



VCS Methodology

VM0003

METHODOLOGY FOR IMPROVED FOREST MANAGEMENT THROUGH EXTENSION OF ROTATION AGE

Version 1.3

16 May 2023

Sectoral Scope 14



Version 1.0 of this methodology was developed by **Ecotrust** and approved on 13 May 2010.

Version 1.1 of this methodology was developed by **Ecotrust** to account for the decay of carbon from the harvested wood products pool, modify the accounting approach for the decay of the dead wood pool and include minor revisions. Version 1.1 was approved on 20 November 2012.

Version 1.2 of this methodology was developed by **Ecotrust** to include clarifications for the selection of the baseline scenario. Version 1.1 was approved on 29 August 2013.

Version 1.3 of this methodology was developed by **Ecotrust**, including minor revisions for FSC certification, improved accounting of wood products, and updates to section 8 in accordance with the most recent VCS requirements for uncertainty. Version 1.3 was approved on 16 May 2023.

Ecotrust

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1 SOURCES

This methodology is based on the following methodologies:

- *AR-ACM0001 Afforestation and reforestation of degraded land*

This methodology uses the latest versions of the following tools:

- *CDM Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities*
- *CDM Tool for the demonstration and assessment of additionality*
- *CDM Tool for testing significance of GHG emissions in A/R CDM project activities*
- *CDM Tool for calculation of the number of sample plots for measurements within A/R CDM project activities*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

| Additionality and Crediting Method | |
|------------------------------------|----------------|
| Additionality | Project Method |
| Crediting Baseline | Project Method |

This methodology quantifies the GHG emission reductions and removals generated from improving forest management practices to increase the carbon stock on land by extending the rotation age of a forest or patch of forest before harvesting. By extending the age at which trees are cut, projects increase the average carbon stock on the land and remove more emissions from the atmosphere.

3 DEFINITIONS

Clear cut

The harvest of all trees in an area

Commercial harvesting

Removing any trees from the project area for any purpose other than for the limited collection of firewood or sanitation removal

Firewood

Wood harvested and burned for personal use or limited sale as a heating fuel in the immediate vicinity

Group selection

A variant of clear cut with groups of trees being left for wildlife habitat, wind firmness, soil retention or other silvicultural goals

Logging slash

Branches, other dead wood residues and foliage left on the forest floor after timber removal

Patch cut

A clear cut on a small area (less than one hectare)

Sanitation removal

The intentional removal of trees to prevent disease or correct a natural disturbance

Seed tree

A variant of clear cut with limited mature trees being left to provide seeds for regeneration

Tree

A perennial woody plant with a diameter at breast height greater than 5 cm and a height greater than 1.3 m

4 APPLICABILITY CONDITIONS

This methodology applies to Improved Forest Management (IFM) project activities that involve an extension in rotation age (ERA).

This methodology is applicable under the following conditions:

- 1) Forest management in both baseline and project scenarios involves harvesting techniques such as clear cuts, patch cuts, seed trees, continuous thinning, or group selection practices.
- 2) Forests which are not subject to timber harvesting, or managed without an objective for earning revenue through timber harvesting in the baseline scenario are not eligible under this methodology.
- 3) Prior to the first verification event, the project area must meet one of the following conditions:
 - a) Certified by Forest Stewardship Council (FSC); or
 - b) Subject to an easement, or equivalent instrument, recorded against the deed of property that prohibits commercial harvesting for the duration of the crediting period unless later certified by FSC.
- 4) Project proponents must define the minimum project length in the project description.

- 5) The project does not encompass managed peat forests, and the proportion of wetlands is not expected to change as part of the project.
- 6) Project proponents must have a projection of management practices in both with- and without-project scenarios.
- 7) Where fire is used as part of forest management, fire control measures such as installation of firebreaks or back-burning must be taken to ensure fire does not spread outside the project area – that is, no biomass burning is permitted to occur beyond the project area due to forest management activities.
- 8) There must be no leakage through activity shifting to other lands owned or managed by project proponents outside the boundary of the project area.

5 PROJECT BOUNDARY

5.1 GHG Sources and Sinks

The carbon pools included in or excluded from the project boundary are shown in Table 1.

Table 1: Selected Carbon Pools

| Carbon Pools | Selected? | Justification/Explanation |
|----------------------|-------------|--|
| Above-ground biomass | Yes | Major carbon pool subjected to the project activity |
| Below-ground biomass | Yes | Below-ground biomass stock is expected to increase due to implementation of the IFM project activity. Below-ground biomass subsequent to harvest is not assessed based on the conservative assumption of immediate emission. |
| Dead wood | Conditional | Dead wood stocks may be conservatively excluded unless the project scenario produces greater levels of slash than the baseline and slash is burned as part of forest management. Where slash produced in the project scenario is left in the forest to become part of the dead wood pool, dead wood may be conservatively excluded. Alternatively, project proponents may elect to include the pool (where included, the pool must be estimated in both the baseline and with-project scenarios) as long as the dead wood pool represents less than 50 percent of total carbon volume on the site in any given modeled year. |
| Litter | No | Changes in the litter pool will be de minimis as a result of rotation extension. |

| | | |
|---------------------|-------------|--|
| Soil organic carbon | No | Changes in the soil organic carbon pool will be de minimis as a result of rotation extension. |
| Wood products | Conditional | This stock may increase or decrease (compared to baseline) due to implementation of the project activity. The methodology provides an approach for accounting for this pool, but the pool may be excluded if transparent and verifiable information demonstrates that carbon stocks in wood products are rising faster in the project scenario than in the baseline or are decreasing faster in the baseline than in the project scenario. |

The emission sources included in or excluded from the project boundary are shown in Table 2. Any of these sources may be neglected (i.e., accounted as zero) where application of the most recent CDM *Tool for testing significance of GHG emissions in A/R project activities* leads to the conclusion that the emission source is insignificant.

Table 2: GHG Sources Included In or Excluded From the Project Boundary¹

| Source | | Gas | Included? | Justification/Explanation |
|----------|--------------------|------------------|-----------|---|
| Baseline | Burning of biomass | CO ₂ | Excluded | Carbon stock decreases due to burning are accounted as a carbon stock change. |
| | | CH ₄ | Included | Non-CO ₂ gas emitted from biomass burning |
| | | N ₂ O | Excluded | Potential emissions are negligible. |
| Project | Burning of biomass | CO ₂ | Excluded | Carbon stock decreases due to burning are accounted as a carbon stock change. |
| | | CH ₄ | Included | Non-CO ₂ gas emitted from biomass burning |
| | | N ₂ O | Excluded | Potential emissions are negligible. |

5.2 Project Area and Eligibility of Land

The project area geographically delineates the improved forest management project activity under the control of the project proponents. The IFM project activity may contain more than one discrete area of land. At validation, the following must be defined:

- 1) Each discrete area of land must have a unique geographic identification.

¹ 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 are not considered here (UNFCCC CDM EB 44, UNFCCC CDM EB 42).

- 2) Aggregation of forest properties with multiple landowners is permitted under the methodology with aggregated areas treated as a single project area.
- 3) The project proponents must describe legal title to the forest, rights of access to the sequestered carbon (or avoided carbon emissions), current land tenure, and forest management for each discrete area of forest.
- 4) The project proponents must justify that, during the project lifetime, each discrete area of land is expected to be subject to a change in forest management through activities under the control of the project proponents.

6 BASELINE SCENARIO

6.1 Selected Baseline Approach

Changes in carbon stocks in the pools within the project boundary from the most likely land use at the time the project starts.

6.2 Preliminary Screening Based on the IFM Project Activity Start Date

In accordance with the *VCS Standard*, projects using this methodology must initiate the pipeline listing process within three years of the project start date and must complete validation within eight years of the project start date.

6.3 Determination of Baseline Scenario

Step 1a. Identify credible alternative forest management scenarios to the proposed VCS project activity

As per the applicability conditions, the project must demonstrate a baseline scenario that involves clear cut, patch cut, seed tree, continuous thinning or group selection forest management techniques, using evidence such as management plans, forest inventories, assessments by reputable forestry consultants, the common practice of alternative landowners and common practice in the region. Where it is not possible to demonstrate such a baseline, this methodology must not be applied. Baseline scenarios with no timber harvesting or management without a timber revenue objective must be excluded as per the methodology applicability conditions. Identify realistic and credible land-use scenarios that would have occurred on the land within the proposed project area in the absence of the IFM project activity under the VCS.² The scenario must be feasible for the project proponents or similar project

² For example, continuation of the pre-project land use or a switch to land use typical for the region in which the planned IFM project is located, establishing agricultural plantation, tourist resort, hunting area/farm, utilizing regionally typical forms of funds investment or other economically attractive activities.

proponents taking into account relevant national and/or sectoral policies³ and circumstances, such as historical land uses, practices and economic trends. The identified land-use scenario must be limited to forested land uses. This process must clearly identify barriers to and benefits of all potential scenarios.

The possible land-use scenarios to be evaluated must include:

- 1) Continuation of pre-project forest management (historical baseline);
- 2) Legal requirements for forest management in the region (legal baseline);
- 3) Common practice forest management in the region (common practice baseline); and
- 4) Forest management as modeled under the project but in the absence of registration as an IFM project activity.

For identifying realistic and credible land-use scenarios, land-use records, field surveys, data and feedback from stakeholders and information from other appropriate sources, including participatory rural appraisal (PRA)⁴ should be used as appropriate. All current land uses within the boundary of the proposed IFM project activity may be deemed realistic and credible.

IFM project proponents must use the following guidelines to define these possible land-use scenarios.

Guidance for Defining the Legal Baseline

The legal baseline is defined by the forest management scenario that maximizes net present value to the forest owner(s) through timber harvesting while reflecting all legal requirements for forest management. In many cases, the specific management practices defined by the project proponent in the legal baseline may not be explicitly addressed in the relevant forest practices regulations, and the legality and plausibility of these practices must be confirmed by an independent forest consulting entity.

Guidance for Defining the Common Practice Baseline

Common practice in the project region must be defined by an independent forest consulting entity and must consider the following elements of forest management:

- 1) Harvest rotations,

³ Annex 3 to the report of the EB at its twenty-second meeting and Annex 19 to the report of the EB at its twenty-third meeting clarify how relevant national and/or sectoral policies should be taken into account during identification of a baseline scenario. Available at: https://cdm.unfccc.int/EB/022/eb22_repan3.pdf and https://cdm.unfccc.int/EB/023/eb23_repan19.pdf

⁴ Participatory rural appraisal (PRA) is an approach to the analysis of local problems and the formulation of tentative solutions with local stakeholders. It makes use of a wide range of visualization methods for group-based analysis to deal with spatial and temporal aspects of social and environmental problems. This methodology is described in Chambers, R. (1992). *Rural appraisal: Rapid, relaxed, and participatory*. Discussion Paper 311, Institute of Development Studies, and Theis, J., & Grady, H. (1991). *Participatory rapid appraisal for community development*. Save the Children Fund.

- 2) Harvest methods,
- 3) Species harvested and planted,
- 4) No-harvest zones,
- 5) Riparian management areas,
- 6) Areas of steep slope or unstable soils, and/or
- 7) Maximum patch cut areas.

Step 1b. Selection of a single baseline forest management scenario

IFM project proponents must evaluate the identified plausible baseline management systems relative to all of the following:

- 1) A documented history of the operator (e.g., operator must have at least 20 years of management records to show normal historical practices). Common records to document history include data on timber cruise volumes, inventory levels or harvest levels on the property;
- 2) The legal requirements for forest management and land use in the area; and
- 3) A common practice standard among similar landowners in the area.

In all cases these three scenarios must be described by the project proponent, then reviewed and approved as plausible and accurate by an independent forest consulting entity. Requirements for forest consultant qualifications will vary by region, however, the validation/verification body must consider the following elements when reviewing consultant qualifications:

- a) In regions where a legally recognized certified forester designation exists, the forest consulting entity must have that designation.
- b) In areas where there are no legal certified forester designations, the consultant must have either of the following:
 - i) Accreditation under a widely recognized elective accreditation program that grants “certified forester” designation (e.g., Society of American Foresters); or
 - ii) Publicly filed management plans or harvest plans that demonstrate the participation of the consulting entity and their qualifications to review the required documentation.

The alternative land-use scenario that is not prevented by any barrier or is the most financially viable is identified as the baseline scenario.

IFM project proponents must use the following guidelines to select the most plausible baseline scenario to be modeled.

Historical Baseline

The historical baseline must be selected as the most plausible baseline scenario where the following documents exist for the forest property:

- 1) Historical records of forest management for 20 or more years preceding the project start date;
- 2) Historical records that indicate that the management practices have surpassed the legal barriers provided by conforming with all local and regional forest legislation; and
- 3) Historical records that indicate that the historical management does not surpass financial barriers as indicated by providing below average market returns.⁵

Where these documents do not exist, the project must be developed using the legal or common practice baselines.

Legal Baseline

Where the historical baseline is not applicable based on the criteria above, the legal baseline must be selected as the most plausible baseline scenario where regulations of forest management practices exist and are readily enforced within the project region.

An independent forest consulting entity must confirm that the practices defined in the legal baseline by the project proponent are plausible considering verifiable evidence. During validation, the forest consultant must share with the validation/verification body evidence for their determination of the plausibility of the legal baseline. Such evidence must in all situations be considered confidential and must not be published or shared by the validation/verification body. Such evidence may include, for example: management plans, records of timber sales or harvesting by the project proponent within the project area or in other properties under their control; management plans, records of timber sales or harvesting by other entities similar to the project proponent in the region; national or regional government statistics on forest management in the region; published data and analyses on forest management in the region; and/or spatial analyses on management options and/or carbon stocks in the focal region. As needed, the validation/verification body may consult additional independent forest consulting entities to verify the opinion provided by the independent forest consulting entity selected by the proponent and to determine that the legal baseline is plausible.

Common Practice Baseline

The common practice baseline must be selected as the most plausible baseline scenario where there is insufficient documentation to utilize the historical baseline and where forest management regulations do not exist or are not readily enforced in the project region.

It is possible that the common practice baseline and project scenarios are the same, in which case the project scenario is not considered additional.

⁵ Below average market returns are defined as 80 percent or less of the current prevailing internal rate of return for forestland investment in comparable forest types and locations, after considering the full array of timber, non-timber and ecosystem service net revenues associated with the property, averaged over the last five years. Forestland investment in comparable forest types and locations is defined as common practice management.

During validation, the forest consultant must share with the validation/verification body evidence for their determination of common practice. Such evidence must in all situations be considered confidential and must not be published or shared by the validation/verification body. Such evidence may include, for example: management plans, records of timber sales or harvesting by the project proponent within the project area or in other properties under their control; management plans, records of timber sales or harvesting by other entities similar to the project proponent in the region; national or regional government statistics on forest management in the region; published data and analyses on forest management in the region; and/or spatial analyses on management options and/or carbon stocks in the region.

7 ADDITIONALITY

This methodology uses a project method for the demonstration of additionality.

The project proponent must test the additionality of the project using the current CDM *Tool for the demonstration and assessment of additionality*. In application of this tool, the project scenario as described ex-ante using this methodology and monitored using this methodology must be evaluated alongside the baseline scenario identified in Section 6.3. Where a financial analysis or a demonstration of barriers does not preclude the project scenario, the project is considered not additional.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Stratification

Where the project area is not homogeneous, it must be stratified 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:

- Management system,
- Site index or anticipated growth rates,
- Forest species, or
- Age class.

For this methodology, it is important to stratify by management system so that all areas to be clear cut or patch cut within a given year or within the years between monitoring events comprise a stratum, with further division where differences exist in site index, species and/or age class.

The project area must be stratified ex-ante. Further stratification beyond the parameters given above is not usually warranted. However, other parameters (e.g., soil type, climate) may be useful for ex-post stratification.

Note – in the equations used in this methodology, i is used to represent a stratum and M the total number of strata. M_B is the number of baseline strata defined ex-ante as determined by the procedures above; M_B remains fixed. M_{PS} is the number of strata in the project scenario as determined ex-ante. Ex-post adjustments of the project scenario strata may be needed where unexpected disturbances occur during the project crediting period (e.g., due to fire, pests or disease outbreaks) that severely affect different parts of an originally homogeneous stratum or stand, or where forest management (thinning, harvesting, replanting) occurs at different intensities, dates and spatial locations than originally planned. In such a situation, the project area affected by the disturbance and/or variation in forest management must be delineated as a separate stratum for the purpose of monitoring carbon stock changes.

8.2 Baseline Net GHG Removals by Sinks

The baseline net removals are averaged over a modeled 100-year period to remove fluctuations and the impact of fluctuations on the difference between the baseline and project scenarios.

The baseline net GHG removals by sinks is determined as follows:

$$\Delta C_{BSL} = \Delta C_{BSLP} - GHG_{BSLE} \quad (1)$$

Where:

ΔC_{BSL} Baseline net greenhouse gas removals by sinks (t CO₂e)

ΔC_{BSLP} Carbon stock changes in all pools in the baseline scenario (t CO₂e)

GHG_{BSLE} Greenhouse gas emissions as a result of forest management activities within the project area in the baseline scenario (t CO₂e)

$$\Delta C_{BSLP} = \Delta C_{BSLtree} + \Delta C_{BSLDW} + \Delta C_{BSLWP} \quad (2)$$

Where:

$\Delta C_{BSLtree}$ Carbon stock changes in above-ground and below-ground biomass of trees in the baseline scenario (t CO₂e)

ΔC_{BSLDW} Carbon stock changes in dead wood in the baseline scenario (t CO₂e)

$\Delta C_{BSL_{WP}}$ Carbon stock changes in wood products in the baseline scenario (t CO₂e)

Dead wood may conservatively be excluded. Wood products may also conservatively be excluded where it is shown that carbon stocks in the baseline scenario are expected to decrease more or increase less, relative to the project scenario.

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

Where:

$\Delta C_{BSL_{AG|BG,i,100}}$ 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 the IFM project activity

$\frac{44}{12}$ Ratio of molecular weight of CO₂ to carbon (t CO₂e t C⁻¹)

If dead wood is selected in Table 1:

$$\Delta C_{BSL_{DW}} = \frac{\left(\sum_{i=1}^{M_B} \Delta C_{BSL_{DW,i,100}} \times \frac{44}{12} \right)}{100} \times t^* \quad (4)$$

Where:

$\Delta C_{BSL_{DW}}$ Carbon stock changes in dead wood in the baseline scenario (t CO₂e)

$\Delta C_{BSL_{DW,i,100}}$ Summed annual net carbon stock change in dead wood for stratum i summed over the 100-year modeled baseline (t C)

If wood products are selected in Table 1:

$$\Delta C_{BSL_{WP}} = \frac{\left(\sum_{i=1}^{M_B} \Delta C_{BSL_{WP,i,t}} \times \frac{44}{12} \right)}{100} \times t^* \quad (5)$$

Where:

$\Delta C_{BSL_{WP}}$ Carbon stock changes in wood products in the baseline (t CO₂e)

$\Delta C_{BSLWP,i,t}$ Baseline annual net carbon stock change in wood products for stratum i at time t (t C yr⁻¹)

8.3 Stock Changes in the Baseline

$\Delta C_{BSLAG|BG}$, ΔC_{BSLDW} and ΔC_{BSLWP} must be estimated using models of forest management across the baseline period. Modeling is conducted with relative ease and confidence using a peer-reviewed forestry model. The PD must detail the model being used and the variants that have been selected. All model inputs and outputs must be available for inspection by the validation/verification body. The baseline must be modeled over 100 years.

The model must not assume the immediate release of carbon stock in the dead wood pool, as set out in the most recent version of the *VCS Methodology Requirements*.

Examples of appropriate models include:

- Forest Vegetation Simulator by US Forest Service
- Stand Projection System within the MBG Tools software from Mason, Bruce, & Girard, Inc.
- The Forest Projection System by Forest Biometrics Research Institute
- California Conifer Timber Output Simulator (CACTOS)
- Cooperative Redwood Yield Project Timber Output Simulator (CRYPTOS)

Models must be:

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

In countries and regions where specific forestry models do not exist or are not available, it is valid to employ a simple spreadsheet-based model (including common simple growth models such as the Chapman Richards model of tree growth appropriately parameterized). Such models must be clearly labeled with all assumptions and justifications for assumptions presented. Spreadsheet models may also be necessary to extrapolate some growth models to include additional pools and harvest schedules.

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 8.5 must be used and detailed in full in the project description.⁶

⁶ Input data including precision bounds must be made available to validation/verification bodies.

The output of the models must be the annual changes in stocks of carbon in live above-ground tree biomass ($\Delta C_{BSLAG|BG,i,t}$), dead wood ($\Delta C_{BSLDW,i,t}$) and wood products ($\Delta C_{BSLWP,i,t}$) by strata in the baseline scenario through the duration of the project.⁷ Where model output is the annual stock (C), the change (ΔC) would be calculated as $C_{t_2} - C_{t_1}$.

Where the output for the tree is the volume, this must be converted to biomass and carbon using Equations (13)–(18) in Section 8.5. Where processing of alternative data on dead wood and wood products is necessary, Equations (24)–(35) must be used.

8.4 Baseline Emissions

The GHG emissions in the baseline scenario within the project area are estimated as follows:

$$GHG_{BSLE} = \sum_{t=1}^{t^*} (E_{BSLBiomassBurn,t}) \quad (6)$$

Where:

$E_{BSLBiomassBurn,t}$ Non-CO₂ greenhouse gas emissions due to biomass burning as part of forest management during year t in the baseline scenario (t CO₂e)

GHG emission sources included or excluded from the project area may be neglected (i.e., accounted as zero) where application of the most recent version of the CDM *Tool for the demonstration and assessment of additionality* determines that the emission source is insignificant.

8.4.1 Estimation of Baseline Non-CO₂ Emissions due to Biomass Burning

The non-CO₂ emissions due to biomass burning as part of forest management ($E_{BSLBiomassBurn}$) are estimated by:

$$E_{BSLBiomassBurn,t} = E_{BiomassBurn_{CH_4},t} \quad (7)$$

Where:

$E_{BiomassBurn_{CH_4},t}$ CH₄ emissions as a result of forest management during year t (t CO₂e)

Estimation of CH₄ emissions based on carbon stock loss from biomass burning during forest management is based on the biomass of logging slash burned, BS , calculated using Equation

⁷ Where modeling produces changes in carbon stocks over five-year periods, the numbers must be annualized to give a stock change number for each year.

(9). This is multiplied by factors that adjust for the mass of CH₄ versus carbon released, and for the global warming potential of CH₄.

$$E_{BiomassBurn_{CH_4},t} = BS_{BSL,t} \times ER_{CH_4} \times \frac{16}{12} \times GWP_{CH_4} \quad (8)$$

Where:

$BS_{BSL,t}$ Carbon stock in logging slash subject to burning as part of forest management (t C)

ER_{CH_4} Emission ratio for CH₄ (where local data on combustion efficiency are not available or it is not possible to estimate combustion efficiency from fuel information, use most recent version of the IPCC's Good Practice Guidance for LULUCF default value, 0.012⁸) (kg C as CH₄ (kg C burned)⁻¹)

GWP_{CH_4} Global warming potential for CH₄; use the most recent version of the VCS Standard's GWP value (t CO₂e (t CH₄)⁻¹)

$\frac{16}{12}$ Ratio of molecular weights of CH₄ and C (mol mol⁻¹)

Where logging slash is not burned as part of forest management, $BS_{BSL,t} = 0$, otherwise:

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

Where:

$V_{l,j,t}$ Harvested merchantable volume of tree l of species j at time t (m³)

D_j Basic wood density of species 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 ; IPCC default value = 0.5 (t C t⁻¹ d.m.)

l 1, 2, 3, ..., N sequence number of trees harvested

j 1, 2, 3, ..., S_{BSL} tree species in the baseline scenario

⁸ Table 3A.1.15, Annex 3A.1, in IPCC (2003). *Good practice guidance: Land use, land-use change and forestry* (GPG-LULUCF). Available at: https://www.ipcc-nggip.iges.or.jp/public/gpplulucf/gpplulucf_files/Chp4/Chp4_3_Projects.pdf

8.5 Project Net GHG Removals by Sinks

The actual net greenhouse gas removals must 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 proponents must provide estimates of the values of parameters that are not available before the start of monitoring activities.⁹ Project proponents must retain a conservative approach in making these estimates.

$$\Delta C_{ACTUAL} = \Delta C_P - GHG_E \quad (10)$$

Where:

| | |
|---------------------|--|
| ΔC_{ACTUAL} | Actual net greenhouse gas removals by sinks (t CO ₂ e) |
| ΔC_P | Sum of the changes in above-ground biomass, dead wood and wood products in the project scenario (t CO ₂ e) |
| GHG_E | Increase in GHG emissions as a result of implementation of the proposed IFM project activity within the project area (t CO ₂ e) |

Note – in this methodology, Equation (14) is used to estimate actual net greenhouse gas removals by sinks for the period of time elapsed between project start (t = 1) and the year t = t, where t* is the year for which actual net greenhouse gas removals by sinks are estimated. The stock change method must be used to determine annual or periodic values.*

8.5.1 Estimation of Changes in Carbon Stock

The verifiable changes in the carbon stock in tree above-ground biomass, dead wood and wood products are estimated using the following approach¹⁰:

$$\Delta C_P = \sum_{t=1}^{t^*} \Delta C_t \times \frac{44}{12} \quad (11)$$

Where:

| | |
|--------------|---|
| ΔC_t | Annual change in carbon stock in all selected carbon pools for year t (t C yr ⁻¹) |
|--------------|---|

⁹ For the ex-ante estimation of changes in above-ground biomass, dead wood and wood products in the project scenario, projects must model the expected changes in stocks through the with-project management scenario using methods described in Section 8.5.1.

¹⁰ Equation 3.2.3 in IPCC (2003). *Good practice guidance for land use, land-use change and forestry – Section 4.3.*

ΔC_t must be estimated using the following equation:

$$\Delta C_t = \sum_{i=1}^{MPS} (\Delta C_{AG,i,t} + \Delta C_{BG,i,t} + \Delta C_{DW,i,t} + \Delta C_{WP,i,t}) \quad (12)$$

Where:

$\Delta C_{AG,i,t}$ Annual carbon stock change in above-ground biomass of trees for stratum i ; may be an average over the monitoring period (t C yr⁻¹)

$\Delta C_{BG,i,t}$ Annual carbon stock change in below-ground biomass of trees for stratum i ; may be an average over the monitoring period (t C yr⁻¹)

$\Delta C_{DW,i,t}$ Annual change in the dead wood carbon pool for stratum i ; may be an average over the monitoring period (t C yr⁻¹)

$\Delta C_{WP,i,t}$ Annual change in the wood products carbon pool for stratum i ; may be an average over the monitoring period (t C yr⁻¹)

Changes in carbon pools that are conservatively excluded from accounting must be set equal to zero.

8.5.1.1 Tree Biomass

The mean carbon stock in above-ground biomass per unit area is estimated based on field measurements in sample plots. Plots may be permanent or temporary,¹¹ and may have a defined boundary or be variable radius plots. Two methods are available: the biomass expansion factors (BEF) method and the allometric equations method.

Method 1: BEF Method

Step 1: Determine based on available data (e.g., volume tables (ex-ante) and measurements (ex-post)), the diameter (DBH, at typically 1.3 m [4.5 ft] above ground level), and also preferably height (H), of all the trees above a selected minimum DBH in the sample plots.

Step 2: Estimate the volume of the commercial (merchantable) component of trees based on available equations or yield tables (where locally derived equations or yield tables are not available, use relevant regional, national or default data as appropriate). Steps 1 and 2 may be combined where field instruments that measure the volume of each tree more directly (e.g., a relascope) are available.

¹¹ Note that due to covariance, tighter precision is obtained and hence fewer measurements may be used where permanent plots are selected. See guidance in IPCC (2003). *Good practice guidance for land use, land use change and forestry – Section 4.3.*

Step 3: Choose BEF and root-shoot ratio R – see definition of BEF within Section 9.1 for guidance on source of data. Where relevant information is available, the BEF and R must be adjusted for forest type or stand structure.

Step 4: 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:

$$CV_{AB_{sp,i,t}} = \sum_{j=1}^{S_{PS}} N_{j,i,sp,t} \sum_{l=1} (V_{l,j,i,sp,t} \times D_j \times CF_j) \quad (13)$$

Where:

$CV_{AB_{sp,i,t}}$ Carbon stock of the commercial component of trees in plot sp in stratum i at time t (t C)

$V_{l,j,i,sp,t}$ Merchantable volume of tree l of species j in plot sp in stratum i at time t (m³) (where necessary, convert from ft³ to m³ by multiplying by 0.0283)

Step 5: Calculate the carbon stock in the commercial component of the trees for each stratum:

$$CV_{AB,i,t} = \sum_{sp=1}^{P_i} \frac{10000}{Ap} \times CV_{AB_{sp,i,t}} \quad (14)$$

Where:

$CV_{AB,i,t}$ Carbon stock of the commercial component of trees in stratum i at time t (t C ha⁻¹)

Ap Area of sample plot (m²) (where necessary, convert from ft² to m² by multiplying by 0.0929)

sp 1, 2, 3, ..., P_i sample plots in stratum i in the project scenario

Where point sampling/basal area prism sampling is used, in Equation (13) each tree must be multiplied by the number of trees per acre that it represents, and in Equation (14) the 10000/ Ap factor is omitted.

Step 6: Convert the mean carbon stock in the commercial component of the trees for each stratum into the total carbon stock in above-ground biomass via the BEF:

$$C_{AB,i,t} = CV_{AB,i,t} \times BEF \quad (15)$$

Where:

| | |
|--------------|--|
| $C_{AB,i,t}$ | Carbon stock in above-ground biomass of trees in stratum i at time t (t C ha ⁻¹) |
| BEF | Biomass expansion factor for conversion of merchantable biomass to total above-ground tree biomass (dimensionless) |

Step 7: Calculate the carbon stock in below-ground biomass of all trees present in stratum i at time t :

$$C_{BB,i,t} = C_{AB,i,t} \times R \quad (16)$$

Where:

| | |
|--------------|--|
| $C_{BB,i,t}$ | Carbon stock in below-ground biomass of trees in stratum i at time t (t C ha ⁻¹) |
| R | Root-shoot ratio appropriate for biomass stock (dimensionless) |

Alternatively, the equations of Cairns et al. (1997)¹² may be used to calculate below-ground biomass stock (t ha⁻¹) from above-ground biomass stock (t ha⁻¹).

Where an appropriate equation exists to calculate below-ground biomass directly from DBH, it may be used in this step.

Step 8: Calculate the mean carbon stock in tree biomass for each stratum:

$$C_{tree,i,t} = A_i \times (C_{AB,i,t} + C_{BB,i,t}) \quad (17)$$

Where:

| | |
|----------------|--|
| $C_{tree,i,t}$ | Carbon stock in trees in stratum i at time t (t C) |
| A_i | Area of stratum i (ha) |

Step 9: Calculate the mean carbon stock change:

$$\Delta C_{AG,i,t} + \Delta C_{BG,i,t} = \frac{C_{tree,i,t_2} - C_{tree,i,t_1}}{T} \quad (18)$$

Where:

| | |
|---------------------|---|
| $\Delta C_{AG,i,t}$ | Annual carbon stock change in above-ground biomass of trees for stratum i (t C yr ⁻¹) |
| $\Delta C_{BG,i,t}$ | Annual carbon stock change in below-ground biomass of trees for stratum i (t C yr ⁻¹) |

¹² Cairns, M. A., Brown, S., Helmer, E. H., & Baumgardner, G. A. (1997). Root biomass allocation in the world's upland forests. *Oecologia*, 111, 1-11. <https://doi.org/10.1007/s004420050201>

T Number of years between monitoring time t_1 and t_2 ($T = t_2 - t_1$) (yr.)

Method 2: Allometric Method

Step 1: Follow Step 1 of the BEF method.

Step 2: Select or develop an appropriate allometric equation (where possible species-specific, otherwise from a similar species) – see Section 9.1 for additional guidance.

Step 3: Estimate carbon stock in above-ground biomass for each individual tree l of species j in the sample plot located in stratum i using the selected or developed allometric equation applied to the tree dimensions resulting from Step 1, and sum the carbon stocks in the sample plot:

$$C_{ABtree_{l,j,i,sp,t}} = \sum_{l=1}^{N_{j,sp}} f_j(DBH, H) \times CF_j \quad (19)$$

Where:

$C_{ABtree_{l,j,i,sp,t}}$ Carbon stock in above-ground biomass of tree l of species j in plot sp in stratum i at time t (t C tree⁻¹)

$f_j(DBH, H)$ Allometric equation for species j linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of trees (t. d.m. tree⁻¹)

Step 4: Convert the carbon stock in above-ground biomass to the carbon stock in below-ground biomass via root-shoot ratio:

$$C_{BBtree_{l,j,i,sp,t}} = C_{ABtree_{l,j,i,sp,t}} \times R_j \quad (20)$$

Where:

$C_{BBtree_{l,j,i,sp,t}}$ Carbon stock in below-ground biomass of tree l of species j in plot sp in stratum i at time t (t C tree⁻¹)

R_j Root-shoot ratio appropriate for biomass stock of species j (dimensionless)

Where an appropriate equation exists to calculate below-ground biomass directly from DBH , it may be used in this step.

Step 5: Calculate total carbon stock in the biomass of all trees present in sample plot sp in stratum i at time t :

$$C_{tree_{i,sp,t}} = \sum_{j=1}^{SPS} (C_{ABtree_{j,i,sp,t}} + C_{BBtree_{j,i,sp,t}}) \quad (21)$$

Where:

$C_{tree_{i,sp,t}}$ Carbon stock in trees in plot sp of stratum i at time t (t C)

Step 6: Calculate the mean carbon stock in tree biomass for each stratum:

$$C_{tree,i,t} = \frac{A_i}{Asp_i} \sum_{sp=1}^{P_i} C_{tree,i,sp,t} \quad (22)$$

Where:

Asp_i Total area of all sample plots in stratum i (ha)

Step 7: Calculate the mean carbon stock change:

$$\Delta C_{AG,i,t} + \Delta C_{BG,i,t} = \frac{C_{tree,i,t_2} - C_{tree,i,t_1}}{T} \quad (23)$$

Note that for permanent plots with tagged trees, changes in carbon stocks are tracked directly through estimates of carbon stock increments in individual trees summed across plots and strata. For detailed guidance see Pearson et al. (2005).¹³

8.5.1.2 Dead Wood (if Selected in Table 1)

Dead wood included in the methodology comprises two components only: standing dead wood and lying dead wood – that is, below-ground dead wood is conservatively omitted. Considering the differences in the two components, different sampling and estimation procedures are used to calculate the changes in dead wood biomass of the two components. In all cases, dead wood modeling must include a decay function that is a 10-year linear decay or a more conservative alternative for dead wood that reflects a pattern of carbon loss over time.

$$\Delta C_{DW,i,t} = \frac{C_{DW,i,t_2} - C_{DW,i,t_1}}{T} \quad (24)$$

Where:

¹³ Pearson, T., Walker, S., & Brown, S. (2005). *Sourcebook for land use, land-use change and forestry projects*. Winrock International and the World Bank Biocarbon Fund. Available at: <https://openknowledge.worldbank.org/handle/10986/16491>

$\Delta C_{DW,i,t}$ Annual carbon stock change in dead wood for stratum i averaged over the monitoring period (t C yr⁻¹)

C_{DW,i,t_2} Carbon stock of dead wood in stratum i at time $t = 2$ (t C)

C_{DW,i,t_1} Carbon stock of dead wood in stratum i at time $t = 1$ (t C)

The methods to be followed in the measurement of standing dead wood and lying dead wood biomass are outlined below:

$$C_{DW,i,t} = (B_{SDW,i,t} + B_{LDW,i,t}) \times CF_{DW} \quad (25)$$

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 (t C t⁻¹ d.m.)

Method: Standing Dead Wood

Step 1: Standing dead trees must 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 very short standing dead trees.

Step 2: The decomposition class of the dead tree and the diameter at breast height must be recorded. The standing dead wood is categorized into one of 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; or
- 4) Bole only, no branches.

Step 3: Biomass must be estimated using an allometric equation for live trees in decomposition class 1. When the bole is in decomposition classes 2, 3 or 4, the estimate of biomass is limited to the main trunk of the tree.

Where the top of the standing dead tree is missing, the top diameter is determined using any of the following:

- Assume top diameter to be zero;

- Measure top diameter where reachable or the broken top is identifiable on the ground, or by using an instrument such as a relascope or laser inventory instrument; or
- Calculate top diameter 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 using the appropriate dead wood density class.

Method: Lying Dead Wood

The lying dead wood pool is highly variable. It is possible for stocks to change as the stands age, depending on whether the forest was previously unmanaged (mature or unlogged) where stocks would likely increase, or logged with logging slash left behind where stocks may decrease over time.

Step 1: Lying dead wood must be sampled using the line intersect method (Harmon & Sexton, 1996).^{14,15} Two 50-meter (164 ft) lines 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: The dead wood is assigned to one of three density states (sound, intermediate and rotten) using the machete test, as recommended by the most recent version of the IPCC's *Good Practice Guidance for LULUCF*.

Step 3: The volume of lying dead wood per unit area is calculated using Equation (26) separately for each density state (Warren & Olsen, 1964¹⁶ as modified by Van Wagner, 1968):¹⁷

$$V_{LDW,i,t} = \frac{\pi^2 \times (\sum_{n=1}^N DM_{n,i,t}^2)}{8 \times L} \quad (26)$$

Where:

$V_{LDW,i,t}$ Volume of lying dead wood per unit area in stratum i at time t ($\text{m}^3 \text{ha}^{-1}$)

$DM_{n,i,t}$ Diameter of piece n of dead wood along the transect in stratum i at time t (cm)
(where necessary, convert inches to cm by multiplying by 2.54)

¹⁴ Harmon, M. E., & Sexton, J. (1996). *Guidelines for measurements of woody detritus in forest ecosystems*. US LTER Publication No. 20. US LTER Network Office, University of Washington.

¹⁵ A variant of the line intersect method is described in Waddell, K. L. (2002). Sampling coarse woody debris for multiple attributes in extensive resource inventories. *Ecological Indicators*, 1(3), 139–153. [https://doi.org/10.1016/S1470-160X\(01\)00012-7](https://doi.org/10.1016/S1470-160X(01)00012-7) This method may be used in place of Steps 1 to 3.

¹⁶ Warren, W. G., & Olsen, P. F. (1964). A line intersect technique for assessing logging waste. *Forest Science*, 10(3), 267–276.

¹⁷ Van Wagner, C. E. (1968). The line intersect method in forest fuel sampling. *Forest Science*, 14(1), 20–26.

| | |
|-----|--|
| N | Total number of wood pieces intersecting the transect |
| L | Length of the transect (m) (where necessary, convert ft to m by multiplying by 0.3048) |

To convert this to a mass per unit area, multiply the volumes of each density state by their respective wood densities (Step 4).

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

$$B_{LDW,i,t} = A_i \times \sum_{dc=1}^3 V_{LDW,i,t} \times D_{DW,dc} \quad (27)$$

Where:

| | |
|---------------|--|
| $B_{LDW,i,t}$ | Biomass of lying dead wood per unit area in stratum i at time t (d.m. ha ⁻¹) |
| $D_{DW,dc}$ | Basic wood density of dead wood in density class dc : sound (1), intermediate (2) and rotten (3) (t d.m. m ⁻³) |

8.5.1.3 Wood Products (if Selected in Table 1)

The wood products pool is calculated through the following general steps for each harvest period h .

Step 1: Calculate the carbon in harvested timber removed from the project area based on wood densities and standard carbon conversions from biomass volumes.

Step 2: Calculate the total carbon in harvested timber that will enter the wood products pool based on mill efficiencies and product disposition percentages.

Step 3: Calculate the total carbon that will be stored for the short-lived (≤ 3 years), medium-lived (> 3 years to 100 years) and long-lived (> 100 years) product pools.

The annual change in carbon stored in wood products is given in the following equation:

$$\Delta C_{WP,t_1,t_2} = \frac{C_{WP,t_2} - C_{WP,t_1}}{T} \quad (28)$$

Where:

| | |
|-------------------------|---|
| $\Delta C_{WP,t_1,t_2}$ | Annual carbon stock change in wood products between times t_1 and t_2 , averaged over the monitoring period (t C yr ⁻¹) |
| C_{WP,t_2} | Carbon stock of wood products at time $t = 2$ (t C) |
| C_{WP,t_1} | Carbon stock of wood products at time $t = 1$ (t C) |

Two methods are available to calculate wood products. The direct (1605b) method is only applicable within the 48 contiguous United States and for limited vegetation types. The less direct (Winjum et al.) method may be applied to any vegetation types throughout the world.

Method 1: 1605b Method

This method uses tables that were originally defined in the *Forestry Appendix of the Technical Guidelines of the US Department of Energy's Voluntary Reporting of Greenhouse Gases Program* (known as Section 1605(b)), which are retained in a USFS General Technical Report, GTR-NE-343 (Smith et al. 2006).¹⁸ All harvested wood is categorized by species and wood product (sawnwood or pulpwood). Wood density values for each species in the project area are used to determine carbon volume for each cubic volume of wood delivered to processing facilities.

Regional data supplied in Tables 4 and 5 of GTR-NE-343 provide values to determine the percentage of harvested softwoods and hardwoods that are converted to sawnwood and pulpwood.

Step 1: Calculate the total carbon in harvested timber removed from the project area. This is calculated by taking the biomass of the total volume extracted from within the project area, from the start of the project to date. Extracted timber is differentiated into hardwood, softwood, sawnwood and pulpwood classes (where necessary, convert volumes in ft³ to m³ by multiplying by 0.0283):

$$EXC_{WP,ty} = \sum_{h=1}^{H_{PS}} \sum_{j=1}^{S_{PS}} (V_{ex,h,s|p,j} \times D_j \times CF_j) \quad (29)$$

Where:

| | |
|------------------|--|
| $EXC_{WP,ty}$ | Summed stock of biomass carbon extracted from within the project area as wood product <i>ty</i> (hardwood sawnwood, hardwood pulpwood, softwood sawnwood or softwood pulpwood) (t C) |
| $V_{ex,h,s p,j}$ | Volume of timber extracted from within the project area during harvest <i>h</i> for species <i>j</i> and wood product <i>ty</i> (m ³) |
| <i>h</i> | 1, 2, 3, ..., H_{PS} harvests since the start of the IFM project activity |
| <i>j</i> | 1, 2, 3, ..., S_{PS} tree species in the project scenario |
| <i>s p</i> | Wood product, defined here as sawnwood or pulpwood |

¹⁸ Available as a US Forest Service General Technical Report at: <https://www.srs.fs.usda.gov/pubs/22954>

Step 2: Calculate the total carbon that enters the wood products pool. All projects must calculate the total carbon in harvested biomass that enters the wood products pool after deducting harvest slash left on-site, bark biomass and waste calculated through mill efficiencies. For the purposes of this methodology Tables 4, 5 and 6 from GTR-NE-343 may be used to estimate these values for different regions within the United States. Examples 4, 5, and 6 are given on pages 10–13 of the GTR-NE-343 and demonstrate methods that may be followed with different existing datasets.

Step 3: Calculate the total amount of carbon stored in short-lived, medium-lived and long-lived wood products. For the purposes of this methodology, the proportion of harvested carbon stored in wood products is equivalent to the proportion listed in the “In Use” column of Table 6 of GTR-NE-343 for any given year after harvest.

Each year’s harvested carbon volume is categorized into one of the following:

- Short-lived wood products: harvested wood products and wood waste that will decay within 3 years;
- Medium-lived wood products: harvested wood products and wood waste that will be retired between 3 and 100 years from the date of harvest; or
- Long-lived wood products: harvested wood products and wood waste that may be considered permanent (stored for 100 years or more).

To determine the proportion of harvested wood products that fall into each category, refer to the “In Use” column in the appropriate regional version of Table 6 of GTR-NE-343. For each harvested wood type (hardwood, softwood, pulpwood, sawnwood), two values are taken from the table: P_{3year} , the percentage of total carbon stored in wood products after 3 years; and $P_{100year}$, the proportion of harvested wood stored for 100 years. Three different values are calculated from these data: the short-lived fraction (P_{SLF}), medium-lived fraction (P_{MLF}) and long-lived fraction (P_{LLF}):

$$P_{SLF} = 1 - P_{3year}$$

$$P_{MLF} = P_{3year} - P_{100year}$$

$$P_{LLF} = P_{100year}$$

Each category of wood products stores carbon according to the following rules:

- Short-lived wood products: immediate loss of all carbon upon harvest
- Medium-lived wood products: no loss of carbon upon harvest, but carbon stored will decrease by 1/20th for the 20 years following harvest
- Long-lived wood products: no loss of carbon

$$C_{WP,t,ty} = \sum_{h=0}^t ((C_{Mill,ty,hy} \times P_{LLF}) + [(C_{Mill,ty,h} \times P_{MLF}) \times \frac{(20 - hy)}{20}]) \quad (30)$$

Where:

| | |
|-------------------|---|
| $C_{WP,t,ty}$ | Total carbon removed from the project area that remains stored in harvested wood products at year t for wood product ty (hardwood, softwood, sawnwood, pulpwood) (t C) |
| $C_{Mill,ty,h}$ | Total carbon volume stored in wood products for harvest h , after deducting for mill efficiencies and product dispositions (t C) |
| hy | Year of harvest |
| $P_{SLF,MLF,LLF}$ | Proportion of carbon stored in short-lived, medium-lived and long-lived sawn hardwood/softwood or pulp hardwood/softwood in use $P_{SLF} = 0$. P_{MLF} must be reduced by 1/20 in each of the 20 years following harvest, after which point it becomes zero. $P_{LLF} = 1$ for the 100 years of the project life. |

Method 2: Winjum et al. Method

Step 1: Calculate the total volume of biomass extracted from within the project area from the start of the project to date (where necessary, convert volumes in ft³ to m³ by multiplying by 0.0283).

$$EXC_{WP,ty} = \sum_{h=1}^{H_{PS}} \sum_{j=1}^{S_{PS}} (V_{ex,h,ty,j} \times D_j \times CF_j) \quad (31)$$

Where:

| | |
|-----------------|--|
| $EXC_{WP,ty}$ | Summed stock of extracted biomass carbon from within the project area for class of wood product ty (t C) |
| $V_{ex,h,ty,j}$ | Volume of timber extracted from within the project area during harvest h for species j and wood product class ty (m ³) |

Step 2: Calculate the total carbon in harvested timber that enters the wood products pool based on mill efficiencies and product disposition percentages. All factors are derived from Winjum et al. (1998).¹⁹

¹⁹ Winjum, J. K., Brown, S., & Schlamadinger, B. (1998). Forest harvests and wood products: Sources and sinks of atmospheric carbon dioxide. *Forest Science*, 44(2), 272–284.

$$C_{Mill,ty} = \sum_{s,w,oir,p}^{ty} EXC_{WP,ty} \times (1 - WW) \quad (32)$$

Where:

| | |
|----------------|--|
| $C_{Mill,ty}$ | Summed stock of carbon remaining in wood products of class ty from within the project area after milling (t C) |
| $EXC_{WP,ty}$ | Summed stock of biomass carbon extracted from within the project area for class of wood product ty (t C) |
| WW | Wood waste fraction based on mill efficiency |
| s, w, oir, p | Wood product categories: sawnwood, wood-based panels, other industrial roundwood, and paper and paperboard |
| ty | Wood product class, defined here as sawnwood, wood-based panels, other industrial roundwood, paper and paper board |

Wood Waste Fraction (WW)

Winjum et al. (1998) indicate that the proportion of extracted biomass that is oxidized (by burning or decaying) from the production of commodities is equal to 19 percent for developed countries and 24 percent for developing countries. WW is therefore equal to $EXC_{WP,ty}$ multiplied by 0.19 for developed countries and 0.24 for developing countries (Winjum et al. (1998); p. 278).

Step 3: Calculate the total carbon that will be stored in short-lived (≤ 3 years), medium-lived (> 3 years to 100 years) and long-lived (> 100 years) products.

Each year's harvested carbon volume must be categorized into one of the following:

- Short-lived wood products: harvested wood products and wood waste that will decay within 3 years;
- Medium-lived wood products: harvested wood products and wood waste that will be retired between 3 and 100 years from the date of harvest; or
- Long-lived wood products: harvested wood products and wood waste that may be considered permanent (stored for 100 years or more).

For each year's harvests, the calculation of carbon in wood products follows this formula:

$$C_{WP,ty} = \sum_{s,w,oir,p}^{ty} \left((C_{Mill,ty} - SLF) - \left(\frac{MLF}{20} \right) \right) \quad (33)$$

Where:

$C_{WP,ty}$ Total carbon removed from the project area stored in each type, ty, of harvested wood products (t C)

SLF Fraction of wood products that will be emitted to the atmosphere within 3 years of timber harvest (t C)

MLF Fraction of wood products that is considered stored for the medium term and emitted to the atmosphere each year after harvest for 20 years (t C)

Table 3: Extrapolated wood product class decay rates

| Wood Product Class | 5-year decay rate from Winjum et al. (1998) | Annualized decay rate | 3-year decay rate, Short-lived proportion (slp) |
|----------------------------|---|-----------------------|---|
| Sawnwood | 0.2 | 0.04 | 0.12 |
| Wood-based panels | 0.1 | 0.02 | 0.06 |
| Other industrial roundwood | 0.3 | 0.06 | 0.18 |
| Paper and paperboard | 0.4 | 0.08 | 0.24 |

The methodology assumes that this proportion of wood and all other classes of wood products are 100 percent oxidized immediately.

Therefore, SLF is equal to:

$$SLF = (C_{Mill,ty}) \times slp \quad (34)$$

Where:

$C_{Mill,ty}$ Sum of carbon remaining in wood products of class ty from within the project area after milling (t C)

slp Short-lived proportion (last column of Table 3)

Medium-lived Fraction (MLF)

Winjum et al. (1998) gives annual oxidation fractions for each class of wood products split by forest region (boreal, temperate and tropical). This methodology projects these fractions over

95 years to give the additional proportion that is oxidized between 5 and 100 years after initial harvest (Table 44).

Table 44: Proportion of Remaining Wood Products Oxidized (f_o) between 5 and 100 Years after Initial Harvest, by Wood Product Class and Forest Region

| Wood Product Class | f_o | | |
|----------------------------|--------|-----------|----------|
| | Boreal | Temperate | Tropical |
| Sawnwood | 0.38 | 0.62 | 0.85 |
| Wood-based panels | 0.62 | 0.85 | 0.98 |
| Other industrial roundwood | 0.85 | 0.98 | 1.00 |
| Paper and paperboard | 0.38 | 0.62 | 1.00 |

To reflect a 20-year linear decay as required by the *VCS Methodology Requirements*, $1/20^{\text{th}}$ of these proportions must be deducted from the harvested wood product pools for each year following harvest. At 20 years after harvesting, the *MLF* term is equal to zero.

The timeframe for short-lived wood products is defined as less than 3 years to meet *VCS Methodology Requirements*. The portion of wood products stored in medium-lived wood products to be emitted to the atmosphere between 3 and 100 years following harvest was estimated using the oxidation fractions found in Table 2 of Winjum et al. (1998). However, Table 2 of Winjum et al. (1998) specifies oxidation fractions for long-lived wood products, defined as 5 years or greater. Additionally, paper requires a separate oxidation rate for the first 5 years (0.2 for sawnwood and 0.4 for pulp). To account for this, split the medium-lived fraction into two portions: $MLF_{3,5}$ to account for the years that Winjum et al. (1998) define as short-lived and $MLF_{5,100}$ for the remaining 95 years.

For the first 20 years after each harvest cycle, the value of *MLF* for that harvest is therefore equal to:

$$MLF = MLF_{3,5} + MLF_{5,100} \quad (35)$$

Where:

$MLF_{3,5}$ Fraction of wood products that is considered stored for the medium term for the period $t = 3$ years to $t = 5$ years (t C)

$MLF_{5,100}$ Fraction of wood products that is considered stored for the medium term for the period $t = 5$ years to $t = 100$ years (t C)

For the first portion, $MLF_{3,5}$, the following equation is used:

$$MLF_{3,5} = C_{mill,ty} \times slp_{adj} \quad (36)$$

Where:

slp_{adj} Short-lived proportion for the period $t = 3$ years to $t = 5$ years (Table 5)

Table 5: Proportion of Short-Lived Wood Products by Product Class

| Product | Winjum et al. slp (<5 years) | VM0003 Version 1.3 slp (<3 years) | slp_{adj} (years 3 to 5) |
|----------|-----------------------------------|--|-------------------------------|
| Sawnwood | 0.2 | 0.12 | 0.08 |
| Pulp | 0.4 | 0.24 | 0.16 |

For $MLF_{5,100}$, project proponents must use the following equation:

$$MLF_{5,100} = (C_{mill,ty} - SLF - MLF_{3,5}) \times fo \quad (37)$$

Where:

$MLF_{5,100}$ Fraction of wood products that is considered stored for the medium term for the period $t = 5$ years to $t = 100$ years (t C)

$C_{mill,ty}$ Summed stock of biomass carbon extracted from within the project area for class of wood product ty after milling (t C)

fo Fraction oxidized – see Table 3 for defaults; tC tC⁻¹

8.5.2 Estimation of GHG Emissions within the Project Area

The change in GHG emissions as a result of implementation of the proposed IFM project activity within the project area is estimated as:

$$GHG_{PSE} = \sum_{t=1}^{t^*} (E_{PSBiomassBurn,t}) \quad (35)$$

Where:

GHG_{PSE} Greenhouse gas emissions as a result of forest management activities within the project area in the project scenario (t CO_{2e})

| | |
|--------------------------|---|
| $E_{PS_{BiomassBurn},t}$ | Non-CO ₂ emissions due to biomass burning as part of forest management during year t in the project scenario (t CO ₂ e) |
| t | 1, 2, 3, ..., t^* years elapsed since the start of the IFM project activity |

The monitoring of emissions by sources is only required where significant; where insignificant, evidence must be provided (e.g., as part of the monitoring of project implementation) that the assumptions for the exclusion made in the ex-ante assessment still hold in the ex-post situation.

8.5.2.1 Estimation of Non-CO₂ Emissions due to Biomass Burning

The non-CO₂ emissions due to biomass burning as part of forest management ($E_{BiomassBurn}$) are estimated by:

$$E_{BiomassBurn,t} = E_{BiomassBurn_{CH_4},t} \quad (36)$$

Where:

$E_{BiomassBurn,t}$ Non-CO₂ greenhouse gas emissions at time t as a result of biomass burning due to forest management (t CO₂e)

$E_{BiomassBurn_{CH_4},t}$ CH₄ emissions at time t as a result of forest management (t CO₂e)

Estimation of CH₄ emissions is based on the carbon stock loss from biomass burning during forest management. The biomass of logging slash burned, BS , is calculated using Equation (38). This is multiplied by factors that adjust for the mass of CH₄ versus carbon released, and for the global warming potential of CH₄.

$$E_{BiomassBurn_{CH_4},t} = BS_{PS,t} \times ER_{CH_4} \times \frac{16}{12} \times GWP_{CH_4} \quad (37)$$

Where:

$BS_{PS,t}$ Carbon stock in logging slash subject to burning as part of forest management in the project scenario (t C)

ER_{CH_4} Emission ratio for CH₄ (where local data on combustion efficiency are not available or it is not possible to estimate combustion efficiency from fuel information, use the most recent IPCC default value, 0.012²⁰) (kg C as CH₄ (kg C burned)⁻¹)

²⁰ Table 3A.1.15, Annex 3A.1 in IPCC (2003). *Good Practice Guidance LULUCF*.

Where logging slash is not burned as part of forest management $BS_{PS,t} = 0$, otherwise:

$$BS_{PS,t} = \sum_{j=1}^{S_{PS}} \sum_{l=1}^{N_{j,t}} \left(\left(f_j(DBH, H) \right) - (V_{l,j,t} \times D_j) \right) \times CF_j \quad (38)$$

8.6 Leakage

Under the applicability conditions of this methodology, leakage emissions in the form of GHG emissions due to market effects resulting from a shift in harvest over time must be calculated.²¹

Therefore, leakage is estimated as follows:

$$LK = LK_{MarketEffects} \quad (39)$$

Where:

LK Total GHG emissions due to leakage (t CO_{2e})

$LK_{MarketEffects}$ Total GHG emissions due to impacts of project on timber supply and demand (t CO_{2e})

Note – in this methodology, Equation (39) is used to estimate leakage for the period of time elapsed between project start (t = 1) and the year t = t, where t* is the year for which actual net greenhouse gas removals by sinks are estimated.*

8.6.1 Leakage due to Activity Shifting

As per the applicability conditions, leakage due to activity shifting is not permitted.

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

$$LK_{ActivityShifting} = 0 \quad (40)$$

Where the project decreases wood product production by more than 5 percent relative to the baseline, then the project proponent and all associated landowners must demonstrate that

²¹ GHG emissions through fossil fuel use outside the project boundary are not considered based on guidance from the CDM Executive Board. Available at: <http://cdm.unfccc.int/EB/044/eb44rep.pdf>

there is no leakage within their operations (i.e., on other lands they manage/operate outside the boundary of the IFM project). Such a demonstration may include:

- 1) Historical records showing trends in harvest volumes paired with records from the with-project time period showing no deviation from historical trends;
- 2) Forest management plans prepared 24 months or more prior to the start of the project showing harvest plans on all owned/managed lands paired with records from the with-project time period showing no deviation from management plans.

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

$$LK_{MarketEffects} = LF_{ME} \times (\Delta C_{ACTUAL} - \Delta C_{BSL}) \quad (41)$$

Where:

$LK_{MarketEffects}$ Total GHG emissions due to market effects leakage through decreased timber harvest (t CO₂e)

LF_{ME} Leakage factor for market effects calculations (dimensionless)

The leakage factor (LF_{ME}) is determined by considering where in the country logging will be increased as a result of the decreased supply of timber caused by the project. It is likely that the proportional leakage will be higher where the areas liable to be logged have a higher carbon stock than the project area.

$LF_{ME} = 0$ where:

- 1) It is possible to demonstrate that no market effects leakage will occur within national boundaries (e.g., 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
- 2) The project is able to demonstrate that any decrease in wood products produced by the project relative to the baseline is less than 5 percent and any temporal displacement in the total production of wood products is less than 5 years.

$LF_{ME} = 0.1$ where:

- 3) Rotations are moderately extended (5–10 years) leading to a shift in harvests across time periods but a change in total timber harvest equal to or less than 25 percent over the project lifetime.²²

²² Defined here as the minimum project lifetime elected by project proponents in the project description. Where the project is extended beyond this time period, harvests must not be decreased by more than 25 percent across the project area through each additional crediting/baseline period.

- 4) Where rotations are extended by more than 10 years and/or harvest is decreased by more than 25 percent over the project lifetime as per *VCS Methodology Requirements*.

Where a lower proportion of forest biomass in commercial species is merchantable material in the forests to which displacement would occur than in the project area, higher emissions would be expected when extracting a given volume, as more trees need to be cut to supply the same volume. In contrast, where a higher proportion of the total biomass of commercial species is merchantable in the displacement forest than in the project area, a smaller area would be harvested, and lower emissions would result.

Thus, each project must calculate within each stratum the proportion of total biomass in commercial species that is merchantable (PMP_i). This must then be compared to the mean proportion of total biomass that is merchantable for each forest type (PM_{LFT}).

Merchantable biomass is defined as “total gross biomass (including bark) of a tree 5 inches (12.7 cm) DBH or larger from a 1 foot (30.48 cm) stump to a minimum 4 inches top diameter outside bark (DOB) of the central stem.”²³

The following deduction factors (LF_{ME}) must be used, based on the merchantable proportion of total biomass for the forest type:

- 1) Where PM_{LFT} is within 15 percent of PMP_i , $LF_{ME} = 0.4$
- 2) Where PM_{LFT} is more than 15 percent smaller than PMP_i , $LF_{ME} = 0.7$
- 3) Where PM_{LFT} is more than 15 percent greater than PMP_i , $LF_{ME} = 0.2$

Where:

| | |
|------------|--|
| PM_{LFT} | Mean merchantable biomass as a proportion of total above-ground tree biomass for each forest type; for default values see parameter table in Section 9.1 (%) |
| PMP_i | Merchantable biomass as a proportion of total above-ground tree biomass for stratum i within the project boundary (%) |

8.7 Summary of GHG Emission Reductions and/or Removals

The net anthropogenic GHG removals by sinks is the actual net GHG removals by sinks minus the baseline net GHG removals by sinks minus leakage. Therefore, the following general formula is used to calculate the net anthropogenic GHG removals by sinks of an IFM project activity (C_{IFM}).

$$C_{IFM} = \Delta C_{ACTUAL} - \Delta C_{BSL} - LK \quad (42)$$

²³ Definition from US Forest Service FIA Program

Where:

C_{IFM} Net anthropogenic greenhouse gas reductions and removals (t CO₂e)

8.7.1 Calculation of Uncertainty

Estimated carbon emissions and removals arising from AFOLU activities have uncertainties associated with measures/estimates of area or other activity data, carbon stocks, biomass growth rates, expansion factors and other coefficients. It is assumed that the uncertainties associated with estimates of the various input data are available, either as default values given in the most recent version of the IPCC's *GPG-LULUCF*, or estimates based on sound statistical sampling. Uncertainties arising from the measurement and monitoring of carbon pools and the changes in carbon pools must always be quantified.

Indisputably conservative estimates may be used instead of uncertainties, provided that they are based on verifiable literature sources. In this case, the uncertainty is assumed to be zero. However, this section provides a procedure to combine uncertainty information and conservative estimates resulting in an overall project uncertainty.

Uncertainty at all times is defined as the 90 percent confidence interval as a percentage of the mean.

Planning to Diminish Uncertainty

It is important that the process of project planning considers uncertainty. Procedures including stratification, and the allocation of sufficient measurement plots helps to ensure low uncertainty and ultimately full crediting.

It is good practice to consider uncertainty at an early stage to identify data sources with the highest uncertainty to allow the opportunity to conduct further work to diminish uncertainty.

Estimation of Uncertainty for Pools and Emissions Sources

For each measurement pool, calculate both the mean and the 90 percent confidence interval. In all cases, uncertainty must be expressed as the 90 percent confidence interval as a percentage of the mean.

For modeled results, use the confidence interval 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 scenario, the total uncertainty is equal to the square root of the sum of the squares of each uncertainty component.

Total Uncertainty of the 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:

$$C_{IFM_ERROR} = \sqrt{Uncertainty_{BSL}^2 + Uncertainty_P^2} \quad (43)$$

Where:

C_{IFM_ERROR} Total uncertainty for IFM project (%)

$Uncertainty_{BSL}$ Total uncertainty in baseline scenario (%)

$Uncertainty_P$ Total uncertainty in the with-project scenario (%)

The uncertainty in the baseline and project scenarios must be defined as the square root of the summed errors in each of the measurement pools. The errors in each pool may 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.

8.7.2 Uncertainty Deduction

Where C_{IFM_ERROR} is less than or equal to 10 percent of C_{IFM} , there is no deduction for uncertainty.

Where C_{IFM_ERROR} is greater than 10 percent of C_{IFM} , the conservatively adjusted value C_{IFM_adj} is calculated as follows to account for uncertainty:

$$C_{IFM_adj} = C_{IFM} \times (1 - Discount\ factor) \quad (44)$$

Where:

C_{IFM_adj} Net anthropogenic greenhouse gas emissions and removals by sinks, adjusted for uncertainty where C_{IFM_ERROR} is greater than 10 percent of C_{IFM} (tCO₂e)

$Discount\ factor$ Discount factor to be applied for calculating the conservativeness deduction (%)

Determine the discount factor using the following equation:

$$Discount\ factor = \frac{C_{IFM_ERROR}}{t_{10\%}} \times t_{66\%} \quad (45)$$

Where:

| | |
|--------------|---|
| $t_{10\%}$ | t-value for the two-sided 90 percent confidence interval, approximately 1.6449 (dimensionless) |
| $t_{66.6\%}$ | t-value for a one-sided 66.67 percent confidence interval, approximately 0.4307 (dimensionless) |

8.7.3 Calculation of VCUs

To estimate the amount of VCUs to be issued at time $t = t_2$ (date of verification) for monitoring period $T = t_2 - t_1$, this methodology uses the following equation:

$$VCUs = (C_{IFM,t_2} - C_{IFM,t_1}) - BRR \quad (46)$$

Where:

| | |
|---------------|--|
| $VCUs$ | Number of Verified Carbon Units |
| C_{IFM,t_2} | Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_2$ (t CO ₂ e) |
| C_{IFM,t_1} | Net anthropogenic greenhouse gas removals by sinks, as estimated for $t^* = t_1$ (t CO ₂ e) |
| BRR | Portion of carbon credits to be withheld as a buffer reserve |

Buffer reserve (*BRR*) must be calculated using the *VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*.

The number of VCUs eligible for crediting in any one monitoring period must not exceed the ex-ante projected total number of VCUs for the defined project lifetime, unless it is demonstrated that the ex-ante estimate created through modeling was conservatively underestimated (e.g., through growth rates in excess of projection or increases in harvest efficiency/decreases in harvest volumes).²⁴

9 MONITORING

9.1 Data and Parameters Available at Validation

In addition to the parameters listed in the tables below, the provisions on data and parameters to be monitored according to the tools referred to in this methodology apply.

²⁴ This requirement is intended to reduce the risk of over-crediting when harvesting is scheduled or expected to occur shortly after a verification event.

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 proponents must retain a conservative approach – that is, where 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 |
| Description | Area of baseline stratum i |
| Equations | Implicitly used in Section 8.4.1 |
| Source of data | GPS coordinates and/or remote sensing data and/or legal parcel records |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | N/A |
| Purpose of data | Calculation of baseline carbon storage |
| Comments | |

| | |
|-----------------------|--|
| Data/Parameter | BEF |
| Data unit | Dimensionless |
| Description | Biomass expansion factor for conversion of merchantable biomass to total above-ground tree biomass |
| Equations | (15) |
| Source of data | <p>The source of data must be chosen from the following, listed in descending order of preference:</p> <ul style="list-style-type: none"> (a) Existing local and forest type-specific; (b) National and forest type-specific or eco-region-specific (e.g., from national GHG inventory); (c) Forest type-specific or eco-region-specific from neighboring countries with similar conditions (sometimes (c) may be preferable to (b)); (d) Specific at a global level to forest type or eco-region using the most recent version of the IPCC <i>GPG-LULUCF</i>. |
| Value applied | |

| | |
|--|--|
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of carbon stocking from inventory measurements |
| Comments | BEFs are age-dependent. Use of average data may result in significant errors for both young and old stands, as BEFs are usually large for young stands and quite small for old stands. |

| | |
|--|--|
| Data/Parameter | CF_j |
| Data unit | t C t ⁻¹ d.m. |
| Description | Carbon fraction of biomass for species <i>j</i> |
| Equations | (9), (13), (19), (29), (31), (38) |
| Source of data | Default value may be used, or species-specific values from the literature. |
| Value applied | Default value is 0.5 |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of baseline and project carbon storage |
| Comments | |

| | |
|----------------|--|
| Data/Parameter | D_j |
| Data unit | t d.m. m ⁻³ |
| Description | Basic wood density of species <i>j</i> |
| Equations | (9), (13), (29), (31), (38) |
| Source of data | <p>The source of data must be chosen from the following, listed in descending order of preference:</p> <ul style="list-style-type: none"> (a) National and specific to a species or group of species (e.g., from national GHG inventory); (b) Specific to a species or group of species from neighboring countries with similar conditions (sometimes (b) may be preferable to (a)); (c) Specific to a species or group of species at a global level (e.g., from IPCC <i>GPG-LULUCF</i>). |

| | |
|--|--|
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | N/A |
| Purpose of data | Calculation of baseline and project carbon storage |
| Comments | |

| | |
|--|---|
| Data/Parameter | D_{DW} |
| Data unit | t d.m. m ⁻³ |
| Description | Basic wood density of dead wood categorized into three classes: sound (1), intermediate (2) and rotten (3) |
| Equations | (27) |
| Source of data | <p>The source of data must be chosen from the following, listed in descending order of preference:</p> <ul style="list-style-type: none"> (a) Research publications relevant to the project area; (b) National and specific to a species or group of species (e.g., from national GHG inventory); (c) Specific to a species or group of species from neighboring countries with similar conditions (sometimes (c) may be preferable to (b)); (d) Specific to a species or group of species at a global level (e.g., IPCC GPG-LULUCF). |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | Project-specific determination of density is most likely necessary. |
| Purpose of data | Calculation of project and baseline carbon storage |
| Comments | |

| | |
|----------------|---|
| Data/Parameter | $f_j(DBH, H)$ |
| Data unit | t d.m. tree ⁻¹ |
| Description | Allometric equation for species j , linking diameter at breast height (DBH) and possibly height (H) to above-ground biomass of living trees |

| | |
|--|--|
| Equations | (9), (19), (38) |
| Source of data | Where available, use allometric equations that are specific to a species or group of species, provided the equations have been derived using a wide range of diameters and heights and are based on datasets that comprise at least 20 trees. Otherwise, default equations from the most recent version of the IPCC's <i>GPG-LULUCF</i> , national inventory reports or published peer-reviewed studies may be used. |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of baseline and project carbon storage |
| Comments | <p>The applicability of the allometric equations used must be verified using one of the following methods:</p> <ol style="list-style-type: none"> 1) Verification of equation conditions: Justification must be provided for the applicability of the equation to the project locations. Such justification must 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 must have an r^2 value greater than 0.5 (50 percent) and a p value that is significant (<0.05 at the 95 percent confidence level). 2) Additional field verification: For field verification either of the two methods below may be used: <ol style="list-style-type: none"> a) Destructive sampling: <ol style="list-style-type: none"> i) Select at least 5 trees covering the range of DBH existing in the project area, and fell and weigh the above-ground biomass to determine the total (wet) weight of the stem and branch components; ii) Extract and immediately weigh subsamples from each of the wet stem and branch components, followed by oven-drying at 70 °C to determine dry biomass; iii) Determine 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: <ol style="list-style-type: none"> i) Select at least 10 trees per species distributed across the age range (but excluding trees less than 15 years old for which relative inaccuracy in equations is usually low); |

| | |
|--|--|
| | <p>ii) 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 percent for spruce/fir, 5 percent for pines or 20 percent for broadleaf forests.²⁵</p> <p>Where the biomass of the harvested trees is within ± 10 percent of the mean values predicted by the selected default allometric equation and is not biased, or where biased, errs on the conservative side (i.e., use of the equation results in under- rather than over-estimates of project net anthropogenic removals by sinks), mean values from the equation may be used.</p> |
|--|--|

| | |
|--|---|
| Data/Parameter | WW |
| Data unit | Dimensionless |
| Description | Fraction of extracted biomass effectively emitted to the atmosphere during production |
| Equations | (32) |
| Source of data | Winjum et al. (1998) ²⁶ |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of project emissions |
| Comments | |

| | |
|----------------|---|
| Data/Parameter | PM_{LFT} |
| Data unit | % |
| Description | Mean merchantable biomass as a proportion of total above-ground tree biomass for each forest type |
| Equations | Section 8.6.1 |

²⁵ Calculated conservatively from the biomass expansion factors used to calculate total tree biomass from the biomass of the bole in Table 3A.1.10 of IPCC (2003). *Good practice guidance for land use, land use change and forestry*.

²⁶ Winjum, J. K., Brown, S., & Schlamadinger, B. (1998). Forest harvests and wood products: Sources and sinks of atmospheric carbon dioxide. *Forest Science*, 44(2), 272–284.

Source of data

The source of data must be chosen from the following, listed in descending order of preference:

- 1) Peer-reviewed published sources (including carbon/biomass maps or growing stock volume²⁷ maps with a scale of at least 1 km)
- 2) Official government data and statistics
- 3) Original field measurements

The forest types considered are only those relevant for the specific market effects leakage (i.e., only forest types with active timber production).

An appropriate source of data is government records on annual allowable cuts for the areas of commercial forests.

Where volumes are used, wood density is required to convert to merchantable biomass. The source of data for wood density must be chosen from the following, listed in descending order of preference:

- a) Knowledge on commercial species and thus an appropriately weighted wood density derived from the density of these species
- b) A region-specific mean wood density for example as given in Brown (1997)²⁸

For the lower 48 US states, the following defaults have been calculated²⁹ from the US Forest Service Forest Inventory Analysis Database and must be used where appropriate.

| Forest Type Group | Merchantable Biomass as Proportion of Total Biomass (%) |
|-------------------------|---|
| White Red Jack Pine | 77 |
| Spruce Fir | 58 |
| Longleaf Slash Pine | 73 |
| Loblolly Shortleaf Pine | 73 |
| Ponderosa Pine | 64 |
| Oak Pine | 71 |
| Oak Hickory | 73 |

²⁷ Volumes must be converted to merchantable biomass using wood densities/specific gravities. A weighted wood density must be used to convert multi-species data on growing stock volume to merchantable biomass.

²⁸ Brown, S. (1997). *Estimating biomass and biomass change of tropical forests: A primer*. FAO Forestry Paper 134. Available at: <http://www.fao.org/docrep/W4095E/W4095E00.htm>

²⁹ The FIA mapmaker program (Lowe and Cieszewski, 2005) was used. For the lower 48 states, the total biomass and merchantable biomass by forest type were downloaded in order to calculate the proportions given here.

| | | |
|---|----------------------------------|----|
| | Oak Gum Cypress | 72 |
| | Elm Ash Cottonwood | 73 |
| | Maple Beech Birch | 76 |
| | Aspen Birch | 61 |
| | Douglas Fir | 70 |
| | Western White Pine | 62 |
| | Fir-Spruce/Mountain Hemlock | 62 |
| | Lodgepole Pine | 64 |
| | Hemlock/Sitka Spruce | 67 |
| | Western Larch | 66 |
| | Redwood | 43 |
| | Western Oak | 69 |
| Value applied | | |
| Justification of choice of data or description of measurement methods and procedures applied | | |
| Purpose of data | Calculation of leakage emissions | |
| Comments | | |

| | |
|-----------------------|--|
| Data/Parameter | <i>R</i> |
| Data unit | Dimensionless |
| Description | Root-shoot ratio appropriate for biomass increment based on forest type or biome |
| Equations | (16), (20) |
| Source of data | The source of data must be chosen from the following, listed in descending order of preference: (a) Research publications relevant to the project area; |

| | |
|--|---|
| | <ul style="list-style-type: none"> (b) National and forest type-specific or eco-region-specific (e.g., from national GHG inventory) (sometimes (b) may be preferable to (a));³⁰ (c) Forest type-specific or eco-region-specific from neighboring countries with similar conditions; (d) Forest type-specific or eco-region-specific at a global level (e.g., from IPCC <i>GPG-LULUCF</i>). |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of project and baseline emissions |
| Comments | <p>Guidelines for conservative choice of default values:</p> <ol style="list-style-type: none"> 1) Where default data are available in the sources of data mentioned above for conditions that are similar to the project (same vegetation genus, same climate zone, similar forest type), mean values of default data may be used and considered conservative. 2) Global values may be selected from the most recent version of the IPCC's <i>GPG-LULUCF</i>, by choosing a climatic zone and species that most closely matches the project circumstances. |

| | |
|----------------|---|
| Data/Parameter | <i>SLF</i> |
| Data unit | Dimensionless |
| Description | Short-lived fraction: proportion of wood products that oxidize immediately in the first three years following harvest |
| Equations | (30), (33), (34), (37) |
| Source of data | <p><i>The Forestry Appendix of the US Department of Energy's Technical Guidelines for The Voluntary Reporting of Greenhouse Gas Program (Section 1605b)</i></p> <p>Also available as a US Forest Service General Technical Report at: https://www.srs.fs.usda.gov/pubs/22954</p> <p>Winjum et al. (1998)</p> |
| Value applied | |

³⁰ (b) must only be used instead of (a) when the dataset for (b) is significantly larger and the relationship between root and shoot tighter. For example, projects may elect to use defaults from Table 4.4. in IPCC (2006). *Guidelines for national greenhouse gas inventories: Volume 4 AFOLU*. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf

| | |
|--|---|
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of project and baseline emissions |
| Comments | |

| | |
|--|---|
| Data/Parameter | <i>MLF</i> |
| Data unit | Dimensionless |
| Description | Medium-lived fraction: proportion of wood products that decay over the 20-year period following harvest |
| Equations | (30),(36), (37), (35) |
| Source of data | <p><i>The Forestry Appendix of the US Department of Energy's Technical Guidelines for The Voluntary Reporting of Greenhouse Gas Program (Section 1605b)</i></p> <p>Also available as a US Forest Service General Technical Report at: https://www.srs.fs.usda.gov/pubs/22954</p> <p>Winjum et al. (1998)</p> |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of project and baseline emissions |
| Comments | |

| | |
|----------------|---|
| Data/Parameter | <i>LLF</i> |
| Data unit | Dimensionless |
| Description | Long-lived fraction: proportion of wood products that remain stored for 100 years following harvest |
| Equations | (30) |
| Source of data | <p><i>The Forestry Appendix of the US Department of Energy's Technical Guidelines for The Voluntary Reporting of Greenhouse Gas Program (Section 1605b)</i></p> <p>Also available as a US Forest Service General Technical Report at: https://www.srs.fs.usda.gov/pubs/22954</p> |

| | |
|--|---|
| | Winjum et al. (1998) |
| Value applied | |
| Justification of choice of data or description of measurement methods and procedures applied | |
| Purpose of data | Calculation of project and baseline emissions |
| Comments | |

9.2 Data and Parameters Monitored

| | |
|---|---|
| Data/Parameter | A_i |
| Data unit | ha |
| Description | Area of stratum i |
| Equations | (17), (22), (27) |
| Source of data | Strata and stand boundaries must be monitored preferably using a Geographic Information System (GIS), which allows for integrating data from different sources (including GPS coordinates and remote sensing data). |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of project emissions |
| Calculation method | |
| Comments | It must be assumed ex-ante that stand boundaries and strata areas do not change over time. |

| | |
|----------------|----------------|
| Data/Parameter | A_p |
| Data unit | m ² |

| | |
|---|--|
| Description | Area of sample plot |
| Equations | (14) |
| Source of data | Recording and archiving of size of sample plots |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | |
| Calculation method | |
| Comments | The size of plots must be defined ex-ante and recorded in the monitoring plan. |

| | |
|---|---|
| Data/Parameter | $DM_{n,i,t}$ |
| Data unit | cm |
| Description | Diameter of piece n of dead wood along the transect in stratum i at time t |
| Equations | (26) |
| Source of data | Field measurements in sample plots |
| Description of measurement methods and procedures to be applied | <p>Lying dead wood must be sampled using the line intersect method (Harmon & Sexton, 1996³¹). 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.</p> <p>Minimum measurement diameter for all sites must not be less than 10 cm.</p> |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of project emissions |

³¹ Harmon, M. E., & Sexton, J. (1996). *Guidelines for measurements of woody detritus in forest ecosystems*. US LTER Publication No. 20. US LTER Network Office, University of Washington.

| | |
|--------------------|--|
| Calculation method | |
| Comments | The change in carbon stocks in all applicable pools will be modeled ex-ante following the requirements in Section 8.5.1. |

| | |
|---|---|
| Data/Parameter | <i>DBH</i> |
| Data unit | cm |
| Description | Diameter at breast height of tree |
| Equations | (9), (19), (38) |
| Source of data | Field measurements in sample plots |
| Description of measurement methods and procedures to be applied | Typically measured 1.3 m above ground. Measure all trees above some minimum <i>DBH</i> in the sample plots of the IFM project activity. The minimum <i>DBH</i> for all sites must not be more than 20 cm. |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of baseline and project emissions |
| Calculation method | |
| Comments | The change in carbon stocks in all applicable pools will be modeled ex-ante following the requirements in Section 8.5.1. |

| | |
|---|------------------------------------|
| Data/Parameter | <i>H</i> |
| Data unit | m |
| Description | Height of tree |
| Equations | (9), (19), (38) |
| Source of data | Field measurements in sample plots |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | |

| | |
|--------------------------------|--|
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of baseline and project emissions |
| Calculation method | |
| Comments | The change in carbon stocks in all applicable pools will be modeled ex-ante following the requirements in Section 8.5.1. |

| | |
|---|--|
| Data/Parameter | L |
| Data unit | m |
| Description | Length of the transect to determine volume of lying dead wood (default 100 m) |
| Equations | (26) |
| Source of data | Field measurements |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of project emissions |
| Calculation method | |
| Comments | The change in carbon stocks in all applicable pools will be modeled ex-ante following the requirements in Section 8.5.1. |

| | |
|------------------------------------|---|
| Data/Parameter | N |
| Data unit | Dimensionless |
| Description | Total number of wood pieces intersecting the transect |
| Equations | (26) |
| Source of data | Field measurements |
| Description of measurement methods | |

| | |
|-----------------------------------|--|
| and procedures to be applied | |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | |
| Calculation method | |
| Comments | The change in carbon stocks in all applicable pools will be modeled ex-ante following the requirements in Section 8.5.1. |

| | |
|---|---|
| Data/Parameter | PMP_i |
| Data unit | % |
| Description | Merchantable biomass as a proportion of total above-ground tree biomass for stratum i within the project boundary |
| Equations | Section 8.6.2 |
| Source of data | Within each stratum i , divide the summed merchantable biomass (defined as “total gross biomass (including bark) of a tree 5 inches (12.7 cm) DBH or larger from a 1 ft (30.48 cm) stump to a minimum 4 inches (10.2 cm) top DOB of the central stem”) by the summed total above-ground tree biomass. |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | At least every five years, at verification |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of leakage emissions |
| Calculation method | |
| Comments | A time-zero measurement must be made of this factor ex-ante. |

| | |
|----------------|---|
| Data/Parameter | T |
| Data unit | yr. |
| Description | Number of years between monitoring time t_1 and t_2 ($T = t_2 - t_1$) |

| | |
|---|--|
| Equations | (18), (23), (24), (28) |
| Source of data | |
| Description of measurement methods and procedures to be applied | |
| Frequency of monitoring/recording | |
| QA/QC procedures to be applied | |
| Purpose of data | Calculation of baseline and project emissions |
| Calculation method | |
| Comments | The monitoring plan must detail ex-ante the planned monitoring intervals through the project life. |

9.3 Description of the Monitoring Plan

All data collected as part of monitoring must be archived electronically and kept for at least 2 years after the end of the project. All of the data must be monitored unless indicated otherwise in Section 9.2. All measurements must be conducted according to relevant standards. In addition, the monitoring provisions in the tools referred to in this methodology apply.

Monitoring of Project Implementation

Information must be provided, and recorded in the project description, to establish that:

- 1) The geographic position of the project area is recorded for all areas of land:
 - a) The geographic coordinates of the project area (and any stratification inside the boundary) are established, recorded and archived. This may be achieved by field survey (e.g., using GPS), or by using georeferenced spatial data (e.g., maps, GIS datasets, orthorectified aerial photography or georeferenced remote sensing images).
- 2) Commonly accepted principles of forest inventory and management are implemented:
 - a) Standard operating procedures (SOPs) and quality control/quality assurance (QA/QC) procedures for forest inventory including field data collection and data management must be applied. Use or adaptation of SOPs already applied in national forest monitoring, or available from published handbooks, or from the most recent version of the IPCC's *GPG-LULUCF* values is recommended;
 - b) The forest management plan, together with a record of the plan as actually implemented during the project, must be available for validation and verification, as appropriate.

Sampling Design and Stratification

Stratification of the project area into relatively homogeneous units may 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. Project proponents must present in the project description an ex-ante stratification of the project area or justify the lack of stratification. The number and boundaries of the strata defined ex-ante may change during the project crediting period (ex-post).

Updating of strata

The stratification must be updated ex-post in the following situations:

- 1) Unexpected disturbances occur during the project crediting period (e.g., due to fire, pests or disease outbreaks), differently affecting various parts of an originally homogeneous stratum; or
- 2) Forest management activities (cleaning, planting, thinning, harvesting, coppicing, re-planting) have been implemented in a way that affects the existing stratification.

Established strata may be merged where reasons for their establishment have disappeared.

Sampling Framework

To determine the sample size and allocation among strata, this methodology uses the latest version of the CDM *Tool for the calculation of the number of sample plots for measurements within A/R CDM project activities* approved by the CDM Executive Board. The targeted precision level for biomass estimation across the project is ± 10 percent of the mean at a 90 percent confidence level. In contrast to the CDM tool, note that temporary plots are permissible under this methodology.

Data and Parameters Monitored

The parameters listed in Section 9.2 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 proponents must provide transparent estimations of the parameters that are monitored during the project crediting period. These estimates must be based on measured or existing published data where possible and project proponents must retain a conservative approach — that is, where 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.

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

Conservative Approach and Uncertainties

To help reduce uncertainties in accounting of emissions and removals, this methodology uses, where possible, the proven methods from the most recent version of IPCC's *GPG-LULUCF* and the tools and methodologies of the CDM Executive Board. Tools and guidance from the CDM Executive Board on conservative estimation of emissions and removals are also used. Despite this, potential uncertainties still arise from the choice of parameters to be used. Uncertainties arising from, for example, biomass expansion factors (BEFs) or wood density would result in uncertainties in the estimation of both baseline net GHG removals by sinks and the actual net GHG removals by sinks, especially when global default values are used.

It is recommended that project proponents identify key parameters that would significantly influence the accuracy of estimates. Local values that are specific to the project circumstances must then be obtained for these key parameters, where possible. These values must be based on:

- 1) Data from well-referenced peer-reviewed literature or other well-established published sources³²; or
- 2) National inventory data or default data from IPCC literature that has, where possible and necessary, been checked for consistency against available local data specific to the project circumstances; or
- 3) In the absence of the above sources of information, expert opinion may be used to assist with data selection. Experts will often provide a range of data, as well as a most probable value for the data. The rationale for selecting a particular data value must be briefly noted in the project description. For any data provided by experts, the project description must also record the expert's name, affiliation and principal qualification as an expert (e.g., member of a national forest inventory technical advisory group), and must include a 1-page summary CV for each expert consulted, included in an annex.

In choosing key parameters or making important assumptions based on information that is not specific to the project circumstances, such as in use of default data, project proponents must select values that will lead to an accurate estimation of net GHG removals by sinks, taking into account uncertainties. Where uncertainty is significant, project proponents must choose data such that it tends to under-estimate, rather than over-estimate, net GHG removals by sinks.

10 REFERENCES

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³² Typically, citations for sources of data used should include: the report or paper title, publisher, page numbers, publication date, etc. (or a detailed web address). Where web-based reports are cited, hard copies must be included as annexes in the project description if there is any likelihood such reports may not be permanently available.

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DOCUMENT HISTORY

| Version | Date | Changes |
|---------|-------------|--|
| v1.0 | 13 May 2010 | Initial version released. |
| v1.1 | 20 Nov 2012 | <p>Revision of Section 8.5.1.3. to account for the decay of carbon from the harvested wood products pool and to make explicit that the decay of the dead wood pool must not be assumed to be immediate.</p> <p>Other minor updates have also been incorporated into the methodology. Specifically, the applicability conditions were revised to clarify the types of forest management techniques which are eligible activities under this methodology. A modification was made concerning the timing by which FSC certification must be in place to allow projects to achieve certification by the start of the project crediting period.</p> |
| v1.2 | 29 Aug 2013 | Clarified Section 6.3 with respect to selection of the most plausible baseline scenario. |
| v1.3 | 16 May 2023 | <p>Modified Section 4 to expand access to non-certified lands that are to become FSC certified.</p> <p>Modified Section 8.5.1 to improve accuracy of wood products accounting in equations 33, 35, 36, and 37.</p> <p>Updated Section 8.7.2, equation 47 to conform with the most recent VCS requirements for quantifying uncertainty.</p> |