(N_2O_{(ATD),t} + N_2O_{(L),t}\right) \times \frac{MW_{N_2O}}{MW_N}$						
Equation 25: $N_2O_{(ATD),t} = [F_{SN,t} \times (Frac_{GASF}) + F_{ON,t} \times (Frac_{GASM})] \times EF_4$						
Equation 26: $N_2O_{(L),t} = \left([F_{SN,t} + F_{ON,t}\right) \times Frac_{LEACH-(H)} \times EF_5$						
$N_2O_{indirect,t}$	Indirect emissions of N_2O as a result of nitrogen application within the project boundary	Tonnes of N_2O	Calculated	N/A	N/A	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*	Tonnes of N_2O	Calculated	N/A	N/A	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*	Tonnes of N_2O	Calculated	N/A	N/A	N/A
MW_{N_2O}	Molecular weight of N_2O	g/mole	N/A	Standard default value	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
MW_N	Molecular weight of N	g/mole	N/A	Standard default value	N/A	N/A
$F_{SN,t}$	Mass of synthetic fertilizer nitrogen applied, tonnes of N in year *t*. See Equation 22.	Tonnes of N	Calculated	N/A	N/A	N/A
$F_{ON,t}$	Mass of organic fertilizer nitrogen applied, tonnes of N in year *t*. See Equation 23.	Tonnes of N	Calculated	N/A	N/A	N/A
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	Tonne N_2O-N / tonne N input	Estimated	Standard default value	N/A	See detailed quantification method.
$Frac_{GASF}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for synthetic fertilizers	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$Frac_{GASM}$	Fraction of Nitrogen that volatilizes as NH_3 and NO_x for organic fertilizers	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$Frac_{LEACH-(H)}$	Fraction of N lost by leaching and runoff.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
EF_5	Emission factor for N_2O-N emissions from N leaching and runoff, tonne N_2O / tonne N input	tonne N_2O / tonne N input	Estimated	Standard default value	N/A	See detailed quantification method.
PE10/BE10 forest fire emissions						
Equation 27: $GHG_{j,PE10/BE10,t} = EF_{ff,j} \times AL_{ff,t} \times CF$						

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
$GHG_{j,\ PE10/BE10,\ t}$	Emissions of GHG_j, in tonnes, from forest fires during reporting period *t*. Note that for this SSP, only CH_4 and N_2O are to be reported, as CO2 is tracked as part of forest carbon pools.	Tonnes CH_4, tonnes N_2O	Calculated	N/A	N/A	N/A
$EF_{ff,\ j}$	The emission factor for GHG *j* applicable to forest fires.	Grams CH_4 per mass or volume of forest biomass combusted, grams N_2O per mass or volume of forest biomass combusted	Estimated	Guidance with respect to combustion emission factors for forest fires shall 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 protocol development such guidance was not included in the BC inventory). Where appropriate factors are not identified, then project proponents will need to justify the use of an adjusted or alternative emission factor based on recognized sources wherever possible.	Annually or every reporting period, whichever is longer.	Direct measurement impractical. Standard GHG reference sources should have the best available information on biomass combustion emissions.
$AL_{ff,\ t}$	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 reversal events that are monitored.	Mass or volume of forest biomass combusted	Estimated	Take from modeling or other approaches being used by the proponent to assess changes in carbon stored in forest carbon pools.	As per forest carbon modelling or other approaches being employed.	Most consistent approach.

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
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*.	Varies	N/A	Standard default values	N/A	N/A
PE11/BE11 Harvested Wood Transport						
Parameters to be monitored are identical to PE6/BE6, except that masses and distances will related to harvested wood rather that site inputs. See detailed quantification method for further details.						
PE12/BE12 harvested wood processing						
Equation 28: $GHG_{j,PE4/BE4,t} = \sum_H EF_{H,j} \times AL_{H,t} \times CF_H$						
$GHG_{j,\ PE12/BE12,\ t}$	Emissions of GHG_j, in tonnes, from production of primary harvested wood products from wood harvested during reporting period *t*.	Tonnes of GHG *j* (e.g. tonnes CO_2, tonnes CH_4, tonnes N_2O); or Tonnes CO_2e	Calculated	N/A	N/A	N/A
$EF_{H,\ j}$	The emission factor for GHG *j* and harvested wood product *H* produced (e.g.	Grams GHG *j* per quantity of raw harvested wood processed, or grams CO_2e per quantity of raw harvested wood processed .	Estimated	Where available, the project proponent may use 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	Annually or every reporting period, whichever is longer.	Emission source not controlled by proponent, and expected to be minor.

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				assumed to be zero for the purposes of this protocol).		
$AL_{f,t}$	The quantity of harvested wood product *H* produced from wood harvested during reporting period *t*.	Mass or volume of harvested wood.	Monitored	Approach must be of a level of accuracy comparable to what would be used to determine mass (or volume, converted to mass units) of wood for commercial sales purposes.	Every time harvesting is conducted.	Key variable, must be monitored. Commercial transactions tend to demand a high level of accuracy, and it will likely not be practical for proponents to monitor this parameters with even more accurate methods.
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*.	Varies	N/A	Standard default values	N/A	N/A
PE15/BE15 harvested wood products and residuals anaerobic decay						
Equation 29: $GHG_{CH4,PE15/BE15,t} = GHG_{CH4,decay,t} \times (1 - \%LFG\ Collection) \times (1 - OX)$						
$GHG_{CH4,PE15/BE15,t}$	Emissions of CH_4 from anaerobic decay of landfilled HWPs harvested in year *t* over a 100 year period since the HWP was produced.	Tonnes CH_4	Calculated	N/A	N/A	N/A
$GHG_{CH4,decay,t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100	Tonnes CH_4	Calculated	N/A	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
	year period since the HWP was produced, as determined in Equation 30.					
$\%_{LFG\ Collection}$	The % of generated CH_4 that is captured and destroyed by a landfill gas collection system. See Appendix B: Determining LFG Collection Efficiency for additional discussion of this parameter.	Percent	Estimated	Standard default value	N/A	See detailed quantification method.
OX	Oxidation factor for the landfill cover layer, expressed as the percentage of CH4 that is oxidized to CO2 as it passes through the cover layer.	Percent	Estimated	Standard default value	N/A	See detailed quantification method.
Equation 30: $GHG_{CH4,decay,t} = \sum_k \left[m_{k,t} \times \left(1 - f_{C,in-use,k} - f_{C,non\ landfill,k} - f_{C,in\ landfill,k}\right) \times \left(1 - f_{Production\ loss,k}\right)\right] \times f_{C,wood} \times \%CH_{4,LFG} \times \frac{MW_{CH_4}}{MW_C}$						
$GHG_{CH4,decay,\ t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100 year period since the HWP was produced.	Tonnes CH_4	Calculated	N/A	N/A	N/A
$m_{k,\ t}$	Dry mass, in tonnes, minus bark, harvested in year *t* that will be processed into HWP k.	Tonnes of harvested wood (Where quantities of harvested wood are available in non-mass	Monitored	Approach must be of a level of accuracy comparable to what would be used to determine mass (or volume, converted to mass units) of	Every time harvesting is conducted.	Key variable, must be monitored. Commercial transactions tend to demand a high level of accuracy, and it will likely not be practical for

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
		units, an appropriate wood density for each species / must be used and justified by the proponent)		wood for commercial sales purposes.		proponents to monitor this parameters with even more accurate methods.
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k.*	Mass fraction	Estimated	Estimated based on the type of wood product produced, and either data from the facilities where the harvested wood will be processed, or default / standardized data that can be shown to be relevant for project-specific circumstances.	Review every five years or every reporting period, whichever is longer.	Since wood product production not controlled by proponent, direct monitoring impractical. These fractions are unlikely to change significantly over time, so less frequent monitoring (i.e. every 5 years vs. every year) is appropriate.
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$f_{C,\ in\text{-}use,\ k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{C,\ non\text{-}landfill,\ k}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 years.	Mass fraction	Calculated	N/A	N/A	N/A
$f_{C,\ in\ landfill,\ k}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$\%CH_{4,LFG}$	Molar % CH_4 in landfill gas.	Percent	Estimated	Standard default value	N/A	See detailed quantification method.
MW_{CH_4}	Molecular weight of CH_4.	g/mole	N/A	Standard default value	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
MW_C	Molecular weight of carbon.	g/mole	N/A	Standard default value	N/A	N/A
Equation 31: $f_{C,non\ landfill,k} = (1 - f_{C,in-use,k}) \times f_{Discard\ non\ landfill,k}$						
$f_{C,\ non\text{-}landfill,\ k}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 years.	Mass fraction	Calculated	N/A	N/A	N/A
$f_{C,\ in\text{-}use,\ k}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{Discard\ non\ landfill,\ k}$	The mass fraction of HWPs of type *k* that are not sent to landfill when discarded	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
Equation 32: $GHG_{CH4,decay,t} = \sum_k \{\sum_{x=0}^{p} [m_{k,t,x} \times (1 - f_{C,in-use,k,(100-x)} - f_{C,non\ landfill,k,(100-x)} - f_{C,in\ landfill,k,(100-x)})] \times (1 - f_{Production\ loss,k})\} \times f_{C,wood} \times \%CH_{4,LFG} \times \frac{MW_{CH_4}}{MW_C}$						
$GHG_{CH4,decay,\ t}$	Mass of CH_4 generated from HWPs harvested in year *t* decaying in landfill over a 100 – *x* year period since the HWP was produced.	Tonnes CH_4	Calculated	N/A	N/A	N/A
$m_{k,\ t,\ x}$	Dry mass of harvested wood, minus bark, harvested in reporting period *t*, that grew *x* years prior to harvest, and that will be processed into HWP *k*.	Tonnes of harvested wood	Measured	Approach must be of a level of accuracy comparable to what would be used to determine mass (or volume, converted to mass units) of wood for commercial sales purposes. Assigning mass in a given tree to different ages must be based on justified	Every time harvesting is conducted.	Key variable, must be monitored. Commercial transactions tend to demand a high level of accuracy, and it will likely not be practical for proponents to monitor this parameters with even more accurate methods. Apportioning of growth to different years

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
				tree growth equations.		necessarily must be done using assumptions / models.
$f_{C,\ in\text{-}use,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{C,\ non\text{-}landfill,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 – *x* years.	Mass fraction	Calculated	N/A	N/A	N/A
$f_{C,\ in\text{-}landfill,\ k,\ (100\text{-}x)}$	The fraction of carbon in HWPs of type *k* that remains in landfill after 100 – *x* years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{production\ loss,k}$	The fraction of wood mass lost as residuals / waste during production of HWP *k*.	Mass fraction	Estimated	Estimated based on the type of wood product produced, and either data from the facilities where the harvested wood will be processed, or default / standardized data that can be shown to be relevant for project-specific circumstances.	Review every five years or every reporting period, whichever is longer.	Since wood product production not controlled by proponent, direct monitoring impractical. These fractions are unlikely to change significantly over time, so less frequent monitoring (i.e. every 5 years vs. every year) is appropriate.
$f_{C,\ wood}$	The fraction of the dry mass of wood, excluding bark, that is carbon.	Mass fraction	Estimated	Standard default value	N/A	See detailed quantification method.
$\%CH_{4,LFG}$	Molar % CH_4 in landfill gas.	Percent	Estimated	Standard default value	N/A	See detailed quantification method.
MW_{CH_4}	Molecular weight of CH_4.	g/mole	N/A	Standard default value	N/A	N/A
MW_C	Molecular weight of carbon.	g/mole	N/A	Standard default value	N/A	N/A

Parameter Coefficient	Parameter Description	Units of Measure	Measured / Estimated	Method	Frequency of Measure	Explanation of method and monitoring frequency
Equation 33: $f_{C,non\ landfill,k,(100-x)} = \left(1 - f_{C,in-use,k,(100-x)}\right) \times f_{Discard\ non\ landfill,k}$						
$f_{C,\ non\text{-}landfill,\ k,\ (100-x)}$	The fraction of carbon in HWPs of type *k* that have been discarded but not sent to landfill after 100 – *x* years.	Mass fraction	Calculated	N/A	N/A	N/A
$f_{C,\ in\text{-}use,\ k,\ (100-x)}$	The fraction of carbon in HWPs of type *k* that remain in-use after 100 – *x* years.	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
$f_{Discard\ non\ landfill,\ k}$	The mass fraction of HWPs of type *k* that are not sent to landfill when discarded	Mass fraction	Estimated	Standard default value, or tailored value justified by proponent.	N/A	See detailed quantification method.
PP10/BP10 Forest Carbon And Wood Product Pools Located Outside Of The Project Boundary That Are Indirectly Affected By The Project Activity						
Given the range of potential approaches to quantifying leakage in this protocol, specific monitoring requirements will not be summarized here. Please see that detailed quantification methods for further details.						

10.0 MANAGING THE RISK OF REVERSAL

It is expected that proponents will use the VCS Program Risk to[illegible]The text below identifies the requirements which must be met under the BC Emission Offsets Regulation.

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 (i.e. to manage the risk of a reversal of carbon storage achieved by a project).

Requirements for risk mitigation and contingency plans for projects quantified under this protocol are described below. Note that this section does not deal with how to quantify reversals (that is addressed in Section 8.1); rather, it presents requirements for how to assess and manage the risk of reversal.

This protocol is intended for use in quantifying GHG offsets that will comply with the BC Emission Offset Regulation by the Province of British Columbia. As such, there is a robust legislative framework in place, through the BC Emission Offset Regulation and the Greenhouse Gas Reductions Targets Act (GGRTA) under which the regulation is enacted to hold project developers accountable for managing the risks of any reversals occurring.

This protocol will provide minimum requirements for assessing the risk of a reversal, but will not specify specific requirements for how to manage that risk. Instead, specific approaches will be left to the users of this protocol (buyers and sellers of forest carbon offsets), with the understanding that in order to be compliant with this protocol, project proponents must manage the risk of reversal and ensure that the atmospheric effect of removals and avoided emissions from reservoirs / pools endures for at least 100 years, according to the quantification requirements stipulated in this protocol.

As policies and legislation related to GHG offsets evolve in British Columbia, the requirements of this section should be reviewed to ensure that requirements are sufficient to ensure compliance with applicable GHG offset rules.

Assessing the Risk of Reversal

The purpose of the assessment of the risk of reversal is to determine 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, and what the extent of reversal is likely to be relative to the baseline should it occur. Such an assessment must be clearly documented and results justified, and must consider the risk associated with various factors, including at minimum the factors listed below.

- **Unavoidable risk of reversal**
  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 should be quantified in a risk mitigation and contingency plan.

Risk assessment must include identification of the reversible elements of the project's GHG reductions, including a discussion of the history and level of risks to the specific ecosystems and tree species involved in the project taking into account changes to historical risks because of the impacts of climate change.

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

1. Wildfire
2. Disease or insect outbreak
3. Other episodic catastrophic events (e.g. windthrow from hurricane or other wind event)

The long term risk for all unavoidable risk of reversal should be determined and expressed as an annualized percentage of area expected to be affected for the project area.

- **Avoidable risk of reversal**
  Illegal harvesting should be considered 0% risk for BC.

  Other avoidable reversals include unplanned harvest, mining activity, or land use change.

In preparing a risk assessment that conforms to the general requirements stated above, the proponent may wish to utilize appropriate (i.e. that are relevant to BC-specific and project-specific circumstances) risk factors, criteria, etc. from existing forest reversal risk assessment approaches and tools, such as those provided in the VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination (including September 2010 update), and the CAR Forest Protocol Version 3.2 Appendix D.

The best aspects of these and other existing approaches for BC circumstances may be adapted, for inclusion in this protocol at a later date.

Mitigating the Risk of Reversal

As previously noted, this protocol will not specify criteria and requirements around specific risk mitigation and contingency approaches. However, project proponents must demonstrate how the results of the risk assessment described above have been used to develop the mitigation and contingency plan. Specifically:

- For the risk mitigation portion of the plan, the proponent must demonstrate how the results of the risk assessment have informed the implementation of mitigation approaches for reducing the likelihood of a reversal event occurring and the extent of such a reversal as much as is practical

- For the contingency portion of the plan, the proponent must demonstrate that contingency plans will be sufficient to ensure that the proponent is able to replace or retire a sufficient quantity of offset credits to make up for any reversals that may occur during the period of the entire project including project, monitoring and reporting.

Project proponents may wish to consider the following potentially relevant mitigation options and contingency approaches when designing their risk mitigation and contingency plan.

Potential Risk Mitigation Options

- Fuel management
- Fire breaks
- Ensuring fire suppression infrastructure is readily available
- Forest management techniques to minimize insects and disease

Potential Contingency Approaches

- Project-specific approaches, including:
  - Ensuring that all anticipated disturbances and associated carbon emissions are included in project and baseline modelling.
  - Setting aside a portion of generated credits in each reporting period in a project-specific buffer pool.
  - Setting aside funds in a project-specific contingency account.
  - Ensuring that sufficient funds or credits will be available at any time to address a reversal event without establishing a separate account.
- Group insurance-type approaches, including:
  - Establishing and contributing each reporting period to a multi-project shared buffer pool, where a group of projects help share the risk of a reversal occurring at any one project.
  - Purchasing insurance where a premium is paid to protect against having to replace credits after a reversal event.

APPENDIX A: GLOSSARY OF TERMS

Aboveground Biomass: All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.[lxxvi]

Additionality: The concept that a project's emission reductions and removal enhancements must go beyond (i.e. be additional to) what would have occurred in the absence of the GHG offset project. In the BC Emission Offset Regulation, projects are deemed additional where they can demonstrate that the incentive of having a greenhouse gas reduction recognized as an emission offset overcomes or partially overcomes financial, technological or other obstacles to carrying out the project.

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.

Carbon Pool: A carbon pool is defined as a physical unit or component of the biosphere, geosphere or hydrosphere with the capability to store or accumulate carbon from the atmosphere by a greenhouse gas sink or carbon captured from a greenhouse gas source through a physical, chemical or biological process. Equivalent to the ISO 14064 term "reservoir".

CO_2 equivalent (CO_2e): The universal unit of measurement to indicate the global warming potential (GWP) of each of the six greenhouse gases, expressed in terms of the GWP of one unit of carbon dioxide. It is used to evaluate releasing (or avoiding releasing) different greenhouse gases against a common basis.

Controlled SSP: A GHG source, sink, or carbon pool whose operation is under the direction and influence of the proponent through financial, policy, management or other instruments.

Dead Wood: Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps.[lxxvii]

Emission factor: A factor allowing GHG emissions to be estimated from a unit of available activity data (e.g. tonnes of fuel consumed, tonnes of product produced) and absolute GHG emissions.

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 gas emission: the release of greenhouse gases to the atmosphere, by a GHG source (e.g. fossil fuel combustion).

Greenhouse gas removal: a removal of greenhouse gases from the atmosphere, by a GHG sink (e.g. growing trees).

Greenhouse gases (GHG): GHGs are the six gases listed in the Kyoto Protocol: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulphur hexafluoride (SF_6).

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

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

Soil Organic Matter: Includes organic carbon in mineral and organic soils (including peat) through the full soil profile and applied consistently through the time series. Live fine roots are included with soil organic matter where they cannot be distinguished from it empirically.[lxxviii]

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.

World Resources Institute (WRI): WRI is an environmental think tank founded in 1982 based in Washington, D.C. in the United States. WRI is an independent, non-partisan and nonprofit organization with the intention of protecting the Earth and improving people's lives. WRI organizes its work around four key goals: Climate, energy & transport, Governance & access, Markets & enterprise and People & ecosystem.

World Business Council for Sustainable Development (WBCSD): The World Business Council for Sustainable Development (WBCSD) is a CEO-led, global association of some 200 companies dealing exclusively with business and sustainable development. The Council provides a platform for companies to explore sustainable development, share knowledge, experiences and best practices, and to advocate business positions on these issues in a variety of forums, working with governments, non-governmental and intergovernmental organizations.

APPENDIX B: DETERMINING LFG COLLECTION EFFICIENCY

Given that it is virtually impossible to trace a given HWP from a given project to a particular final landfill site at end of life likely many years later, general assumptions must be used to estimate *an overall* $\%_{LFG\ Collection}$ from Equation 29 for project and baseline HWPs.

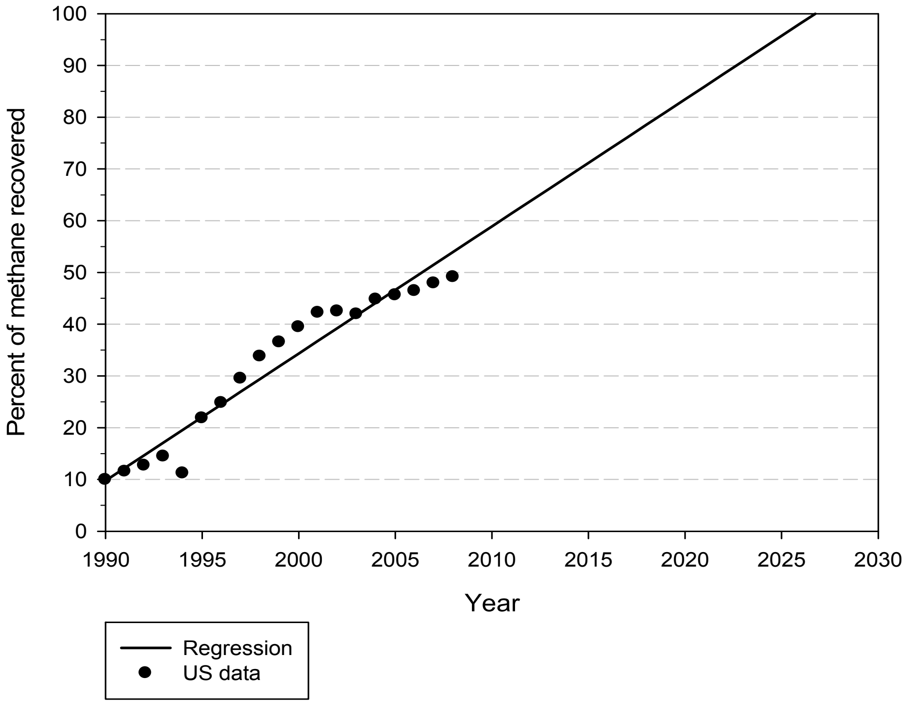
Key factors to consider, and associated assumptions used in this protocol, are discussed below.

Proportion of HWPs sent to large landfill that have or are likely to have in the future LFG collection systems, versus smaller landfills that are less likely to have LFG collection systems

It is assumed that the vast majority of HWPs will be disposed of at large landfill sites, given that the bulk of Canadian and US populations are located in urban centers served by large landfills. For the purposes of this protocol, it will be assumed that 100% of HWPs that are disposed of and sent to landfill are sent to large landfills.

1. **Proportion of large landfills in BC and export markets (primarily the US) that are likely to have LFG collection systems installed in the future by the time that HWPs produced today are likely to have been used, disposed of, and starting to generate CH_4.**

   BC, other Canadian provinces, and some US states have already required or established mandatory timelines for requiring large landfills to install LFG collection and destruction systems, and this trend is expected to continue into the future. As illustrated in Figure 5, below, by 2010 over 50% of CH_4 emissions from all US landfills (both with and without LFG collection) are expected to be captured, and based on the trend observed (the linear regression plotted in Figure 5 explains 93.5% of the variability) this rate is expected to continue.



Source: 2010 US greenhouse gas inventory, Table A-242[lxxix], with regression analysis added

Figure 5: Methane Capture Trend (US)

2. **Expected typical collection and destruction efficiency of installed LFG systems in the future by the time that HWPs produced today are likely to have been used, disposed of, and starting to generate CH_4.**

   Performance of landfill gas collection and destruction systems can vary. However, the US EPA has indicated that for modern gas collection systems that comply with related Clean Air Act regulations, an assumption of 75% efficiency would be conservative[lxxx]. The same reference cites the IPCC 4th Assessment Report, Chapter 10 – Waste Management (p. 600) as indicating that over 90% recovery can be achieved at sites with proper final cover and efficient systems installed.

   As an estimate of expected future average LFG collection efficiencies, this protocol will assume a value of 80%, based on the above.

Therefore, based on the above assumptions, it will be assumed that 80% of CH_4 emissions from decay of HWPs in landfill will be collected and destroyed, and thus will not need to be counted as emissions for forest carbon offset projects.

APPENDIX C: 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, Equation 38) 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.[lxxxi] The market share of the base case offset project is assumed to be 1% (Φ = .01)[lxxxii] 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.[lxxxiii]

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.[lxxxiv] Since approximately 60% of total Canadian softwood lumber production (m^3) was exported from 2007-2009, 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.[lxxxv] 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., 2010)[lxxxvi]. 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 19 below:

Table 19: Northern Interior Leakage Estimation

e = .342
E = -.181
C_R = 1
C_N = 1
Φ = .01
γ = 1
L = 65%

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.[lxxxvii] Tree species that have a high number of alternative species, in terms of the product lines they are geared for are referred to as highly substitutable.[lxxxviii] 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.[lxxxix]

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 20 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 20: Coastal Leakage Estimation

Perfect Substitutes	**Moderate Substitutes**
e = .342	
E = -.181	
C_R = 1	
C_N = 1	
Φ = .01	
γ = 1	γ = .8479
%Leakage = 65%	**%Leakage = 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).[xc] For the coastal base case red cedar and cypress are identified as low substitutability woods, white pine is identified as moderately substitutable.[xci] All other commercially harvested trees in the coastal region are assumed to be perfectly substitutable (100% substitutability).[xcii]

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.

Table 21: Low and moderately substitutability wood as a contribution of total coastal harvest

	Cedar	Cypress	White Pine[xciii]	Other	Total
Harvest Contribution (T)	22.4%	2.9%	.1%	74.6%	100%
Substitution (S)[xciv]	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.[xcv] 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 22: Low and moderately substitutable wood as contribution of total southern interior harvest

	Cedar	Larch, Yellow & White Pine[xcvi]	Other	Total
Harvest Contribution	2.9%	2.0%	95.1%	100%
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 D: 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 base on the references listed below:

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)[xcvii]

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 in eqs. 6 and 7. 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)[xcviii]

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 Hsue 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 E: SUBSTITUTABILITY ESTIMATES FOR COMMERCIAL TREE SPECIES IN BRITISH COLUMBIA

Low and Moderately Substitutable woods in BC

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%)		

APPENDIX F: BC TIMBER HARVESTING VOLUME BY SPECIES AND REGION

Timber harvesting volume proportion five-year average (2006-2010)

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%
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 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

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

REFERENCES AND OTHER INFORMATION

Include any relevant references and any other information relevant to the methodology/revision.

[1] Removal means the uptake of carbon dioxide from the atmosphere through processes such as growing trees. Removal enhancement means increasing removals over and above the baseline. Removal does not mean timber harvesting.

[2] ISO 14064-2:2006, Greenhouse gases - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (2006).

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

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

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

[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

[8] Voluntary Carbon Standard, Tool for AFOLU Methodological Issues, November 18, 2008

[9] Voluntary Carbon Standard ,Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination, November 18, 2008

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

[11] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 4: Forest Land, 2006

[12] 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.

[13] Removal means the uptake of carbon dioxide from the atmosphere through processes such as growing trees. Removal enhancement means increasing removals over and above the baseline. Removal does not mean timber harvesting.
[14] ISO 14064-2:2006, Greenhouse gases - Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements (2006).
[15] Taken from the British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009
[16] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[17] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[18] Modified from http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[19] The term "carbon pool" has been substituted for "reservoir", the standard ISO 14064 term, in this protocol to enhance clarity given general familiarity with the term carbon pool in the forest sector. "Carbon pool" has an identical meaning to "reservoir".
[20] The BC Emission Offsets Regulation, established by the BC Ministry of the Environment under the provisions of the Greenhouse Gas Reduction Targets Act (GGRTA) (2008).
[21] Available at http://www.for.gov.bc.ca/code/cfstandards/
[22] 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.

[23] Zero Net Deforestation policy http://www.for.gov.bc.ca/hfp/znd/definitions.htm
[24] Modified from British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009
[25] 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.
[26] Turning the Corner, Canada's Offset System for Greenhouse Gases Guide for Protocol Developers, Draft for Consultation, Environment Canada (2008).
[27] Climate Change Technology Early Action Measures (TEAM) Requirements and Guidance for the System of Measurement And Reporting for Technologies (SMART), Government of Canada (2004).
[28] ISO 14040:2006, Environmental management - Life cycle assessment - Principles and framework (2006).
[29] CAR, Forest Project Protocol Version 3.2, August 31, 2010
[30] VCS, Tool for AFOLU Methodological Issues, November 18, 2008
[31] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 4: Forest Land, 2006
[32] From CAR Forest Project Protocol Version 3.2.
[33] Stumps are assumed to be part of the Litter and Forest Floor carbon pool.
[34] From CAR Forest Project Protocol Version 3.2.
[35] From CAR Forest Project Protocol Version 3.2.
[36] From CAR Forest Project Protocol Version 3.2.
[37] 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.
[38] http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/12_14_2004#part4_division1

[39] For all related emission sources, this requirement is necessary in order to comply with the BC Emissions Offset Regulation. Where it cannot be demonstrated in advance that project emissions will be less than or equal to baseline emissions for a particular emission source for all years of the project, the SSP must be included in the GHG Project Plan and quantified in each emission report, though net emission reductions would be set to zero if project emissions are found to be less than baseline emissions.
[40] Turning the Corner, Canada's Offset System for Greenhouse Gases Guide for Protocol Developers, Draft for Consultation, Environment Canada (2008).
[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.
[43] Modified from the British Columbia Forest Offset Guide Version 1.0, B.C. Ministry of Forests and Range, April 2009.
[44] Tree and Stand Simulator. See http://www.for.gov.bc.ca/hre/gymodels/tass/index.htm for further details.
[45] Table Interpolation Program for Stand Yields. See http://www.for.gov.bc.ca/hre/gymodels/TIPSY/ for further details.
[46] Variable Density Yield Prediction. See http://www.for.gov.bc.ca/hts/vdyp/ for further details.
[47] See http://www.for.gov.bc.ca/hre/gymodels/progbc/ for further details
[48] See http://www.bvcentre.ca/sortie-nd for further details.
[49] Forest Service Spatial Analysis Model: http://www.barrodale.com/bcs/index.php/timber-supply-model
[50] Forest Simulation and Optimization System: http://www.forestecosystem.ca/technology_fsos.html
[51] Forest Service Simulator: http://www.cortex.org/case-mana-case17b.html
[52] http://www.spatial.ca/
[53] Spatially Explicit Landscape Event Simulator: http://www.seles.info/index.php/Main_Page
[54] Critical Analysis by Simulation of Harvesting version 6.21, Timberline Natural Resource Group Ltd.
[55] http://www.remsoft.com/
[56] See http://www.landis-ii.org/ for further details.
[57] 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.
[58] See http://www.forestry.ubc.ca/ecomodels/moddev/forecast/forecast.htm for further details.
[59] 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
[lx] James E. Smith, Linda S. Heath, Kenneth E. Skog, and Richard A. Birdsey, 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. Available at http://www.fs.fed.us/ne/durham/4104/papers/ne_gtr343.pdf
[lxi] US DOE, Technical Guidelines for Voluntary Reporting of Greenhouse Gas Program, June 2006. Available at http://www.eia.doe.gov/oiaf/1605/January2007_1605bTechnicalGuidelines.pdf
[lxii] Based on 2008 softwood commodity export and log use statistics from http://www.bcfii.ca/industry_resources/pdf/BC%20Softwood%20Commodity%20Product%20Sales.pdf, and http://www.for.gov.bc.ca/ftp/HET/external/!publish/Web/Mill%20List/Public%20Report%202008.pdf, it is suggested that ~90% of BC wood products remain in North America.
[lxiii] Smith *et al*, 2006 spreadsheet files can be found at http://www.fs.fed.us/ne/durham/4104/1605b.shtml
[lxiv] 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.

[lxv] The trees known in BC as "balsam" are true firs

[lxvi] Estimated from 2003, 2005, 2006 and 2008 editions of Major Primary Timber Processing Facilities In British Columbia published by the Ministry of Forests and Range Policy and Trade Relations Branch and a pulp mill efficiency of 72% (NCASI personal communication). 25% represents losses due to milling efficiency, use as bioenergy and raw log exports (which are assumed to represent an immediate emission), with the remaining 75% constituting lumber (35%), veneer / OSB (10%), and paper (30%).
[lxvii] The Reporting Regulation, under authority of the Greenhouse Gas 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
[lxviii] Available at http://www.ghgenius.ca/
[lxix] 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
[lxx] 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
[lxxi] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 3: Solid Waste Disposal, 2006, Table 3.2, page 3.15
[lxxii] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 3: Solid Waste Disposal, 2006, page 3.15
[lxxiii] IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 3: Solid Waste Disposal, 2006, page 3.15
[lxxiv] Murray, B., et al. 2004. “Estimating Leakage from Forest Carbon Sequestration Programs”. *Land Economics* 80(1): 109-124.

[lxxv] Refer to Provincial Base Case Approach for the Coastal Market for an example of the application of the substitutability parameter.
[lxxvi] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[lxxvii] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[lxxviii] Modified from http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf
[lxxix] ANNEX 3 Methodological Descriptions for Additional Source or Sink Categories epa.gov/climatechange/emissions/downloads10/US-GHG-Inventory-2010-Annex-3-Addtl-Source-Sink-Categories.pdf
[lxxx] US Environmental Protection Agency, Landfill Methane Outreach Program (LMOP) Frequently Asked Questions, available at http://www.epa.gov/lmop/faq/lfg.html#17

[lxxxi] 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.

[lxxxii] 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.
[lxxxiii] 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.
[lxxxiv] Refer to Appendix g: BC Forest Districts by Region for the BC Forest Districts Used to delineate the regions used in the base cases.
[lxxxv] 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>.
[lxxxvi] Song, N., et al., 2010. "U.S. softwood lumber demand and supply estimation using cointegration in dynamic equations". Journal of Forest Economics.
[lxxxvii] 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).
[lxxxviii] Wood substitution is generally a function of product line. Wood can also be substituted with other materials such as vinyl, steel or manmade fibres 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.
[lxxxix] Elasticities appropriate for determining leakage are long-run supply and demand elasticities for the total North American market.
[xc] The tree species composition of the project area would need to be verified.
[xci] Refer to Appendix d: Example Substitutability Equationsfor calculation on how to derive substitutability estimates for tree species.
[xcii] 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 d: Example Substitutability Equations for deriving wood substitutability estimates.
[xciii] 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.
[xciv] See Appendix d: Example Substitutability Equations 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.
[xcv] Refer to Appendix g: BC Forest Districts by Regionfor the BC Forest Districts Used to delineate the regions used in the base cases.
[xcvi] 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.

[xcvii] 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.

[xcviii] 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.