Title	Date of Issue
Improved Forest Management – Logged to Protected Forest (IFM-LtPF) on Lands Subject to Unextinguished Rights and Title	January 6, 2010
Version	**Sectoral Scope**
1.1	14
Element Type	**Prepared By**
New Methodology	Carbon Credit Corp

Executive Summary

Scope

This is methodology for estimating and monitoring greenhouse gas (GHG) emissions of *Improved Forest Management project activities* that result in *Logged to Protected Forests (LtPF).* It includes methods to estimate carbon stock enhancement of forests that would be severely impacted in the absence of the IFM project activity.

This methodology document supports and does not fully replace the VCS 2007.1, Program Guidelines 2007.1 and VCS Guidance for AFOLU Projects documentation, and therefore project proponents should also refer directly to the VCS documentation for further guidance and details throughout the project development process.

Conceptual Approach

The underlying conceptual approach of this methodology is based on drafts of the AFOLU Guidance Document of the Voluntary Carbon Standard (VCS) available at the time of writing.

Improved Forest Management is the title used for project situations, where activities are implemented on forest lands that are managed for wood products such as sawtimber, pulpwood and fuelwood and are included in the IPCC category “forests remaining as forests”. The activities in these areas must be designated, sanctioned or approved by the national or local regulatory bodies to qualify.

Only areas that have been designated, sanctioned or approved for such activities (e.g., as logging concessions or plantations) by the national or local regulatory bodies are eligible for crediting under the VCS Improved Forest Management (VCS) category.

Conversion of logged forests to protected forests (LtPF) includes: (1) protecting currently logged or degraded forests and plantations from further logging and degradation; and, (2) protecting unlogged forests that would be logged in the absence of carbon finance.

Generally speaking, converting logged forests to protected forests reduces emissions caused by harvesting (i.e. protects carbon stocks) and increases the carbon stock as the forest re-grows and/or continues to grow.

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I. SOURCES, DEFINITIONS and APPLICABILITY OF METHODOLOGY

1 Sources

Sources used in the development of the Proposed Methodology:

1. VCS Program Guidelines 2007.1[1]
2. Guidance for Agriculture, Forestry and Other Land Use Projects[2]
3. VCS Tool for AFOLU Methodological Issues[3]
4. AR-ACM0001 Afforestation and reforestation of degraded land[4]
5. Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination[5]
6. VCS Tool VT0001- Tool for the Demonstration and Assessment of Additionality[6]
7. CDM Tool for testing significance of GHG emissions in A/R CDM project activities[7]
8. REDD Methodology Framework (Avoided Deforestation Partners)[8]
9. Approved VCS Methodology VM0003 – through extension of Rotation Age[9]
10. IFM – Proposed Methodology for Conversion of Logged to Protected Forests (GreenCollar Climate Solutions)[10]
11. Clean Development Mechanism (CDM) New Methodologies Template (v3)[11]
12. Climate Action Reserve – Forest Project Protocol v. 3.2[12]
13. IPCC Guidelines for National Greenhouse Gas Inventories Volume 4 Agriculture, Forestry and Other Land Use 2006[13]
14. IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry Glossary[14]

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[1] http://www.v-c-s.org/docs/Voluntary%20Carbon%20Standard%202007_1.pdf

[2] http://www.v-c-s.org/docs/Guidance%20for%20AFOLU%20Projects.pdf

[3] http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Methodological%20Issues.pdf

[4] http://cdm.unfccc.int/UserManagement/FileStorage/NQOMTAU7I5J4LWK08XY9VRHSGCFZ31

[5] http://www.v-c-s.org/docs/Tool%20for%20AFOLU%20Non-Permanence%20Risk%20Analysis%20and%20Buffer%20Determination.pdf

[6] http://www.v-c-s.org/docs/VCS-Tool-VT0001_Tool-for-Demonstration-and-Assessment-of-Additionality-in-AFOLU-Project-Acitivities.pdf

[7] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf

[8] http://www.netinform.net/KE/Wegweiser/Guide2.aspx?ID=6141&Ebene1_ID=49&Ebene2_ID=1978&mode=4

[9] http://www.v-c-s.org/docs/VM0003-Methodology-for-Improved-Forest-Management-through-Extension-of-Rotation-Age.pdf

[10] http://www.v-c-s.org/docs/LtPF%20Methodology_V1-4.pdf

[11] http://cdm.unfccc.int/methodologies/ARmethodologies/approved_ar.html

[12] http://www.climateactionreserve.org/wp-content/uploads/2009/03/Forest_Project_Protocol_Version_3.2.pdf

[13] http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

2 List of Acronyms

AFOLU Guidelines	Agriculture, Forestry and Other Land Uses section of Guidelines for National Greenhouse Gas Inventories 2006
A/R	Afforestation/Reforestation (under CDM)
CAR	Climate Action Reserve
CDM	Clean Development Mechanism
DOM	Dead Organic Matter
GPG LULUCF	Good Practice Guidance for Land Use Land Use Change and Forestry (under IPCC)
IFM	Improved Forest Management
IPCC	Intergovernmental Panel on Climate Change
LtPF	Logged to Protected Forest
VCS-PD	Project Design Document
REDD	Reduced Emissions from Deforestation and Degradation
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Voluntary Carbon Standard

[14] http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Glossary_Acronyms_BasicInfo/Glossary.pdf

3 Definitions

Logging slash	Branches, dead wood material and foliage left on forest floor after timber harvesting
Project proponent	Indigenous group that has unextinguished indigenous rights and title
Tree	A perennial woody plant with a diameter at breast height ≥ 4 cm and a height greater than 1.3 m.
Land cover	The type of vegetation covering the earth's surface.

4 Applicability

At the time of writing, there are five VCS approved AFOLU methodologies available. They are:

- 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 Forest to High-Productive Forest" (v1.0)
- VM0006 "Methodology for Carbon Accounting in Project Activities that Reduce Emissions from Mosaic Deforestation and Degradation" (v1.0)
- VM0007 "REDD Methodology Modules (REDD –MF)

Presently, there are no approved CDM and VCS methodology standards for Improved Forest Management-Logged to Protected Forests (IFM-LtPF) projects. Clean Development Mechanism (CDM) methodologies are not applicable to this type of project. CAR does not currently have methodologies developed for Canada. Regardless, each of these other methodologies provides input into the derivation of this methodological protocol.

The new methodology is based primarily on the VCS Standard 2007.1, VCS AFOLU Guidance Documents and approved VCS IFM Methodologies.

Relationship to Approved Methodologies

While there are a number of VCS approved methodologies that have been utilized in the development of this methodology, the proposed methodology is a new methodology based on the following:

- The proposed methodology uses an approach to setting the baseline that is different than any of the similar methodologies

- The proposed methodology uses an approach to determining and assessing additionality that is different than any of the similar methodologies and includes the development of a new additionality tool that is undergoing the double approval process.

- The proposed methodology is applicable under a different set of applicability conditions than any of the similar methodologies

- The proposed methodology uses, includes, refers to or relies upon part of a number of the similar methodologies such that it would have been problematic to revise any particular one of the similar methodologies

- The proposed methodology is applicable to a different type of IFM project activity than the similar methodologies currently approved under the VCS

The new methodology is applicable under the following conditions:

1. Unlogged forest that would be logged by delineation of and clearcut harvesting of a sequence of cutblocks, so as to convert a predominantly old-growth forest to second growth; in the absence of the carbon project
2. The Projects meet the VCS IFM-LtPF eligibility criteria
3. The land in the Project Area is subject to unsettled land claims by indigenous communities with unextinguished indigenous rights and title
4. The Project Area has undergone a material change in forest management practices resulting from negotiations and agreements between governing authority and indigenous communities.
5. The boundaries of the planned timber harvest area are clearly defined and documented
6. There is minimal risk of external illegal timber harvesting and/or unplanned development in the Project Area.
7. The risk of devastating fire is extremely low risk in the Project Area.
8. The risk of significant forest degradation from pest and disease outbreaks in the Project Area is extremely low
9. The methodology is applicable to grouped projects.
10. This methodology is not developed for timber harvest for fuelwood.

II. BASELINE METHODOLOGY

1 Project Boundary

Geographic Boundary

To be eligible for VCS crediting, the land defined as "forest" must meet internationally accepted definitions of what constitutes a forest as given in the VCS standards for IFM activities. IFM activities are those implemented on forest lands managed for sawtimber, pulpwood and fuelwood and are included in the IPCC category "forests remaining as forests" (see IPCC 2006 Guidelines).

The IFM boundary shall be clearly delineated and defined and include only land qualifying as "forest" and covered by the harvest or land management plans for a minimum of 10 years prior to the project start date.

Project proponents shall clearly define the spatial boundaries of a project so as to facilitate accurate measuring, monitoring, accounting and verifying of the project's emissions reductions and removals. Aggregation of forest areas by multiple indigenous communities with unextinguished indigenous rights and title is permitted under the methodology with aggregated areas treated as a single project area.

The IFM project area may contain more than one discrete area of land. Each discrete area of land shall have a unique geographical identification. This methodology allows for grouped projects. Once a project has been validated to this methodology, projects can be grouped together.

When describing physical project boundaries, the following information shall be provided per discrete area:

- Name of the project area;
- Unique identifier for each discrete parcel of land;
- Map(s) of the area (preferably in digital format);
- Geographic coordinates of each polygon vertex (preferably obtained from a GPS or from a geo-referenced digital map);
- Total land area; and
- Details of forest ownership and legal title to the forest
- Indigenous groups have unextinguished indigenous rights and title

The geographic boundaries of an IFM project are fixed and thus do not change over the project lifetime. In a situation where projects are grouped together at verification, each project must retain its identified geographic boundaries that were approved at validation.

Following the VCS definition of market leakage, the geographic boundaries for leakage from market effects are those of the country in which the project area occurs.

Temporal Boundary[15]

The temporal boundary for projects applying this methodology is equal to the project's Crediting Period: the period of time for which the net GHG emissions reductions or removals will be verified. The Project Crediting Period is defined by the VCS standard 2007.1[16]

The Project Crediting Period Start Date is defined by the VCS standard 2007.1[17] and is the date on which the 1st monitoring period commences.

The Project Start Date has equally been defined by the VCS standard 2007.1 and is the date on which the project begins reducing or avoiding GHG emissions.

Project proponents shall determine the Crediting Period, the Crediting Period Start Date and the Project Start Date and provide verifiable evidence when the 1st monitoring period started and when the project begins to reduce or avoid GHG emissions.

2 Carbon Pools

The project methodology must consider all carbon pools required for IFM-LtPF projects under VCS Program update to the Guidance for AFOLU Projects[18] (see Table 1): Since reducing the quantity of live biomass in harvested timber does not necessarily equate to a direct emission to the atmosphere, wood products are also included in the calculation of carbon stocks. Belowground and soil carbon pools are considered optional carbon pools and are to be included if determined significant.

The project shall account for any significant decrease in carbon stock that is reasonably attributable to the project activities. The "Tool for Testing Significance of GHG emissions in A/R CDM project activities[19]" shall be used to test the significance of each carbon pool.

Harvested wood products and dead-wood shall be included when they increase more or decrease less in the baseline than in the project scenario. If a carbon pool is included in the baseline accounting, it shall also be included in the project scenario and in leakage accounting. Insignificant carbon pools (determined through the approved significance test) can always be ignored.

In the event that the project proponent chooses to account for all carbon pools identified as excluded or optional in Table 1, the project proponent is not required to apply the significance test.

Table 1 with the selection of the carbon pools and appropriate justification must be presented in Section 2.3 of the VCS Project Document (VCS-PD).

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[15]Section guided by VCS Approved Methodology VM0005 - http://www.v-c-s.org/docs/VCS%20Methodology%20Improved%20Forest%20Management%20-%20Low%20Productive%20to%20High%20Productive%20Forest%20Version1%200.pdf

[16] http://www.v-c-s.org/docs/Voluntary%20Carbon%20Standard%202007_1.pdf

[17] http://www.v-c-s.org/docs/Voluntary%20Carbon%20Standard%202007_1.pdf

[18] http://www.v-c-s.org/docs/VCS-AFOLU_Program_Update_21May10.pdf.

[19] http://cdm.unfccc.int/methodologies/ARmethodologies/tools/ar-am-tool-04-v1.pdf

Table 1: Carbon Pools in IFM-LtPF activities[20]

Carbon Pool	Included/Optional/Excluded	Justification/Explanation of Choice
Above-ground trees	Included	At minimum, the stock change in the above-ground tree biomass must be estimated
Above-ground non-tree	Excluded	Not a required carbon pool for VCS activity
Below-ground	Optional	Below-ground biomass stock is expected to increase due to implementation of the VCS activity. Must be included if significant carbon pool
Litter	Excluded	Not a required carbon pool for VCS activity
Dead-wood	Included	Must be included if greater in baseline than project scenario and significant
Soil organic carbon	Optional	Must be included if greater in baseline than project scenario and significant
Harvested wood products	Included	Must be included if greater in baseline than project scenario and significant

3 Greenhouse Gases and Sources

The project shall account for any significant increases in emissions of carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) that are reasonably attributable to the project activity. The GHG emission sources included in or excluded from the project boundary are shown in Table 2.

Table 2 with the selection of sources and the appropriate justification must be presented in Section 2.3 of the VCS-PD.

Table 2: Sources of emissions and related greenhouse gases from IFM-LtPF activities

Source	Gas	Included/Optional /Excluded	Justification/Explanation
Burning of Biomass	CO_2	Excluded	Counted as carbon stock change in Table 1
	CH_4	Optional	Can be neglected if excluded from baseline

[20] According to VCS Program Update May 24, 2010 - http://www.v-c-s.org/docs/VCS-AFOLU_Program_Update_21May10.pdf

	N_2O	Optional	accounting. Shall be included if accounted in the baseline and significant.

Following the guidance of the Executive Board of the CDM, emissions caused by combustion of fossil fuels and through the use of fertilizers are considered insignificant and not considered here[21]

4 VCS Eligible Activity and Baseline Selection

VCS Eligible Activity

This methodology applies activities related to improved forest management which are those implemented on forest lands managed for wood products such as sawtimber, pulpwood and fuelwood and are included in the IPCC category "forests remaining as forests"[22]. Specifically this methodology applies to VCS IFM LtPF (unlogged) where, in the Project Area, timber harvest has been planned, and legal authority to harvest is in place but where actual harvest has not yet commenced

Preliminary screening based on the starting date of the IFM project activity

The start date for AFOLU projects can be earlier than 1 January 2002, provided that project validation and verification against the VCS has been completed by 1 October 2011, the project proponent can verifiably demonstrate that it had been designed and implemented as a climate change mitigation project from its inception, and that prior to 1 January 2002 the project engaged independent verifiers/monitoring experts and applied methodologies that now conform to this VCS-approved methodology to assess and quantify the project's baseline scenario, leakage and net emissions reductions/removals.

If the project participants claim that the start date of the IFM VCS project activity is before the date of validation, then the project participants shall:

- Provide evidence that the starting date of the IFM VCS project activity was after 1 January 2002, and
- Provide evidence that the incentive from the planned sale of VCUs was seriously considered in the decision to proceed with the project activity. This evidence shall be based on (preferably official, legal and/or other corporate) documentation that was available to third parties at, or prior to, the start of the project activity.

Determination of Baseline Scenario

Identify credible alternative forest management scenarios to the proposed VCS project activity

As per the applicability conditions, the project must demonstrate a significant change in forest management practices on the forest area under management which resulted from negotiations between

[21] http://cdm.unfccc.int/EB/044/eb44rep.pdf - http://cdm.unfccc.int/EB/042/eb42rep.pdf

[22] See VCS (2008) Guidance for AFOLU Projects

the legislated authority and indigenous communities with unextinguished indigenous rights and title. The changes in harvest practices requires that land use objectives and forest management requirements are amended to achieve social and economic benefits, including carbon values, for indigenous communities and other groups that are dependent on the area.

The baseline scenario shall be realistic and credible and based on the forest management practices that would have most likely occurred in the absence of the project. It consists of logging the project area without the establishment of protected areas and without meaningful consultation of forest management with the indigenous communities.

The following information shall be provided to demonstrate that the project proponent meets the minimum acceptable standards outlined for this baseline scenario:

1. The legal requirements for forest management and land use in the area required by the legislated authority.
2. For projects, where the project proponent, who has unextinguished indigenous rights and title of a property and becomes engaged with the legislated authority to change forest management practices to develop a conservation economy, may consider the project baseline to be the prescribed management plans proposed by the legislated authority who previously had enacted legislation that did not incorporate unextinguished indigenous rights and title.
3. Proof that the environmental practices equal or exceed those commonly considered a minimum standard among similar landowners in the area.
4. Historical records must be provided to show the extent indigenous communities have been involved and consulted on land use management on lands that are subject to unextinguished indigenous rights and title.

5 Additionality

The project proponent shall demonstrate that the project is additional through the use of the latest version of the Tool for the Demonstration and Assessment of Additionality in IFM Projects subject to unextinguished indigenous rights and title, (Version 1.0)

6 Stratification[23]

If the project activity area is not homogeneous, stratification must be carried out to improve the accuracy and precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios in order to achieve optimal accuracy and precision of the estimates of net GHG emissions reductions or GHG removal by sinks.

For estimation of baseline carbon stocks strata must be defined on the basis of parameters that are key variables in any method used to estimate changes in managed forest carbon stocks, for example:

[23]Section taken from VCS Approved Methodology VM0003, Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age" - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

- Management regime
- Site index / anticipated growth rates
- Forest species
- Age class

Note: In the equations used in this methodology, the letter i is used to represent a stratum and the letter M for the total number of strata: MB is the number of ex ante defined baseline strata as determined with the procedures above; MB remains fixed. MPS is the number of strata in the project scenario as determined ex ante.

7 Net Baseline Greenhouse Gas Removals by Sinks

Under the baseline scenario, planned timber harvest in the project area (for sawtimber and pulpwood) is expected to occur as stipulated in the terms of an immediate site-specific forest management agreement or timber harvest plan.

The baseline of an IFM-LtPF project activity is estimated *ex ante*.

The baseline scenario shall be determined *ex ante* on the basis of the following:

a) Base year stratification specific to the forest region where the project area is located, where available and documented in the existing forest management agreement, or developed by project proponents through sampling in a reference area or a set of proxy areas; and

b) Detailed planned timber harvest schedule for the project area, developed on the basis of information available in the site-specific forest management plan or agreement which is current at the project start date.

Periodical adjustments to the baseline shall be established on the basis of monitoring performed on a reference area, or a set of reference areas that have undergone planned timber harvest. Project proponents shall, for the duration of the project, conduct inventory localization to update the inventory every 10 years, as defined in Section III.

Ex-ante baseline estimations are therefore used in both the *ex ante* and *ex post* estimation of net carbon stock changes and GHG emission reductions.

Any source of how the baseline scenario is identified and the description of the identified baseline scenario shall be provided in the VCS-PD.

The results of the estimations shall be presented in the VCS-PD.

Baseline net greenhouse gas removals by sinks[24]

Baseline net GHG Removals by sink will be determined as:

[24] Equations taken from by VCS Approved Methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

$$\Delta C_{BSL} = \Delta C_{BSL,P} - GHG_{BSL,E} \quad \textbf{1.}$$

where:

ΔC_{BSL} Baseline net greenhouse gas removals by sinks; tCO_2-e

$\Delta C_{BSL,P}$ Carbon stock changes in all pools in baseline; tCO_2-e

$GHG_{BSL,E}$ Greenhouse gas emissions as a result of forest management activities within the project boundary in the baseline;

$$\Delta C_{BSL,P} = \Delta C_{BSL,tree} + \left(\Delta C_{BSL,DW}\right) + \left(\Delta C_{BSL,WP}\right) \quad \textbf{2.}$$

where:

$\Delta C_{BSL,P}$ Carbon stock changes in all pools in the baseline; tCO_2-e

$\Delta C_{BSL,tree}$ Carbon stock changes in trees in the baseline; tCO_2-e

$\Delta C_{BSL,DW}$ Carbon stock changes in dead wood in the baseline; tCO_2-e

$\Delta C_{BSL,WP}$ Carbon stock changes in wood products in the baseline; tCO_2-e

$$\Delta C_{BSL,tree} = \frac{\left(\sum_{i=1}^{M_s} \Delta C_{BSL,AG|BG,i,100} * \frac{44}{12}\right)}{100} * t^* \quad \textbf{3.}$$

where:

$\Delta C_{BSL,tree}$ Carbon stock changes in above-ground and below-ground biomass of trees in the baseline; tCO_2-e

$\Delta C_{BSL,AG|BG,i,100}$ Summed annual net carbon stock change in above-ground and below-ground biomass for stratum i,(summed over the 100 year modeled baseline); t C

i 1,2,3…M_B strata in the baseline scenario

t 1,2,3…t* years elapsed since the start of IFM VCS project activity

$\frac{44}{22}$ Ratio of molecular weight of CO_2 to carbon; t CO_2-e tC^{-1}

Dead Wood

Carbon stock changes in dead wood calculated by:

$$\Delta C_{BSL,DW} = \frac{\left(\sum_{i=1}^{M_s} \Delta C_{BSL,DW,i,100} * \frac{44}{12}\right)}{100} * t^* \quad \textbf{4.}$$

where:

$\Delta C_{BSL,DW}$	Carbon stock changes in dead wood in the baseline; tCO_2-e
$\Delta C_{BSL,DW,i,100}$	Summed annual net carbon stock change in dead wood for stratum i, (summed over the 100 year modeled baseline); t C
i	1,2,3…M_B strata in the baseline scenario
t	1,2,3…t* years elapsed since the start of IFM VCS project activity
$\frac{44}{22}$	Ratio of molecular weight of CO_2 to carbon; t CO_2-e tC^{-1}

Wood Products

Carbon stock changes in wood products calculated by:

$$\Delta C_{BSL,WP} = \frac{\left(\sum_{i=1}^{M_S} \Delta C_{BSL,WP,i,t} * \frac{44}{12}\right)}{100} * t^* \qquad \textbf{5.}$$

where:

$\Delta C_{BSL,WP}$	Carbon stock changes in dead wood in the baseline; tCO_2-e
$\Delta C_{BSL,WP,i,t}$	Summed annual net carbon stock change in wood products for stratum i, (summed over the 100 year modeled baseline); t C
i	1,2,3…M_B strata in the baseline scenario
t	1,2,3…t* years elapsed since the start of IFM VCS project activity
$\frac{44}{22}$	Ratio of molecular weight of CO_2 to carbon; t CO_2-e tC^{-1}

Carbon stock changes in the baseline[25]

Carbon stock changes in above-ground, below-ground and dead wood must be estimated using models of forest management across the baseline period. Modeling can be conducted with relative ease and confidence using a peer-reviewed forestry model. The VCS-PD must detail what model is being used and what variants have been selected. All model inputs and outputs must be available for inspection by the validator. The baseline must be modeled over 100 years.

Models must be:

- IPCC compliant
- Peer reviewed in a process involving experts in modeling and biology/forestry/ecology
- Used only in scenarios relevant to the scope for which the model was developed and evaluated
- Parameterized for the specific conditions of the project

[25] Section guided by Approved VCS Methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

It is inevitable that the input to models will be inventory data. However, the exact form of the input data is not prescribed here as this will vary by model but may include: cruised volumes, stand tables or plot data. The equations given in Section 6 must be used and detailed in full in the VCS-PD.

The output of the models must be the annual changes in stocks of carbon in live above-ground tree biomass ($\Delta C_{BSL,AG|BG,i,t}$) and dead wood ($\Delta C_{BSL,DW,i,t}$) by strata in the baseline scenario through the duration of the project.

GHG emissions within the project boundary in the baseline

GHG emissions in the baseline within the project boundary can be estimated as:

$$GHG_{BSL,E} = \sum_{t=1}^{t^*} \left(E_{BSL,BiomassBurn,t} \right) \qquad \textbf{6.}$$

where:

$GHG_{BSL,E}$	Greenhouse gass emissions as a result of forest management activities within the project boundary in the baseline; tCO_2-e
$E_{BSL,BiomassBurn,t}$	Non-CO_2 emissions due to biomass burning as part of forest management during the year t in the baseline; tCO_2-e
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

Non-CO_2 emissions due to biomass burning as part of forest management

If non-CO_2-emissions are included in the baseline, the following calculations must be completed. The non-CO_2 emissions due to biomass burning as part of forest management shall be estimated by:

$$E_{BiomassBurn,t} = E_{BiomassBurn,CH_4,t} \qquad \textbf{7.}$$

where:

$E_{BiomassBurn,t}$	Non-CO_2 greenhouse gas emission at time t as a result of biomass burning due to forest management; t CO_2-e
$E_{BiomassBurn,CH_4,t}$	CH_4 emissions at time t as a result of forest management; t CO_2-e

Estimation of CH_4 emissions is based on the carbon stock loss from biomass burning during forest management (logging slash burned). This is multiplied by factors that adjust for the mass of CH_4 versus carbon released, and for the global warming potential of CH_4.

$$E_{BiomassBurn,CH_4,t} = BS_{BSL,t} * ER_{CH_4} * \frac{16}{12} * GWP_{CH_4} \qquad \textbf{8.}$$

where:

$E_{BiomassBurn,CH_4,t}$	CH_4 emissions at time t as a result of forest management; tCO_2-e
$BS_{BSL,t}$	Carbon stock in logging slash subject to burning as part of forest management; t C
ER_{CH_4}	Emission ratio for CH_4 (if local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value, 0.012[11]); kg C as ("kg C as CH_4 (kg C burned)$^{-1}$
GWP_{CH_4}	Global warming potential for CH_4; tCO_2-e (t CH_4)-1
$16/12$	Ratio of molecular weights of CH_4 and C; mol mol-1
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

Carbon stock in logging slash

If logging slash is not burned:

$BS_{BSL,t} = 0$

Otherwise:

$$BS_{BSL,t} = \sum_{j=1}^{S_{BSL}} \sum_{l=1}^{N_{j,t}} \left(\left(\left(f_j(DBH, H) \right) - \left(V_{l,j,t} * D_j \right) \right) * CF_j \right) \quad \textbf{9.}$$

where:

$BS_{BSL,t}$	Carbon stock in logging slash to burning as part of forest management; t C
$V_{l,j,t}$	Harvested merchantable volume of tree l of species j at time t; m^3
D_j	Basic wood density of species j; D_j t d.m.m^{-3}
$f_j(DBH, H)$	Allometric equation for species j linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of living trees; t d.m.$tree^{-1}$
CF_j	Carbon fraction of biomass for tree species j; t C t^{-1} d.m. (IPCC default value = 0.5 t C t^{-1} d.m.)
l	Sequence number of trees harvested
j	1,2,3 … S_{BSL} tree species in the baseline scenario
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

<u>Actual net GHG removals by sinks</u>

Actual GHG removals shall be estimated using the equations in this section. When applying these equations for the *ex* ante calculation of net anthropogenic GHG removals by sinks, project participants shall provide estimates of the values of those parameters that are not available before the start of monitoring activities. Project participants must retain a conservative approach in making these estimates.

Estimation in the of changes carbon stock

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \qquad \textbf{10.}$$

where:

ΔC_{ACTUAL}	Actual net greenhouse gas removals by sinks; tCO_2-e
ΔC_P	Sum of the changes in above-ground biomass,dead wood and wood products in the project scenario; tCO_2-e
GHG_E	Increase in GHG emissions as a result of the implementationof the proposed IFM VCS project activity within the project boundary; tCO_2-e

The verifiable changes in the carbon stock in tree above-ground biomass, dead wood and wood products are estimated using the following approach:

$$\Delta C_P = \sum_{t=1}^{i^*} \Delta C_t * \frac{44}{12} \qquad \textbf{11.}$$

where:

ΔC_P	Sum of the changes in above-ground biomass,dead wood and wood products in the project scenario; tCO_2-e
ΔC_t	Annual change in carbon stock in all selected carbon pools for year t; t C yr^{-1}
t	1,2,3…t* years elapsed since the start of IFM VCS project activity
$\frac{44}{22}$	Ratio of molecular weight of CO_2 to carbon; t CO_2-e tC^{-1}

$$\Delta C_t = \sum_{i=1}^{M_{PS}} \left(\Delta C_{AG,i,t} + \Delta C_{BG,i,t} + \Delta C_{DW,i,t} + \Delta C_{WP,i,t}\right) \qquad \textbf{12.}$$

where:

ΔC_t	Annual change in carbon stock in all selected carbon pools for year t; t C yr^{-1}
$\Delta C_{AG,i,t}$	Annual change in carbon stock in above-ground biomass of trees for stratum i, (possibly average over a monitoring period); t C yr^{-1}
$\Delta C_{BG,i,t}$	Annual change in carbon stock in below-ground biomass of trees for stratum i, (possibly average over a monitoring period); t C yr^{-1}
$\Delta C_{DW,i,t}$	Annual change in the dead wood carbon pool for stratum i, (possibly average over a monitoring period; t C yr^{-1}

$\Delta C_{WP,i,t}$	Annual change in the wood product carbon pool for stratum i, (possibly average over a monitoring period; t C yr^{-1}
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

Changes is carbon pools that are conservatively excluded from accounting shall be set equal to zero.

Carbon stock in tree biomass[26]

The mean carbon stock of above-ground biomass per unit area is estimated based on field measurement plots. A sampling plan must be developed that describes the inventory process, including sample design, size, layout and locations. Field plots may be temporary or permanent. Plots may also have defined boundaries or variable radius. Total above-ground biomass is calculated from merchantable volume data and appropriate biomass expansions factors (BEF).

Carbon stock in above-ground biomass

The following steps are used to calculate above-ground biomass:

Step 1: Determine based on available data (volume tables and measurements) the diameter (DBH, typically 1.3m above ground level) and height (H) of all trees above minimum DBH in sample plots.

Step 2: Estimate the volume of the commercial (merchantable) component of trees based on available equations or yield tables (if locally derived equations or yield tables are not available use relevant regional, national or default data as appropriate). It is possible to combine steps 1 and 2 if there are field instruments (e.g. a relascope) that measure the volume of each tree more directly)

Step 3: Convert the volume of the commercial component of the trees into the mean plot level carbon stock biomass of the commercial component of trees via wood density and carbon fraction (IPCC default value = 0.5 t C t^{-1} d.m.):

Step 4: Calculate the carbon stock in the commercial component of the trees for each stratum.

Step 5: Convert commercial component to total above-ground carbon stock ($C_{AB,I,t}$) using appropriate biomass expansion factor (BEF), adjusted for forest type and stand structure if available.

[26] Section guided by Approved VCS Methodology VM0003 Version 1.0, approved May 17, 2010, titled “Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

Carbon stock in below-ground biomass

Below-ground carbon stock per stratum ($C_{BB,I,t}$) is calculated from above-ground biomass data by multiplying by a root-shoot ratio appropriate to the forest type and stand structure.

Mean carbon stock in tree biomass for each stratum

$$C_{tree,i,t} = A_i * \left(C_{AB,i,t} + C_{BB,i,t}\right) \quad \textbf{13.}$$

where:

$C_{tree,i,t}$	Carbon stock in trees in stratum i at time t; t C
$C_{AB,i,t}$	Carbon stock in above-ground biomass of trees in stratum I at time t; t C ha^{-1}
$C_{BB,i,t}$	Carbon stock in below-ground biomass of trees in stratum I at time t; t C ha^{-1}
A_i	Area of stratum i; m^2
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

Mean carbon stock change

$$\Delta C_{AG,i,t} + \Delta \mathrm{C}_{\mathrm{BG,i,t}} = \frac{\mathrm{C}_{\mathrm{tree,i,t2}} - \mathrm{C}_{\mathrm{tree,i,t1}}}{\mathrm{T}} \quad \textbf{14.}$$

where:

$\Delta C_{AG,i,t}$	Annual carbon stock change in above-ground biomass of trees for stratum I, i; t C yr^{-1}
$\Delta \mathrm{C}_{\mathrm{BG,i,t}}$	Annual carbon stock change in below-ground biomass of trees for stratum i; t C yr^{-1}
$\mathrm{C}_{\mathrm{tree,i,t}}$	Carbon stock in trees in stratum i at time t; t C
T	Number of years between monitoring time t1 and t2 (T=t2-t1); yr
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

<u>Dead wood</u>

Dead wood included in the methodology comprises two components only – *standing dead wood* and *lying dead wood*. Below-ground dead wood is conservatively neglected.

$$\Delta C_{DW,i,t} = \frac{\mathrm{C}_{\mathrm{DW,i,t2}} - \mathrm{C}_{\mathrm{DW,i,t1}}}{\mathrm{T}} \quad \textbf{15.}$$

where:

$\Delta C_{DW,i,t}$	Annual carbon stock change in dead wood for stratum i; t C yr^{-1}
$C_{DW,i,t1}$	Carbon stock of dead wood in stratum i at time t=1; t C
$C_{DW,i,t2}$	Carbon stock of dead wood in stratum i at time t=2; t C
T	Number of years between monitoring time t1 and t2 (T=t2-t1); yr
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

$$C_{DW,i,t} = \left(B_{SDW,i,t} + B_{LDW,i,t}\right) * CF_{DW} \quad \textbf{16.}$$

where:

$C_{DW,i,t}$	Carbon stock of dead wood in stratum I at time t; t C
$B_{SDW,i,t}$	Biomass of standing dead wood in stratum i at time t; t d.m.
$B_{LDW,i,t}$	Biomass of lying dead wood in stratum i at time t; t d.m.
CF_{DW}	Carbon fraction of dry matter in dead wood; tC t^{-1} d.m.
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

Standing dead wood[27]

Step 1: Standing dead trees shall be measured using the same criteria and monitoring frequency used for measuring live trees. The decomposed portion that corresponds to the original above-ground biomass is discounted. Stumps must be inventoried as if they are very short standing dead trees.

Step 2: The decomposition class of the dead tree and the diameter at breast height shall be recorded and the standing dead wood is categorized under the following four decomposition classes:

1. Tree with branches and twigs that resembles a live tree (except for leaves);
2. Tree with no twigs but with persistent small and large branches;
3. Tree with large branches only;
4. Bole only, no branches.

Step 3: Biomass must be estimated using an allometric equation for live trees in the decomposition class 1. When the bole is in decomposition classes 2, 3 or 4, it is recommended to limit the estimate of the biomass to the main trunk of the tree. If the top of the standing dead tree is missing, then the top diameter:

1. May be assumed to be zero;

[27] Section taken from Approved VCS Methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

2. May be measured if reachable or the broken top is identifiable on the ground or by using an instrument such as a relascope or laser inventory instrument;
3. May be calculated proportionally to height assuming that the height of the intact dead tree would be equal to average height of all intact dead trees present in the same sample plot.

Step 4: The volume of dead wood is converted to biomass (B_{SDW}) using the appropriate dead wood density class.

Lying dead wood[26]

The lying dead wood pool is highly variable, and stocks may or may not increase as the stands age depending if the forest was previously unmanaged (mature or unlogged) where it would likely increase or logging with logging slash left behind where it may decrease through time.

Step 1: Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996)[28]. Two 50-meter lines (164 ft) are established bisecting each plot and the diameters of the lying dead wood (≥ 10 cm diameter [≥ 3.9 inches]) intersecting the lines are measured.

Step 2: Dead wood is assigned to one of the three density states (sound, intermediate, rotten) using the 'machete test', as recommended by *IPCC Good Practice Guidance for LULUCF* (2003), Section 4.3.3.5.3.

Step 3: Volume of lying dead wood per unit area is calculated using the equation (Warren and Olsen 1964)[29] as modified by Van Wagner (1968)[30] separately for each density state:

$$V_{LDW,i,t} = \frac{\pi^2 \left(\sum_{n=1}^{N} D_{n,i,t}{}^2 \right)}{8 * L} \qquad \textbf{17.}$$

where:

$V_{LDW,i,t}$	Volume of lying dead wood per unit area in stratum I at time t; $m^3\ ha^{-1}$
$D_{n,i,t}$	Diameter of piece n of dead wood along the transect in stratum i at time t; (if necessary convert inches to cm by multiplying by 2.54)
N	Total number of wood pieces intersecting the transect; dimensionless
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

Step 4: Volume of lying dead wood shall be converted into biomass using the following relationship:

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[28] Harmon, M.E. and J. Sexton (1996) Guidelines for measurement of wood detritus in forest ecosystems. US LTER Publication No. 20. US LTER Network Office, University of Washington, Seattle, WA, USA

[29] Warren, W.G. and Olsen, P.F. (1964) A line intersect technique for assessing logging waste. *Forest Science* 10: 267-276

[30] Van Wagner, C.E. (1968). The line interest method if forest fuel sampling. *Forest Science* 14: 20-26

$$B_{LDW,i,t} = A_i * \sum_{dc=1}^{3} V_{LDW,i,t} * D_{DW,dc} \qquad \textbf{18.}$$

where:

$B_{LDW,i,t}$	Biomass of lying dead wood per unit area in stratum i at time t; d.m. ha^{-1}
$V_{LDW,i,t}$	Volume of lying dead wood per unit area in stratum i at time t; m^3 ha^{-1}
$D_{DW,dc}$	Basic wood density of dead wood in the density class - sound (1), intermediate (2), and rotten (3); t d.m. m^{-3}
A_i	Area of stratum i; m^2
i	1,2,3…M_{PS} strata in the baseline scenario
t	1,2,3…t years elapsed since the start of IFM VCS project activity

<u>Soil Carbon</u>

The soil carbon pool is an optional pool under the VCS guidance and shall be included if the carbon stock is significantly reduced by the project. It may be included if the soil carbon stock is significantly increased by the project. According to CAR's Forest Project Protocol, changes in total soil carbon are dependent on the rate of biomass input relative to soil decomposition. It is difficult to determine changes in soil carbon stock over a short period of time as the soil carbon stock changes slowly.

The soil carbon stock pool changes slowly over a short period of time and can be difficult to measure and monitor the incremental change in the soil carbon stock pool. The project proponent is required to include soil carbon sampling as part of an overall sampling methodology and is required to utilize relevant methodologies or standards for sampling soil carbon pool.

Results must be provided in metric tons of carbon.

<u>Harvested Wood Products</u>

$$\Delta C_{WP,t} = \frac{C_{WP,t2} - C_{WP,t1}}{T} \qquad \textbf{19.}$$

where:

$\Delta C_{WP,t}$	Annual carbon stock change in wood products, (averaged over a monitoring period); t C yr-1
$C_{WP,t2}$	Carbon stock of wood products at time t = 2; t C
$C_{WP,t1}$	Carbon stock of wood products at time t = 1; t C
T	Number of years between monitoring time t1 and t2 (T=t2-t1); yr
t	1,2,3…t years elapsed since the start of IFM VCS project activity

1605(b) method from Climate Action Reserve's Forest Protocol 3.2[31]

This methodology utilizes the 1605(b) methodology provided in the Climate Action Reserve's Forest Project Protocol 3.2[32]. To approximate the climate benefits of carbon storage, this methodology accounts for the average amount of carbon stored over 100 years. While the current CAR Forest Project Protocol states that it is only applicable in the United Stated, this methodology utilizes CAR's US based values as these are supported by North American literature[33]. Many forest types are similar in areas of the United States as they are in Canada (for example, the forest types for the Pacific Northwest West apply to an extensive range from Washington state to Alaska and include coastal BC. Additionally, products and technologies applied in US forest operations are similar to those found in Canada with many products and technologies crossing the border.

Where available, the project proponent must utilize Canadian values, however, in the absence of data, may utilize CAR's HWP method based on the US 1605(b) rules.

There are 5 steps required to calculate carbon stored in wood products ($C_{WP,t}$):

1. Determining the amount of carbon in harvested wood that is delivered to mills
2. Accounting for mill efficiencies
3. Estimating average carbon storage over 100 years in in-use wood products[34]
4. Estimating average carbon storage over 100 years in wood products in landfills (when applicable)
5. Summing the results to determine total average carbon storage over 100 years

Estimate the Average C Storage Over 100 Years in In-Use Wood Products

The amount of carbon that will remain stored in in-use wood products for at least 100 years ($WP_{in\text{-}use,t}$) depends on the rate at which wood products either decay or are sent to landfills. Decay rates depend on the type of wood product that is produced. Thus, in order to account for the decomposition of harvested wood over time, a decay rate is applied to wood products according to their product class. To approximate the climate benefits of carbon storage, this methodology accounts for the average amount of carbon stored over 100 years. Thus, decay rates for each wood product class have been converted into "average storage factors".

Estimate the Average C Storage Over 100 Years for Wood Products in Landfills

Wood product carbon in landfills ($WP_{landfill,t}$) is only calculated for years in which the project's actual harvesting volumes are below estimated baseline harvesting levels. Otherwise, landfall product carbon storage ($WP_{landfill,t}$) = 0.

Average carbon storage factors differ between in-use and landfill products.

[31]Section guided by CAR Forest Protocol V. 3.2 -http://www.climateactionres.erve.org/wp-content/uploads/2009/03/Forest_Project_Protocol_Version_3.2.pdf
[32] http://www.climateactionres.erve.org/wp-content/uploads/2009/03/Forest_Project_Protocol_Version_3.2.pdf
[33] Please refer to CAR Forest Project Protocol for supporting NA literature on HWP.

Determine Total Average Carbon Storage in Wood Products Over 100 Years[35]

The total average carbon storage in wood products over 100 years for a given harvest volume must be calculated and reported as follows:

$$C_{WP,t} = WP_{in-use,t} + WP_{landfill,t} \quad \textbf{20.}$$

where:

$C_{WP,t}$	Average carbon stored over 100 years from wood harvested in year t (actual or baseline)
$WP_{in-use,t}$	Average carbon stored in in-use wood products over 100 years from wood harvested in year t (actual or baseline)
$WP_{landfill,t}$	Average carbon stored in landfills wood products over 100 years from wood harvested in year t (actual or baseline)

Winjum et al 1998 Annual Oxidation HWP Method

If the project area is located outside of North America,, the project proponent is required to apply Winjum et al, 1998; an internationally accepted method of HWP calculation[36]

GHG emissions with the project boundary

$$GHG_{PS,E} = \sum_{t=1}^{t^*} \left(E_{PS.BiomassBurn,t}\right) \quad \textbf{21.}$$

where:

$GHG_{PS,E}$	Greenhouse gas emissions as a result of forest management activities within the project boundary in the project scenario; t CO_2-e
$E_{PS.BiomassBurn,t}$	Non-CO_2 emissions due to biomass burning as part of forest management during the year t in the project scenario; t CO_2-e
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

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[35] Equation adapted from CAR Forest Protocol v3.2 - http://www.climateactionres.erve.org/wp-content/uploads/2009/03/Forest_Project_Protocol_Version_3.2.pdf

[36] Winjum J.K., Brown, S. and Schlamadinger, B. 1998. Forest harvests and wood products: sources and sinks of atmospheric carbon dioxide. *Forest Science* 44: 272-284

Non-CO_2 emissions due to biomass burning

$$E_{BiomassBurn,t} = E_{BiomassBurn,CH_4,t} \quad \textbf{22.}$$

where:

$E_{BiomassBurn,t}$	Non-CO_2 greenhouse gas emission at time t as a result of biomass burning due to forest management; t CO_2-e
$E_{BiomassBurn,CH_4,t}$	CH_4 emissions at time " t" as a result of forest management; t CO_2-e

$$E_{BiomassBurn,CH_4,t} = BS_{BSL,t} * ER_{CH_4} * \frac{16}{12} * GWP_{CH_4} \quad \textbf{23.}$$

where:

$E_{BiomassBurn,CH_4,t}$	CH_4 emissions at time " t" as a result of forest management; t CO_2-e
$BS_{BSL,t}$	Carbon stock in logging slash subject to burning as part of forest management; t CO_2-e
ER_{CH_4}	Emissions ratio CH_4 (if local data on combustion efficiency is not available or if combustion efficiency cannot be estimated from fuel information, use IPCC default value, 0.012[11]; kg C as CH_4 (kg C burned)$^{-1}$
GWP_{CH_4}	Global warming potential for CH_4; t CO_2-e (t CH_4)-1
$16/12$	Ratio of molecular weights of CH_4 and C; mol mol^{-1}
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

$BS_{BSL,t} = 0$ if no logging slash burned

$$BS_{BSL,t} = \sum_{j=1}^{S_{BSL}} \sum_{l=1}^{N_{j,t}} \left(\left(\left(f_j(DBH,H) \right) - \left(V_{l,j,t} * D_j \right) \right) * CF_j \right) \quad \textbf{24.}$$

where:

$BS_{BSL,t}$	Carbon stock in logging slash to burning as part of forest management; t C
$V_{l,j,t}$	Harvested merchantable volume of tree l of species j at time t; m^3
D_j	Basic wood density of species j; D_j t d.m.m^{-3}
$f_j(DBH,H)$	Allometric equation for species j linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of living trees; t d.m. tree^{-1}
CF_j	Carbon fraction of biomass for tree species j; t C t^{-1} d.m. (IPCC default value = 0.5 t C t^{-1} d.m.)

l	Sequence number of trees harvested
j	1,2,3 … S_{BSL} tree species in the baseline scenario
t	1,2,3…t* years elapsed since the start of IFM VCS project activity

8 Leakage[37]

Leakage is defined as any increase in greenhouse gas emissions that occur outside a project's boundary (but within the same country) that is measurable and attributable to the project activity. Its effects on all carbon pools shall be assessed and significant effects taken into account when calculating net emission reductions.

The only type of leakage emissions calculated is GHG emissions due to market effects resulting from a shift in harvest through time[38]. The Project proponent must demonstrate that zero activity shifting occurs as a result of the project.

Leakage

Leakage shall be estimated as follows:

$$LK = LK_{MarketEffects} \quad \textbf{25.}$$

where:

LK	Total GHG emissions due to leakage; t CO_2-e
$LK_{MarketEffects}$	Total GHG emissions due to impacts of project on timber supply and demand; t CO_2-e

Note: In this methodology the equation above is used to estimate leakage for the period of time elapsed between project start (*t*=1) and the year *t*=*t**, *t** being the year for which actual net greenhouse gas removals by sinks are estimated.

Leakage due to activity shifting

The Project proponent must demonstrate that zero activity shifting has occurred by either:

a) Third party certification to forest management standards (CSA, SFI, FSC or equivalent[39]

[37]Section and equations guided by VCS Approved Methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

[38]GHG emissions through fossil fuel use outside the boundaries of the project are not considered based on guidance from the CDM Executive Board: http://cdm.unfccc.int/EB/044/eb44rep.pdf

[39] An equivalent to the above mentioned standards must be approved by the Program for the Endorsement of Forest Certification (PEFC). http://www.pefccanada.org/default.htm

b) Compliance audit to demonstrate compliance with provincial forest law and timber harvest requirements

If the project is able to demonstrate that any decrease in wood products produced by the project relative to the baseline is less than 5% and any temporal displacement in the total production of wood products is less than 5 years then:

$$LK_{ActivityShifting} = 0 \qquad \textbf{26.}$$

Leakage due to market effects

Leakage due to market effects is equal to the baseline emissions from logging multiplied by a leakage factor:

$$LK_{MarketEffects} = LF_{ME} * (\Delta C_{ACTUAL} - \Delta C_{BSL}) \qquad \textbf{27.}$$

where:

$LK_{MarketEffects}$	Total GHG emissions due to market- effects leakage through decreased timber harvest; t CO_2-e
LF_{ME}	Leakage factor for market-effects calculations; dimensionless
ΔC_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e
ΔC_{BSL}	Baseline net greenhouse gas removals by sinks; t CO_2-e

The leakage factor is determined by where timber harvesting is likely to be shifted, as shown in Table 3.

Table 3: VCS default leakage adjustments to account for potential leakage from reduced timber production[40]

Project Action	Leakage Risk	Leakage Credit Adjustment (discount)
Substantially reduce the harvest levels permanently (e.g., forest protection/no logging project)	Moderate to High	Depends on where timber harvest likely to be shifted: • Similar carbon dense forests within country: 40% • Less carbon dense forests within country: 20% • More carbon dense forests within country: 70% • Out of country: 0% (according to states VCS and CDM policy of not accounting international leakage)

[40] Table adapted from VCS Tool for AFOLU Methodological Issues http://v-c-s.org/docs/Tool%20for%20AFOLU%20Methodological%20Issues.pdf

Therefore, LF_{ME} can be determined as:

$LF_{ME} = 0.40$	if harvest likely shifted to similar carbon dense forests within country
$LF_{ME} = 0.20$	if harvest likely shifted to less dense forests within country
$LF_{ME} = 0.70$	if harvest likely shifted to more dense forests within country

Instead of applying the default market leakage discounts (Table 3), project proponents may opt to estimate the project's market leakage effects across the entire country and/or use analysis (es) from other similar projects to justify a different market leakage value[40].

$LF_{ME} = 0$ — if harvest likely shifted out of country or if the project proponent can demonstrate that the project will have no impact on the timber supply and demand market within country

e.g. if no new concessions are being assigned AND annual extracted volumes cannot be increased within existing national concessions AND illegal logging is absent (or *de minimis*) in the host country

OR if the project is able to demonstrate that any decrease in wood products produced by the project relative to the baseline is less than 5% and any temporal displacement in the total production of wood products is less than 5 years.

9 Uncertainty[41]

Calculation of Uncertainty

In the case of AFLOU activities, there are uncertainties about carbon emissions and removals associated with measures/estimates of: area or other activity data, carbon stocks, biomass growth rates, expansion factors, and other coefficients. Determining and reducing uncertainties related to forest inventories, merchantable volume yield curves, data describing forest management and disturbance activities, and any values or parameters substituted in place of default values and parameters are the user's responsibility. In general, uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools shall always be quantified.

In accordance with the VCS 2011 standard, the relevant range of uncertainty at all times is defined as the 95% confidence interval as a percentage of the mean.

Estimation of Uncertainty for Pools and Emissions Sources

For each measurement pool calculate both the mean and the 95% confidence interval. In all cases the relevant range of uncertainty should be expressed as the 95% confidence interval as a percentage of the mean.

[41]Section taken from VCS Approved Methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

- For modeled results use the confidence mean of the input inventory data.
- For wood products use the confidence interval of the stocks of extracted timber. For biomass burning emissions use the confidence interval of the pre-burning stocks.

For both the baseline and the with-project case the total uncertainty is equal to the square root of the sum of the squares of each component uncertainty.

Total Uncertainty of VCS-IFM Project

The total project uncertainty is calculated at the time of reporting through propagating the error in the baseline stocks and the error in the project stocks:

$$C_{IFM\_VSC\_ERROR} = \sqrt{Uncertainty_{BSL}{}^2 - Uncertainty_P{}^2} \quad \textbf{28.}$$

where:

$C_{IFM\_VSC\_ERROR}$	Total uncertainty for IFM-VCS Project; %
$Uncertainty_{BSL}$	Total uncertainty in baseline scenario; %
$Uncertainty_P{}^2$	Total uncertainty in the with-project scenario; %

The uncertainty in the total measured carbon pools is defined as the square root of the summed squared errors in each of the measured carbon pools. The errors in each pool can be weighted by the size of the pool so that projects may reasonably target a lower precision level in pools that only form a small proportion of the total stock.

Uncertainty Deduction

In accordance with the VCS 2011 standard:

$C_{IFM\_VCS\_ERROR} \leq 15\%\ of\ C_{IFM\_VCS}$	No deduction should result for uncertainty. If the sampling error and uncertainty is progressively reduced in years 3-5, a lower uncertainty deduction can result.[42],[43]
$C_{IFM\_VCS\_ERROR} > 15\%\ of\ C_{IFM\_VCS}$	The modified value for $C_{IFM\text{-}VCS}$ to account for uncertainty should be:

$$C_{IFM\_VCS} = \frac{100 - C_{IFM\_VCS\_ERROR}}{100} * C_{IFM\_VCS} \quad \textbf{29.}$$

where:

C_{IFM_VCS}	Net anthropogenic greenhouse gas removals by sinks; t CO_2-e

[42] The CAR Forest Project Protocol v. 3.2 allows for a lower uncertainty deduction, if the project proponent increases the accuracy of the sampling plots which results in reduced sampling error

[43] This methodology will reward the additional cost and effort required to reduce the sampling error and uncertainty to the project, by allowing for lower uncertainty deductions to occur 3-5 years after project start

$C_{IFM\_VCS\_ERROR}$	Total uncertainty for IFM-VCS Project; %

10 Calculating Net Voluntary Carbon Units (VCUs)[44]

The voluntary credit unit (VCU) is the carbon offset that is registered and traded and represents emission reductions of 1 metric tonne of CO_2. VCUs are calculated by subtracting the baseline scenario from the project scenario carbon stocks on an annual basis.

Summary Gross Emissions Reductions (VCUs) for the Project

Net Anthropogenic GHG Removals by sinks

$$C_{IFM-VCS} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK \qquad \textbf{30.}$$

where:

$C_{IFM-VCS}$	Net anthropogenic greenhouse gas removals by sinks; t CO_2-e
ΔC_{ACTUAL}	Actual net greenhouse gas removals by sinks; t CO_2-e
ΔC_{BSL}	Baseline net greenhouse gas removals by sinks; t CO_2-e
LK	Total GHG emissions due to leakage; t CO_2-e

Calculation of VCUs

$$VCUs = \left(C_{IFM\_VCS,t2} - C_{IFM\_VCS,t1}\right) - BRR \qquad \textbf{31.}$$

where:

$VCUs$	Number of Voluntary Carbon Units
$C_{IFM\_VCS,t2}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for t* = t2; t CO_2-e
$C_{IFM\_VCS,t1}$	Net anthropogenic greenhouse gas removals by sinks, as estimated for t* = t1; t CO_2-e
BRR	Portion of carbon credits to be withheld as a buffer reserve

Permanence Risk Buffer Reserve

Buffer reserve should be calculated using *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*[45].

[44] Section guided by Approved VCS methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

11 Data and parameters not monitored (default or possibly measured one time)

In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of existing published data, project participants must retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

Data/Parameter:	$A_{BSL,i}$
Data Unit:	Ha
Used in equations:	Implicityly used in Section 4.1
Description:	Area of baseline stratum, i
Source of data:	GSP coordinates and/or Remote Sensing data and/or legal parcel records
Measurement procedures (if any):	N/A
Comments:	

Data/Parameter:	CF
Data Unit:	t C t^{-1} d.m.
Used in equations:	9, 10, 24
Description:	Carbon fraction of dry matter
Source of data:	
Measurement procedures (if any):	
Comments:	Default value 0.5 t C t^{-1} d.m. can be used, or species specific values from the literature

Data/Parameter:	*D*
Data Unit:	t d.m. m^{-3}
Used in equations:	9, 24
Description:	Basic wood density
Source of data:	The source of data shall be chosen with priority from higher to lower

[45]http://v-c-s.org/docs/Tool%20for%20AFOLU%20Non-Permanence%20Risk%20Analysis%20and%20Buffer%20Determination.pdf

	preference as follows: (a) National and species-specific or group of species-specific (e.g. from National GHG inventory); (b) Species-specific or group of species-specific from neighboring countries with similar conditions. Sometimes (b) may be preferable to (a); (c) Globally species-specific or group of species-specific (e.g. IPCC GPG- LULUCF).
Measurement procedures (if any):	
Comments:	

Data/Parameter:	D_{DW}
Data Unit:	t d.m. m^{-3}
Used in equations:	18
Description:	Basic wood density of dead wood in the density class – sound (1), intermediate (2), and rotten (3)
Source of data:	The source of data shall be chosen with priority from higher to lower preference as follows: (a) Research publications relevant to the project area; (b) National and species-specific or group of species-specific (e.g. from National GHG inventory); (c) Species-specific or group of species-specific from neighboring countries with similar conditions. Sometimes (b) may be preferable to (a); (d) Globally species-specific or group of species-specific (e.g. IPCC GPG- LULUCF).
Measurement procedures (if any):	Project-specific determination of density is most likely necessary
Comments:	

Data/Parameter:	f_j(DBH,H)
Data Unit:	t d.m. $tree^{-1}$
Used in equations:	9, 24

Description:	Allometric equation for species j linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of living trees
Source of data:	Whenever available, use allometric equations that are species-specific or group of species-specific, provided the equations have been derived using a wide range of diameters and heights, based on datasets that comprise at least 20 trees. Otherwise, default equations from IPCC literature, national inventory reports or published peer-reviewed studies may be used – such as those provided Tables 4.A.1 to 4.A.3 of the GPG-LULUCF (IPCC 2003)
Measurement procedures (if any):	
Comments:	It is necessary to verify the applicability of equations used. Allometric equations can be verified by both: 1. Verification of equation conditions: Justification should be provided for the applicability of the equation to the project locations. Such justification should include identification of climatic, edaphic, geographical and taxonomic similarities between the project location and the location in which the equation was derived. Any equation used should have an r^2 value of greater than 0.5 (50%) and a p value that is significant (<0.05 at the 95% confidence level). 2. Additional field verification For field verification either of the two methods below may be used: A. Destructive Sampling • Selecting at least 5 trees covering the range of DBH existing in the project area, and felling and weighting the above-ground biomass to determine the total (wet) weight of the stem and branch components; • Extracting and immediately weighing subsamples from each of the wet stem and branch components, followed by oven drying at 70˚ C to determine dry biomass; • Determining the total dry weight of each tree from the wet weights and the averaged ratios of wet and dry weights of the stem and branch components. B. Limited Measurements • Select at least 10 trees per species distributed across the age range (but excluding trees less than 15 years old for which there is rarely a great relative inaccuracy in equations)

	• Calculate volume of tree from basal and top diameters and tree height. Multiply by species-specific density to gain biomass of bole. Add an additional percentage to approximately cover biomass of branches: 15% for spruce/fir, 5% for pines and 20% for broadleaf forests If the biomass of the harvested trees is within ±10% of the mean values predicted by the selected default allometric equation, and is not biased – or if biased is wrong on the conservative side (i.e., use of the equation results in under- rather than over-estimate of project net anthropogenic removals by sinks) – then mean values from the equation may be used.

III. MONITORING METHODOLOGY

1 Project Implementation[46]

All data collected as part of monitoring must be archived electronically and be kept at least for 5 years after the end of the project. All measurements must be conducted according to statistical standards or conventions relevant for the project. In addition, the monitoring provisions in the tools referred to in this methodology apply.

Quality Control/Quality Assurance (QC/QA) procedure is to be developed by the project proponent and provided in the VCS-PD. Individuals must be trained or provided training to complete the data collection and ensure accuracy. Certification requirements or training procedures will be developed and provided in the VCS-PD.

In order to determine if an unanticipated disturbance has taken place in the project area, satellite imagery should be utilized by the project proponent. If an unexpected disturbance event has taken place the project proponent will dispatch a monitoring team to the location of detected disturbance.

The monitoring team will establish sample plots in the disturbance area according to relevant standards for the project area.

A description of the monitoring plan including the items listed above shall be provided in the VCS-PD. A review of actual harvest levels and timber supply is required every 5 years or at verification to ensure accurate GHG accounting.

The plan is for monitoring changes in forest carbon stocks and emissions in the baseline case and from project activities and should address the following monitoring tasks that result in:

- Periodical revision of the baseline
- Monitoring of actual carbon stock changes and greenhouse gas emissions
- Monitoring of leakage carbon stock changes and greenhouse gas emissions
- Estimation of *ex-post* net carbon stock changes and greenhouse gas emissions

For each of these tasks, the monitoring plan shall include the following sections:

a) Technical description of the monitoring task
b) A list of data and parameters to be collected
c) Overview of data collection procedures
d) Quality control and quality assurance procedure
e) Data archiving

[46] Section guided by Approved VCS methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

f) Organization and responsibilities of the parties involved in all of the above

All data collected as part of the monitoring will be archived electronically and be kept at least for 5 years after the end of the last crediting period. All measurements will be conducted according to relevant standards.

Inventory localization will augment existing inventory information and will focus to improve the precision of the inventory for a specific geographic area, which may be contiguous or non-contiguous. Inventory localization will provide operational level information when such information is required and improve species composition, height and age distributes for target polygons.

Project Proponents that conduct a continuous forest inventory may use that inventory data for true-up prior to each field verification cycle.

Additional carbon stocks are estimated and reported on the basis of the measured or modeled inventory amounts that exceed the baseline plus any credits previously sold. If measured or modeled carbon stocks are less than the baseline, plus any credits previously sold, the project is subject to reversal conditions.

Data archiving will take both electronic and paper forms, and copies of all data shall be provided to each project participant.

All electronic data and reports shall also be copied on durable media such as CDs and copies of the CDs are stored at multiple locations.

The archives will include:

- Copies of all original field measurement data, laboratory data, data analysis spreadsheets;
- Estimates of the carbon stock changes in all pools and non-CO_2 GHG and corresponding calculation spreadsheets;
- GIS products;
- Copies of the measuring and monitoring reports.

Information will be provided, and recorded in the VCS-PD, to establish that:

- The geographic position of the project boundary is recorded for all areas of land;
- The geographic coordinates of the project boundary (and any stratification inside the boundary) are established, recorded and archived. This will be archived by field survey (eg. using GPS) or by using geo-referenced spatial data (eg. maps, GIS datasets, aerial photography or geo-referenced remote sensing images);
- Commonly accepted principles of forest inventory and management are implemented;
- Standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for forest inventory including field data collection and data management shall be applied. Use or adaptation of SOPs already applied in national forest monitoring or available from published handbooks or from the IPCC GHG LULUCF 2003 is recommended;
- The project plan, together with a record of the plan as actually implemented during the project, will be available for validation or verification as appropriate.

2 Sampling Design and Stratification[47]

Stratification of the project area into relatively homogeneous units can either increase the measuring precision without increasing the cost unduly, or reduce the cost without reducing measuring precision because of the lower variance within each homogeneous unit.

As the number and boundaries of the strata defined ex-ante may change during the crediting period (ex-post), the ex-post stratification shall be updated because of

a) Unexpected disturbances occurring during the crediting period (eg, due to fire, pests or disease outbreaks) affecting differently various parts of an originally homogenous stratum

   And/or

b) Forest management activities (planting, thinning, harvesting) that are implemented in a way that affects the existing stratification in the baseline case.

Established strata may also be merged if the reasons for their establishment have disappeared. The sampling framework including sample size, plot size, plot shape and determination of plot location will be specified in the VCS-PD.

Sampling must be compatible with the relevant standard for the project area and meet the requirements for targets on precision (Confidence Interval = 90%) and accuracy (sampling error ≤10%).

Carbon stock changes and GHG emissions over time shall be estimated by taking measurements in plots at each monitoring event. Monitoring events shall take place at intervals of maximum 5 years with updated timber supply reviews completed. For intermittent years it is good practice to use extrapolations of trends as they have occurred up until that moment. Monitoring reports can use such extrapolated parameter values for the determination of net emissions by sources and removals resulting from the project.

Project proponents will also apply all relevant equations for the ex-ante calculation of net anthropogenic GHG removals by sinks with care and provide transparent estimations for the parameters that are monitoring during the crediting period. These estimates shall be based on measured or existing published data where possible and project proponents should retain a conservative approach: that is, if different values for a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

3 Data and parameters used in monitoring[47]

The following parameters must be monitored during the project activity. When applying all relevant equations provided in this methodology for the *ex-ante* calculation of net anthropogenic GHG removals by sinks, project participants shall provide transparent estimations for the parameters that are monitored during the crediting period. These estimates shall be based on measured or existing published data where possible and project participants must retain a conservative approach: that is, if different values for

[47] Section guided by Approved VCS methodology VM0003 Version 1.0, approved May 17, 2010, titled "Methodology for Improved Forest Management through Extension of Rotation Age - http://www.v-c-s.org/docs/VM0003%20Methodology%20for%20Improved%20Forest%20Management%20through%20Extension%20of%20Rotation%20Age%20C2010.pdf

a parameter are equally plausible, a value that does not lead to over-estimation of net anthropogenic GHG removals by sinks must be selected.

Future developments may allow remote sensing of carbon stocks and changes in carbon stocks, however, a new version of this methodology will be necessary to accommodate the currently unknown components of such future technology.

Data/Parameter:	A_i
Data Unit:	ha
Used in equations:	13,
Description:	Area of stratum *i*
Source of data:	Monitoring of strata and stand boundaries shall be done preferably using a Geographic Information System (GIS), which allows for integrating data from different sources (including GPS coordinates and Remote Sensing data).
Measurement procedures (if any):	
Comments:	It shall be assumed ex-ante that stand boundaries and strata areas shall not change through time

Data/Parameter:	$D_{n,I,t}$
Data Unit:	cm
Used in equations:	17
Description:	Diameter of piece *n* of dead wood along the transect in stratum *I*, at time *t*
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	Lying dead wood must be sampled using the line intersect method (Harmon and Sexton 1996). Two 50-meter lines are established bisecting each plot and the diameters of the lying dead wood (≥ 10 cm diameter) intersecting the lines are measured. Minimum measurement diameter for all sites must not be less than 10 cm
Comments:	Ex-ante the change in carbon stocks in all applicable pools will be modeled following the requirements in Section 7

Data/Parameter:	DBH
Data Unit:	Cm
Used in equations:	9, 24
Description:	Diameter at breast height of tree
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	Typically measured 1.3m aboveground. Measure all trees above some minimum DBH in the sample plots. The minimum DBH varies depending on tree species and climate; for instance, the minimum DBH may be as small as 2.5 cm or as high as 120cm
Comments:	Ex-ante the change in carbon stocks in all applicable pools will be modeled following the requirements in Section 7

Data/Parameter:	*H*
Data Unit:	m
Used in equations:	9, 24
Description:	Height of tree in sample plots
Source of data:	Field measurements in sample plots
Measurement procedures (if any):	
Comments:	Ex-ante the change in carbon stocks in all applicable pools will be modeled following the requirements in Section 7

Data/Parameter:	*L*
Data Unit:	m
Used in equations:	17
Description:	Length of the transect to determine volume of lying dead wood (default 100m)
Source of data:	Field measurements
Measurement procedures (if any):	
Comments:	Ex-ante the change in carbon stocks in all applicable pools will be modeled following the requirements in Section 7

Data/Parameter:	*N*

Data Unit:	Dimensionless
Used in equations:	17
Description:	Total number of wood pieces intersecting the transect
Source of data:	Field measurements
Measurement procedures (if any):	
Comments:	Ex-ante the change in carbon stocks in all applicable pools will be modeled following the requirements in Section 7

Data/Parameter:	t
Data Unit:	Years
Used in equations:	14, 15, 19
Description:	Number of years between monitoring t and t1 (T=t2 – t1)
Source of data:	
Measurement procedures (if any):	
Comments:	Monitoring plan should include the monitoring intervals through the project lifetime; Ex-ante the monitoring plan shall detail the planned monitoring intervals through the project life

4 Monitoring of actual carbon stock changes and greenhouse gas emissions

When new and more accurate carbon stock data become available, these can be used to estimate the net anthropogenic GHG emission reduction of the subsequent crediting period. For the current crediting period, new data on carbon stocks can only be used if they are validated by the operational entity that verifies the project activity. If new data are used in the current crediting period, the baseline must be recalculated using the new data.

5 Methodological procedure for verification

The ex-post methodology is to be implemented immediately after project start and includes two main tasks:

1) Monitoring according to the monitoring plan; and
2) Periodical review of the timber supply and inventory levels